Complex Systems Engineering for Rapid Computational Socio-Cultural Network Analysis and Decision Support Systems

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***Abstract*—The advent and adoption of internet-based social networking has significantly altered our daily lives. The educational community has taken notice of the positive aspects of social networking such as creation of blogs and to support groups of system designers going through the same challenges and difficulties. This paper introduces a social networking framework for collaborative education, design and modeling of the next generation of smarter products and services. Human behavior modeling in social networking application aims to ensure that human considerations for learners and designers have a prominent place in the integrated design and development of sustainable, smarter products throughout the total system lifecycle. Social networks blend self-directed learning and prescribed, existing information. The self-directed element creates interest within a learner and the ability to access existing information facilitates its transfer, and eventual retention of knowledge acquired. In conclusion, this research paper introduces the application of social-networking to design and modeling of products and services and provides a novel technology for facilitating the understanding of complex human behavior and to better identify crucial user needs.**

Keywords - social modeling; decision support systems; behavioral modeling.

I. INTRODUCTION

The concept of smartness of consumer products and services has been investigated by several authors. This section presents a synthesis and summary of the most innovative work that influenced research in this field. Allmendinger and Lombreglia [1] highlighted smartness in a product from a business perspective. They regard “smartness" as the product's capability to predict business errors and faults, thus “removing unpleasant surprises from [the users'] lives.” Ambient Intelligence (AMI) group [2] describes a vision where distributed services, mobile computing, or embedded devices in almost any type of environment (e.g., homes, offices, cars), all integrate seamlessly with one another using information and intelligence to enhance user experiences [3, 4, 5, 23]. The advent and adoption of internet-based social networking sites such as MySpace TM and Facebook TM has significantly altered social interactions of their users. Users of social networking sites vary their activities; some may be very active sharing their daily life experiences with comments and pictures, while others simply use the sites as a personal directory service. The educational community has taken notice of the following positive aspects of social networking:

- Peer feedback, increasingly fast response times for scientific discovery, collaborative design and research
- Creation of blogs and support groups of individuals going through the same or similar difficulties
- Providing a social context in line with the university, company, design group, or field of study
  A venue with links not directly related to a given educational alignment or resource.

Social networking applications support the development of a methodology to better assess and predict imprecision and variability in user behavior by applying advanced mathematical and soft computing techniques to aid in studying human social, cultural and behavioral aspects. Application of soft computing techniques helps identify erroneous, problematic activities and issues that might otherwise go undetected for their obscurity, complexity, or elaborate inter-relationships. In addition to these above, social networks themselves are highly adaptable, flexible, and mobile. For example, the “blogging” paradigm became the “micro-blogging” concept known as Twitter, which now is integrated with Facebook’s “status updates.” Arguably, social networking provides an effective method of satisfying the primal human desire of communication.

Rapid technological advancements and agile manufacturing created what is called today smart environments. Definitions of smart environments may be taken into account as a first reference point, since smart products have to be considered in the context of their environment. For example, Das and Cook [6] define a smart environment as the one that is able to acquire and apply knowledge about an environment and adapt to its inhabitants in order to improve their experience in that environment. It is noticed that the knowledge aspect has been recognized as a key issue in this definition. Mühlhäuser [2] refers to smart product characteristics that are attributed to future smart environments, i.e., "integrated interwoven sensors and computational systems seamlessly embedded in everyday systems and tools of our lives, connected through a continuous network." In this respect, smarter products can be viewed as those products that facilitate daily tasks and augment everyday objects. In 2007, AMI identified two motivating goals for building smart products [7]:

1) Increased need for simplicity in using everyday products, as their functionalities become ever more complex. Simplicity is desirable during the entire life-cycle of the product to support manufacturing, repair, or use.

2) Increased number, sophistication, and diversity of product components (for example, in the aerospace industry), as well as the tendency of the suppliers and manufacturers to become increasingly independent of each other which requires a considerable level of openness on the product side.

