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ICDS 2022

Forward

The Sixteenth International Conference on Digital Society (ICDS 2022) was held in Porto, Portugal, June 26 - 30, 2022.

Nowadays, most of the economic activities and business models are driven by the unprecedented evolution of theories and technologies. The impregnation of these achievements into our society is present everywhere, and it is only question of user education and business models optimization towards a digital society.

Progress in cognitive science, knowledge acquisition, representation, and processing helped to deal with imprecise, uncertain or incomplete information. Management of geographical and temporal information becomes a challenge, in terms of volume, speed, semantic, decision, and delivery.

Information technologies allow optimization in searching an interpreting data, yet special constraints imposed by the digital society require on-demand, ethics, and legal aspects, as well as user privacy and safety.

The event was very competitive in its selection process and very well perceived by the international scientific and industrial communities. As such, it is attracting excellent contributions and active participation from all over the world. We were very pleased to receive a large amount of top quality contributions.

The accepted papers covered a large spectrum of topics related to advanced networking, applications, social networking, security and protection, and systems technologies in a digital society. We believe that the ICDS 2022 contributions offered a panel of solutions to key problems in all areas of digital needs of today's society.

We take here the opportunity to warmly thank all the members of the ICDS 2022 technical program committee as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and efforts to contribute to the ICDS 2022. We truly believe that thanks to all these efforts, the final conference program consists of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations and sponsors. In addition, we also gratefully thank the members of the ICDS 2022 organizing committee for their help in handling the logistics and for their work that is making this professional meeting a success.

We hope the ICDS 2022 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress on the topics of digital society. We also hope that Porto provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city

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Machine Learning Method Within the Context of a Socially Aware Solution for Vehicle Routing Problems

Robert Maurer
Department of Business and Management
University of Applied Sciences Brandenburg
Brandenburg, Germany
E-Mail: maurer@th-brandenburg.de

Andreas Johannsen
Department of Business and Management
University of Applied Sciences Brandenburg
Brandenburg, Germany
E-Mail: johannse@th-brandenburg.de

***Abstract*—The market for courier, express and parcel services has seen an immense increase in sales and relevance in times of the pandemic. Not only has the volume of shipments increased, but also the demand for social Vehicle Routing Problems (VRP) solution procedures based on modern IT solutions supporting the dispatching or routing process. This article provides an answer to social responsible and sustainable logistics services and a conceptual prototype for the practical implementation of a Machine Learning method to solve Vehicle Routing Problems (VRP) in the context of sustainable "last mile" logistics. Aspects of combinatorial optimization algorithms in the form of an ant algorithm were used to support the applied Machine Learning (ML) system. The prototype is based on the "Reinforcement Learning" system and uses "REINFORCE with baseline" as the algorithm for updating a parameterized policy. A benchmark analysis provides a comparison between the prototype and Google-OR, as a representative for combinatorial optimization algorithms, applied in two examples. The results show that Google-OR prevails over the prototype in terms of solution quality, but the prototype convinces in runtime and automatism. In addition, the applied Machine Learning context results only in minor advantages for small to medium sized logistic domains, as they do not generate enough data. Hence, using Machine Learning methods for Vehicle Routing problems is recommended for a larger stop volume in urban areas. Furthermore, the prototype represents an alternative solution to outsourcing to third party providers and provides an approach to gain a competitive advantage for solving Vehicle Routing Problems.**

Keywords-Vehicle Routing Problem; Machine Learning; Reinforcement Learning; last mile logistics

I. INTRODUCTION

A. Motivation and goals

In 2020, the amount of shipments in Germany comprised 4,05 billion package, express and courier shipments. The amount of shipments tends to increase within the upcoming years whereby the majority of shipments is serving the B2B sector [1]. In addition to the increased amount of package shipments and the resulting routing problems, the scientific interest in Vehicle Routing Problems (VRP) based on modern IT solutions has also increased. A search led by the keyword "Vehicle Routing" in the IEEE Explore database resulted in more than 6500 hits within the last ten years. Nevertheless, there is just a limited amount of scientific work in the field of Machine Learning (ML)-methods to solve VRP. A search through Google Scholar resulted in 15 publications within the last five years that used the terms "Vehicle Routing" and Machine Learning" in their titles. In addition, the current research findings are predominantly in a theoretical environment with a focus on mathematical models and assumptions, such as [2] and [3], but without proper practical relevance. Furthermore, social factors such as comfort of driving (e.g., through weather conditions), route preferences, road conditions or interactions between the drivers are barely considered. Additionally, there is only limited literature considering comprehensive solutions for sustainability related challenges [4]. The main motivation of this work is to develop a practical concept, in form of a prototype, to solve VRP. Furthermore, the paper shows that ML-methods - in a productive working environment - can be a long-term alternative to outsourcing to third party suppliers and can be a potential tool to increase employee loyalty. This is shown by a comparison in terms of effectiveness under selected evaluation criteria between ML-methods and classical optimizing algorithms to solve VRP.

B. Thematical Introduction

In the subject area of the zero-emissions „Last-Mile"-metropolitan logistics, the VRP describes a combinatorial optimization problem that addresses the following basic question: "What is the optimal set of routes for a specific vehicle fleet to deliver goods to a specific amount of customers?" [5]. VRP was first discussed by [6] in their scientific work „The Truck Dispatching Problem" where the problem context was the delivery of fuel, which was solved by using algorithmic ways. To solve VRP, ML- methods are especially suitable because their decision making process is based on algorithms and experience. The experience arises from specific subscription structures occurring in certain subject domains and the resulting known VRP instances. In this work, the specific use case of the VRP is within the context of the "Last- Mile" metropolitan logistics. This is a modern form of the urban logistics, which contains the last step of a package delivery. Especially a zero-emissions approach was pursued. That is realized through the usage of cargo bikes and micro-depots, which justifies the term "Green VRP" [7]. The aspect of „Last Mile" metropolitan logistics is relevant for solving combinatorial optimization

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problems in the way that it can be assumed that there is a small distance between the routes and the delivery tours are limited in capacity through the usage of cargo bikes. Looking at rural areas, these factors are becoming more important because the distances between the stops are longer and the amount of stops is less, compared to urban areas. Therefore, the planning of efficient routes, as well as the driving conditions, are not only a decisive factor for the high logistic costs of zero emission delivery, but also necessary in order to keep up with the alternative of Diesel- or Petrol- based transporters.

C. Challenges and Competitive Position

There are challenges in the later implementation of the prototype regarding the competition between classical optimization algorithms and the used ML-method to solve VRP. Especially concerning performance, the ML- method of the prototype is going to be very demanding in the beginning, because it includes more process steps such as training the model. The prototype is competitive, if it generates short routes based on the length of the tour, provides the results within a few seconds, generally reacts to unknown VRP instances, performs equally well on VRP instances and does not need a manual intervention. A further competitive advantage could be gained by the prototype though the consideration of social framework conditions.

II. METHODOLOGY

A. Selection of a Machine Learning Method

In the context of this article, the ML-model uses a Reinforcement Learning (RL)-system to solve VRP of the "Last Mile" metropolitan logistics. In this paragraph, we explain why we chose reinforcement learning in our work. The RL differs significantly from the alternative supervised- and unsupervised learnings because it uses a different approach for the construction of a learning system. The learning model describes an agent or a decision maker in the RL that observes an environment, executes actions on it and independently learns the dynamics from an unknown starting point [8]. After each action, the agent can receive two different kinds of rewards: an immediate or a delayed reward. An immediate reward is applied for actions of the agent that allow an immediate assessment, which are also used in the developed prototype. For instance, the crossing of a red traffic light can be assessed immediately because a negative behavior is directly identifiable and does not only become identifiable through subsequent behavior. A delayed response can be thought of as an action in the game of chess where the reward is measured to the follow up reaction, which was also used in the scientific work of [9]. For this article, RL was chosen in order to find solutions to complex optimization problems without prior human knowledge to reduce development and dispositioning effort.

B. Training and Result Data

Through the cooperation with a Germany based company, a solid foundation of anonymized customer were used for training and testing the model. Due to the missing availability of data, certain framework conditions such as route preferences or impact of the weather could not be directly considered in the learning process. The data objects have the following properties: longitude, latitude, stop weight, stop volume and an anonymized identifier. The data objects are specific to a certain date and a micro depot.

C. Prototyping

For the foundation of the research and based on the practical motivation, a qualitative-constructivist approach in the form of the prototyping was chosen. The final version of the prototype is supposed to be a service that trains, stores and applies ML-models. The ML-model is sensitive towards the sender, the micro depot, the supplier, the weekday, the vehicle weight, the vehicle volume and the ML-method. The ML-model is instance-based saved. The ML-model should only be trained by stops from one day to one week in order to avoid that subscribed customers change the strategy of the agent through repetitive appearance.

D. Comparative Analysis

In the context of this article, a comparative analysis between the developed prototype and the VRP-solver of Google-OR was performed. According to [10] the VRP-solver is based on heuristic algorithms that are categorized as „First Solution Strategy" and are optionally extendable through „Local-Search"- strategies. Since the competitor's solution is not considering any social framework conditions regarding the driver, the comparison is mainly focused on the technical factors. The results of this comparison are supposed to evaluate the prototype, reveal opportunities for improvement and consider the potential for the implementation of the RL-method for solving the VRP. The analysis is structured in two parts. In the first part of the comparative analysis, the main focus lies on an estimation of the effectiveness of the developed prototype including the predefined basic functionalities of the chosen RL-algorithm "REINFORCE with baseline" to solve VRP. The estimation of the effectiveness is based on the focus of the trainings and testing time, as well as further comparison criteria such as distance and time effort. The Haversine formula proves the distance effort. The time effort is calculated through the deposited vehicle speed, the distance and a predefined stop dwell time of five minutes. For a larger experiment, further comparison criteria could be profitability, service quality, consistence, external (especially social factors) and further [11]. It is looked at a stop volume of 430 stops spread over four weeks in May 2021, whereby the ML-model is trained with 200 iterations after each day. Since the training is progressive, each training of each week builds on the experience of the previous one. The second part of the analysis focused on the scope for improvement of the ML-method and the developed adjustment impulses, which are derived from the previous first part. The goal is it to converge as close as possible to the calculated distance and time effort compared to the competitors in order to convince with a better runtime. In the third part, the same problem context is looked at for a more significant comparison. The training was analogous to the first part with adjusted 115

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iterations per day. The amount of iterations was reduced to minimize the possibility of "overfitting" of the ML model compared to the training data.

III. RESEARCH RESULTS

A. Modelling and Conception of the Machine Learning Model

The Machine Learning model is fundamentally based on the Markov Decision Process (MDP) in conjunction with an Ant Colony Optimization (ACO)-algorithm, which is a combinatorial optimization method, whose foundation was laid by [12]. The ACO-procedure was used in the training mode for the prototype within the first instance of the process to provide the RL-method in the following step of the process with a premonition of the transition probability distribution in the subsequent process step and to tune already trained ML-models for the considered problem context. Comparatively, a similar sub-procedure was performed by [13]. They considered an ACO-model supported by ML as the starting point. The ML-model is defined by MDP. In Markov-models, the subsequent states and the RL-reward only depend on the current state and the chosen action of the agent [17]. The adapted MDP in the developed prototype was modeled in accordance to [15]. As an ML-algorithm the prototype uses the "REINFORCE"-algorithm or Monte-Carlo Policy-Gradient, in order to find an optimal policy π^*. For the development of the prototype and the application of the "REINFORCE"-algorithm, the book "Reinforcement Learning- An Introduction" from [16] was used for guidance. The Monte-Carlo-methods are characterized by the fact that there is no holistic knowledge about the environment needed to find an optimal policy. This is because systems are learning from the interaction with the environment [16]. A modified form the "REINFORCE" with baseline"-algorithm was constructed according to [16]. A baseline can be a random variable or, as used in the context of this prototype, a „state-value"-function, which reflects valuations of possible rewards of the entire condition space [16].

B. Development of the Prototype

The backend of the prototype was developed in the programming language python and the web-frontend, which was necessary for better debugging, in react. Consciously, no existing ML-frameworks, such as Keras, Tensorflow or PyTorch, were used. This decision was made because, in case complex ML-frameworks were used, there would constantly be a risk of becoming dependent on the respective framework support. Furthermore, the usage of self-developed complex ML-methods lead to better gains of understanding and experience, than the usage of ML-frameworks. However, there is a stronger tendency to learn the framework rather than the ML-procedure based on it. In addition, special challenges occurred during the development of the prototype. Above all the thematic of the local minimum, in which the prototype often was stuck in the early stages of the development. The progression of cumulated rewards, which are understood as total length in km of all formed tours within one episode were monitored over 2000 episodes. In this case, the agent considers a problem context of 19 stops, which are distributed in the city, and detects an adequate solution towards the end, but not the best one even though it already detected it in the first 250 iterations. This was caused by the learning factor being set too low and by the fact, that the exploration factor did not influence the agent enough for an extended exploration of the environment. For a better exploration, a dynamic epsilon exploration was used [16]. In the use case of the prototype, the fundamental goal was finding the global minimum in a specific problem context in order to reach the shortest possible total distance. Furthermore, it proved to be difficult to implement the "Baseline" update exactly according to [16]. Partial updates of specific parameters were too "heavy" and caused a noise in policy rewards. In order to solve this problem, two areas in the concept were adjusted. On the one hand, the advantage calculation was replaced by a „Simple every-visit Monte Carlo"[16]. On the other hand, a direct update of the parameterized policy was prohibited and instead handled through an adjustable increase and decrease factor. Moreover, after the first part of the comparative analysis, certain adaptation impulses regarding "local-search" and "bin-packing" strategies were implemented in the prototype. In the case of "local-search" strategies, the agent's action-selection execution is matched to ensure that the made decision does not exceed an adjustable threshold against the lowest possible reward. A simple „First Fit Decreasing"-approach, realized the "bin-packing"-strategy, which enables an optimal distribution of the capacity requirements to the maximum capacity of the vehicle.

IV. INTERPRETATION

A. Evaluation of the Results

In the first part of the comparative analysis and the used basis implementation, it was shown that the ML-procedure performed worse than the competitor in the chosen aspects of evaluation did. Enforcement, based on the runtime is possible, but the tours should not require significantly higher distances for that. The payment in the area of the "last-mile"-logistics is usually per finished stop. Because of this, the driver does not want to be slowed down by badly optimized routes. The prototype with the basic implementation of „REINFORCE with Baseline" partially does not recognize nearby stops and chooses unnecessary long distances in the first step of the analysis. It deviates +6.94 km and +14.13 min on average from the competitor's solution. The results in the second step of the analysis show an increase in the aspects of evaluation, compared to the first version. The average deviations between prototype solution and OR-strategy are +6,51 km +11,01 min. Also in the second part of the analysis, regarding runtime, the prototype is significantly faster in solving VRP-instances compared to the competitor, because he can execute the experience-based decisions. This is still too expansive for a productive environment in relation to the number of stops and should be optimized in terms of competitiveness. With regard to the named challenges and the resulting indirect requirements to the competitiveness of

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the prototype in point one, the following resulting points can be derived, which the prototype is capable to fulfil or not.

- After finishing the training process, the prototype was able to detect a "good" up to an "excellent" solution.
- The prototype can detect solutions without manual interference.
- In the testing modus, the results of the prototype are provided within milliseconds.
- The prototype performs optimally on mainly known VRP-instances. If the major part of the VRP-instances is not known to the prototype, the prototype will not get close to finding an optimal solution.
- Because the prototype reacts badly to unknown VRP-instances, it is not possible that the prototype performs equally on all VRP-instances.

B. Comparison to Combinatory Optimization Algorithm

The comparative analysis has shown that the ML-procedure in the current implementation does not provide the same level of solution quality VRP-instances compared to optimization algorithms. Furthermore, it was shown that the chosen adjustment impulses for the basic implementation of "REINFORCE with baseline" did not provide a significant improvement. The adjustment impulses attained that the prototype was able to reach a better solution with less iterations. However, the improvement of the solution differs only slightly from the basic implementation. Regardless, the comparative studies of RL-methods, with different evaluation criteria and the same runtime, show rarely an optimal solution compared to combinatorial optimization algorithms [17]. This is justified by the fact that the fundamental goal of the RL-method is both, to avoid bad solutions as well as to achieve an average solution. Therefore, it also defines the goal of the prototype. In contrast to the prototype, the Google-OR-Solver considers the holistic structure of the problem and reaches an asymptotically optimal solution with enough runtime and processing power. Besides Google-OR, there are other alternatives for solving combinatorial optimizing problems, such as Concorde TSP Solver or the services of openrouteservices.

C. The Relevance of the „Last-Mile"-Logistics

With regard to the relevance of the prototype for the „last-Mile"-logistics and in consultation with the cooperating company, which is supporting a network of the "last-mile"-metropolitan logistics, the following results can be derived. The prototype is not efficient enough for low stop volume with less than 1200 stops per day. One of the reason for that is the fact that the manual dispatch effort and the usage of combinatorial optimizing algorithms, for less than 400 stops within a small "last-mile" area, are significantly less than the training effort of the prototype.

Starting from 400 stops, the Google-OR-Solver shows signs of weakness with a runtime of 10s. This was also shown by the work of [2], where the developed RL-method lead partially to even better results, for a high stop volume, compared to the OR tools. Considering the retro perspective and the feedback of the company, the decision of the RL for the "last-mile" was reconsidered and ideas regarding other ML-systems were elaborated. One of the favorite solutions is the implementation of supervised-learning to learn the dispatch mode of the supplier-dispatchers so that the ML-component is supportive and does not automatically solve VRP-instance. However, looking at solving Green Vehicle Routing Problems as a whole, e.g. [4] just partially agrees, because applying a multi-dimensional approach is suggested.

V. CONCLUSION

This article, provides a concept for the basic implementation of a reinforcement learning (RL)-method, in the form of a "REINFORCE with baseline", in combination with an Ant Colony Optimization (ACO)-algorithm to solve Vehicle Routing Problems (VRP). Regarding rural areas, the prototype is not suitable due to the necessary high amount of stops for the training. However, due to the large amount of stops, the developed prototype based on the enhanced implementation of "REINFORCE with baseline" can be, especially for urban areas, an alternative to third party providers such as Google-OR. In addition, impulses for the adaptive solving of VRP by using different optimization mechanism within the prototype are provided. It is also shown that the social factor is barely considered in the ML-context for solving VRP. Therefore, there is a potential for the prototype to gain a competitive advantage.

Looking ahead to further research landscapes of Machine Learning (ML) and VRP, the research results have shown that an enhanced implementation of an RL-method can achieve a good, up to an excellent result, regarding the investigated evaluation criteria compared to classic optimization methods. For future improvement of the prototype, a reduction of the complexity of the adjustable parameter could be considered in order to avoid possible "overfitting". Additionally, a redesigned prototype by using a different proximal policy according to [3] could lead to a relevant increase in performance. An extension of the prototype regarding other RL-procedures would be possible and important to validate the results. An exploration of further RL-procedures would be important as well, because in the field of RL the slightest changes in parameters or the used procedure result in strong deviations in the results. However, the human factor, such as personal preferences of the delivery personnel, should be incorporated in the optimization model and algorithm. This, for example, could consider preferences of dealing with environmental conditions (e.g., construction areas or traffic jams) on the proposed routes.

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Distinguishing Between Truth and Fake

Using Explainable AI to Understand and Combat Online Disinformation

Isabel Bezzaoui, Jonas Fegert, Christof Weinhardt
Information Process Engineering
FZI Forschungszentrum Informatik
Karlsruhe/Berlin, Germany
e-mail: bezzaoui@fzi.de, fegert@fzi.de, weinhardt@fzi.de

***Abstract* — Disinformation campaigns have become a major threat to democracy and social cohesion. Phenomena like conspiracy theories promote political polarization; they can influence elections and lead people to (self-)damaging or even terrorist behavior. Since social media users and even larger platform operators are currently unready to clearly identify disinformation, new techniques for detecting online disinformation are urgently needed. In this paper, we present DeFaktS, an Information Systems research project, which takes a comprehensive approach to both researching and combating online disinformation. The project develops a data pipeline in which (i) messages are extracted in large quantities from suspicious social media groups and messenger groups with the help of annotators. Based on this corpus, a Machine Learning-based System (ii) is trained that can recognize factors and stylistic devices characteristic of disinformation, which will be used for (iii) an explainable artificial intelligence that informs users in a simple and comprehensible way about the occurrence of disinformation. Furthermore, in this paper an interdisciplinary multi-level research approach focusing on media literacy and trust in explainable artificial intelligence is suggested in order to operationalize research on combating disinformation.**

Keywords - Fake news; disinformation detection; machine learning-based systems; design science research.

