Survey on Intelligent Dialogue in e-Learning Systems

Felix G. Hamza-Lup
Computer Science
College of Engineering and Computing
Georgia Southern University
Savannah, Georgia, USA
e-mail: fhamzalup@georgiasouthern.edu

Ioana R. Goldbach
Center for Research and Studies in
Management and Marketing
Valahia University of Targoviste
Targoviste, Dambovita, Romania
e-mail: ioana.goldbach@icstm.ro

Abstract— **Ever since ancient times, learning was a two-way process, a dialogue among the tutor and the learner. The transfer of knowledge implies social interaction, hence the dialogue is of utmost importance. With the widespread of social media and mobile systems, learners expect quick, easy responses to their questions any time of the day. As e-Learning systems promote time and location flexibility, synchronous dialogue in such systems should not be bound to the time frames that the instructor is available, but should allow learners active real-time feedback throughout the day. Such synchronous interaction is possible through a variety of tools like: automated intelligent grading, intelligent tutoring systems and intelligent facilitator agents embedded in the Learning Management System or social networks. This paper provides an overview of automated dialogue characteristics and a survey on recent research efforts in academia and industry in building intelligent dialogue capable systems. Imagine a system that adapts intelligently to learners' requests and allows them to take control of their own learning, making the bulky learning interface transparent to the user.**

Keywords-adaptive chatbots; intelligent user interfaces; artificial intelligence; adaptive dialogue.

I. INTRODUCTION

Generation Z, the first generation after Millennials, is defined as people born from the mid-1990s to the early 2000s makes up approximate 25% of the U.S. population, making them a larger cohort than the Baby Boomers or Millennials [1][2]. The young generation is very comfortable with technology, and keen on using mobile devices in their daily routine. They want their learning to be personalized to meet their needs while still enabling collaboration with their peers and mentors. Learning on the move, using mobile devices and liberated from a static classroom environment such learners still require the face-to-face-like traditional classroom interaction.

Due to the increase of multimedia content on the web, and deeper penetration of machine learning into various applications, it is possible to deploy adaptive systems that guide student learning at the users' request. While multimedia is gaining popularity on the Web with many technologies that support animation, video, audio and even novel forms of haptic (i.e., tactile) interaction [3], unconstrained use of multimedia results in user interfaces that confuse users and makes it harder for them to understand the information [4]. To cope with the amount of information available online, the dialogue has to be adaptively managed based on the user's requirements and level of knowledge [5]. Adaptive dialogues can be implemented through Artificial Intelligence (AI) supported active assistants (e.g., chat bots) and other intelligent tutoring systems [6]. Such automated systems respond to natural language requests, provide answers and learn in this process. Building on the data they acquire about the users' requests, they can make suggestions, adapt information to the users' needs, and simulate an instructor.

While the course content is important, the content exchanged through the teacher and learner's dialogue (synchronous and asynchronous) is the most important component in the e-Learning environment [7], even for hybrid courses approaches [8][9].

The paper is structured as follows. Section 2 provides a brief overview of synchronous/asynchronous tools for dialogue support followed in Section 3 by a brief review of intelligent, adaptive dialogue with a tutoring agent. Section 4 provides a survey on recent intelligent automated facilitators, including the avatar forms in Virtual Reality/Mixed Reality (VR/MR) environments. Near future trends are discussed in the conclusion.

II. INTELLIGENT DIALOGUE IN E-LEARNING

A new study [10], indicates that over 80% of high school students use smartphones regularly, while 90% of the students agree that tablets will change the way students learn in the very near future and more than 80% of them agree that using tablets in the classroom allows them to optimize their learning. In an effort to cope with these fast technological advances, a continuous improvement of course materials and adaptation to the mobile devices is required but not sufficient. Generating intelligent dialogue among the users of an e-Learning system becomes a challenge. Moreover, dialogue becomes itself the central piece of learning as the lack of dialogue usually is associated with the lack of interest in the topic. Research suggests that learning is also enabled from the observation of the dialogue, the reflection induced by the potential of submitting questions and answers, and in the interaction between the face-to-face and on-line environments [11].

Intelligent dialogue is an enabling discussion allowing the learner to advance his/her understanding of concepts and paradigms associated with a specific paradigm. Such dialogue may be established between the learner and the following types of tutors:

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- *Instructor* – in a synchronous or asynchronous session, where the instructor is the main decision factor in providing learning directions to the learner.
- *Peer* – refers to the peers of the leaner (i.e., other learners) that have understood a particular concept or paradigm and are capable of explaining the concept to the learner in a sometimes, more "understandable" way.
- *Intelligent agent*. A software component designed to manage and adapt to the learner's requirements and background knowledge. Such a software component is usually driven by a machine learning algorithm [12] and it establishes a meaningful dialogue considering the learner's requirements and background.

Regardless of the type of the participants in the dialogue, an e-Learning systems supports different types of communication tools. In case of an intelligent software agent, the integration of the software module with one or more communication tools must be achieved. The communication tools can be divided into synchronous and asynchronous as illustrated in Figure 1, and their use depends on the time availability of the participants.