Mühlhäuser [2] observed that these product characteristics can now be developed due to recent advances in information technology as well as ubiquitous computing that provides a "real world awareness" in these systems through the use of sensors, smart labels, and wearable, embedded computers. According to Mühlhäuser [2], product simplicity can be achieved with improved product to user interaction (p2u). Furthermore, openness of a product requires an optimal product to product interaction (p2p). Knowledge intensive techniques enable better p2p interaction through self-organization within a product or a group of products. Indeed, recent research on semantic web service description, discovery, and composition may enable self-organization within a group of products and, therefore, reduce the need for top-down constructed smart environments [8]. Smart products also require some level of internal organization by making use of planning and diagnosis algorithms as stated by [2]:

> "A Smart Product is an entity (tangible object, software, or service) designed and made for self-organized embedding into different (smart) environments in the course of its lifecycle, providing improved simplicity and openness through improved p2u and p2p interaction by means of context-awareness, semantic self- description, proactive behavior, multimodal natural interfaces, AI planning, and machine learning."

Major characteristics of smart products are illustrated by comparing their essential features. For example, [9] define six major characteristics for smart products illustrated in Table 1 below. Table 2 provides a comparative presentation of the main characteristics of smart products. These characteristics include the following:

- Context-awareness - the ability to sense context
- Proactivity - the ability to make use of this context and other information in order to proactively approach users and peers
- Self-organization - the ability to form and join networks with other products.

In addition to the above characteristics, Mühlhäuser [2] and SPC emphasize the fact that smart products should support their entire life-cycle. In addition, special care should be devoted to offering multimodal interaction with the potential users, in order to increase the simplicity characteristics of the products.

TABLE 1. SMART PRODUCTS CHARACTERISTICS [9]

Characteristic	Description
Personalization	Customization of products according to buyer's and consumer's needs.
Business-awareness	Consideration of business and legal constraints.
Situatedness	Recognition of situational and community contexts.
Adaptiveness	Change product behavior according to buyer's and consumer's responses to tasks.
Network ability	Ability to communicate and bundle with other products.
Pro-activity	Anticipation of user's plans and intentions.

TABLE 2. A COMPARISON OF SMART PRODUCT'S CHARACTERISTICS [7]

Maass and Varshney [9]	Mühlhäuser [2]	Smart Products consortium [4]
Situatedness	Context-aware	Situation- and context-aware
Pro-activity	Proactive Behavior	Proactively approach the user
Network ability	Self-organized embedding	Self-organized embedding in smart product environments
	Support the entire life-cycle	Support the user throughout whole life-cycle

Maass and Varshney [9]	Mühlhäuser [2]	Smart Products consortium [4]
	Multimodal Natural Interfaces	Multimodal interaction
Personalization		
Business-awareness		
Adaptiveness		
		Autonomy
		Support procedural knowledge
		Emerging knowledge
		Distributed storage of knowledge

II. Social Networking for Smarter Products and Services Design

Communication of ideas, as a core for effective education and collaborative design, is the basis of distance and virtual learning. Social networks blend self-directed learning and prescribed, existing information. The self-directed element creates interest within a learner and the ability to access existing information facilitates its transfer, and eventual retention of knowledge acquired. There may also be a competitive element for educators to explore, since design activities are transparent in social networking. Ziegler [10] observed that social networking sites may radically change the educational system, since they offer the "capacity to motivate students as engaged learners", rather than what he considers the usual "passive observers of the educational process." However, there are also conflicting views in the literature regarding the usefulness of social networks in education and design. In today's interconnected world, social networking provides a great source of information and knowledge sharing that has not yet been fully explored to support collaborative products design and education.

Selwyn [11] performed an observational study of a group of students' online interactions with Facebook^{TM} in the UK. Though the author cited many limitations of the study, some interesting findings included an observation that the social network site did not serve a meaningful role in making new partnerships. Rather, it maintained strong links already established in an emotionally close-knit group of people. Social networks share many functional elements with blog, a term coined recently as a shortened form of "web log," describing a page that is frequently updated with comments, links, images, and other media pertaining to a given subject. The blog makes a statement and offers a space below for readers to comment and respond. Social networks have taken the blog concept and applied it to a directory concept. People who are "linked" together can receive updates from others micro-blog inputs. The concept of social networking can be extended to collaborative design and modeling as means of facilitating team work and sharing product design experience in order to enhance team learning process, including collaborative online discussions, idea generation, peer review activities, and even debate [12,13].