I. INTRODUCTION

As the major news source of today, social media channels and online news portals suffer from non-fact-based reporting and opinion dissemination [1]. Spreading virally, disinformation poses a central threat to the political process and social cohesion. Disinformation is defined as false information, spread with the intention to deceive. Fake news is an example of disinformation, which is why we use these two terms interchangeably [2]. It influences elections, and tempts people to engage in (self-)damaging or even terrorist behavior. Accordingly, it displays a generally undesirable phenomenon in public information and opinion-forming processes [3][4]. Besides political radicalization [5], vaccination boycotts are increasingly attributed to disinformation campaigns [6][7]. Therefore, on the one hand, there is a need for a comprehensive understanding of their mechanisms and spread, and on the other hand, based on this, methods to combat them. People are naturally inclined to consume content with which they are familiar (familiarity bias), whose authors are similar to them (similarity bias), or whose statements they agree with (confirmation bias). In particular, confirmation bias is a decisive factor in the spread of disinformation [8]. Platforms, such as WhatsApp and Telegram in particular play a major role here and could take many preventive measures. They generally lack the appropriate approaches for this, because more emotional arousal and dissent lead to more activity on the platform, and in turn generate more advertising revenue [9][10]. Even though Twitter, for example, is experimenting with fact checks, these are far from sufficient to limit the spread of fake news as they do not operate across platforms. Therefore, DeFaktS intends to empower actual users across various platforms to critically question news and social media posts. For this purpose, the project will develop an artefact for a participation platform that aims to combat online disinformation campaigns and foster critical media literacy among users by informing them about the occurrence of fake news in a transparent and trustworthy way. The paper is structured as follows: Section II will give an introductory overview on the current knowledge base on the combat of disinformation as well as the concepts of critical media literacy and trust. Subsequently, the scientific method and first research activities in the project will be presented in Section III. Finally, the paper concludes with a summary of the project's research endeavors and an outlook on future work related to the project in Section IV.

II. THEORETICAL FOUNDATION

A. Combating Disinformation Using Machine Learning-Based Systems

The fact that nowadays almost anyone can publish content on the internet not only increases the possibility of social participation - it also creates new opportunities for

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spreading disinformation and propaganda. The COVID-19 pandemic has already produced a flood of false reports and demonstrated the importance of being able to distinguish reliable information from half-truths and fake news, and most recently the war in Ukraine also demands a special confrontation with fake news [11]. Currently, research on fake news detection using Machine Learning-based Systems (MLS) is a rapidly expanding field that spans numerous disciplines, including computer science, social science, psychology, and information systems [12]-[14]. Synoptically, empirical efforts to detect and combat disinformation can be divided into four categories: data-oriented, feature-oriented, model-oriented and application-oriented [1]. The majority of methods concentrate on extracting multiple features, putting them into classification models, such as naive Bayes, logistic regression, or decision trees, and then selecting the best classifier based on performance [15]-[18]. What is missing from the previous work, however, are empirical evaluations of when the classifiers are put into practice with real users and of what benefits and impact the presented tools may have. For instance, Guess et al. [19] showed that promoting media literacy can help people judge the accuracy of online content more accurately. Their findings suggest that a lack of critical media literacy is a major factor in why people fall prey to disinformation. Pennycook and Rand [20] found that susceptibility to fake news is driven mostly by poor critical thinking rather than by partisan bias per se. Thus, in order to counter false news, more critical media competence is needed on the part of users. From this point of view, it seems crucial to investigate the potential of MLS detection tools for promoting critical media literacy among social media users.

Furthermore, previous research has demonstrated the importance of trust for the acceptance and perceived usefulness of ICT tools, and MLS in particular [21][22]. Trust is one of the vital components to fostering active, engaged and informed citizens [23]. Transparency is therefore an important aspect when it comes to dealing with disinformation. In this regard, the challenge of how to positively affect trust when developing tools for fake news detection arises. The implementation of an XAI-approach into the development process seeks to make the system's internal dynamics more transparent, as well as the analysis' conclusions more understandable and hence trustworthy to the user. These observations give rise to the need to examine the effect of XAI (Explainable Artificial Intelligence) elements on user trust and thus acceptance and perceived usefulness of the final tool. In order to fill the two above-mentioned research gaps, we would therefore like to address the following research questions in the DeFaktS project:

How to design an artifact for the detection of online disinformation that helps to foster an informed and critically thinking citizenry?

i. (How) Does the tool promote critical media literacy by helping users identify disinformation more accurately?
ii. (How) Does the tool's XAI-component help users trust the algorithm's assessment?

B. Critical Media Literacy

Disinformation is producing uncertainty in the fact-checking process, endangering the public's ability to make informed decisions [24]. In order to foster a critical comprehension of both manipulative communications and the internet as a distribution medium, users must have broad knowledge and a deeper understanding of social media functionalities [25]. Critical media literacy encourages people to consider why a message was sent and where it came from [26]. Following Kellner and Share [27], critical media literacy entails developing skills in analyzing media codes and conventions, and the ability to critique stereotypes, dominant values, and ideologies, as well as the competence to interpret media texts' multiple meanings and messages. Furthermore, it assists individuals to use media responsibly, to discern and assess media content, to critically examine media forms, to explore media effects, and to deconstruct alternative media. However, systematic evaluation of positive or potential non-intended negative effects of the usage of MLS fake news detection tools on the cultivation of critical media literacy is scarce [28]. Schmitt et al. [28] define three dimensions of critical media literacy that can be referred to the critical handling of online disinformation:

i. Awareness: "Awareness" in this case means awareness of the existence of disinformation. This includes knowledge of various forms of disinformation (disinformation in picture, text, or video form, distorted articles, and political pseudo-press) as well as a deeper understanding of how media, and online media in particular, operate.
ii. Reflection: Reflection in the context of critical media literacy is about applying analytical criteria to internet content and determining whether or not it is deceptive. The conscious consideration ("reflection") of content with the character of news is relevant, the thorough thinking before an article is liked, shared or the claim of a headline is taken at face value. As a result, reflection utilizes an individual's knowledge, abilities, and attitudes to critically evaluate (media-communicated) information based on specific criteria including credibility, source, and quality.
iii. Empowerment: Individuals' confidence in their ability to detect manipulative messages, participate in social discourses, and actively position themselves against disinformation is cultivated

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through empowerment strategies and methods. In this context, empowerment can be defined as a certain form of behavior that encompasses a person's ability to recognize and express doubts about specific content as well as express their own thoughts.

In the DeFaktS project, these three dimensions will be used to investigate whether and to what extent the developed MLS can make a positive contribution to the cultivation of critical media competence among social media users. To this end, it will be analyzed whether and to what extent awareness, reflection, and empowerment are strengthened through the use of the artifact.

C. Trust

Niklas Luhmann [29] understands trust in the broadest sense as an elementary component of social life, interpreting it as a form of security, which can only be gained and maintained in the present. First and foremost, trust is needed to reduce a future of more or less undetermined complexity. According to Luhmann's understanding, the constant technical progress of society brings with it a simultaneous increase in complexity, which subsequently results in an increased need for trust. Thus, trust is a necessary condition to live and act with growing complexity in relation to modern events and dynamics [29]. However, trust is severely shaken by negative experiences [30], for instance experienced deception through disinformation. As MLS systems and algorithms become more complex, people increasingly regard them as "black boxes" that defy comprehension in the sense that understanding an MLS's decision requires growing amounts of specialized expertise and knowledge. Non-expert end-users are not able to retrace how the algorithmic code cascades led to a given decision [31]. Accordingly, there has been increased demand to offer the proper explanation for how and why a particular result was obtained [32]. Recent empirical evidence on algorithm acceptance [33] insinuates that explainability plays a heuristic role in algorithm and MLS service acceptance. Currently, however, research gives light to a controversy over whether the implementation of XAI-features actually helps increase user-trust or not. Shin [34] analyzed the impact of explainability in MLS on user trust and attitudes towards MLS and concluded that the inclusion of causability and explanatory features in MLS assists to increase trust as it helps users understand the decision-making process of MLS algorithms by providing transparency and accountability. In contrast, through their experiment on transparency and trust in MLS, Schmidt et al. [35] found that transparency features can actually affect trust negatively. These recent contradictory observations give rise to the need for further investigation of the effect of explainability on user trust. In the DeFaktS project, this research gap will be addressed through the evaluation of whether, and if so which, XAI elements increase user trust in the application.

III. Method and First Activities in Design Science Research

The goal of DeFaktS is to develop an artifact that is as close as possible to the needs of the subsequent user so that it contributes precisely to solving the above-mentioned issues. To implement this, the project is embedded in a Design Science Research (DSR) approach according to Peffers et al. [36]. DSR provides an adequate framework for contributing to both the theory and practice of solving real-world problems as it helps generate prescriptive knowledge on how to effectively design and deploy novel solutions to relevant problems [37]. The chosen approach divides the research process into six steps: problem identification and motivation, definition of the objectives for a solution, design and development, demonstration, evaluation, and communication [36]. Based on reviewing relevant literature from various disciplines, such as computer science, social science and information systems, we identified the problem and formulated the motivation to contribute to a solution (1). Inferred from the problem specification, the objectives of a solution with an emphasis on fostering critical media literacy and user trust were defined (2). On the basis of Step One and Two, the design science artifact, an XAI-tool detecting and warning social media users about online disinformation, will be created (3). For this purpose, trained annotators will extract and label messages from suspicious social media groups in large quantities. Subsequently, the data corpus will be provided for the training of a Machine Learning-based System to detect factors and stylistic devices characteristic of fake news. Finally, this system will be used for the XAI component that informs users in a simple and transparent way about the occurrence of these factors. In the fourth step, conducting a field study, the performance of the DeFaktS artifact will be demonstrated in a real world scenario (4). In this way, we will test whether our artifact serves to solve the identified problem in a suitable context. By conducting additional experimental studies in a lab environment, the efficiency and effectiveness of the tool will be evaluated. This step will help to assess whether the artifact factually helps to promote critical media literacy and increases user trust. Depending on the empirical results, possible iterations in the design and development process will follow (5). Finally, we will communicate our findings from Step 1 to 5 in scholarly and professional publications as well as at conferences and other suitable events. Furthermore, we will enable companies to create corresponding products for customers from business and civil society through an API, ensuring the artifact's sustainability (6).

Currently, researchers are concerned with Step Two and Three: The development of a 'Fake News Taxonomy' that

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entails linguistic features and dimensions of disinformation content shall facilitate and ensure the quality of the data labeling process. One of the difficulties in detecting false news is that some terms and expressions are unique to a particular type of event or topic. When a fake news classifier is trained on fake versus real articles based on a certain event or topic, the classifier learns event-specific features and may not perform well when used to identify fake versus real articles based on a different type of event. As a result, fake news classifiers must be generalized to be event-independent [2]. Another challenge is that the majority of datasets are in English, and German-language datasets are scarce [38]. These observations call for the creation of a taxonomy of fake news that encompasses broad and event-independent dimensions and characteristics of disinformation, which is still specific enough to precisely identify and label deceiving content. The final taxonomy will display a design artifact in and for itself that will be demonstrated and evaluated within the labeling process. After some possible iterations, the artifact will be made accessible to other researchers through scientific publications or open access services.

IV. Conclusion and Future Work

In this research-in-progress, we contribute to the knowledge base of fake news detection using MLS by developing an XAI-artifact and evaluating its performance in the context of fostering critical media literacy and trust among social media users. The innovative aspects of DeFaktS are multifold: Non-expert users shall be enabled to understand, trust, and utilize the tool's interpretation and explanation of detection results. Further, the DeFaktS-tool shall increase overall critical thinking and awareness of online disinformation, cultivating an informed citizenry and fostering political participation. The presented project is to be understood as work in progress during which the six steps of design science research are followed and critically evaluated simultaneously. For now, this paper intends to show the scientific community initial approaches to researching and combating online disinformation campaigns using Machine Learning-based Systems while remaining receptive to future developments in empiricism and civil society.

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Socially Aware Information Systems: Delimitation and Characterization

Olga Levina

Brandenburg University of Applied Science
Brandenburg an der Havel, Germany
e-mail: levina@th-brandenburg.de

***Abstract*— Information systems increasingly surge not only in the topics areas of task automation in business and personal contexts, but also in the areas of the recommendation of content and information that can be consequentially used to support business or individual decisions. Thus, the design of these information systems needs to expand its considerations above the user and towards the effects the system implementation has on the users affected by the actions that result from the application of the system. The scope of the affected users can be as broad as a cultural circle or the society. This extended abstract introduces the term of socially aware information systems, hence those information systems that consider their impact from the design, requirements engineering and testing, into the focus of the design science and information system research.**

Keywords- socio-technical systems; systems engineering; software engineering, socially aware information systems.

I. INTRODUCTION

With information technologies striving to automate and to support many of the activities in business and private context, the effects of their application on the users as well as the society, where these technologies are engaged, are increasingly visible. Although, it is acknowledged among managers and system users that adopting a socio-technical approach to system development leads to systems that are more acceptable to end users and deliver better value to stakeholders [1], this socio-technical design approach is only slowly gaining recognition in the software engineering and software user community.

Given the public discussions on machine learning based systems (MLS), value-based software engineering has gained popularity in public discussion. As when digital products are being designed, their (negative) effects such as the effects on the environment or the society should be part of the public discussion and responsibility that are not (and maybe should not be) regulated, but can be supported by socially acceptable IT artefacts [2] and ethical frameworks. Recommendations, ethical frameworks and principles for MLS design merge in the business and legal environments, e.g., in [3]–[6]. Nevertheless, ethical aspects can also be interpreted during the software design differently [7].

Following the development of the value-sensitive design [8], [9], user-centered design [10], [11], design thinking and socio-technical systems design [1] over the years, the term "socially aware information systems" (SAIS) is proposed. The term describes an information system that considers users beyond the ones that are directly involved with the information system and includes affected users and system stakeholders into its requirements analysis and testing. The affected user is explicitly singled out of the composed term "stakeholder" [12] for a specific focus during the requirement analysis. SAIS are thus defined as IT artifacts that extend the design of socio-technical systems by comprising the consideration of the effects of their use and implementation on a scale that includes the directly involved process actors but also the individuals affected by the results of the system implementation and use. This scope can be as broad as the customers affected by the information system or the society that includes these information systems into its interaction and social exchange, e.g., in its administrative processes. This focus is especially important in domains where these systems build or use personal-specific data, e.g., decision automation and decision support in human resources domain.

Participation, Transparency, Human Autonomy, Human Rights and Auditability are suggested based on the ALTAI criteria for MLS introduced by the European Commission as main pillars of the design of an information system that is socially aware. SAIS thus follow the thought schools of value sensitive [8] and value-based [13] design, problem orientation in design science research [14] and ethical information systems design [15]. Evidently, Information Systems Research (ISR) should manifest its leading role in pursuing practices for the creation of IT artifacts that are not only technically innovative but also socially acceptable.

SAIS extends the characteristics of socio-technical systems by Baxter and Sommerville [1] with following additions:

- SAIS address a (business) problem with a resulting significant increase in efficiency of business operations or significant advantages for the process workers or affected users.
- SAIS does not use behavioral approaches to un-ethically draw on user's or affected user's data.
- SAIS considers users and affected users in the requirement analysis.
- SAIS has audit and testing mechanisms that consider the mid-term effects of its application on the user, the affected users and their environment.
- SAIS has a laboratory testing environment and is subject to regular audits concerning the stated values, but at least the values of Participation,

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Transparency and Human Autonomy and Human Rights.

- SAIS use includes a definition of the contextual, cultural and value-based scope of the environment it shall be implemented in and can lead to accordant modifications, e.g. in the context of data processing.
- SAIS has a feedback mechanism that allows a flow of information between the user and SAIS, as well as affected users and SAIS that enables necessary changes in the SAIS functionalities and architecture.

Following this reasoning, the requirements engineering for socially aware information systems should apply the analysis of ethical and legal issues that appear during the design of the system's features and its usage. As methods scenario analysis, surveys, workshops documented with use case analysis and user stories can be applied. As personas external actors need to be considered. Here, the actors "user" and the "affected user", i.e., an actor affected by the results of the information system application, need to be differentiated.

II. CONCLUSION

This extended abstract motivated and presented the term of socially aware information system that extends the context of design science research, user- centered and value-sensitive design as well as the term of socio-technical systems. The necessity of this extension was motivated with the upcoming prevalence of data-based systems that are increasingly used to provide recommendations, information and support decisions on individual and business scales. Involving this term in the research and practice will allow including a mid-term thinking in the design of information systems as well as robust testing plans that consider mid- and long term effects of the system use on its direct and affected users. Also the use of behavioral science for increased engagement of the system can be critically tested for the expected and actual added value within the SAIS design.

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Requirements Analysis Towards Future Design of an Innovative Distance Learning Device Intended for French Orthodontic Practitioners

Contribution of a Community of Practice Analysis

Aurélie Mailloux
Orthodontics
Reims Hospital
Reims, France
e-mail: aurelie.mailloux@univ-reims.fr

Jérôme Dinet
CNRS, INRIA, Loria
University of Lorraine
Nancy, France
e-mail: jerome.dinet@univ-lorraine.fr

***Abstract*-The COVID-19 crisis has changed behaviors and needs of orthodontic practitioners related to (i) cancellation of all the continuing education events, which led to the disappearance of formal and informal exchanges on the practice (ii) emergence of numerous videoconferences, but without prior identification of practitioners' needs. The problem of interaction within a continuing education online environment is paramount: promoting interaction between peers within the system is essential to (i) reduce the feeling of loneliness (ii) promote users' commitment. Most French orthodontic practitioners were already involved in a virtual active Community of Practice (CoP) with their own way of fostering identification, cohesion, and collaboration. The purpose of this user-centered research is to identify requirements for creating an innovative comprehensive distance continuing education environment that would meet expectations and needs in terms of interactions of most CoP members, according to their experience (novices to experts). After an extensive state-of-the-art, used to better understand the changes in training and education related to orthodontic domain, we conducted (a) a detailed examination of the discursive activities within a CoP (e.g., content, interactions, rhythm, objectives, etc.) (b) four focus group and (c) an online survey. The collected data confirmed that an innovative complete distance continuing education environment could meet many CoP members needs, such as: anonymous, scientifically validated content, extensive or limited discussion forums, clinical case sharing, videoconferences instant translation, ease of access and cost and time saving. From a theoretical point of view, this study highlighted the crucial role of the community of practice in producing requirements for creating a useful, usable, and acceptable digital education environment for orthodontic practitioners.**

Keywords-elearning; community of practice; psycho-ergonomic study; innovative device; orthodontics; continuing education.

I. INTRODUCTION

The COVID-19 crisis has changed behaviors and needs of orthodontic practitioners towards continuing education. Among others, the replacement of face-to-face congresses by videoconferences had led to the disappearance of direct formal and informal exchanges between novices and/or experts of the Community of Practice (CoP): the videoconferences current format only allows one-to-one vertical interactions between participants and speakers. However, in the field of distance continuing education, it is necessary to support a form of "e-presence" between members because one of the major dropout factors is the loneliness felt within the education device. Indeed, attrition rate is lower when the user is supported by his/her peers and interacts with them regularly [7][8]. According to the state-of-the-art [9]–[12], several solutions are mentioned to promote interactions and commitments within an education distance device, such as distance tutoring, and e-portfolio. However, their results are heterogeneous, and their implementation complex.

This innovative continuing education environment is addressed to French orthodontic practitioners who are mostly already involved in an informal active virtual CoP, built on Facebook© in 2014. In 2022 February, this CoP were gathering almost half of the French orthodontic practitioners. The purpose of this user-centered research is to analyze requirements to promote interactions within an innovative learning system based on a dual approach (i) the analysis of the virtual CoP discursive activity (ii) the identification of the CoP members' needs by conducting focus group and an online survey.

The remainder of this paper is organized as follows. After a state-of-the-art (Section II), Section III describes the data gathered and methodology applied in three different studies to identify the CoP members interactions needs and attitudes according to their experience (novices to experts). This is followed by an overview of findings in Section IV, categorized by the discursive analysis, the CoP members interaction needs and the requirements. Section V summarizes the value of these findings and outlines elements of future research to be conducted on the subject.

II. STATE-OF-THE-ART

We conducted an extensive state-of-the-art to identify (i) the possible benefits of designing an innovative distance learning device in the orthodontic domain (ii) the current solutions to promote interactions within distance education.

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A. *Contribution of an innovative device*

The COVID-19 crisis has changed behaviors and needs of orthodontic practitioners. The need to evolve the traditional format to remote access is now widely shared. The COVID epidemic has greatly accelerated this trend related to cancellation of all the continuing education events [15]–[17].

The state-of-the-art [11]-[18][30][31] demonstrated that many devices dedicated to the continuing education of dentists or orthodontists have been created over the past 20 years, particularly in Anglo-Saxon countries. These devices were a source of satisfaction for the participants and effective in terms of learning and acquisition of skills but they were mainly centered on one unique theme (e.g., recognition of oral pathologies) and were not focused on the orthodontic discipline [13][14]. However, an innovative complete distance continuing education environment could have many advantages, such as flexibility, lower costs, no office closing and accreditation by the French body of Continuing Professional Development (CPD) [21]–[25].

B. Existing distance learning device

According to the state-of-the-art [11]-[18], there was no complete distance learning environment adapted to the French orthodontic practitioners' needs. Only two complete websites dedicated to distance continuing education were intended for orthodontic practitioners: the World Federation of Orthodontists (WFO) and the *e-orthodontie.com* websites.

First, the WFO website, with online videoconferences access and its smartphone application (with notifications), is the most complete digital continuing education environment available to date, particularly concerning the diversified content, supports, and the scientific validity. Despite this, none of the interviewed practitioners were registered with WFO probably because this device was neither adapted (i) to their expectations and attitudes (ii) nor to their way of interacting with each other. Correlation between cultural and/or social dimensions with the use of a distance education device has already been highlighted in a previous study [18].