III. Social Networking in Education

The proliferation of broadband-enabled interactive devices, such as smart cellular phones and media players, with social networking gadgets and application allows social communication and collaborative education activities to occur outside of lecture times. Another offshoot of social networking and blogging sites is that of wiki articles and their massive compilation, Wikipedia. A traditional understanding of an academic resource that "anyone can edit" seems unreasonable. The seemingly micro-managed and endlessly peer reviewed "live" nature of the document made Wikipedia a compelling new way to create, store, and integrate vast stores of knowledge [14]. The pull of social networking technologies cannot be ignored, as they have attracted millions of users in a short amount of time since their introduction. Ahram et. al. [23, 24, 25, 26] cited that the shortcomings such as the necessity of pre-existing offline relationships and, as of yet, unexploited educational and design opportunities may be addressed by serious initiatives and the integration of such technologies into modern educational and design methods and practices. The accessibility of these networks is more pervasive now than ever, thanks to gaming consoles and mobile devices. Prensky [15] claims that today's students "think and process information differently" from their pre-digital world counterparts. People born after the mid 1980s are part of a group of "digital natives" who take information technology and its use for granted. Today, data can be created anywhere and on a great variety of computing platforms. The ability to create and view data anywhere can translate to new learning opportunities. Several universities have already turned towards the web and outlets previously used only to sell music and video as a way to disseminate lecture materials. Apple Computer's iTunes TM software dominates the digital media player market. It has recently launched "iTunes University," a subset of its online media store devoted to distributing lectures and presentations from various academic institutions. All of these novel technologies and media distribution platforms offer unimagined learning opportunities. As of yet, the educational elements are largely unused compared to their strictly entertainment-related digital media. Many opportunities exist for providing students with this media but dissemination is not enough alone. Serious educational games, educator's involvement, and classroom activities sent to these services offering interaction rather than "passive observation" would be valuable aids to the learning process. There is no doubt that today's traditional students consume more media and games than previous generations. They need only be given some structure and appropriate interactive learning media to augment their already media-enriched lives.

IV. SOCIAL NETWORKING SYSTEMS ENGINEERING APPROACH TO STUDY COMPLEX HUMAN BEHAVIOR

The contemporary systems engineering process is an iterative, hierarchical, top down decomposition of system requirements [16]. The hierarchical decomposition includes Functional Analysis, Allocation, and Synthesis. The iterative process begins with a system-level decomposition and then proceeds through the functional subsystem level, all the way to the assembly and program level. The activities of functional analysis, requirements allocation, and synthesis will be completed before proceeding to the next lower level. SysML is a general-purpose visual modeling language for specifying, analyzing, designing, and verifying complex systems which may include hardware, software, information, personnel, procedures, and facilities (OMG SysML: http://www.omgsysml.org). SysML provides visual semantic representations for modeling system requirements, behavior, structure, and parametrics, which is used to integrate with other engineering analysis models [17, 23, 26].

Ahram et al. [23, 26] indicated that traditional machine learning techniques have some limitations for modeling human behavior, mainly the lack of any reference to the inherent uncertainty that human decision-making has. This problem can be partially solved with the introduction of Soft Computing (SC) to model human behavior via social networking applications. SC is an innovative approach to building computationally intelligent systems that differs from conventional (hard) computing in that it is tolerant of imprecision, uncertainty and partial truth. The guiding principle of soft computing is to exploit the tolerance for imprecision, uncertainty and partial truth to achieve tractability, robustness and low solution cost. SC consists of several computing approaches, including neural networks, fuzzy set theory, approximate reasoning, and search methods, such as genetic and evolutionary algorithms. SC technologies provide an approximate solutions to an ill-defined problems encountered in social networking application and can help creating human behavioral models in an environment, such as during conflicts , in which users are not willing to give feedback on their actions and/or not able to fully define all possible interactions due to social and cultural barriers. Different techniques provide different capabilities to support the development of smarter products and services. For example, Fuzzy Logic provides a mechanism to mimic human decision-making that can be used to infer goals and plans; Neural Networks a flexible mechanism for the representation of common characteristics of a user and the definition of complex stereotypes; Fuzzy Clustering a mechanism in which a user can be part of more than one stereotype at the same time; and Neuro-Fuzzy systems a mechanism to capture and tune expert knowledge which can be used to obtain assumptions about the user.

Systems engineering teams along with product and service designers are responsible for verifying that the developed products and services meet all requirements defined in the system specification documents. The following procedures outline the relevant systems engineering process steps [18, 21, 26]:

- Requirements analysis: review and analyze the impact of operational characteristics, environmental factors, functional requirements and develops measures suitable for ranking alternative designs in a consistent, objective manner. Each requirement should be re-examined for consistency, desirability, applicability, and potential for improved return on investment [19]. This analysis verifies that the requirements are appropriate or develops new requirements for the smart product operation.

- Functional analysis - systems engineers and product designers use the input of performance requirements to identify and analyze system functions in order to create alternatives to meet system requirements. Systems engineering then establishes performance requirements for each function and sub-function identified.

- Performance and functionality - systems engineering allocates design requirements and performance to each system function. These requirements are stated in appropriate detail to permit allocation to software, systems components, or personnel. Performance and functionality allocation process identifies any special personnel skills or design requirements.

- Design Synthesis - designers and other appropriate engineering specialties develop a system architecture design to specify the performance and design requirements which are allocated in the detailed design. The design of the system architecture is performed simultaneously with the allocation of requirements and analysis of system functions. The design is supported with block and flow diagrams. Such diagrams support:

    - Identifying the internal and external interfaces
    - Permitting traceability to source requirements
    - Portraying the allocation of items that make up the design

  - Identifying system elements along with techniques for its test and operation
  - Providing a means for comprehensive change control management

- Documentation - the primary source for developing, updating, and completing the system and subsystem specifications. Smart product requirements and drawings should be established and maintained.

- Specifications - to transfer information from the smart product systems requirements analysis, system architecture design, and system design tasks. The specifications should assure that the requirements are testable and are stated at the appropriate specification level.

- Specialty engineering functions - participate in the systems engineering process in all phases. They are responsible for system maintainability, testability, producibility, human factors, safety, design-to-cost, and performance analysis to assure the design requirements are met.

- Requirements verification - systems engineering and test engineering verify the completed system design to assure that all the requirements contained in the requirements specifications have been met.

Model-based interactive human system approaches for design and modeling of smart systems and products differentiate between human performance and effectiveness criteria. These criteria determine a total system mission performance level and acceptability that is directly attributable to specific actions allocated to human performance metrics. These are indicators measure which performance effectiveness criteria are met [20, 21].

Currently there are few applications to facilitate human behavior modeling in social networking applications. One of the applications that support a full Human Systems Integration (HSI) within a systems engineering process is DOORS^{TM} by Rational. DOORS or Dynamic Object Oriented Requirements System specifically tracks requirements for product or software design. Since the requirements process has many shared elements to knowledge management, DOORS facilitates requirements entry, organization into hierarchies, and display. Users make changes and link any requirement to sub requirements and related requirements. DOORS require individual users to have accounts. Each account can be restricted to elements of the database and given read-only or administrative-level rights. Changes made are tracked by user, allowing managers to trace changes down to the individual user level. IBM Rational DOORS [27] provides a structured framework for adding, viewing, and changing requirements.

V. HYBRID COMPUTATIONAL SOCIAL NETWORK ANALYSIS

The interest in Computational Social Network Analysis (CSNA) has been growing massively in recent years. Psychologists, anthropologists, sociologists, economists, and statisticians have given significant contributions, making it actually an interdisciplinary research area. This research summarizes the development of CSNA framework composed of methods used to (1) rapidly collect and (2) visualize socio-cultural network data in order to analyze economic and social data relationships between people, groups, organizations- and other knowledge-processing entities by integrating knowledge from available databases [23,26]. In particular, the first category (methods used for network data collection) aims to provide a dataset that helps study the effects that social networks have on different aspects of social and cognitive activities. To achieve this aim, the following methods were considered: (a) Socio-centric modeling: to examine sets of relationships between actors that are regarded for analytical purposes as bounded social collectives. (b) Ego-centric: to select focal actors (egos), and identify the nodes they are connected to.