Secondly, the French *e-orthodontie.com* website has been created in 2007 without no prior user-centered research to evaluate practitioners' needs and expectations [19][20]. That could explain why this website was very little used by French orthodontic practitioners, as evidenced by the closed to zero activity of the forums section.

C. The interactions within the devices

According the state-of-the-art [29], the loss of peer-to-peer interactions was the major drawback of the current distance education experiences for participants. That is why interaction represents one of the main issue to be considered for the design process. Nevertheless, several solutions are mentioned in the literature to create a kind of "e-presence" within the distance device, such as (i) virtual small groups of practitioners sharing same centers of interest or geographical proximity [27] (ii) creation of a collaborative e-portfolio [11][12] or (iii) tutoring [9][10]. But interactions between novices and their teachers *via* an e-portfolio were often limited, because, among other factors, teachers considered the digital feedback as a waste of time [11]. Concerning the remote tutoring, it remained generally underused because users struggled to meet their "ideal" tutoring model [9][10].

There are difficulties to maintain mutual commitment and trust in an online environment, hence the importance of examining the interactions within a current active CoP for creating a useful, usable, and acceptable digital education environment for orthodontic practitioners. We considered that an innovative distance continuing education environment, supported by the CoP members (and vice versa), could promote users' commitment. We based our approach on the horizontal social learning theories [3]-[6].

D. Contribution of a community of practice analysis for education device design

Several research-actions involving the design of training devices, in particular digital ones, are based on the notions of professional community in the education fields [33][34]. Although CoPs (i.e., traditional and virtual) have been developed and studied extensively in the education fields, they were fewer and less structured in the health sector [35].

However, horizontal exchanges between peers represent an important source of cohesion and group identification within the CoP [1]–[6][21]. Besides, learning results from the interaction with other individuals and particularly with the peers [3][4].

III. DATA & METHODOLOGY

To produce design recommendations for creating a useful, usable, and acceptable digital education environment for orthodontic practitioners, three techniques have been used (Figure 1). We conducted (i) observation of interactions and discursive activities within a virtual CoP *"discutons entre spécialistes (let's discuss between specialists)"*. (ii) Four different focus groups of 4 to 6 CoP novices to identify their actual behaviors related to training and education, their needs, and expectations (iii) an online survey of 59 participants to collect data about attitudes and expectations towards education addressed to the CoP members. Figure 1 presents an overview of the methodology adopted and its objectives:

Figure 1. The triangulation of our methodology.

A. Focus group

Four focus groups bringing together 4 to 6 novices of the CoP novices were conducted: three focus groups were conducted before the health crisis and one after. The process was carried out in three stages:

(1) Identification of the difficulties, obstacles, and prospects of continuing education.

(2) Presentation of an existing French training system: the website *e-orthodontie.com*, to evaluate the participants' perception of digital training tools.

(3) Co-construction of "an ideal" website architecture dedicated to continuing education.

B. Questionnaire Survey

The online survey was conducted among practitioners, members of a virtual CoP. The electronic survey was prepared and distributed by the software Limesurvey© to all CoP members, first on January 11, then on January 25, 2022 (n=59 CoP members, including 41 CoP experts and 18 novices).

This online survey was conducted to identify:

(1) Reasons for which practitioners became members.

(2) what the CoP actually provided for its members.

(3) The members status: novices or experts.

In this study, CoP novices were defined as either orthodontic resident (i.e., already qualified in dental medicine) or practitioner with less than three years of clinical experience. CoP experts were defined as orthodontic practitioners with more than three years of clinical experience.

C. Examination of a virtual CoP

The dual purpose of this examination was (i) an identification of the current interactions and (ii) description of the discursive activity (in term of content, nature of exchanges, objectives, rhythms, comments and likes generated…) according to their experience (expert vs novice) within the CoP. This enables to study the discursive activity (e.g., rhythm, type of interactions, content within this CoP) and to identify the needs, attitudes, and expectations of the CoP members according to their experience (expert vs novice).

D. Data analysis

The focus group and the online survey data were analyzed as follows:

The textual analysis was carried out using free software IRAMUTEQ based on the R software and the Python language. After a manual thematic analysis, several automated analyzes were applied and in particular (i) the Reinert Descending Hierarchical Classification (DHC) model (ii) the Factorial Correspondences Analysis (FCA) and (iii) the similarity analysis. The DHC made it possible to divide the statements into classes marked by the contrast of their vocabulary. We completed DHC with a FCA which enabled us to observe the classes "geographical" proximity or distance. We also applied the similarity analysis when the number of segments was insufficient to obtain a saturation of the statements. We analyzed together the first three focus groups data (conducted before the health crisis), to compare them with the last focus group data (conducted after the health crisis). We also compared the online survey collected data between experts and novices (41 experts and 18 novices) to identify their common or divergent expectations and benefits of becoming member of a CoP.

The CoP interactions collected data were analyzed as follows:

All posts and interactions (in the form of comments or likes) of the month of September 2021 were subjected to a thematic content analysis to group them within categories /themes. The nature of the exchanges (e.g., copresence, cooperation, collaboration, identification), correlated with different contents and levels of interaction, have been studied in accordance with Proulx's taxonomy [36]. Interactions level was measured as the sum of comments and/or likes of each publication (low: < or= to 10; medium: > to 10 and < or = to 20; and high: >20).

We analyzed the comments (i.e., categories, feedback type and specific application) generated by clinical case posts basis on an evaluation grid of the "quality" of peer comments, produced in a previous study [32].

IV. MAIN RESULTS

Our findings indicates that (i) COVID-19 crisis modified the CoP members learning needs (ii) the interactions needs, attitudes, and expectations of CoP novices and experts were different.

A. Contribution of the virtual CoP discursive analysis

This innovative continuing education environment is addressed to French orthodontic practitioners who are mostly already involved in an informal virtual CoP, built on Facebook© in 2014. This virtual active CoP "*let's discuss between specialists"* (in French: discutons entre spécialistes) has significantly grown these last years. The growth of the informal virtual CoP these last three years (see Figure 2) seemed to be an underlying trend (i.e., +170% members since 2019). Indeed, the first COVID lockdown (i.e., start date 03/17/2020) did not seem to have modified this growth. In 2022 February, this CoP were gathering 1082 practitioners, representing almost half of the population (i.e., 2420 orthodontic specialists).

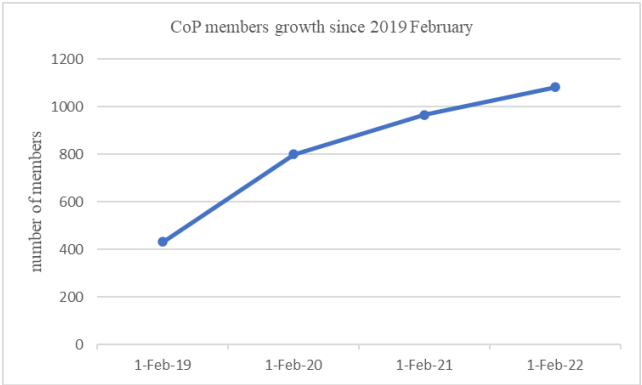

Figure 2. CoP growth since 2019.

The analysis of the publication's rhythm in September 2021 (n=59) revealed its cyclical aspect (see Figure3).

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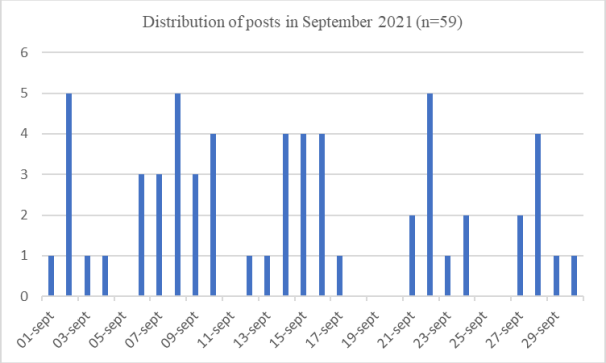

Figure 3. Distribution of the posts in September 2021.

The analysis of the authors' status showed that the start of a new cycle of publications coincided with a publication by a central CoP member (i.e., moderator, administrator, or recognized expert): their role was crucial in maintaining and developing the interaction.

Number of publications, interactions level and type after thematic classification (n=59 on september 2021)			
Thematic / *sub theme*	number	interaction level *(low, medium, high or inconstant)*	Interactions type *(none/comments and/or likes)*
Co-presence (n=24)			
job ads	3	low	likes
training information	8	low	likes
sale of practice	5	low	likes
patient communication	1	low	comments/likes
patient transfer	6	low	comments
link to other CoP	1	none	none
Cooperation (n=18)			
product/equipment advice	7	medium	comments
HR/legal advice	11	medium	comments
Collaboration (n=14)			
sharing of clinical cases	11	low or high	comments/likes
clinical tips	3	medium or high	comments/likes
Identification (n=3)			
ethical problem	1	medium	comments
criticism of private training	2	high	likes

Figure 4. Publications thematic analysis and the level of interactions generated.

Figure 4 shows the publications thematic analysis and the level of interactions generated. Most publications were of the order of co-presence among members, creating few reactions (mostly *likes)*. Their content was mainly informational. Publications on the mode of cooperation were less frequent but generated a higher level of interaction (mostly *comments*). The collaborative publications, generating a sustained interaction (i.e., clinical cases and clinical tips) were also rarer. During the month of September, three publications with strong identity value were published (i.e., one ethical problem and two criticisms of private training). These elicited many reactions (*likes* or *comments*).

However, all CoP members did not publish in all categories. The publications allowing either reflection on the orthodontics practice or collaboration among members, came exclusively from the CoP core experts, administrators, and moderators. The novices never participated in the form of posts or comments and very rarely in the form of likes. This observation agreed with the focus group collected data: all CoP novices (pre and post COVID-19 focus group) expressed their fear of being judged by the CoP experts. That was indeed the main barrier to their participation [5][37]. It is for this reason that anonymity was such a strong novices' expectation.

Thematic analysis of clinical posts (n=11 on september 2021)			
Thematic/*sub-theme*	number	interaction level	interactions type
Requested concerning a rare pathology	5	low	comments
=>including referring practitioners	2	low	comments
Sharing of successful clinical cases	4	high	comments/likes
Requested concerning complex diagnoses	2	high	comments/likes

Figure 5. Shared clinical cases detailed thematic analysis.

Figure 5 shows that practitioners never shared failures or treatments incidents, although this was an explicit strong request from novices, according to post COVID-19 focus group collected data.

Concerning the comments "quality" evaluation of the two "complex diagnoses" posts, they were rich in terms of content, supports (video, training, clinical case articles, etc.), feedback type (questions, suggestions, sharing of "imaginary" clinical cases, etc.) and reflections level (e.g., recommendations for good practices). But practitioners never shared personal clinical case to illustrate their comments, although it could enrich the discussion [32]. In this "clinical posts" category (unlike in the others), experts could sometimes contradict and criticize each other, revealing some disagreements. Nevertheless, the exchanges were much more subdued between novices and/or experts (and rarer). All publications related to illustrated clinical treatment (successful and complex diagnoses) generated feedback and initiated discussions, debates, and links to other problems.

According to the online survey collected data, the clinical publications were at the heart of the CoP (novices and experts) members' commitment (see Figure 5). In addition, discussions between peers about clinical cases could help novices to connect theoretical and practical knowledges [32].

B. Impact of the COVID-19 crisis on the CoP members learning needs

The comparison between the focus groups data collected before *versus* after the health crisis enabled us to describe finely the changes of continuing education perception, raised by the literature [15]–[17]. Regarding the interactions, in the pre COVID-19 focus group, the lack of informal exchanges between peers was a significant barrier to distance learning. The "ideal" learning experience was a

face-to-face conference, with limited costs and duration. In contrast, in the post COVID-19 focus group, the" ideal" learning experience consisted in clinical cases sharing (i.e., especially failed treatment) illustrated step by step, anonymous, internet-based literature search, scientifically validated content, and videoconference instant translation into French. The need to translate was strong for CoP novices, probably because they were afraid of misunderstandings without being able to detect them. The health crisis changed deeply the practitioners' perception toward distance learning. According to the literature, an innovative complete distance continuing education environment could henceforth meet many CoP members' needs [21][22][23].

C. Experts/novices : interactions attitudes, needs, and expectations

The distinct similarity analysis produced from novices and experts' responses to the online survey, allowed us to distinguish their expectations and needs towards the CoP (Figure 6). Figure 6 shows two different profiles in terms of content, interaction needs and attitudes within the virtual CoP "*let's discuss between specialists"*. The experts expected to (i) be informed about the novelties, (ii) discover the practice and clinical tips of their peers. Their main goals were to evaluate their own practice and eventually modify them: that was a reflective learning process based on reciprocity. Concerning novices' needs, they expected to obtain expert opinions and were in an observant attitude.

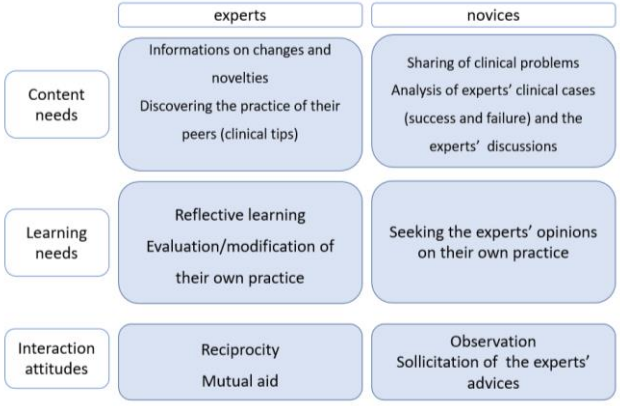

Figure 6. Experts and novices' needs in terms of content, learning and interaction.

D. Several requirements to promote peers interactions

The current virtual CoP supported via Facebook© did not allow to make small groups, nor to publish anonymously. An innovative continuing education environment should offer these possibilities to encourage novices' participation and ultimately stimulate interactions between peers. To promote practitioners' participation, according to the state-of-the-art and our collected data, some criteria should be respected:

First, participation in discussions forums could be done under a pseudonym. However, each practitioner's status should be known (novices/experts), so that novices could trust in the posted information.

Secondly, the content scientific validity could be ensured by various means:
-Review by known International/European clinical experts.
-Review by teachers from universities.
-Review by a mixed college (universities teachers and clinical experts).

Some of these experts should also ensure the discussion forums animation and take on the role of moderator to promote the interactions, as in the virtual CoP "*let's discuss between specialists".*

Thirdly, the device should allow the possibility of exchanging on his/her clinical cases via a forum, seeking the opinions of other practitioners or even having access to very detailed clinical cases (step by step).

Fourthly, the device should allow the creation of limited or extended discussions groups based on professional status (expert/novices). The geographical discussion group could also be relevant according to the CoP discursive analysis: 2 of the 11 clinical posts were indeed requests for referring practitioners in the same region (see Figure 5).

Finally, to improve the efficiency of the practitioners' comments in terms of learning and collaboration, a "quality" charter could be draw up, according to the peers' comments quality evaluation grid, to encourage them to: share illustrated personal clinical cases (successful and unsuccessful), ask for questions, make suggestions, share scientific articles, use a friendly tone, etc. [32].

V. DISCUSSION

The collected data (focus group, online survey, virtual CoP examination) agreed and complemented each other. This confirmed the interest of adopting a data triangulation method to formulate relevant recommendations [38].

Although learning within a CoP is a trajectory from novice to expert passing through intermediate stages. Despite this, the data analysis by dividing them into two groups (novices vs experts) allowed us to reveal different attitudes, needs and expectations in terms of continuing education.

It is commonly accepted that novices participated less than experts, because of their peripheral position within the CoP [3]-[6]. However, an education device should encourage all CoP members to participate on a voluntary basis, to reduce the feeling of loneliness and foster their commitment [4]. But, if virtual CoPs share the same principles than traditional ones (e.g., commitment and mutual trust), this is more difficult to maintain in an online environment [2].

Our collected data explained more precisely why the WFO and the *e-orthodontie.com* websites did not match users' expectations. Concerning the WFO website, there was a strong language barrier: in all focus group, the need to translate everything into French was commonly shared. Concerning the French *e-orthodontie.com* website, the content was perceived as not scientifically valid by interviewed practitioners. Moreover, this website was accessible to patients, specialist, and non-specialist

orthodontic practitioners. This “open access” was the subject of numerous criticisms by all the interviewed practitioners. All surveys revealed indeed the significant tension within this CoP related to the various academic backgrounds (specialists versus non-specialists). The open or limited access of non-specialists to the innovative distance learning environment should be carefully considered: the specialists considered the non-specialists as an outgroup of the CoP, whereas the non-specialist probably considered the specialists as experts of the CoP.

This paper showed that orthodontic practitioners commonly needed (i) scientifically validated content, (ii) discussion extensive or limited groups, (iii) anonymous, (iv) publications on clinical cases (successful AND unsuccessful). These results were consistent with the state-of-the-art. But contrary to the literature, in our study, the discussion forums group should be centered on the professional status (CoP novices and/or experts) and not on the center of interest [27].

It would have been interesting to carry out focus group of CoP experts but professional constraints (solitary practice, geographically scattered, lack of time) prevented us from doing so. Nevertheless, the online survey by questionnaire enabled us to include mostly CoP experts. The experts were numerous either because they participated more actively into the CoP, and/or because they were more represented there.

VI. Conclusion and Future Work

A complete, careful analysis of the orthodontic practitioners’ needs, expectations, and interactions behavior within the virtual active CoP *“let’s discuss between specialists”* was done for this innovative distance environment to comply with the criteria of usability and acceptability.

According to our data collection, a comprehensive distance learning environment could meet many novices and experts’ expectations. Indeed, the CoP novices reported their need to (i) interact with experts anonymously (to avoid being judged) (ii) create restricted or extended online discussion (iii) ask for questions about all available content (e.g., videoconferences, articles) (iv) be informed of news by notification. The needs and attitudes of novices and experts we described in this study are supported by the data on the CoPs [1]-[6], particularly concerning cohesion, sharing of experiences and identity needs. However, the way to proceed is specific to each profession and, to our knowledge, no previous study has analyzed the orthodontic practitioners’ community.

This study allowed us to identify the CoP members needs and expectations in terms of (i) content (and the categories structuring it), (ii) expected interactions between novices or experts (e.g., rhythm, themes, anonymity, etc), (iii) scientific validity, (iv) sharing or observing the peers’ positives or negatives clinical experiences. On this basis, several requirements in term of interactions and contents have been proposed.

This users’ center research showed that an innovative education environment would greatly enrich the CoP, particularly in terms of content, support, and variety of possible exchanges. All focus groups participants co-created a website architecture and discussed their expectations in terms of supports and contents to design an “ideal” distance learning device. The contents and supports will be the focus of a future article.

Our user-centered approach must be extended during the design/redesign phases by empirical methodology at different stages without and /or with “real” users, to ensure compliance with the device ergonomic criteria [39].

The security and legality of shared medical data such as X-rays and/or photographs of patients must be questioned. Further studies on the security aspects of the device are also important to be conducted to minimize the risks of malicious attacks and gain more confidence from the practitioners.

More extensive experimentation should be carried out, especially to deepen practitioners’ expectations in post COVID-19 period to justify usefulness of the proposed requirements.

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Combining Model Driven Development and Agile Software Development

Himesha Wijekoon, Vojtěch Merunka
Department of Information Engineering
Faculty of Economics and Management
Czech University of Life Sciences Prague
Prague, Czechia
email: wijekoon@pef.czu.cz, merunka@pef.czu.cz

Vojtěch Merunka
Department of Software Engineering
Faculty of Nuclear Sciences and Engineering
Czech Technical University in Prague
Prague, Czechia
email: vojtech.merunka@fjfi.cvut.cz

***Abstract*— Agile Software Development (ASD) is certainly the mostly used software development methodology now. ASD is lightweight and it provides faster development of software in an agile manner without unnecessary time-consuming activities. In contrast, Model Driven Development (MDD) is a heavyweight methodology which considers models as the basis of software development. MDD relies on extensive modelling which ensures consistent models. But this requires extensive tool support and automation. In this study, we review state of art of merging these two approaches. We found that most of the related research focus on coming up with new methodologies which apparently violate lightweight agile principles. However, it seems beneficial to keep ASD as lightweight as it is and try to assist it with components from MDD in problematic areas such as agile requirements engineering. In the end, we propose future research to investigate how to use components of MDD to improve the agile requirements engineering.**

Keywords- Model Driven Development; Agile Software Development; Requirements Engineering; Software Engineering.

I. INTRODUCTION

Agile Software Development (ASD) has become a major software engineering discipline and the most popular software development methodology [1]. ASD treats the customer in the center of the development process and aims to develop software fast as possible by cutting down unnecessary activities.

On the other hand, Model Driven Development (MDD) is based on the use of models through the development life cycle of a system. MDD uses methods and tools to provide this involving automation and semi-automation such as model generation and model transformation. MDD focuses to ensure traceability and completeness between the different levels of software design. Yet, MDD is not as popular as ASD due to its complexity, time consumption and the requirement for extensive tools.

In this paper, we review the work related to combine MDD and ASD to identify potential future research. We believe combining of these two approaches will bring huge benefits in the software development.

This paper is organized as follows. In Section II a brief description about MDD is provided. Then ASD is briefly described in Section III. Section IV provides a review of previous work combining MDD and ASD. In Section V, we describe a potential future research opportunity. Finally, Section VI provides the conclusion of the study.