The second category (methods used for network data visualization) aims to render data in easily understood graphical formats, thus making complex information usable and understandable by a broad community within the civilian economics and decision leaders to enable better decision-making at various levels (policy, and private sector sales operations) and to support cultural situational awareness for tactical decision-making and training. To achieve this aim, the following representations are used:

(a) **Graphs:** to visualize relationships among members of a narrow socio-cultural Network;

(b) **Matrices:** to visualize dense socio-cultural networks

(c) **Maps:** to manage a wide amount of data and information; and

(d) **A mixed hybrid approach:** to integrate different visualization perspectives according to the rapid socio-cultural assessment goals.

Different techniques provide different capabilities to support extensive cultural situational awareness analysis for tactical decision-making and rapid socio-cultural assessment. For example, techniques such as Self Organizing Maps (SOM) and Cellular Automata (CA) can be used to construct a user model by themselves or in combination with traditional machine learning techniques. Generated models based on available datasets can be classified in this work based on how human behaviors are represented as models, and their purpose (Figure 1). To this end, two main dimensions are considered:

1) <u>Granularity of the model</u>: A model can be created for each individual (content-based modeling) or for clusters of users or a group (collaborative modeling)

2) <u>Type of task for which the model is going to be used:</u> Ahram et al. [26] define four basic types of tasks: (i) Filtering, (ii) Classification, (iii) Prediction, and (iv) Recommendation

The developed model supports prediction, which is the capability of anticipating future actions using past behavior [23,26]. A basic assumption is made with this approach: a user's immediate future is very similar to his/her immediate or midterm past, an approach used to describe and model the social network system emergent behavior as shown in Figure 1 [23, 26]; this is traditionally presented in the literature as content-based filtering [28]. Recommendation is the capability of suggesting interesting socio-cultural dataset elements relationships; Clustering is the process of locating "interesting" data and groups of interests from among the data. It is a technique that groups data with similar characteristics. The purpose of visualization using a Geographic Information System (GIS) is to map data presented in the models with SOM and CA onto a graphical representation to provide a qualitative idea of its properties. [26].

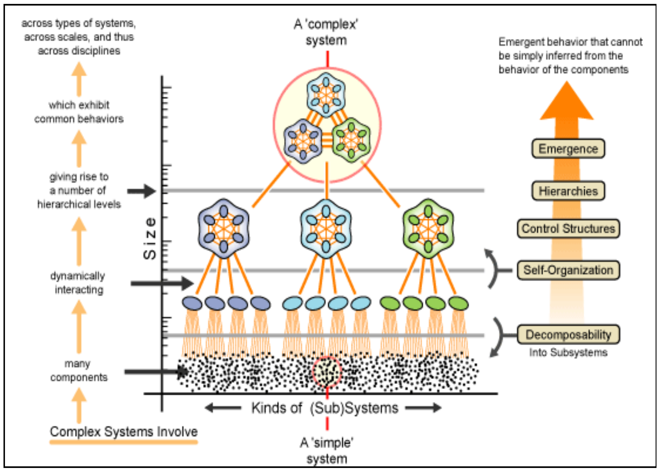

Figure. 1. Characterisitcs of a socio-economic cultural system to reflect emergent behavior

Self-Organizing Map's (SOM) is a neural network model for clustering and visualizing high-dimensional data. The SOM can be used to map high-dimensional complex socio-cultural data onto a low-dimensional space that is usually two dimensional. In general, data visualization is used as a way to aggregate large quantities of data (see Figure 2), and present them in a way that allows to: (1) quickly communicate rich messages (communication). (2) discover new, previously unknown facts and relationships (discovery). (3) getting better insight into things we already know (insight).

The visualization can be performed by using (i) graphs made up of nodes and connection lines and the numbers in each cell stand for specific relationships among these values, (ii) matrices where row and columns stand for actors and properties, (iii) maps, and/or (iv) a hybrid approach.

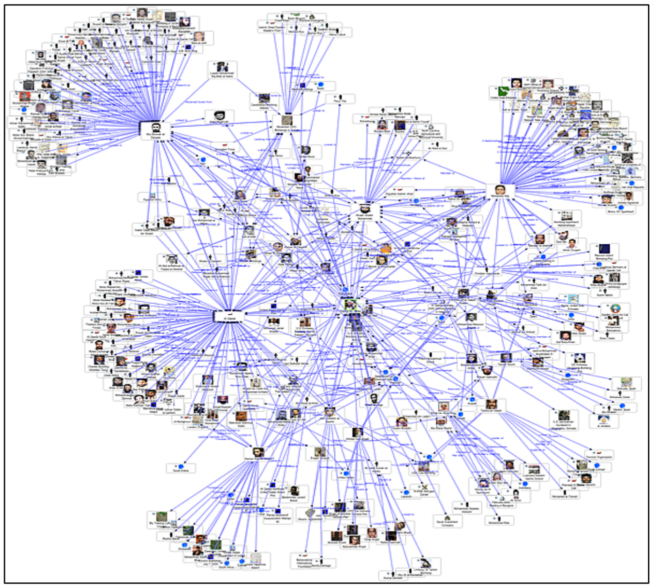

Figure.2. Example Visual Socio-Cultural Network Analysis

VI. CONCLUSION AND FUTURE WORK

As an introductory contribution to the application of social networking and systems engineering process for the design and development of smarter products and services, this paper provides a motivation and quest for integrated social networking approach to systems engineering and to study complex human behavior. While a large number of disciplines and research fields must be integrated towards development and widespread use of smarter products, considerable advancements achieved in these fields in recent years indicate that the adaptation of these results can lead to highly sophisticated yet widely useable collaborative social networking applications for smart products.

Future research will emphasize the applications of systems engineering and social-networking to design and modeling of specific services and will demonstrate the benefits in supporting and facilitating the understanding of complex human behavior and to better identify crucial user needs.

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REFERENCES

[1] G. Allmendinger and R. Lombreglia, “Four Strategies for the Age of Smart Services”, Harvard Business Review, 2005, 83(10):131-145.

[2] M. Mühlhäuser, “Smart Products: An Introduction. In Constructing Ambient Intelligence”, AMI 2007 Workshop, pages 154 – 164, 2008.

[3] M. Weiser, “The computer of the 21st century”, Scientific American, 1991, 265(3):66-75.

[4] J. Ahola, “Ambient Intelligence”. ERICM News, 2001, (47).

[5] E. Arts and B. de Ruyter, “New research perspectives on ambient intelligence”. Journal of Ambient Intelligence and Smart Environments, 2009, 1:5-14.

[6] S. Das and D. Cook, “Designing Smart Environments: A Paradigm Based on Learning and Prediction”, In: Shorey, R., Ananda, A., Chan, M.C., Ooi, W.T. (eds.) Mobile, Wireless, and Sensor Networks: Technology, Applications, and Future Directions, 2006, pp. 337–358. Wiley, Chichester.

[7] M. Sabou, J. Kantorovitch, A. Nikolov, A.Tokmakoff, X. Zhou and E. Motta. “Position Paper on Realizing Smart Products: Challenges for Semantic Web Technologies”, Report by Knowledge Media Institute, 2009, http://people.kmi.open.ac.uk/marta/papers/ssn2009.pdf form [retrieved: August, 2012].

[8] S. Chandrasekharan, “The Semantic Web: Knowledge representation and affordance”, In: B. Gorayska, and J.L. Mey (eds). Cognition and Technology: Co-existence, Convergence, and Co-evolution, Amsterdam/Philadelphia: Benjamins, 2004, pp.153-174

[9] W. Maass and U. Varshney, “Preface to the Focus Theme Section: 'Smart Products'. Electronic Markets”, 2008, 18(3):211-215.