II. MODEL DRIVEN DEVELOPMENT (MDD)

MDD is a software development methodology which uses models to drive the development. In the ideal scenario, MDD uses and manipulates domain models instead of code when developing software. Therefore, in MDD models are created before source code [2]. These models are used to generate code to produce software. Thus, MDD facilitates Domain Driven Design (DDD) as well. MDD and Model Driven Architecture (MDA) are subsections of Model Driven Engineering (MDE) [3]. The difference between MDD and MDA is that MDA follows standards of Object Management Group (OMG). MDA promotes the detachment of Platform-Independent Models (PIM) from Platform-Specific Models (PSM). Even though the MDD methods approach to reduce development time, they do not allow sufficient client involvement [4]. Therefore, MDD methodologies are not agile as they highly focus on modelling activities.

III. AGILE SOFTWARE DEVELOPMENT (ASD)

The "Agile Manifesto", which was published in 2001 aims to provide best practices for software development [5]. The agile manifesto values following principles.

- Individuals and interactions over processes and tools.
- Working software over comprehensive documents.
- Customer collaboration over contract negotiation.
- Responding to change over following plans.

ASD is a collection of software development methods based on an iterative development. ASD advocates the incremental development of software based on continuous interaction with the client and implementation starts much earlier (e.g., prototypes) in the life cycle rather than detailed specifications and documents [6]. Agile methodology has shown advantages over traditional software development by focusing on fast delivery of business value and assisting teams to continuously evolve and change. This minimizes the overall risk connected to software development. In ASD the software development team works with short iterations which includes development of features [7]. Yet ASD put less emphasis on analysis and design to speed up the making of working software and can create difficulties in large-scale projects [8].

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IV. COMBINING MDD AND ASD

There have been numerous attempts for combining MDD and ASD. The idea behind combining these approaches is to overcome the shortcomings of each approach and to create a superior methodology. For an example ASD has difficulties with larger projects with the need of a high-level design and MDD practices don't have the full support of stakeholders which decreases the chances of a desirable application.

Matinnejad defines that the integration of Agile in MDD process can be developed by [9]:

- MDD-based: introducing Agile method to an MDD process,
- Agile-based: applying MDD process to an agile method and
- Assembly-based: integrating some fragments from Agile and others from MDD to develop the process.

Until now there is only one related survey [9] and two Systematic Literature Reviews (SLR) [10][11] in this area. All three surveys conclude that Agile MDD is still in its early stages. It is also mentioned that most of the attempts of combining MDD and ASD have not clearly mentioned the comprehensive details about the integration, benefits, and challenges. Therefore, it is suggested that more experience reports and evaluations are required to advance the area of Agile MDD. Agile MDD approaches have reported different positive impacts of such as improvement in productivity and quality, faster development rate and better customer satisfaction. Most often reported problems are lack of model management, lack of verification, and steep learning curve and start-up overheads.

Following are major Agile MDD approaches carried out by the researchers.

- Alfraihi & Lano have proposed a general and comprehensive process for integrating ASD and MDD [12]. It allows applications to be safely developed in an iterative and incremental manner.
- Romano and da Cunha have developed the Agile and Collaborative Model Driven Development (AC-MDD) [13]. A novel Unified Modeling Language (UML) profile named Web-AML was designed, allowing to represent agile models of web applications. To apply the proposed framework using these new models, a method was defined providing steps to transform agile models into web application source-codes.
- eXtreme Modeling is a model-based development analogue of eXtreme Programming [14]. It is an agile development approach based on the use of software models to specify and synthesize software systems.
- Essebaa and Chantit have combined MDA and Scrum agile methodology to improve sprints of scrum and benefit from MDA principles [15]. It is proposed to use V life cycle in each sprint of the project where they combine another variant of MDE, to generate automatically different tests applying Model Based Testing (MBT) principles.
- Agile Concern-Driven Development (Agile CDD) is a software development process that uses concerns as its primary artifact and applies agile practices [16]. Agile CDD is a reuse-focused development process in which an application is built incrementally by repeatedly reusing other existing concerns.
- ScrumDDM is a hybrid metaprocess which integrates MDD practices into the SCRUM method used in ASD. It is a as metaprocess, which can be used for multiple domains to support software maintenance and evolution [17].

V. RESEARCH OPPORTUNITY

As per the analysis, most of the Agile MDD work are towards specifying a new software development process or methodology by merging ASD and MDD. On the contrary the popularity of the ASD is due to its simplicity and faster feedback from customers. Therefore, it seems most of these proposed methodologies/processes break original intentions of Agile Manifesto. Further, when the processes are complex and difficult to follow, the chances are low for software development community to embrace them. On the other hand, very few research have been conducted to empower agile development with the MDD components preserving the simplicity of ASD. In this way, we could try to use fragments from MDD to overcome issues with ASD.

ASD has its own shortcomings. Especially agile requirement engineering process has its challenges and limitations. Rasheed et. al provides a comprehensive review about these issues [18]. Therefore, agile requirements engineering is a good place to involve the MDD practices as modelling seems to be lacking in ASD. However, the requirements modelling performed in agile software development methods is different from models developed in traditional software development methods [19]. Another difference in ASD is to use user stories as specifications of the customer requirements. Therefore, there is a need of novel techniques to automate/semi-automate model generation to assist agile requirements engineering.

There are only few research attempting to help ASD with automatic generation of models from user stories. Gupta et. al have developed a tool that automatically creates conceptual models from a given set of user stories [20]. The tool takes user stories with acceptance criteria as input and produces four conceptual models (Domain Model, Process Model, Use Case Model and Finite State Machines) as output. Robeer et. al have developed a Visual Narrator tool which automatically generates a conceptual model from a collection of agile requirements expressed as user stories [21]. Gilson et. al have developed a tool to create robustness diagrams, i.e., a form of semi-formal use case scenarios, from the automated analysis of user stories [22]. All these approaches use Natural Language Processing techniques to some extent to process the textual user stories.

As this is a quite new research area there is a need for proposing more useful techniques to generate or assist generating models in agile requirements engineering. The proven MDD practices such as automatic model generation

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and model transformations can be utilized in this regard. Stable architecture is important in ASD to achieve a flat effort curve. Support modelling in the agile requirements engineering can help to achieve this.

VI. CONCLUSION

In this paper, we have first reviewed the work related to combining MDD and ASD. Then we have analyzed the findings to identify areas for future research in this regard. Most of the related work so far focus on creating a new software development methodology combining ASD and MDD. These approaches seem to be complex and break the simplicity of ASD which is the main software development methodology embraced by the software development community now.

Therefore, we believe it could be very useful to the industry if we bring good practices from MDD into ASD to improve it without making the process too complex. Hence, agile requirements engineering is identified as a problematic area which can be improved using modelling support from MDD components and tools.

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Transformation of Class Hierarchies During Software Development in UML

Himesha Wijekoon, Vojtěch Merunka
Department of Information Engineering
Faculty of Economics and Management
Czech University of Life Sciences Prague
Prague, Czechia
email: wijekoon@pef.czu.cz, merunka@pef.czu.cz

Vojtěch Merunka
Department of Software Engineering
Faculty of Nuclear Sciences and Engineering
Czech Technical University in Prague
Prague, Czechia
email: vojtech.merunka@fjfi.cvut.cz

***Abstract*—This article discusses support for the Unified Modelling Language (UML) standard in Model Driven Architecture (MDA) style software development. There are described some of the weaknesses of the UML standard that software developers should know about, to take full advantage of this otherwise very good and desirable standard. Specifically, it is a hierarchy of object classes, which belongs to the basic concepts of the object-oriented paradigm. This hierarchy is considered well known, but in fact there are three slightly different hierarchies that fortunately fit well with the MDA philosophy. The problem is mainly that all these three hierarchies appear in UML in the same way, as if they were just one type of hierarchy. The article describes and explains these differences and suggests a refinement to the UML using stereotypes. The conclusions written in this article are a summary of the authors' experience of software projects for the international consulting company Deloitte and of university education.**

Keywords-UML; software development life cycle; transformation of concepts; MDA; class hierarchies.

I. INTRODUCTION

The objective of Unified Modelling Language (UML) has been and is to replace older methodologies by one methodology that is a combination of the best of the older ones. Likewise, the Model Driven Architecture (MDA) philosophy is a synthesis of previous best experiences in the creation of large-scale software, where there is a semantic gap between programmers and people in the area of the modeled problem.

The history of software engineering could be simply described as a human struggle with complexity. The solution is to split a complex task into a set of many smaller and therefore simpler tasks that one can already handle. Incidentally, this idea, which is the basis, for example, of the programming of computers is not new. It was probably first pronounced by a Persian scientist Muhammad ibn Musa al-Khwarizmi in his book "The Compendious Book on Calculation by Completion and Balancing" which became the basis of modern mathematics and was the forerunner of software engineering [1][2].

Authors, based on their practical experience in an international consulting company, have experienced that the same UML diagram is understood differently by different development team members (e.g., problem domain experts, IT architects, data analysts, programmers). This increases the semantic gap between users and developers and makes software development more complicated, expensive, and error prone.

This paper discusses about using UML standards in the MDA approach for software development. More precisely, the paper discusses how different types of hierarchies can be expressed in UML class diagrams.

This paper is organized as follows:

- The Introduction is followed by Section II on UML and its problems.
- This is followed by Section III on the MDA approach.
- Section IV is central because it contains our own research, which is described in a concrete example.
- Section V is a discussion and suggested solution.
- The Conclusion of this article.

II. OBJECT-ORIENTED APPROACH AND THE ORIGIN OF UML

Before the arrival of UML, in early 1990s, we had several competing object-oriented methodologies with mutually different notations. These were so called first generation object-oriented methodologies. Many software companies used a combination of several methodologies instead of just one methodology – mostly object models from Object Modelling Technique (OMT) along with interaction diagrams from the Booch method and the Use-Case approach of the Jacobson Object-Oriented Software Engineering (OOSE) method [3][4][5]. Most of these methodologies have later become the foundation for UML [6]. UML has brought along a unification of the previous notations. The UML notation is mostly based on OMT and has become a recognized standard. UML includes many different elements from the original methodologies. There is, for example, the so called "business extension" from the original Jacobson method that has been added in version 1.x, or the absorption of the Specification and Description Language (SDL) methodology for supporting real-time processes in version 2.x [7].

Obviously, the UML is not a method. UML is "only" a modelling language [8]. That, itself should not be a problem as it is good that since 1996, we have had a standard for object modeling. The problem, however, is the fact that for the "universal" language there are more methodologies (e.g., Rational Unified Process) and even mere knowledge of UML is often considered a methodology [9].

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A. Is UML a Method?

Experience proves that it is not a method. UML is definitely not a method that could be understood by a layman in reasonable time (for instance in 15 minutes at the beginning of a meeting with analysts), to be able to read and understand the diagrams. This is not an unrealistic requirement, because in the past it was possible to work like this with entity-relational and data-flow models. Unfortunately, in object-oriented modeling we do not have such an elegant and simple method. Instead, we send customers to attend long training sessions on UML, where we make them work with Computer Aided Software Engineering (CASE) tools.

B. Some Issues of UML

Most criticism at UML is directed at its complexity and inconsistency. It is, for example, the direction of the arrows of different links that sometimes draws in reverse with reality. Another criticism is the varying level of detail. For example, terms directly related to C++ or Java and similar programming languages have beautiful distinguishable symbols, but concepts are also very important but not supported in Java-like programming languages have very little support or only optional textual stereotype. The third and last part of the criticism speaks of complicated or even no UML support for the decomposition and generalization of diagrams that no longer have the elegance of the old Data Flow Diagram (DFD). A good publication on this topic is an article by Simons and Graham [10].

However, we know many of these things also from other areas of science. As a typical example, let's look at the direction of the flow of the electric current that is drawn from the positive pole to the negative pole in electric circuit diagrams since Michael Faraday's time, which is the opposite of reality, as every bright student knows today.

Individuals who are not familiar with programming find UML too difficult, and then they incorrectly interpret the entire object-oriented approach [10][11][12]. It is possible to pick an acceptable set of concepts out of UML for non-programmers; nevertheless, most professional books and training sessions are too often unnecessarily based on programmer experience. Comprehensibility and simplicity of UML is corrupted by the following facts:

1. UML models contain too many concepts. The concepts are at different levels of abstraction, and sometimes they semantically overlap (e.g., relations between use-cases); and even their concepts sometimes differ. The same model can therefore be interpreted differently by an analyst and a programmer (the typical example is associations between objects).
2. There are several ways in the UML diagrams to show certain details in models (e.g., qualifiers and link class objects or state diagrams that are a mix of Mealy and Moore automata). It is up to analysts, which option they choose.
3. Some concepts are insufficiently defined such as events in state diagrams. One UML symbol covers several different concepts (e.g., in sequence diagram the data flow between objects blends with control flow).
4. Although UML is generally good from the graphics aspect, some analysts do not like for example the same symbol of a rectangle for instance and class (they are differentiated only by internal description), as well as the direction of the inheritance arrow that leads toward the parent object in spite of the fact that in the codes of programming languages (even in users interpretations) inheritance is represented by opposite direction (i.e., from the parent object toward the descendant).

C. UML Support of Object-Oriented Approach

Although UML has the ambition to be truly versatile and is also registered as a universal International Standards Organization (ISO) standard [6], it is true that the largest field of application is object-oriented analysis and programming. UML supports many object-oriented concepts, and there is currently no other “more” object-oriented as well as standard modelling language. The success of UML in practical usage is based on many successful projects where the software has been developed in C++ or Java (i.e., languages that use object-oriented approach).

Practically speaking, UML is associated with object-oriented software creation for many users, who do not even know that UML has an overlap with other areas of software engineering, such as relational database modelling.

III. MDA Approach

MDA is an Object Management Group (OMG) specification based on fixed standards of this group [13]. The main idea behind MDA is to separate business and application system from the technology platform. This idea is not new as the need to create a separate analytical and design model has existed for quite some time. What MDA brings are procedures and ways to transform these models. The primary objectives of this approach are to ensure portability, interoperability, and reusability through a separate architecture [14].

The MDA approach advises a complex system to evolve as a gradual transformation of three large models:

1. Computer-Independent Model (CIM): This model, also known as the domain model, focuses exclusively on the environment and general requirements of the system. Its detailed structure and specific computer solution are hidden or unspecified at this stage. This model reflects customer's business requirements and helps to accurately describe what is expected of the system. Therefore, they must be independent of technical processing and describe the system in a purely factual and logical way. It does not require to know any details of computer programming, but rather requires knowledge of the real target environment.
2. Platform Independent Model (PIM): This model deals with the part of the complete system specification which does not change according to the particular type of computer platform chosen. In fact, PIM mediates a certain degree of independence of a particular solution to a given problem area to suit different platforms of a similar type. It describes the behaviour (algorithms) and structure of the application only within those limits that

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will ensure its portability between different technological solutions. Compared to the CIM model, it is supplemented with information (algorithms, principles, rules, constraints, etc.) that are essential for solving the problem area through information technology. The big advantage of the PIM model is its reusability and therefore it can serve as a starting point for various assignments when it is necessary (e.g., to change to another programming language, the need to reuse some legacy component or data, etc.). It's like abstract programming in an ideal programming environment. At this stage of development, the so-called expansion of ideas is also taking place, as the target environment has not yet restricted us.

3. Platform-Specific Model (PSM): The latest MDA model, which is already platform dependent, combines PIM with a specific technology solution. There is a so-called consolidation where the previous ideas must be realized in a specific target computer environment with all the shortcomings and limitations of the version and configuration of the technology used.

IV. THREE DIFFERENT TYPES OF CLASS HIERARCHIES IN THE PROCESS OF SOFTWARE DEVELOPMENT

Conceptual hierarchy of classes, hierarchy of data types, and hierarchy of inheritance do not necessarily mean the same thing regardless all three hierarchies are drawn in the same way in UML. We can only use UML stereotypes to distinguish among them in detail. These hierarchies have a strong connection with MDA ideas and can be recognized as follows:

1. From the perspective of the user/analyst: The instances of lower-level classes then must be elements of the same domain that also includes the instances of the classes of the superior class. It means that a lower-level domain is a sub-set of a higher-level domain. This hierarchy is also called the IS-A hierarchy or also taxonomy of classes. In specific cases, it can differ from the hierarchy of types because it does not deal with the behaviour of the objects at the interface; rather it deals with the object instances as a whole including their internal data structure. Formally, we can define this hierarchy of a superclass A and subclass B as

$$A \prec B \;=\; \text{extent}(A) \supset \text{extent}(B) \qquad (1)$$

This hierarchy corresponds to the CIM phase of MDA.

2. From the perspective of polymorphism: This is a view of an application programmer who needs to know how to use the objects in the system but does not program them. The object in lower levels of hierarchy then must be capable of receiving the same messages and serve in the same or similar context, such as high-level objects. Therefore, this hierarchy is the hierarchy of types. Formally, we can define this hierarchy of a superclass A and subclass B as

$$A \prec B \;=\; \text{interface}(A) \subseteq \text{interface}(B) \qquad (2)$$

This hierarchy corresponds to the PIM phase of MDA.

3. From the designer's perspective: new object designer. This is a view of a system programmer who needs to create these objects. This hierarchy is a hierarchy of inheritance because inheritance is a typical tool for the development of new classes. Formally, we can define this hierarchy of a superclass A and subclass B as

$$A \prec B \;=\; \text{methods}(A) \subseteq \text{methods}(B) \qquad (3)$$

This hierarchy corresponds to the PSM phase of MDA.

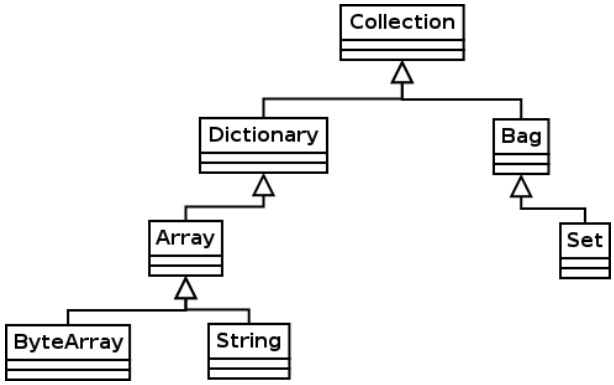

Figure 1. IS-A Hierarchy (Class Taxonomy)

In simple problems, it is obviously true that these three above-mentioned hierarchies are identical. However, this is not true in more complex problems (e.g., in the design of system libraries that are often re-used when developing specific systems).

A. *An Example - Library of Object Collections*

Figure 1 is a good example showing IS-A hierarchy, hierarchy of types and hierarchy of inheritance which is a part of a system library of the Smalltalk language concerning collections of objects. A similar library can be found in each object-oriented programming language, of course. There are the following classes:

- Collection: This is an abstract class from which the individual specific classes are derived. A common quality of all these objects is the ability to contain other objects as their own data.
- Dictionary: This is a collection where each value stored has a different value assigned to it (therefore forming a pair), which serves as an access key to the specific value. Dictionaries can be really used as dictionaries for simple translations from one language to another. Another frequently used example of the use of object dictionaries is a telephone book (i.e., the key is the names of the people and the values connected with the keys are the telephone numbers).
- Array: Simply said, an array is a dictionary where the keys can only be natural numbers from 1 to the size of

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the array. So, the array values are also accessed as if through keys.

- Byte Array: It is an array where the permitted scope of values is limited to whole numbers in the interval from 0 to 255.
- String: A string of characters can be also viewed as an array where the permitted scope of values is limited to characters.
- Bag: This is a collection in which internal objects can be stored inside without any accessing key.
- Set: This is a special type of a bag where, in addition, the same value can occur only once. If the set already contains a specific value, another input of the same value is ignored unlike the above-mentioned bag, which allows multiple occurrences of the same value. The objects which are elements of the set are functionally corresponding with mathematical concept of sets. Therefore, they have this name.

This description of the classes from Figure 1 follows the IS-A hierarchy (or class taxonomy) as we know it from natural sciences. But we may define a slightly different perspective as it is presented at Figure 2, but equally important as first one from Figure 1. If we concentrate on behaviour of objects, we obtain a bit different hierarchy that is defined by the scope of permissible messages. Or we can also declare this hierarchy as a hierarchy of object interfaces. It is the hierarchy of types corresponding with the PIM phase of MDA. This supertype-subtype hierarchy has following differences from previous IS-A hierarchy:

- Because Dictionaries can receive the same messages as Sets, they can be therefore viewed as sub-types of Sets. The same applies also for Bags.
- Arrays and String are interpreted as almost independent classes because each of them supports very specific operations (messages) with very little common intersection.

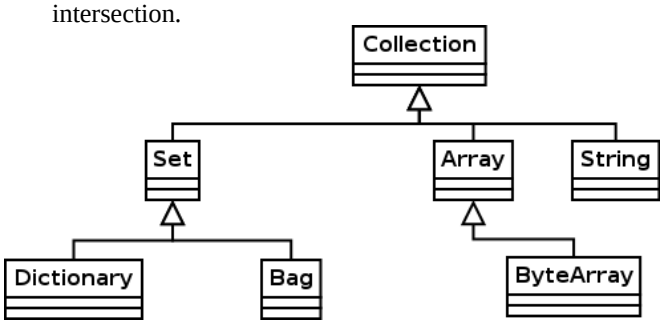

Figure 2. Hierarchy of Types (Supertype - Subtype Hierarchy)

This second hierarchy is not the last one. We can create yet one more hierarchy to match the PSM phase of MDA. See Figure 3. This hierarchy of inheritance is very important for the programming when programmers have to create their objects in some programming languages. Again, we will have some differences from previous hierarchies:

- Strings can be implemented as a special kind of ByteArrays (e.g., inherited subclass), because separate character elements are typically encoded into bytes of tuples of bytes.