[10] S. Ziegler, “The (mis)education of Generation M’ Learning, Media and Technology”, 2008, 32, 1, pp.69-81

[11] N. Selwyn, “Screw blackboard… do it on Facebook!: An investigation of students’ educational use of Facebook”, Paper presented to the Pole 1.0 – Facebook social research symposium, November 15, 2007 at University of London: http://www.scribd.com/doc/513958/Facebook-seminar-paper-Selwyn [retrieved: October, 2009].

[12] J. Davies, and G. Merchant, “Looking from the inside out: academic blogging as new literacy” in C. Lankshear, and M. Knobel, (eds.) ‘A New Literacies Sampler’ New York, Peter Lang, 2007.

[13] F. Dubet, “Dimensions and representations on student experience in mass universit”, Revue Francaise de Sociologie, 2004, 35, 4, pp.511-532

[14] C. Madge, J. Meek, J. Wellens and T. Hooley, “Facebook, social integration and informal learning at university: ‘It is more for socialising and talking to friends about work than for actually doing work”, Learning, Media and Technology, 2004, Routledge.

[15] M. Prensky, “Digital Game-Based Learning”, McGraw-Hill, New York, 2001, ISBN 0-07-136344-0

[16] D. K. Hitchins, “Systems Engineering: A 21st Century Systems Methodology. Chichester, UK: John Wiley & Sons, 2007.

[17] S. Friedenthal, A. Moore and R. Steiner, “A Practical Guide to SysML: The Systems Modeling Language”, Morgan Kaufmann; Elsevier Science, 2008.

[18] Defense Acquisition University (DAU) Guidebook 2004, Chapter 4: Systems Engineering.

[19] T. Z. Ahram and W. Karwowski, “Measuring Human Systems Integration Return on Investment”. The International Council on Systems Engineering – INCOSE Spring 2009 Conference: Virginia Modeling, Analysis and Simulation Center (VMASC), 2009, Suffolk, VA. USA.

[20] T. Z. Ahram, W. Karwowski, B. Amaba and P. Obeid, “Human Systems Integration: Development Based on SysML and the Rational Systems Platform”, Proceedings of the Industrial Engineering Research Conference, 2009, Miami, FL. USA.

[21] Systems Engineering Fundamentals, Defense Acquisition University Press, 2001.

[22] W. Karwowski and T. Z. Ahram, “Interactive Management of Human Factors Knowledge For Human Systems Integration Using Systems Modeling Language”. Special Issue for Information Systems Management, Journal of Information Systems ManagemenT, 2009, Taylor and Francis.

[23] T. Z. Ahram, W. Karwowski, and B. Amaba, “Collaborative systems engineering and social networking approach to design and modeling of smarter products”. Behav. Inf. Technol. 30, January, 2011, 13-26.

[24] T. Z. Ahram and W. Karwowski, “Social Networking Applications: Smarter Product Design for Complex Human Behavior Modeling”, Human Computer Interaction Proceedings. 14th International Conference on Human-Computer Interaction (HCII 2011), Orlando, FL, July 9-14, 2011.

[25] T. Z. Ahram, W. Karwowski, “ Visual Social Network Analysis: Effective Approach to Model Complex Human Social, Behavior & Culture”. The 18th World Congress on Ergonomics (IEA) held February 12-16, 2012, in Recife, Brazil.

[26] T. Z. Ahram and W. Karwowski, “Developing Human Social, Cultural, Behavior (HSCB) Ontologies: Visualizing & Modeling Complex Human Interactions”, Presented at the Office of Secretary of Defense Human Social, Culture Behavior Modeling (HSCB Focus 2011), Chantilly, VA, February 8-10, 2011

[27] IBM Rational DOORS software website: http://www.ibm.com/software/awdtools/doors/ [retrieved: September, 2012].

[28] M. Balabanovic and Y. Shoham, “Learning Information Retrieval Agents: Experiments with Automated Web Browsing”. In Working Notes of the AAAI Spring Symposium Series, 1995, pp. 13-18. Stanford University.