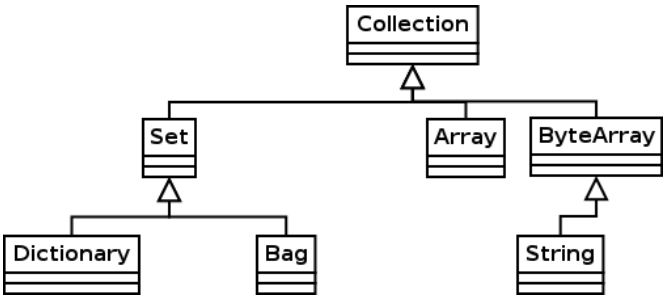

Figure 3. Hierarchy of Inheritance

- Implementation of Arrays and ByteArrays has nothing in common and therefore it makes no sense to inherit anything together. Arrays are implemented using pointers which point to the internal objects that make their elements, but ByteArrays are contiguous sections of computer memory, where their elements are stored directly in these bytes. Although these two classes have much in common and can receive the same messages in terms of external behaviour (that is, they have polymorphism), the code of their methods cannot be shared and it is necessary to program each method separately, although they seem very similar.

V. DISCUSSION - UML SUPPORT FOR SOFTWARE DEVELOPMENT PHASES

In Section IV, we have just explained the need for different class hierarchies. The problem remains to be resolved is, how to express them in the UML class diagrams. Fortunately, the UML standard includes an extension mechanism that allows new concepts to be introduced in a standard way. They are so-called stereotypes. All we have to do is select some graphic element, and we can give it a different interpretation by typing the text in double angle brackets « ». The result is in Figure 4.

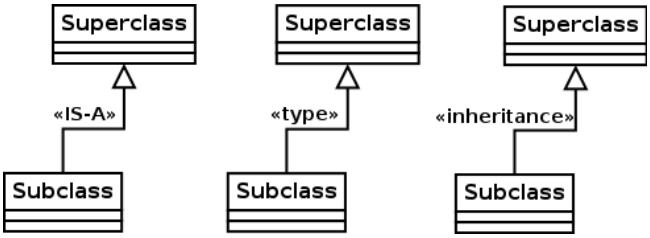

Figure 4. UML Extension Proposal

Of course, if each UML class diagram clearly indicates what phase of the model it is (CIM, PIM, or PSM in the style of MDA, for example), then this stereotype is unnecessary.

A. The Need of MDA Way of Thinking

During system development it is necessary to gradually transform the system model into a condition that is necessary for physical implementation of the system in program form in the specific programming language.

According to our experience, initial objects cannot be viewed only as initial simplification of the same future software objects, as the common error of the analysts in

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UML [15]. The initial business model is simpler, but at the same time it contains concepts which are not directly supported by current programming languages.

In the work on major projects, IS analysts face problems when not all system requirements are known at the start of the project and the customer expects that discovery and refinement thereof will be part of the project. These problems are even more complicated because the function of the major systems built has impact on the very organizational and management structure of a company or organization where the system is implemented (e.g., new, or modified job positions, management changes, new positions, new departments, etc.). Therefore, it is desirable to also address the change of these related structures during the work on information systems.

VI. CONCLUSION

In this paper, we demonstrated the need of precise interpretation of modelling concepts on an example of gradually transforming object class hierarchy. This approach is a practical realization of MDA ideas in UML.

Underestimation of the model differences in the individual phases of development of an information system happens, when the analysis using UML is viewed by programmers as the sole graphical representation of the future software code. Analytical models are then used not to specify the problem formulation with the potential users of the system who are also stressed by the complexity of the models that are presented to them. In our practical experience, many projects in UML suffer from this problem. In response to that, there are two "remedial" approaches used in practice: Extreme Programming [16] and Domain Specific Methodologies [15]. But it is as if also the baby itself had been spilled with dirty water from the bath.

The objective of this article is not to suggest that UML is a bad tool. On the contrary, UML is a good and rich tool. The fact that it is not perfect in all areas is not anything horrible. UML is the first successful attempt to introduce a reasonable object-oriented standard, and it is good to use it. We only wanted to point out some of the problems that relate to the use of the UML. We see a danger that results in the fact that the UML is taught and used incorrectly. The problems discussed can be summarized as follows:

1. UML is not a method. It is "only" a standardized tool for recording. UML needs some method, otherwise it doesn't help.
2. UML is complicated. People who are not familiar with programming have difficulty learning it. It is not easy to explain UML to laymen and non-programmers in just a few minutes at the first meeting.
3. Analysis in UML must not be a graphical representation of the future program code.
4. UML itself does not accurately emphasize which concepts are to be used in the analysis phase and which concepts to be used in the design and implementation phase. Unfortunately, many books on UML look at modelling through the eyes of implementation and are written in a language for programmers and particularly programmers in C++ or Java or a similar programming language.

The thoughts described in this article are a synthesis of our own experiences from object-oriented modelling at the international consulting company Deloitte, from own research activities and from teaching the development of information systems at the universities.

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Review of Gestalt Principles used in Computer Games

An Evaluation of Graphical User Interface Design

Christy Martin, Michael Cooper
Visual Communication Studio + Consultancy
Queensland, Australia
e-mail: voxelandpixel@gmail.com

Manolya Kavakli
AIE Institute
33 Mountain St, Ultimo
Sydney, Australia
e-mail: manolya.kavakli@aieinstitute.edu.au

***Abstract*—Our goal in this paper is to review the use of Gestalt Principles in computer games. Our hypothesis is that Gestalt Principles can be used in games to improve user engagement with the Graphical User Interface (GUI) and this in turn affects User Experience (UX). First, we define the key elements of the Gestalt, as they apply to graphic design. Then, we demonstrate how Gestalt Principles are used in computer games and discuss how this may affect consumer behaviour and GUI design for games.**

Keywords - computer games; GUI design; Gestalt principles; user interface; analysis.

I. INTRODUCTION

Consumer behaviour is associated with the study of consumers and their activities, associated with the purchase, use and disposal of goods and services. It is driven by how the consumer's emotions, attitudes and preferences affect buying behaviour. The Gestalt theory helps us to understand which visual elements are most effective in certain positions and how these cause behavioural changes in consumers, affecting primarily their perception and attention.

Developed in the early twentieth century by the German psychologists, Wertheimer, Koffka and Kohler [4], the concept of Gestalt Principles began with a psychological study into vision; what the eye or the gaze perceives and comprehends about what it **sees** [1]. The discovery was that the brain's natural tendency is to group smaller elements into a larger, more complete picture, to "find and create order" [2]. The overarching concept being that by reducing the sum of parts to a whole, we are producing an ultimate simplicity of form.

The application to graphic design is that in visual communication we can direct the user or viewer to comprehend patterns of association - to take in and process hierarchies of information more easily - and therefore create an order of importance which allows for direct and simple understanding [5].

Gestalt Principles are incorporated as part of the overall design process in computer games, to assist the designer of GUI to simplify what could be quite complex informational structures, and thus improve the overall user experience of gameplay, by providing logical and rational visual choices for player direction and selections.

The Gestalt Principles in design involve perceptions relating to space and form.

We observe those visual relationships are based on the principles of:

1. **Proximity**: space forms, or separates, groups
2. **Similarity**: similar elements will form a group
3. **Common fate**: change can occur as a group
4. **Figure/ground ambiguity**: negative or positive space can be used to manipulate the eye
5. **Closure or continuation**: of lines and structure – we close gaps in recognisable objects ourselves or are directed by repeated or continuous elements.

Graphic designers take advantage of these visual comprehension tendencies, employing design strategies to incorporate them, such as:

- reducing elements to **basic shapes.**
- using **positive and negative space**, both foreground and background.
- using **pattern** (or disruption of pattern).
- using '**the known**' to challenge the viewer to fill in missing information or identify shapes.
- utilising **grouping modes,** which include simplicity, similarity, proximity, closure, continuity, and symmetry.

Whilst analysis of Gestalt Principles as an element of graphic design for print and digital spaces are plentiful, investigations and evaluations for review or comparison into Gestalt Principles as a strategic approach for the unique, highly interactive nature of computer game GUI, were hard to come by, and have inspired this avenue of research.

In Section II, we look further into the graphic design techniques used to apply Gestalt Principles. Grouping modes represent the strategy we use to incorporate the Gestalt into our designs, and we will examine the use of these modes in several computer games in Section III. A general analysis of Gestalt Principles in our selected GUI examples (Section IV) and the conclusions drawn from this (Section V), finalize this paper.

II. GESTALT PRINCIPLES: WHAT WE KNOW

By grouping related elements into wholes, we target simplicity. This allows us to understand large tracts of data more easily. How we read a visual communication is

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complex and involves appraisal of the visual hierarchy (setting an order of importance), including: viewing or reading patterns, such as in a 'Z' or 'F' pattern (Figure 1), graphic and typographic content, and narrative features [10].

GUI is the interactive element of computer games. The GUI is the "arrangement of visual components that act as a means of communication between the user and various aspects of the game code, for example, in-game interactivity, information displays, narrative, and settings" [7].

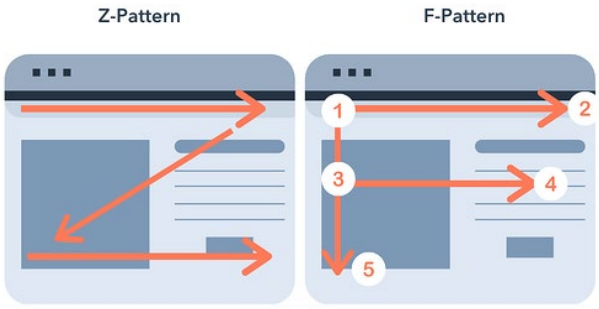

Figure 1. Patterns of viewing [10]

The focus of graphic design in this setting is to design appropriately for the aesthetic and technical functions of the game design, as multiple user interface styles may be used within the one game. UI in games takes on different forms, such as **diegetic**, which involve elements that exist within the game world, or **non-diegetic**, referring to an on-screen UI element that is separate from the game world [11]. Other UI types are **Meta**, referring to elements which exist within the game world (and are used as a form of UI) and **Spatial**, which often appears as an element, or pop-up, appearing in the game but is not of the game world [7].

*A. Reducing elements to **basic shapes***

Figure 2. Example of basic shapes

In visual communication, we can reduce complex ideas into simple graphic representations (like Figure 2), by incorporating a type of 'visual shorthand', as in use of iconography and, more recently, 'emoji' [1].

Icons, like logos, are simple graphic devices that we infer with meaning, due to the associations we imply from the shapes used in construction of those elements. An example (Figure 3) shows male and female sides for the bathroom, and we understand (without any text to describe), which side is which based on shape alone.

Figure 3. Icons for male/female bathrooms [23].

Development of icons is an oft-used design tool, to cater toward simplicity of communication, and is indeed a universal language which crosses dialect and cultural barrier, not unlike use of colour, which can have some universal associations such as the red, green, and yellow of stoplights [3]. In computer games, too, we use icons and basic shapes to designate functions of UI, such as in Tool Bars or Backpacks, where multiple actions may be stored in shaped unit blocks, with basic icons inside (see Figure 11).

B. Using positive and negative space

According to Lupton and Phillips, Contrast plays a key role in the separation of "figures (forms) from the space, color or patterns that surround them" [2]. Using overlapping elements to create ambiguity as to the positioning of fore and background, the meaning or narrative within the negative or positive space created reveals itself, as in the example movie poster for "Brave," by Pixar [12], in Figure 4. Here we can see both the figure of a girl with wild red hair on a black backdrop in the positive space or foreground, but also and a bear's head in the negative, or background. This is a clever way of incorporating two perspectives of the same narrative.

Figure 4. Positive and negative space, "Brave" by Pixar poster [12].

C. Using pattern

Pattern can manifest as both a behavioral, and graphic, occurrence. Certain repetitions of graphic may also prompt patterns in behaviour, encouraging players to do the same action or sequence of actions repeatedly.

Patterns have power, both in terms of continuity and regularity of shape, but can also be dynamic. When a break in pattern occurs, a deliberate disruption of order is intended. Patterns can take many forms, as an aesthetic choice in a background, exampled by Figure 5 [15], or gameplay related, such as a pattern-based puzzle within a game (Figure 6) [21].

Figure 5. Example of a literal Pattern in "Cozy Grove" by Spry Fox [15].

Figure 6. Example of a puzzle Pattern in "Wolfenstein II:The New Colossus" by Bethedsa Softworks [21].

D. Using 'the known'

Links and associations with known shapes and ideas allow the designer to use clever visual tricks, and combinations of concepts, to pull together multiple meanings into singular graphics. As noted with the design of icons or logos, we can reduce complexity by relying on pre-conceived notions or visual memory.

In the logo for "The Good Avocado," Figure 7 [22], the designer has taken a universal symbol for good (an 'OK' hand gesture) and within the negative space created placed an 'avocado' shape. Because we know what an avocado looks like, our prior knowledge, we can make the appropriate association.

Figure 7. "The Good Avocado" logo by TwoFromTwo [22]

E. Utilising grouping modes

As mentioned in Section I, the main grouping modes for Gestalt Principles are:

- Proximity
- Similarity
- Symmetry
- Simplicity
- Continuity
- Closure

The natural tendency of the mind to group and structure complex objects or even concepts back to simplicity, give us the ability to demonstrate these groupings easily in most design settings, including computer game UI. We will explore this in Section III.

III. An Analysis of Gestalt Principles in Games Using Grouping Modes

How do Gestalt Principles affect the design of UI? It is worthwhile examining a small selection of games with different visual layouts to identify where these principles exist and how they are beneficial to design.

Modes of grouping are a useful way to address how Gestalt Principles interact with the user in a games format – and here we discuss where in the GUI of a game these principles can be clearly seen in action.

A. Proximity

Proximity is used as a design strategy, to position elements in such a way that they, due to their location in relation to other elements, become related – and thus are grouped together. Proximity is a tool used by designers to develop hierarchical forms, be they graphic or typographic.

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This connected spatial relationship allows the viewer or user to identify where elements belong and direct the eye or "gaze" (Lupton, 2015), as seen in Fig8. Proximity is one of the most widely used Gestalt Principles in games, as the interactive nature of the medium makes it crucial to give swift and easy visual access to UI tools, and information, therefore the creation of relationships through Proximity assists with this. The limited screen area also dictates the placement and size of these elements, along with the genre and style of game.

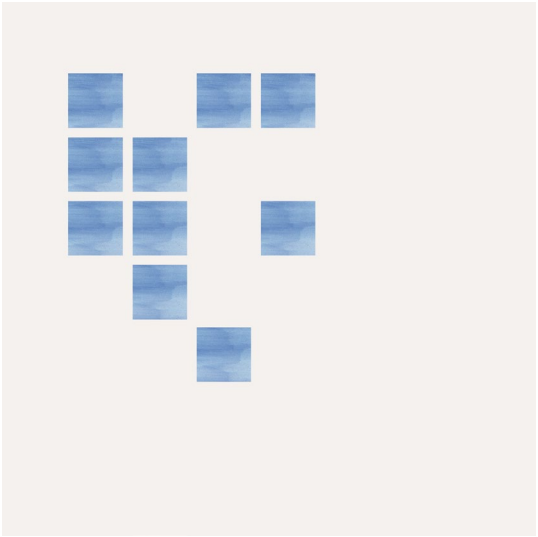

Figure 8. Example of Proximity

In the example (given in Figure 9), from "A Total War Saga: Troy", by Creative Assembly Sofia (2020), we note the Skill Tree elements are all round, and the same size, but divided into five separate areas of Skill.

Figure 9. Example of Proximity, "A Total War Saga: Troy" [17].

Proximity links the Skill sets, but also separates them - as the proximity distance is increased between sets but decreased between individual circles – to connect them together, along with their paths, and create specific groups.

With the box element encasing these shapes, we can clearly perceive a set of five different Skill Trees, related but separate.

B. *Similarity*

Our viewing patterns tend toward creating order, to organize concepts in a rational way, and group what we see. In this example (Figure 10), the similarity of the objects allows us to create two distinct groups (circles and squares). This, like Proximity, also plays to maintaining simplicity (another grouping mode) of form, and designers use this principle to link graphic representations.

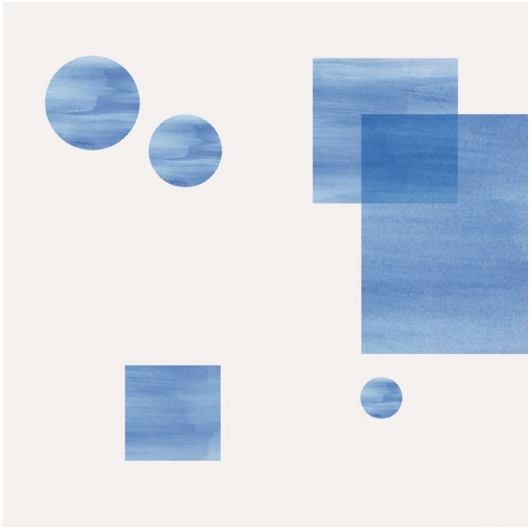

Figure 10. Example of Similarity

As this concept applies to game UI, we often see similar shapes repeated throughout to indicate specific information or apply hierarchy.

In the example from "Cozy Grove," (Figure 11) by Spry Fox, the small, rounded squares all contain icons related to collected objects, acquired skills or inventory in some way. Our eye recognizes these shapes as belonging to the content system of the game, as the same forms are repeated for like-structures relating to the character played (such as the Backpack, Weapons or Skills, Inventory, Chests).

Colour, here, also plays a part, indicating a specific informational hierarchy. This can be seen from the use of a pop colour (jade green), which draws the eye to the icons, encouraging us to click and reveal the objects within.

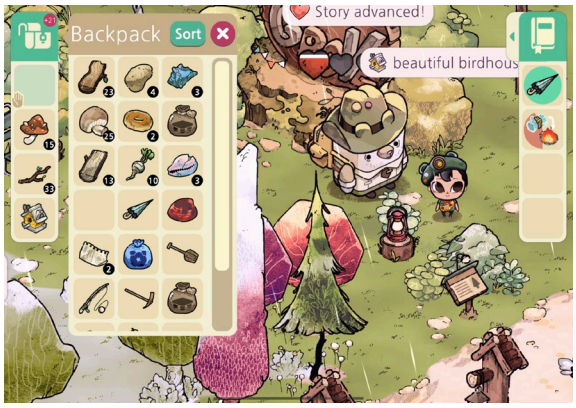

Figure 11. Example of Similarity from "Cozy Grove" by Spry Fox [15].

C. Symmetry

Creating balance in a design is often the function of Symmetry (see Figure 12). Symmetry gives rest to the eye and where asymmetry challenges and provides dynamic differentiation, symmetry balances with a certain neutrality.

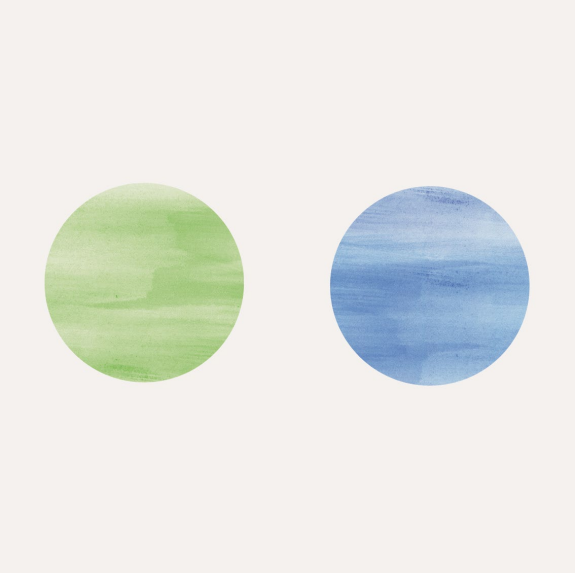

Figure 12. Example of Symmetry

Figure 13, the "Fortnite" UI, by Epic Games [18] shows a central character, with symmetrical UI elements of text and image on either side. Whilst content may vary, the space allowed - using a grid or column system - is clearly designed to show symmetry (and thus balance the visual).

Figure 13. Example of Symmetry from "Fortnite" by Epic Games [18].

D. Simplicity

The goal of creating a great game UI is to communicate all necessary information to the user or player in the clearest and simplest of terms, appropriately and in keeping with the mood and style of the game.

Simplicity of communication in a game UI, could be utilizing iconography to interpret specific information, such as in the following level map from "Anthem," (Figure 15) by Bioware [13] and as such, reducing elements to basic shapes (Figure 16).

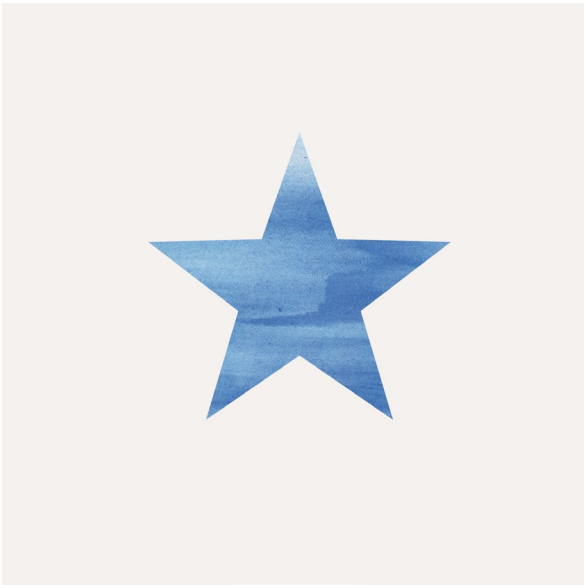

Figure 14. Example of Simplicity

Simplicity, in terms of use of space, is also a factor in UI design, keeping the playing area clear and tools accessible, as demonstrated in a padlock input execution (Figure 17), in "Firewatch", by Campo Santo [15]. Here we see an expanse of unencumbered screen space, drawing our attention to the minimalist design elements of simple linework icons and text. This serves to shift the eye of the player to the desired UI features and perceive immediately how they are to interact with them (use the 'up' or 'down' icons, to achieve the correct number combination).

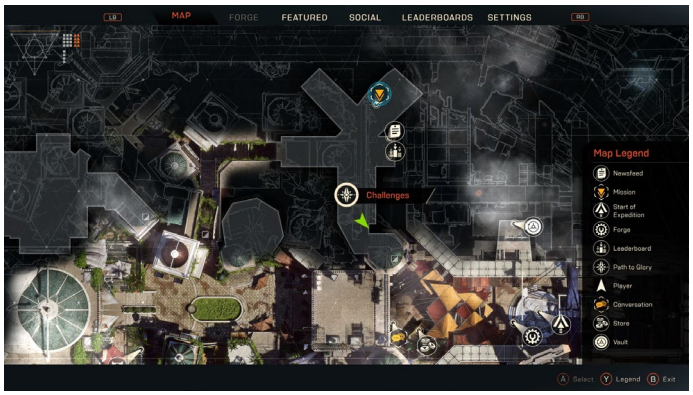

Figure 15. Example of Simplicity, iconography in a level map from "Anthem" by Bioware games [13].

Figure 16. Example of Simplicity, iconography in a map legend from "Anthem" by Bioware games [13].

Figure 17. Example of Simplicity, UI text and icon elements in "Firewatch" by Campo Santo [15].

E. Continuity

According to Graham [4], the eye looks for relationships, through the space between elements, thus "continuation occurs when the eye follows along a line, curve, or a sequence of shapes" as seen in Figure 18. A designer can facilitate this in several ways, from linework or animations to direct the gaze, or harnessing Proximity in tandem to bounce the eye from shape to shape, colour to colour.

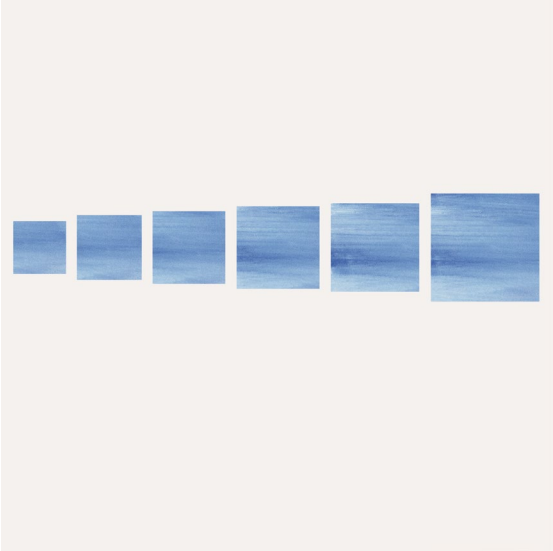

Figure 18. Example of Continuity

Graham also points to the nature of time as being relevant here, as a flow of information or communication based on visual elements shows a certain progression [4]. Figure 19 is an example of a continuous line, where the driver can follow a line of 'best fit' for the roads or tracks available [20].

Figure 19. Example of Continuity, showing a blue, continuous driving line (arrows) from "Forza Horizon 5", by Playground games [20].

F. Closure

The title screen from "Anthem," (Figure 20) by Bioware games [13] is a classic example of how the mind perceives Closure. We know the name of the game, and despite the elements placed in the way of our visual comprehension of the word, "Anthem," we are still able to complete the association. Our minds close the open letters (such as the A) and fill in the blanks of information we do not have (such as the incomplete M, E or H).

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Figure 20. Example of Closure from "Anthem" logo, Bioware games [13].

Closure also comes to the fore in UI, where a sense of time or completion need to be visualized, a notable example of which is present in the loading icon for "Darksiders" (Figure 21) by Vigil/Gunfire Games [14]. The icon is circular in nature, a commonly used structure for time-based animations (as the progression can continue seamlessly in a circular device). We know, however, that this progression must end, or close, for us to move forward in the game, so our eye is anticipating this occurrence.

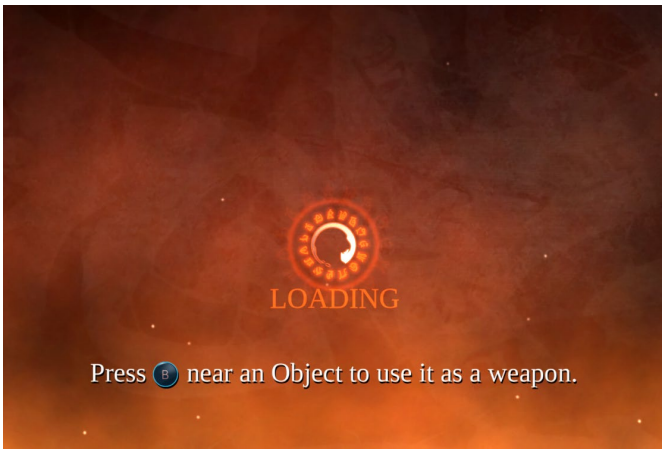

Figure 21. Example of Closure from "Darksiders" loading icon byVigil/Gunfire games [14].

A similar circular graphic animation, indicating loading time, can be seen in a game for mobile/tablet, "Animal Crossing: Pocket Camp" (Figure 22) by Nintendo [19]. The UI analysed also includes a download bar with a similar Closure-based principle – in this graphic we await the end of the download, and finalization of loading.

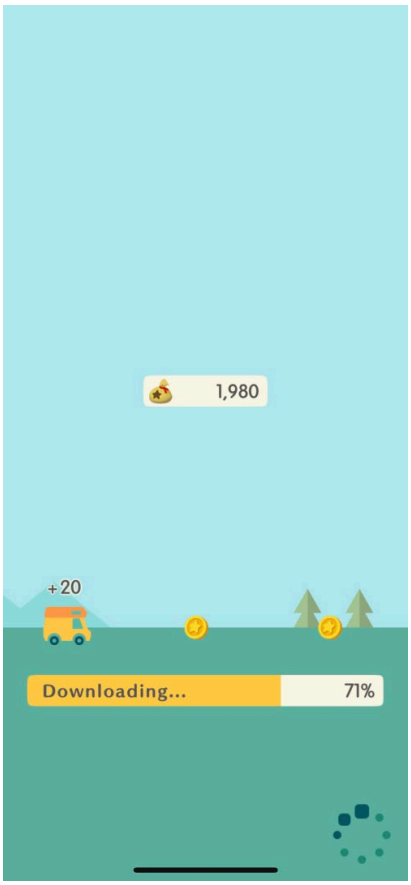

Figure 22. Example of Closure from "Animal Crossing: Pocket Camp" by ND Cube/Nintendo, download bar [19].

IV. Analysis of Gestalt Principles as utilised In Game UI

The UI of a computer game is an informational, directive and interactive action tool. Unlike the design for a logo or magazine spread, the utilitarian nature of such a digital, user-based design necessitates clear and swift communication of information, logical placements, and proximities – and thus the appropriateness of incorporating some aspects of Gestalt Principles in design (those which require deciphering or complicate the overall navigation) may be undesirable.

A. Underutlised Gestalt Principles in computer game GUI

1) Figure/Ground Ambiguity: We may see this principle used for in-game design (where heavy contrast may be needed, or in animations or graphic designs in the game environment), or utilised as a design device in marketing for games, but it could be argued that creating ambiguity is not a goal of UI design.

Dynamics, it could be argued, should give way to symmetry, legibility, and clarity and, in an overall sense, a more utilitarian design response which puts direct communication to the fore to enhance comprehension.

B. Review of Gestalt Principles in computer game GUI

Computer games are a media in which the principles of the Gestalt, as applied to GUI graphic design, can be easily observed. Indeed, the interactions required of the user demand we consider the visual perceptions, prior knowledge, and diverse ways of seeing of the player.

1) Proximity: Establishing relationships between elements is the goal of Proximity, and our analysis reflects this, with many games using this principle to link (or separate) graphic elements.

2) Similarity: This principle exists throughout game UI in general, as similarity is one of the key visual touchpoints for recognition and therefore response. If simplicity is the goal of an effective UI (to promote clarity and functionality), the use of shape and colour works to not only differentiate, but allow navigation through like objects as well.

3) Common fate: Elements regularly used in computer games such as directional menus or sub-menus demonstrate this principle by continually opening or tracking in the same direction and ending when the desired outcome is reached. Elements of Continuation also exist in this Gestalt Principle, as often a Continuous line will have sections repeating to the same end (Figure 19).

4) Figure/ground ambiguity: This principle applies less to GUI design than it does to the brand and marketing of games, such as in logo design, where mood and graphic creativity are necessary to attract attention and differentiate through contrasts and clever manipultion of forms. Elements containing or displaying overt ambiguities are less functional, and therefore could cause confusion in the UI space.

5) Closure or continuation: Closure, again, relates more to static logo designs traditionally, but could be seen to be used in any progress-related element which necessitates an end point, such as a progress bar or loading icon (Figure 22), as our eye naturally seeks to close or end sequences [8]. Continuation can be seen in linework, colour referencing and animations throughout UI spaces [4], sometimes even within gameplay, along with patterns or animated elements which loop or run parallel to the action (as in Figure 19).

V. CONCLUSION

Gestalt Principles have long been recognized around interactive media and User Experience (UX) [6], as being a product of psychological reaction to, and perception of, how a game functions or is designed [4]. This paper, however, has presented a brief analysis of how Gestalt Principles, as applied through the lens of graphic design in game GUI, are used within that sphere to influence and engage the user from a practical standpoint. This analysis suggests that Gestalt Principles are certainly a part of the overall UI design response, utilizing the knowledge gained through established "ways of seeing" [2] – from use of Simplicity to create clear and easily understood graphics in an inventory, to Proximity to establish navigation routes through a complex talent or Skill Tree. UI design, and therefore the user or player at large, can benefit from the application and assessment of these basic principles.

The strength of the Gestalt theory lies in its ability to provide support to marketing and graphic design activities, by providing more engaging content that stimulates the user attention and perception [9]. In this paper, we have demonstrated how Gestalt principles are applied to GUIs in games. In future studies, we plan to investigate the relationships between Gestalt principles in game GUIs and the game's commercial success, by doing a market analysis.

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Reentry ID: Helping Rehabilitated Citizens Regain Their Government Issued Identification

Navid Shaghaghi, Ju Young Park, Jay Kanakiya, Martin Rios-Cardenas, Connor Azzarello, and Colleen Chien
The Paper Prisons Initiative and the Ethical, Pragmatic, and Intelligent Computing (EPIC) Research Laboratory
Departments of Mathematics & Computer Science (MCS) of the College of Arts & Sciences,
Computer Science & Engineering (CSE) of the School of Engineering, and
Information Systems & Analytics (ISA) of the School of Business, and the School of Law
Santa Clara University, Santa Clara, California, USA
Email: {nshaghaghi, jpark11, jkanakiya, mrioscardenas, cazzarello, cchien}@scu.edu
Max Calcoen
Head-Royce School, Oakland, California, USA
Email: maximilianc2024@headroyce.org

***Abstract*—With the largest prison population in the world, the United States releases more than 650,000 individuals from prison every year. A significant hurdle encountered by many released individuals is that their state issued identification documents such as driver licenses have expired while they were in prison and the process of obtaining identification has significantly changed due to the advents of technologies such as the internet and smartphones. While various Checklists, Guides, and ID programs around the country have attempted to address this issue by disseminating information about the steps needed to obtain a government issued ID, they have proven to be either too rudimentary to be useful or too complex to navigate. Hence, this paper reports on the development of the Reentry ID tool at Santa Clara University (SCU), which helps guide users through the process of finding all the information they need for obtaining their state identification cards. As part of doing so, the tool warehouses various lists of all eligible proof of identity and residency documents accepted for applying for state identifications, such as driver's licenses, by each of the 50 US states' Department of Motor Vehicles (DMV), into a single database.**

Keywords*—*Criminal Justice Reform, Digital Society, Government Identification, Legal Technology, Paper Prisons, Web Application

I. Introduction

With the largest prison population in the world, the United States releases more than 650,000 individuals from prison per year as reported by the United States Department of Justice [1]. In order for these newly released individuals to reintegrate into their communities, they need housing, jobs, and maybe the ability to drive. All these activities require the possession of some form of government issued identification, such as a driver's license, which many recently released inmates do not possess due to it, for example, having expired while they were incarcerated. This issue was exacerbated by the COVID-19 pandemic when a significant increase in releases occurred for low-level or non-violent offenders in order to slow the spread of the virus within the United States' prison system. This abrupt release of inmates caused logistical issues regarding reintegration into society. Although inmates may be released along with their prison ID card and release papers, many states do not allow the use of these documents to easily procure state issued identification that allows them to become a productive member of society again. The lack of a government ID - or the "ID Gap" - is however not a problem limited to reentry populations: it is estimated that 11% of Americans do not have government issued ID [2] and that the problem disproportionately impacts African American individuals [3].

To make matters worse, government agencies are severely understaffed due to chronic budget cuts and, at the time of this writing, the COVID-19 pandemic. This has further impacted people's ability to simply walk into a Department of Motored Vehicles (DMV) office to be guided through the process by a staff member. Hence, many released inmates may need to apply for identification through the web. Thus, the recently released inmates may be once again pushed to the margins of society if they do not possess the technology or knowledge to effectively navigate the internet. Furthermore, bureaucratic websites are sometimes prohibitively complicated, especially for a person that may have been in prison since before websites were a mainstream consumer technology. For this reason, the criminal advocacy group *cut50* approached Santa Clara University's Paper Prisons Initiative team to assist in developing a web application to make the procurement of government issued ID's accessible to recently released inmates.

The main challenge in developing such a tool is to implement efficient yet simple methodology for guiding users to properly navigate through the process of getting an ID. Thus the tool was developed as a short questionnaire that intelligently adapts to previously answered questions and navigates the user to the most relevant agency's relevant web page to initiate the process for receiving their *most necessary article of identification*, which is a state issued ID or driver's license for most people. This necessitated the collection and databasing of massive amounts of complex information from bureaucratic websites as well as the paraphrasing of their terminology using accessible everyday language. The development underwent multiple iterations, and at the end of each iteration, user testing was conducted. The user testing was, however, limited due to

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the tool's specific target users.

Section II analyzes other attempts to provide technical guidance for getting an ID and section III explains the development process and technical methodology used in building the Reentry ID tool. Sections IV reports user testing results and updates made to the tool in relation to the user feedback. And lastly, Sections V and VI provide future steps for improving the tool and some concluding remarks, respectively.

II. Related Work

Many advocacy groups have developed different tools to help reentry court planners with their work.

A. Basic Checklists

One type of tool reentry planners use is a checklist to see what a released offender may need right after their release [4]. These checklists include questions related to identification, benefits and finances, health care, housing, and personal care. Although these checklists give a general idea of what a reentry court planner should focus on, it's not tailored towards a state and thus, the planner needs to gather more data based on their region.

B. Detailed Guides

Although the checklists give a general idea of what a released individual needs, they're not helpful when the released individuals are left on their own without any reentry program's support [5]. For these individuals, detailed self-study guides of all sorts have been developed. However, even though a detailed guide is a great way to help the released individuals sort out their plans after prison and get on the right track, they tend to either be too general and thus lack answers to questions for particular states, or are too detailed and try to answer many of the questions the released individuals may have, all at once before the individuals even know they may have said questions. Stated more directly, they tend to either be too scant on details to be truly useful, or too overwhelming and complicated for some individuals to go through and utilize.

C. ID Programs

California's Department of Corrections and Rehabilitation offers a CAL-ID program that provides certain state prisoners with a valid California state ID card for free, and its informative web page lists the required documents to prove eligibility for the program [6]. In order to enroll in the program, one must have their Social Security Number, an issued identification card or driver's license from the DMV within the previous 10 years, and an address with a zip code. This, however, requires those who do not have the required documents to have to go through other processes for getting each of the required documents first. Hence, one who does not already have an expired identification card or driver's license from the DMV faces another hurdle to getting a valid California state ID.

Even with the numerous details and information available, all the aforementioned are only useful for reentry program staff and court planners to use as reference. Many of the released individuals may find the guides, instructions, and whole process too overwhelming and difficult to understand and undertake especially if they cannot find an answer to their question in a few relatively simple steps. Therefore, the need for a unified tool which can direct users to where they can find the latest details for each step regardless of their state of residency, can not be further apparent.

III. Reentry ID

In collaboration with Dream Corps' #Cut50 initiative, an initiative to cut prison population and crime by 50 percent in the next 10 years [7], a team of Santa Clara University graduate, undergraduate, and law Students prototyped a simple proof of concept website during Santa Clara University Law School's 2019 Second Chances Empathy Hackathon [8]. In order to transform the prototype into a live tool which can be confidently used by released individuals or their advocates, over the years since, the work was continued by the Web and Tools subteam of the Paper Prisons Initiative, which has experience in developing humanitarian tools such as a tool for narrowing the Second Chance Gap [9] in support of released rehabilitated individuals. Several iterations of the tool were created and user tested until the current optimal solution which is available live on the Paper Prisons Initiative's website [10] was reached.

As any web application, the tool consists of a frontend and backend infrastructure as detailed below.

A. Frontend

The frontend was built into a designated page of the Paper Prisons Initiative's website with the same styling and aesthetics. It consists of two views: one for users seeking information on how to obtain their IDs and another for Admins to perform maintenance and updates without having to interact with the programming of the tool directly. Both consist of questionnaires designed using Survey.js [11] which uses familiar form elements such as check-boxes, Drop-down menus, and sliders.

1) User View: The questionnaire was placed lower in the page as to encourage the user to read the description first and get a better understanding of the tool before proceeding. Figure 1 shows what the user sees before proceeding with the survey.

Figure 2 shows the first question in the tool which asks the user about the type of identification (Passport, Social Security Card, or State ID / Driver's License) they are looking for.

Based on the document they choose, they either get a link to a government website or are directed further down the decision process. If the user selects "State ID / Driver's License" as the document they're looking for, after selecting a state they must determine all the necessary documents they will need to take with them to the DMV for getting their State ID or Driver's License. The documents fall within three categories:

- **Proof of Identity:** a document that proves the holder of the document is a citizen (natural or naturalized) of the United States of America or a legal alien residing within the United States.

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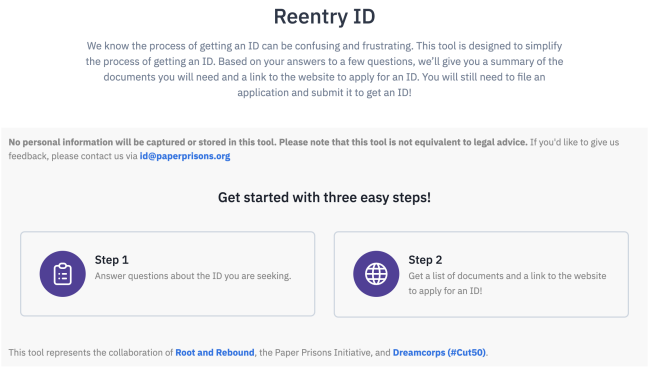

Fig. 1. Reentry ID tool overview and start page

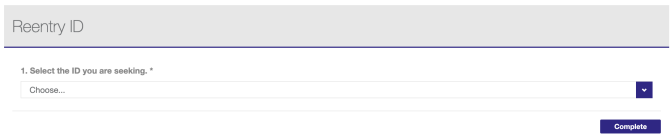

Fig. 2. Reentry ID tool's first question

- **Social Security Number:** a de facto national identification nine-digit number issued to United States citizens, permanent residents, and temporary (working) residents for taxation and other purposes.
- **Proof of Residency:** a document proving that the holder of the document lives and receives their mail at an address within the state they are trying to get a State ID or Driver's License in.

Reentry ID helps with this step by listing all of the documents the DMV will accept in the user's selected state for each of the said categories. Figure 3, shows the selections for the state of California, as an example. Reentry ID retrieves and renders these accurate and up to date lists from its manually and carefully populated backend database. The user selects the approved Proof of Identity document(s) they posses, a "Yes" or "No" for the possession of a document with their social security number, and the approved Proof of Residency document(s) they possess, and then click the "Next" button.

Based on the answers provided by the user, their results page may vary as depicted in figures 4 and 5. Figure 4 displays the successful navigation to the link for the user to get their document at their corresponding government office. From here, the user can either click the link and navigate to the said site and/or email the link to their email address so they can retain it for later usage. However, if the link provided is broken, the user can report it by clicking a button under the horizontal line at the bottom of the result page, as can also be seen in Figure 4. Administrators will be notified via email to review the link and update it as necessary.

Figure 5 displays a sample of an unsuccessful navigation to the needed link due to the user missing needed documents along with a list of what documents they can get to satisfy

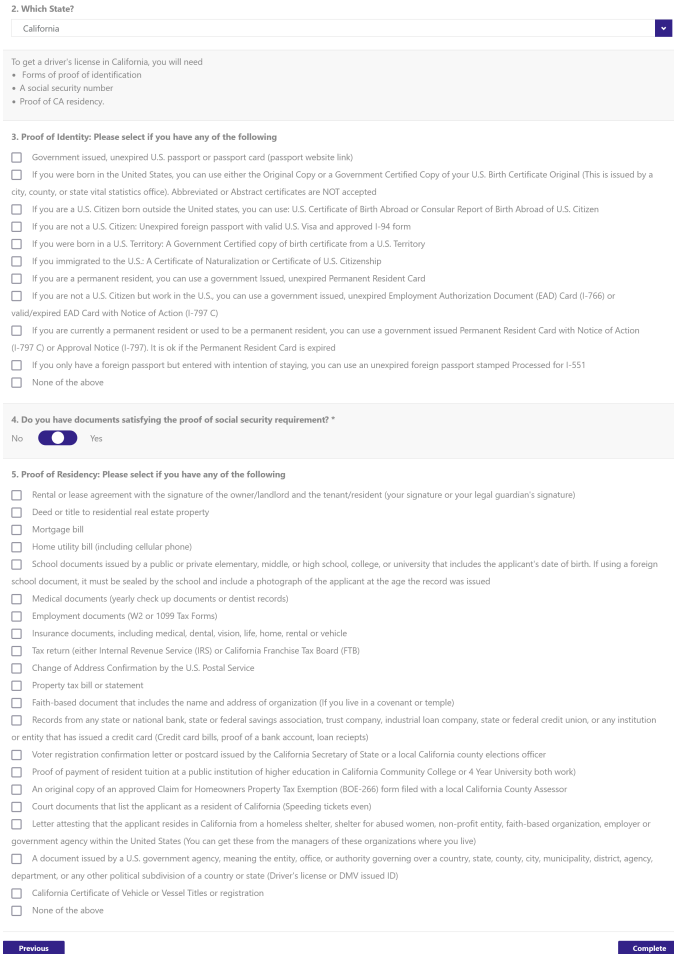

Fig. 3. Documents that qualify as Proof of Identity and Residency for obtaining a State ID or Driver's License in the State of California as seen in the Reentry ID tool

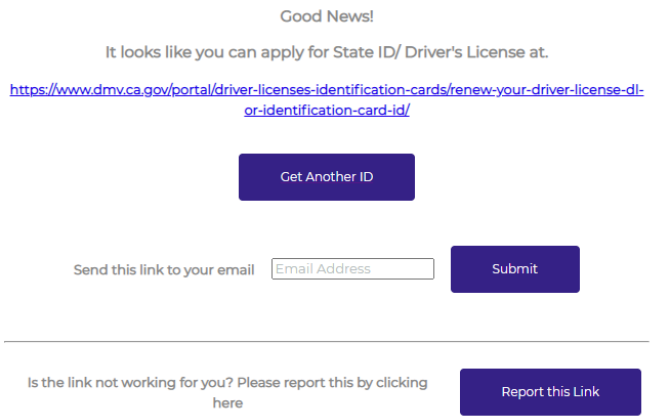

Fig. 4. Success page with link to get the State ID / Driver's License, option to send link to email, and report button for any issues encountered

that step and continue with this process.

It should be noted that the Reenty ID tool does not collect any personally identifiable data nor stores any answers given by the user that are used for navigating the decision tree. Since

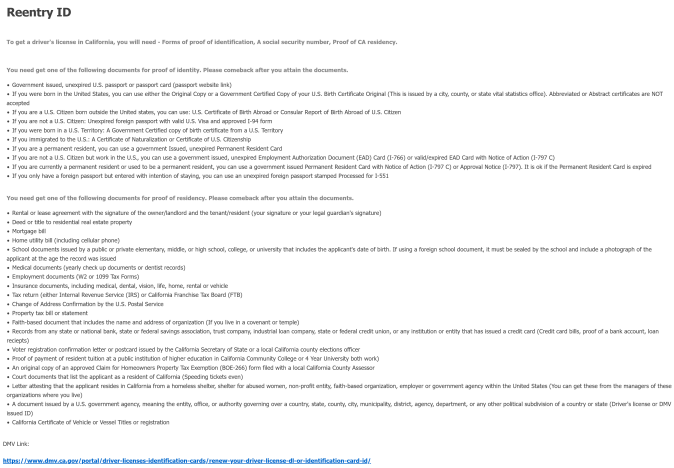

Fig. 5. Failure page with information about the qualifying document(s) the user needs to gather in order to successfully apply for and obtain their corresponding State Identification card or Driver's License

the tool dose not store session details either, it is expected that the users complete the survey in one session. Hence, if they exit or reload the website, they will need to start over.

2) Admin Panel: As state-wise rules change frequently, the data on the various government websites are updated. Some times these updates include the modification of the URLs for a particular resource on the website. Due to this, such links in the database may no longer be valid and thus need to be updated. For this purpose, the tool includes a separate panel for administrators to view and change any broken links. Administrators will receive an email notification to review reported broken or no longer accurate links which they will handle via this panel as depicted in the example in Figure 6.

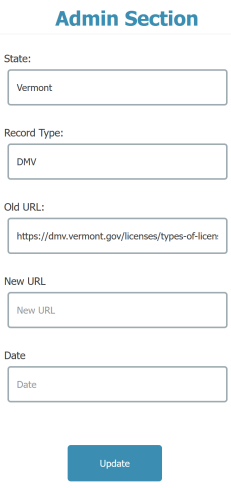

Fig. 6. Reentry ID Admin Panel

3) Technology: In order to deliver all the content, The frontend utilizes HTML [12], CSS [13], JavaScript [14] , and SurveyJS [11] - a JavaScript library for easy development of surveys.

B. Backend

The backend consists of a Flask server application [15] and MySQL [16] database hosted on the Paper Prisons Initiative's server and managed via a CPanel [17] instance - which is a web hosting platform containing a collection of automation tools that help simplify the hosting process. The Flask application uses an Apache server [18] to actively listen and respond to the HTTP requests from REST APIs defined in python, to serve client-side requests as well as interact with the database. The input data from the user is sent to the server using a POST request. These REST APIs help process the data and find relevant resources that are to be sent as a response. The resources and links are then fetched from the MySQL database and sent as a JSON [19] response to the client's web browser for visualization. Lastly, a PHPMailer [20] is used on the result page to send the retrieved link to the user's email address as well as to report broken links to the admin(s).

IV. User Testing Results

User testing was conducted with various groups, which included people who were either recently released from prison or who work closely or in-relation with low-level or nonviolent offenders.

1) Specificity: While testing an early version of the Reentry ID tool, users noted the intuitiveness and simplicity of the tool but commented on the lack of specificity in rendering results. This was due to the fact that originally, the tool would only recognize a Social Security card and U.S. passport as acceptable prerequisite proof-of-identity documents for getting a state ID or Driver's license. The users pointed out that:

(i) Getting a Passport for the purpose of providing a proof of identity to DMV is neither an affordable nor timely option for many individuals, and that they usually utilize other inexpensive options.

(ii) Even if getting a U.S. passport is an affordable option for some users, the first version of the tool would not provide appropriate guidance to those individuals who are not eligible to get a U.S. passport since there will be users who do not have U.S. birth/naturalization certificates, who are refugees, or who have green cards only.

Based on that feedback, in order to make the tool comprehensive enough to provide guidance for various groups of users, lists of all eligible proof of identity documents as recognized by each state's DMV were manually collected from each state's DMV website and properly databased. The tool was then updated to render all possible options for proof of identity approved by a user's selected state rather than social security card and passport only. Moreover, lists of state-specific eligible documents for proof-of-residency were also collected for all 50 states and added to the tool.

2) Accessibility: Accessibility of the tool was also tested against the Web Content Accessibility Guidelines (WCAG) 2 standards and the minim requirements of the WCAG standards was implemented within the tool in order to ensure its

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inclusiveness. Reentry ID is now a one stop guide for anyone before applying for a state ID or Driver's license.

V. Work in Progress and Future Steps

A. Dynamic approach

Reentry ID's database is currently maintained manually. A dynamic scraper is currently under development by the team to regularly retrieve and update the database via the latest requirements and information from each state's DMV website. This is however, a long and arduous task due to a lack of uniformity among the 50 states' DMV websites. Which means that a different scraper will have to be built for each site. The scrapers will need to be scheduled to run automatically at set intervals to ensure that the database includes the latest data for each state.

B. More user testing

As the research team partners with more related advocacy organizations, more user testing will become necessary to ensure that the easiest and most suitable user experience is provided for the actual users of the tool. It is important to note that conventional best practices for web application design are not sufficient here due to a segment of the actual users having been away from technology for decades and perhaps even before the use of the internet, let alone web applications, was common practice.

VI. Conclusion

The Reentry ID tool is a first of its kind tool for assisting released rehabilitated individuals to begin their journey into reassimilating into society. This research recognizes long standing user problems in navigating through overwhelming information and complicated processes of getting an id at bureaucratic websites. Thus the tool is implemented to provide simplified guidance to help users receive all necessary information for getting an ID in one place. As such, the development utilized easy to build, use, and maintain web technologies and draws immense power from the centralization of the various rules as well as lists of all eligible proof of identity and residency documents utilized by each of the 50 US states, into a single database. The development of Reentry ID was only possible because of the countless hours of research and databasing of these resources. After multiple iterations and corresponding user testing, the tool has been updated to deliver all necessary information in an easily accessible format and everyday language.

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Personalized Item Review Ranking Method Based on Empathy

Taketoshi Ushiama
Faculty of Design
Kyushu University
Fukuoka, Japan
email: ushiama@design.kyushu-u.ac.jp

Daichi Minami
Graduate School of Design
Kyushu University
Fukuoka, Japan
email: minami@kyudai.jp

***Abstract*—In e-commerce, online reviews posted about items play an essential role in helping users select products. However, when many reviews are posted for the same product, it is sometimes difficult for users to find the most valuable reviews among them. This paper proposes a method for ranking online reviews of a target item based on the user's empathy for reviewers. Using the target user's feedback on reviews for known items as input, the proposed method estimates the empathy toward the reviewer and ranks reviews for unknown items based on it. Evaluation experiments showed that the proposed method is effective against comparative methods.**

Keywords - online reviews; recommendations; rankings; natural language processing; machine learning.

I. INTRODUCTION

E-commerce sites often provide reviews about products. Reviews play an important role in users' selection of items. However, when a large number of reviews about the same item are included, it is impractical to browse through all reviews [1]. It has been reported that 80% of users read only a maximum of 10 reviews when purchasing an item on online review sites such as Amazon. Therefore, functions that rank reviews are essential to assist users in merchandising recommended items.

Some reviews are helpful to the user, while others are not. Therefore, e-commerce sites provide a mechanism for rating reviews and ranking highly rated reviews at the top. However, there exist cases where reviews that are valuable to one user are not valuable to another user. Since existing review ranking is not personalized, reviews that are not valuable to a user may appear at the top of the list. Therefore, the review ranking mechanism is expected to reflect the values and preferences of users.

This paper proposes a method for ranking online reviews of a target item based on user empathy. The proposed method predicts a target user's empathy for a reviewer based on the reviews the user has rated in the past. It then ranks the reviews based on their empathy for the reviewer.

Section II introduces a method for ranking item reviews based on empathy. Section III shows the experimental results for evaluating the effectiveness of the proposed method. Section IV describes the summary and future work.

II. PROPOSED METHOD

A. Typicality of reviews to authors

Reviews are considered to reflect the values and personality of the author (reviewer). The degree to which a review reflects the values and personality of the reviewer who wrote it is called the "typicality" of the review. $\mathrm{typi}(d, r)$, which is the degree of typicality of a review document d to a reviewer r, is defined by the following equation.

$$\mathrm{typi}(d, r) = p(r|d) \tag{1}$$

where $p(r|d)$ is the conditional probability that given a review document d, its author is d.

The proposed method uses machine learning to predict $p(r|d)$. Specifically, reviews are vectorized using Doc2Vec [2], and machine learning are performed with that author as the correct label. A neural network with two hidden layers is used for machine learning.

B. Similarity of reviewers

To predict empathy for unknown reviewers, similarities between reviewers are used. In a two-layer neural network that takes reviews as input and predicts authors, the all-connected layer in front of the output layer is considered to be the manifestation of the features used to classify reviewers. The vector obtained by inputting a single document that is a concatenation of all reviews posted by reviewer r as input to the machine learning model of author estimation is denoted as $\boldsymbol{v}(r)$.

$\mathrm{sim}(r_1, r_2)$, which is the similarity between two reviewers r_1 and r_2, is defined by the following formula.

$$\mathrm{sim}(r_1, r_2) = \frac{\boldsymbol{v}(r_1) \cdot \boldsymbol{v}(r_2)}{\|\boldsymbol{v}(r_1)\| \times \|\boldsymbol{v}(r_2)\|} \tag{2}$$

where $PR(u)$ represents the review set that was positively rated by user u, $NR(u)$ represents the review set that was negatively rated by user u and $\mathrm{reviewer}(d)$ represents the reviewer who submitted a review d.

C. Estimation of the empathy for reviewers based on review ratings

The proposed method uses the user's ratings of previous reviews to extract the level of empathy toward the reviewer. In this study, we assume that users can vote "like" and "dislike" for some reviews. The user is not required to rate all reviews. We predict the empathy $\mathrm{empathy}(u, r)$ of a user u toward a reviewer r who has posted a review he has rated, using the following formula.

$$\mathrm{empathy}(u, r) = \sum_{d \in D_{pos}(r)} \mathrm{typi}(d, r) - \sum_{d \in D_{neg}(r)} \mathrm{typi}(d, r) \tag{3}$$

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where $D_{pos}(r)$ represents the set of review documents posted by reviewer r that the target user rated as "like" and $D_{neg}(r)$ represents the set of review documents that the target user rated as "dislike". $\mathrm{tipi}(d, r)$ denotes the topicality of a review document d to reviewer r.

D. Ranking of reviews for unknown items

Estimate the value of a review of an unknown item I_u based on the feedback of the evaluation of a review of a known item I_k. The recommendation score $score(u, d)$ of a review d for a target user u is defined by the following equation.

$$\mathrm{score}(u, d) = \frac{\sum_{r \in R(u)} \mathrm{empathy}(u, r) \times \mathrm{sim}(r, \mathrm{reviewer}(d))}{\sum_{r \in R(u)} \mathrm{sim}(r, \mathrm{reviewer}(d))} \quad (4)$$

The reviewer set $R(u)$ with respect to user u is defined by the following equation.

$$\mathrm{R}(u) = \{x | x = \mathrm{reviewer}(d), d \in PR(u) \cup NR(u)\} \quad (5)$$

where $\mathrm{reviewer}(d)$ denotes the reviewer who submitted the review d.

III. Evaluation

A. Experimental setup

Experiments were conducted to evaluate the effectiveness of the proposed method. The dataset used for the experiments was obtained by crawling from one of the famous Japanese online book review sites "Dokusho meter". Six subjects were asked to select two books from among those they had recently read and to input their evaluation feedback for the reviews of the two books. The subjects were asked to rate the reviews of two books on a three-point scale of "agree," "don't know," and "don't agree," based on the question of "do you agree with this review?" The evaluation data for one book review was used as training data to predict the recommendation score for the other book review.

To evaluate the effectiveness of the proposed method, we compared the results with those of three different methods. They are random sampling, vote ranking, and Support Vector Regression (SVR). In the vote ranking, we compared the top 10 reviews with the highest number of votes with the top 10 reviews using the proposed method. In SVR, the explanatory variables for the regression analysis were the Term Frequency–Inverse Document Frequency (TF-IDF) vector of words, the percentage of each part of speech in the reviews, the total number of words, and the number of word types.

B. experimental results

We calculated the percentage of reviews that subjects rated as "sympathetic" and the percentage of reviews that they rated as "not sympathetic" out of the top 10 ranked reviews in the proposed and comparative methods.

The results for the reviews that were evaluated as "sympathetic" are shown in Fig. 1. When significant differences were confirmed by T-test, significant differences were observed between the proposed method and the random sampling method, and between the proposed method and the order of the number of votes, at a significance level of 5 percent.

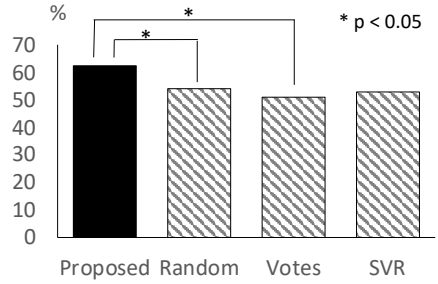

Fig. 1. Percentage of "sympathetic" reviews in top 10 ranked.

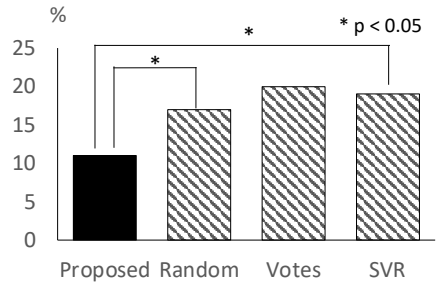

Fig. 2. Percentage of "not sympathetic" reviews in top 10 ranked.

The results for the reviews that were evaluated as "not sympathetic" are shown in Fig. 2. When the T-test was used to confirm the significant differences, significant differences were observed between the proposed method and the random sampling method and between the proposed method and the support vector regression at a significance level of 5 percent.

The above results show that the proposed method includes more reviews with content that users can relate to and fewer reviews that users cannot relate to in the top ranking than the comparative methods.

IV. Conclusion

In this paper, we propose a review ranking method based on user empathy. The proposed method predicts the reviewer's empathy based on the user's review ratings to achieve a personalized ranking. Results of evaluation experiments using subjects showed the effectiveness of the proposed method. As future work, we are considering the use of advanced resource language models such as BERT [3] to more accurately predict the degree of empathy of unknown users.

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Design Thinking Applied to the Internet of Things

A Project on Technological Innovation in Agriculture and Food Processing

Lasse Berntzen
School of Business
University of South-Eastern Norway
Kongsberg, Norway
e-mail: lasse.berntzen@usn.no

Adrian Florea
School of Engineering
Lucian Blaga University of Sibiu
Sibiu, Romania
e-mail: adrian.florea@ulbsibiu.ro

***Abstract*— Agriculture experiences rapid changes due to advances in technology. The introduction of mechanical equipment caused the first agricultural revolution. Agriculture is moving into the information age, where data are collected and analyzed to improve production and quality. Internet of Things (IoT) plays an essential role in innovative developments. This paper introduces the use of Design Thinking (DT) to create innovative solutions for agriculture and food processing. DT is well suited for multidisciplinary teams. An ongoing project is presented where agriculture and technology students meet farmers and other stakeholders in a summer school setting to learn from each other and innovate together. DT is used as the framework for innovation and co-creation.**

Keywords-design thinking; agriculture; Internet of Things; IoT; innovation.

I. INTRODUCTION

In 2021, Lucian Blaga University of Sibiu, Romania, and the University of South-Eastern Norway won a grant for a project to exploit the Internet of Things (IoT) within agriculture and food processing. This paper discusses the ideas behind the project and its practical implementation. The main assumptions are:

- IoT has a great potential to improve agriculture and food processing.
- The design process itself is essential for innovation to take place.
- The involvement of different stakeholders in the design process is necessary to unleash the potential of IoT technology.
- Innovation is achieved by bringing teachers and students from agriculture, food processing, engineering, and computer science together in a workshop with farmers and IoT specialists.

The rest of the paper is organized as follows: Section II discusses the importance of technological innovations in agriculture. Section III takes a closer look at the IoT. Section IV describes potential areas of IoT applications in agriculture. Section V discusses the design process and methodology. Section VI describes the practical implementation of the project as two summer schools focusing on IoT in agriculture. Section VII discusses the practical implications of the project, while Section VIII provides a conclusion.

II. AGRICULTURAL DEVELOPMENTS

Agriculture is essential for society because it represents a source of livelihood and raw materials for industry, ensures food and fodder supply for people and animals, and contributes to national revenue, economic development, and international trade. Agriculture provides many employment opportunities, such as farm work, building irrigation and drainage systems, transporting goods, and retailing products.

Through the European Horizon 2020 research program, the European Union acknowledges the importance of focused research and testing of the IoT to support the development and take-up of the technology in different economic sectors (industry, agriculture, logistics, transport) [1]. On April 9th, 2019, EU Member States signed the declaration of cooperation on "A smart and sustainable digital future for European agriculture and rural areas" [2]. The declaration acknowledges the potential of digital technologies and proposes actions for the digitalization of agriculture in Europe. The use of technology substantially impacts agricultural production, and the introduction of automation, robotics, IoT, knowledge-based systems, and artificial intelligence facilitates further improvements in farming practice [3]. New technology impacts the whole agrarian ecosystem and provides new opportunities for monitoring and control, ensuring the safety of agricultural food products.

Agriculture is moving into the information age, where data are collected and analyzed to improve production and quality. IoT plays an essential role in innovative developments. As the global population increases, smart farming and precision agriculture [4] are crucial for a sustainable future. Smart farming and precision agriculture reduce human intervention and increase production quantities.

Specifically, IoT systems and drones are used in applications like precision agriculture, crop irrigation planning, plant disease detection, and soil texture mapping. It is also used for crop maturity monitoring to correctly assess optimal harvest time and monitoring growth to plan the necessary equipment for harvesting, transporting, and storing the production.

Images collected with drones can lead to a correct estimation of biomass or identify fruit diseases. Automated harvesting using mobile robots and robotic arms can reduce human labor and increase productivity. The development of

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computer engineering and information technology created the premises of a data-driven society. Data has become a key element in modern agriculture (Agriculture 4.0 [5]), helping producers make critical decisions [6].

IoT devices equipped with sensors can collect data and forward the data to cloud-based solutions using artificial intelligence techniques to maximize productivity and improve sustainability.

Sustainable agriculture is not restricted to the EU; it is global. In this sense, the United Nations (UN) [7] targets the following sustainable development goals (see Table 1).

TABLE I. UN SUSTAINABILITY GOALS RELATED TO AGRICULTURE

Goal	Description
Zero hunger	Implementing sustainable food production systems and resilient practices in agriculture, especially for developing countries, such that by 2030, hunger and malnutrition will end worldwide.
Clean water and sanitation	International cooperation for protecting wetlands and rivers and sharing water treatment technologies to ensure clean water and sanitation of the planet's population in the conditions of population growth and climate changes.
Industry, innovation, and infrastructure	Increasing investment in scientific research, innovation, and infrastructure to reduce the digital gap (digital technologies and Internet connectivity) between countries and promote sustainable development in industry and agriculture.
Responsible consumption and production	More efficient management of natural resources and removal of toxic waste, halving global food waste per capita, waste recycling, and education toward more responsible consumption.
Life on land	Preserving and restoring the use of terrestrial ecosystems such as forests, wetlands, deserts, and mountains, stopping the biodiversity loss by 2030, affected by population growth, industrialization, and transition to cities and climate changes.

III. INTERNET-OF-THINGS

IoT refers to devices exchanging data with other devices and systems through the Internet. IoT is expected to offer advanced connectivity of devices, systems, and services beyond Machine-to-Machine (M2M) communications and covers various protocols, domains, and applications. In 2014, the number of IoT devices was estimated to be approximately 19.7 billion and is expected to grow to 95.5 billion in 2025 [8].

Figure 1 shows a model of a typical IoT device with a microcontroller, sensors, actuators, and communication technology.

IoT systems are multilayer architectures [9]. Figure 2 shows a simple architectural model with an application layer and two sublayers: the perception sublayer and the network sublayer.

The sensors (perception sublayer) collect data from the outside world. A sensor transforms the detection or measurement of a physical property into an electric signal. Physical properties include temperature, humidity, moisture, barometric pressure, gases, movement, distance, light, voltage, and current.

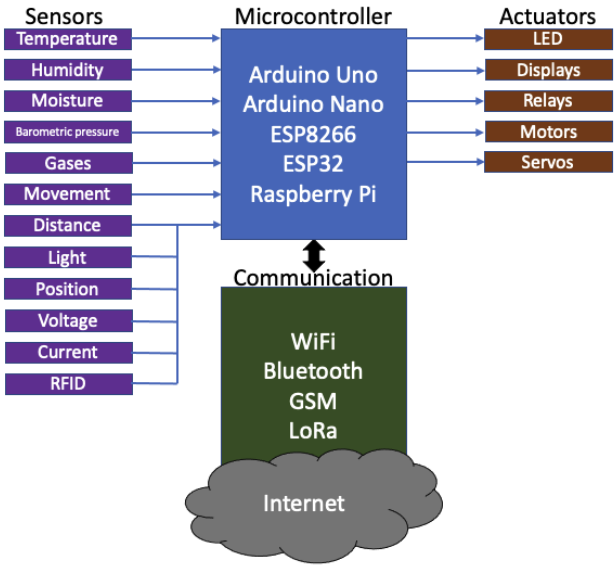

Figure 1. Typical IoT device.

More advanced sensors may read RFID tags or positions from satellites through the Global Positioning System (GPS).

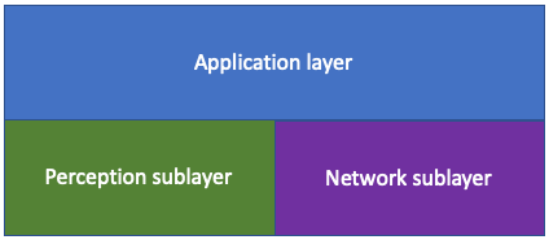

Figure 2. IoT basic architecture.

Actuators may be simple output devices such as light-emitting diodes (LEDs), displays, motors, and servos. All kinds of electric units can be controlled through relays. The microcontroller processes the inputs from sensors and controls the actuators. An IoT device also needs communication capabilities to communicate through the Internet. Communication (the network sublayer) can be wired or wireless. Several technologies exist for wireless communication, such as WiFi, Bluetooth, LoRa, NFC, and GSM [10].

Data collected by an IoT device can be used to control its surroundings and sent for further processing through the Internet. A typical application is shown in Figure 3, where a temperature sensor is used to control a heating element. The program code in the application layer reads the temperature and decides whether the heating element should be turned on or off. At the same time, the temperature data is sent to a

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decision support system that may influence when to turn the heating element on and off to optimize energy use.

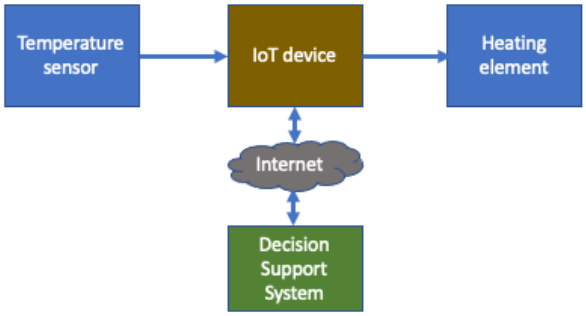

Figure 3. An example of an IoT application.

IV. IoT IN AGRICULTURE

Agriculture is a promising field for the use of IoT. The agricultural processes rely on collecting data, analyzing the data, and using the results to create optimal conditions for growth. A typical example is a greenhouse where optimizing temperature, humidity, lighting, CO_2, and fertilizers can significantly increase the yield. Table II and Table III show examples of how IoT solutions can be used for crops and livestock management.

TABLE II. IoT SOLUTIONS FOR CROPS MANAGEMENT

Solution	Description
Environmental monitoring	Collect data about environmental variables (temperature, humidity, moisture, barometric pressure). Data is used for automated decision-making and forecasting. Environmental monitoring may be done by a network of interconnected sensor stations or using land and aerial drones.
Crop measurement	Measuring when the crop reaches a certain height or size. Used to optimize harvesting according to requirements set by customers; rot detection.
Irrigation	Use of sensor data and machine learning algorithms to decide on irrigation. Reduce unnecessary spills of water.
Fertilizing	Use of data to optimize the use of fertilizer. Reduce the amount of fertilizer used.
Pest control	Detecting pests, e.g., through discoloration, and minimizing the use of pesticides by targeting only crops with specific needs.
Decision-making	Deciding when to sow and harvest based on updated measurements and forecasting.
Automation	Automating machinery for sowing and harvesting. Possibilities for detecting malfunctions and suggesting preventive maintenance

IoT in agriculture contributes to improved quality and efficiency and is essential for value creation for farmers.

The examples presented show how IoT can be utilized on farms. However, IoT also has a role in the whole value chain, from raw materials to the end customer. Table IV lists some opportunities for using IoT in the agricultural value chain.

TABLE III. IoT SOLUTIONS FOR LIVESTOCK MANAGEMENT

Solution	Description
Monitoring	Monitor livestock for health problems, find the right moment for insemination using birthing sensors or check for mastitis signs. It can also monitor and increase the quality of milk and wool.
Feeding	Optimize livestock feeding by mixing combinations of food and feeding at optimal cycles.
Control/ logistics	Keep track of livestock locations using RFID and GPS tracking devices. Control animals by virtual fences (*Geofences*). It saves physical fences and reduces the need for maintenance. Virtual fences also improve human access to nature.
Automation	Robots can take care of milking and harvesting wool.

Recent approaches combine IoT and blockchain technology with smart agriculture. Blockchains and smart contracts can improve the logistics and traceability of agricultural products [11]. With increased focus on product origins and food safety, small IoT devices may follow the products from the farm to the consumer. Such devices will keep track of the supply chain and detect anomalies in storage temperatures, etc. [12].

TABLE IV. IoT IN THE AGRICULTURAL VALUE CHAIN

Solution	Description
Origin tracking	Use intelligent tags (RFID, NFC) to track deliveries through the value chain.
Quality tracking	Smart IoT devices can keep track of environmental conditions during transport and storage.

Precision agriculture-specific approaches combine IoT with big data and decision support systems, combined with artificial intelligence prediction techniques for efficient control of farm irrigation valves and soil moisture prediction [13].

A practical example of the innovative use of IoT in agriculture is the early detection of soft rot in potato storage bins [14]. Soft rot spreads on contact, and if detected early, rotten potatoes can be removed from the container and save the rest of the batch. The farmer can be alerted by an app connected to the Internet.

V. DESIGN THINKING

This section describes Design Thinking (DT). DT was first introduced worldwide in 2005 at Stanford University in Palo Alto, USA. In Europe, DT was adopted in 2007 by the Hasso Plattner Institute in Potsdam, Germany [15]. DT contemplates human needs while considering both a technical perspective (technological feasibility) and an economic perspective (economic viability).

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DT is based on the creative power of teamwork, collaboration, innovation, and interdisciplinary teams. Implementing this concept involves an iterative process based on the following states: understanding, observation, defining a point of view, design, developing a prototype, and testing/validation (see Figure 4).

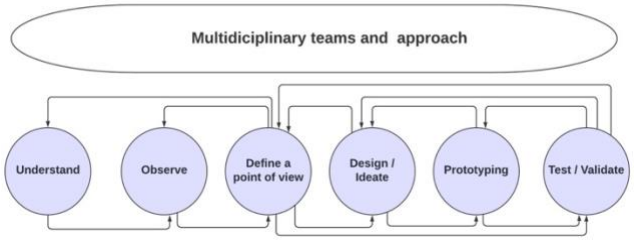

Figure 4. Design Thinking: An Iterative but not Linear Process.

The authors have experience using DT in workshops and hackathons and see it as a feasible methodology to enhance innovation in agriculture. A bibliometric analysis was performed to investigate the influence of DT on agriculture. The period examined was from 2004 to 2021. Only 36 articles containing the phrases "design thinking" + "agriculture" + "innovation" in the "Title," "Abstract," or "Keywords" or appeared at least ten times in the article's content were selected.

VOSviewer is a software tool for constructing and visualizing bibliometric networks using advanced clustering and visualization techniques to show the relationships between keywords characterizing articles from the Scopus database.

VOSviewer enabled us to determine how often each item occurred within the network and how often the elements were cited together. The use of the software also facilitated combining the analyzed data set into clusters which were then marked out on the map in different colors.

The bibliometric study shows that very few researchers have considered DT for innovation in agriculture. Four clusters, drawn in different colors, are visible in the chart (see Figure 8 at the end of the paper). The first cluster (red) focuses on the system and design thinking related to company, business models, value, collaboration, diversity, application, and sustainability. The keywords belonging to the second cluster (yellow) gravitate around innovation and link innovation with keywords like approach, knowledge, idea, research, use, policy, process, and decision. The third cluster (blue) reflects the entrepreneurship approach learned in university and focuses on real farmers' challenges and needs, (case) studies, and their role for economic profit and animal welfare. Finally, the fourth cluster (green) focuses on sustainable agricultural developments based on science and engineering. Table V shows the clustering of keywords in the 36 articles found.

For example, DT in building agricultural equipment aims to understand the needs of the customers, farmers, workers, and machine operators, to convert the ideas through a useable approach to develop a problem-solving activity or machine. A challenge for integrating DT in agriculture consists of bringing the farmers into the process of designing solutions. Technology innovation has become an important trend in the development of various sectors. Compared with manufacturing and high-tech industries, agriculture typically pays more attention to the conditions of farm sites than technology. The successful growth and transformation of the agriculture industry require a deep understanding of local social contexts and farmers' habits.

TABLE V. CLUSTERS GENERATED BY THE BIBLIOMETRIC STUDY

Cluster #	Number of keywords	Important (relevant) Keywords
1.	13	design thinking with relations to problem, model, system, company, business, industry, technology, collaboration, value, diversity, application and sustainability
2.	10	innovation, approach, research, policy, process, decision, knowledge, idea, use, evidence
3.	10	entrepreneurship, university, challenge, (case) study, paper, role, farmer, need, animal welfare
4.	10	agriculture, (sustainable) development, (agricultural) engineering, project, science, integration, implementation, world

The intention of young farmers to employ innovative technologies depends on the perceived usefulness and the perceived ease of use of IoT devices. The reputation of system suppliers and users' trust in software and hardware suppliers affect users' intention to adopt innovative technologies. Young farmers' intention to adopt smart sensor technology increases with the reputation of IoT suppliers, field-level information analysis quality, and individual privacy security [16].

DT may innovate agriculture by combining expertise from multiple perspectives and disciplines, primarily computer science and agriculture/food processing, stimulating collaborative work to facilitate the deployment of digital technologies in agriculture. More precisely, the innovation is based on transferring knowledge and skills from the computer science domain to the agriculture/food processing domain and vice versa.

The farmers (who may have basic knowledge of digital technologies but almost no knowledge of IoT systems, artificial intelligence, robotics, or drones) should see possible opportunities in agriculture provided by digitalization. The engineers need to understand agriculture's practical problems and challenges to design and implement proper solutions [17].

VI. ENTREPRENEURIAL AGRICULTURE AND EDUCATION

As shown in Figure 5, DT connects technology with the needs of the market or the society. In this context, the

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technology is IoT, while the market is the agricultural sector. Research is done from the initial idea, and a product or process is designed and developed. A prototype is made and tested before continuing with manufacturing, followed by marketing and sales.

The idea generation requires knowledge of both technology and agriculture. IoT experts need to share their knowledge with farmers and vice versa. Most farmers are unaware of the opportunities provided by IoT. At the same time, engineers often lack the domain knowledge to create products and processes that create high value for the agricultural sector.

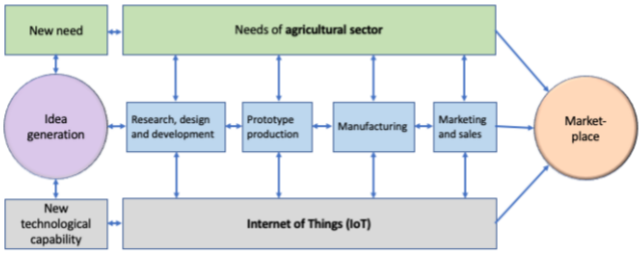

Figure 5. Design Thinking process for IoT in agriculture.

Usually, in universities, engineering and agriculture are separate study programs within their respective faculties. Agriculture students do not learn about IoT, and engineering students do not study agriculture. Therefore, a viable approach would be to create multidisciplinary activities where students from both programs meet, learn from each other, and co-create new products and processes. Such activities could be:

- Cross-disciplinary course modules where students work together to identify and solve real problems in agriculture by using IoT.
- Shorter "Hackathon" style events where students do the same, but within a strict timeframe, e.g., 24 or 48 hours.
- Summer schools where students do the same, but within a longer timeframe, e.g., two weeks.

The students will bring their respective backgrounds, but they also need training in DT. The DT process is the catalyzer for innovation and will be the common ground for the students. The DT process is a good framework for co-creation activities.

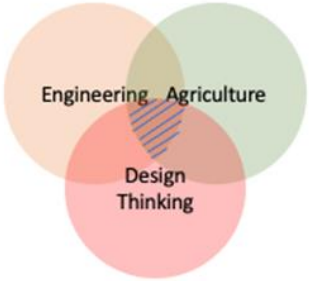

Figure 6. Skillset.

Figure 6 shows the different skills required to contribute to IoT in agriculture.

Creating value for the customer (farmer) should be the primary goal of IoT products and services. The agriculture sector includes the whole value chain from the farmer to the end consumer. Figure 7 presents the different elements of the agricultural value chain. The input is seeds, fertilizer, water, fodder, etc. The production results are grain, vegetables, fruits, dairy products, meat, etc. The products must be cleaned, graded, and packed before they are either distributed to the retail market or refined into more complex products.

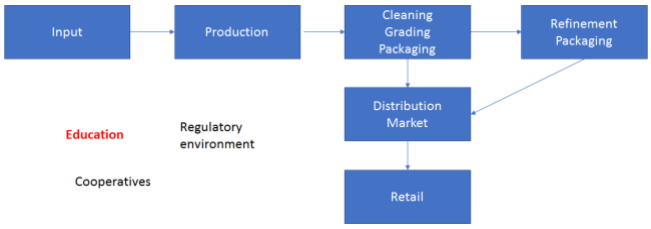

Figure 7. Agricultural value chain (crops and livestock).

Education, stakeholder cooperation, and the regulatory environment supports this value chain. IoT can be integrated at any stage of this agricultural value chain to digitalize the process, optimization, tracking, and quality assurance. As documented earlier, developments in agriculture are high on the political agenda and closely connected to the United Nations sustainability goals. Developments within agriculture can potentially revolutionize how the global population can be fed.

VII. Conclusion

Agriculture is essential in achieving the sustainability goals set by the United Nations, in particular. The imbalance regarding the agriculture performance of world countries must be reduced only by changing the agricultural landscape through new technologies or new methodologies and cross-fertilizing different scientific and educational sectors.

This paper has discussed the use of IoT in agriculture. DT has been suggested as a viable methodology to achieve innovation.

As already mentioned, this paper reports on an ongoing project to examine and promote IoT use in agriculture. An essential part of the project is two editions of a summer school, one in Norway and one in Romania, where technology students will work with agriculture and food processing students to innovate together. The summer schools will be on farms where students explore real problems in an authentic setting.

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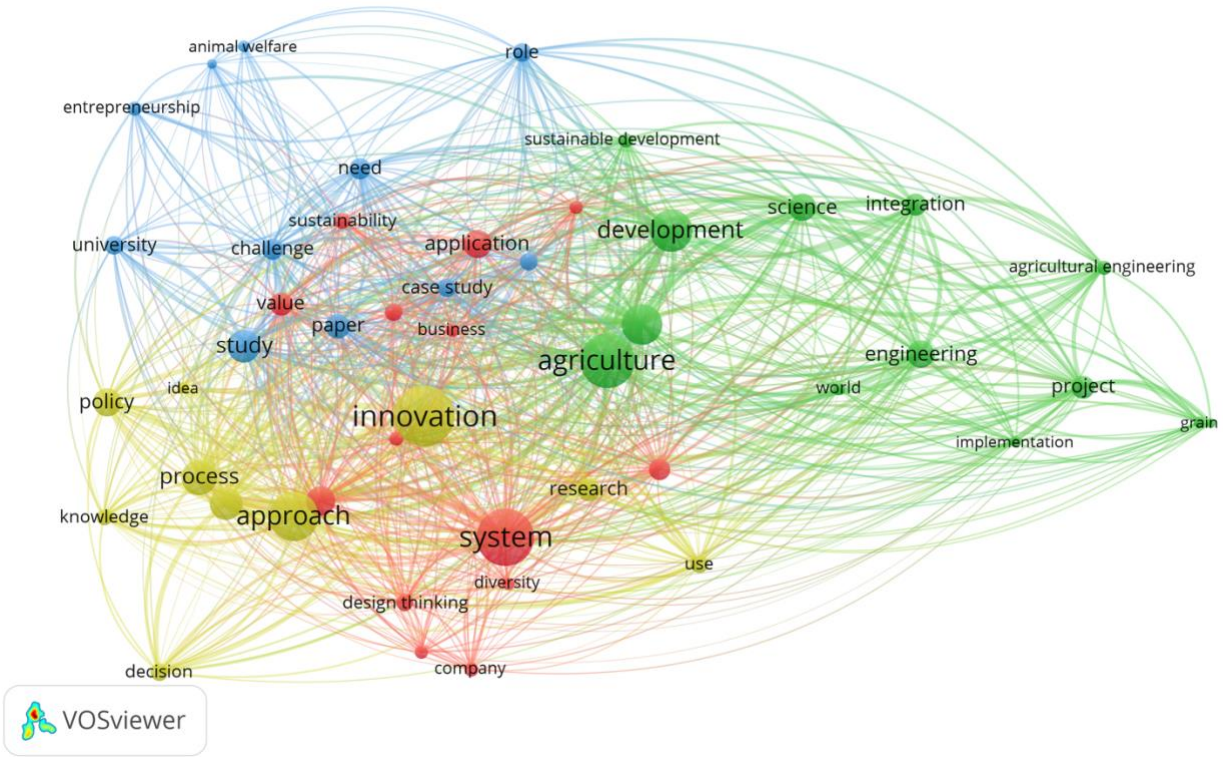

Figure 8. Keyword clusters from VOSviewer.