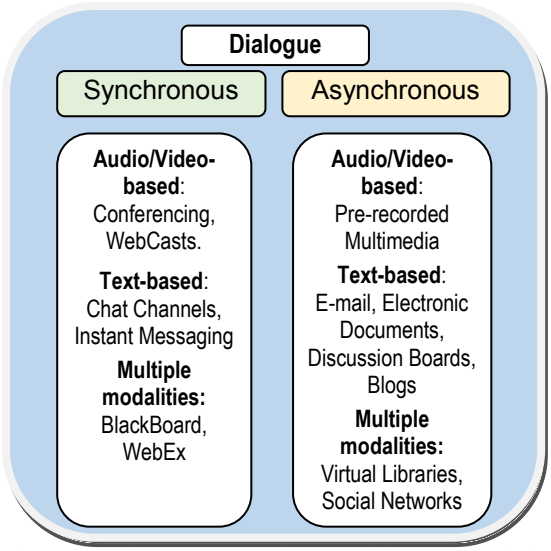

Figure 1. Synchronous vs Asynchronous Dialogue Technologies

A. *Intelligent Synchronous Dialogue*

Synchronous dialogue is an essential component of discussions, lectures and in general presentations that occur at a predefined point in time and are typical in a face-to-face lecture. With the wide spread and proliferation of the Internet, such synchronous dialogue is supported through learning environments that provide multiple ways of interacting, sharing and the ability to ask and answer questions in real-time using synchronous learning technologies. Videoconferencing, web-casts, instant messaging and interactive learning systems supporting chat-based communication are just a few examples.

Synchronous dialogue requires participants to be available at the same time, however there is another essential requirement that is sometimes forgotten: the participants must also have to dedicate similar time frames for dialogue (i.e., class times are often set to 50 minutes intervals). Care must be taken to keep the dialogue from degrading into a monologue.

Techniques to improve synchronous dialogue from the tutor's perspective include: assessing the learners' background knowledge and skills level to predict the capability of the learners to grasp the content and ensure class uniformity; establishing a rapport with the learner at the beginning of the dialogue; High interactivity by keeping text-light and activity-heavy to stimulate the interaction; Encourage the learner to send queries and share his insights; Adapt dialogue pace based on the learner.

On the learner's side, it is important that the learner assumes an active participation role in the dialogue. Furthermore, self-directed motivation is expected of the participants in synchronous dialogue.

B. *Intelligent Asynchronous Dialogue*

An asynchronous dialogue is usually built upon the idea of time flexibility from the participant's perspective. While synchronous dialog requires participant to be online at the same time, asynchronous systems dialogue is usually build on communication systems like e-mail and discussion forums and their various forms under social networks or specialized research networks (e.g., Academia, Research Gate, etc.)

In an asynchronous learning environment learners are encouraged to actively participate in their own learning, providing them the chance to cooperate with their peers, provide peer feedback, and reflect on their personal learning objectives and outcomes. Such an environment implemented through a discussion forum for example and associated with a proper reward grading system, can increase the learner's motivation as well as inter-peer interaction, generating the basis for an intelligent dialog among peers and hence improving the learning outcomes [9][10].

In a web-based client-server environment, even though there are many types of asynchronous applications, communication can be classified as: poll, push, and long-poll [13]. If a parallel is drawn among these categories and the asynchronous dialogue between the tutor and learner, the following dialogue categories are obtained, see Figure 2:

- **Polling, asynchronous dialogue**: the learner asks to the tutor at regular intervals and the tutor responds with guiding information. Such an approach can be implemented for example using an e-mail system with the *"polling"* initiated by the learner.
- **Long-polling, asynchronous dialogue**: is similar with the first approach in that the learner is sending a question to the tutor however the connection is kept open and the tutor provides an answer when s/he has the information available. Interestingly, such asynchronous communication can be implemented thorough a *synchronous* tool (e.g., web-chat) with the

condition that, both the learner and the tutor keep the chat channel open for a long period of time and monitor it for activity.

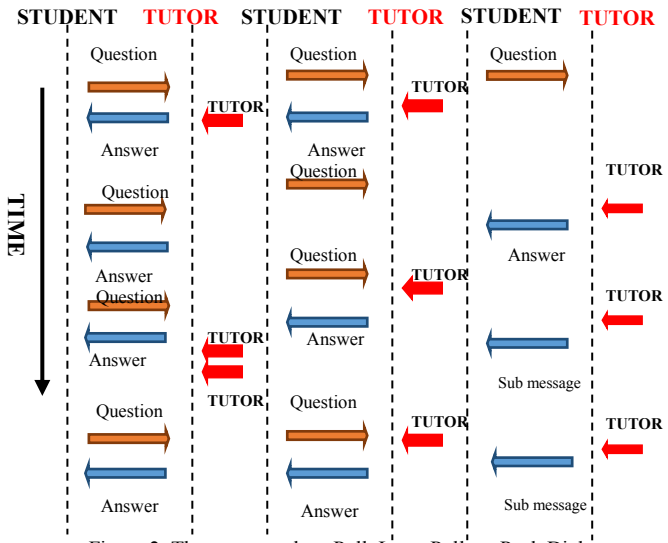

Figure 2. Three approaches: Poll, Long-Poll vs. Push Dialogue

- **Push asynchronous dialogue:** the learner subscribes to a tutor channel by sending an initial request/question and from that point on s/he receives answers/updates *"pushed"* by the tutor. Such a dialogue can be initiated through a subscription to a discussion thread in a discussion forum for example.

III. INTELLIGENT AND ADAPTIVE DIALOGUE

The establishment of an intelligent *dialogue* itself is fundamental, as a simple one-way communication between the tutor and the learner, i.e., a *monologue* is a one way communication channel that eventually requires feedback. Although a monologue is theoretically defined as a "prolonged talk or discourse by a single speaker" conversations between two parties who are not really listening to each other are, essentially, monologues concealed as dialogues. The intelligent, adaptive and automated dialogue attributes have the following meaning:

- *Intelligent* dialogue must reveal good judgment and/or sound thought from both the tutor and learner.
- *Automated* dialogue implies a computing algorithm behind the user interface generating and managing the dialogue (i.e., an intelligent agent) with the learner and augmenting or replacing temporary the real tutor.
- *Adaptive* dialogue implies that various aspects are taken into account (e.g., user's background knowledge and progress) and the tutoring agent is able to adapt to the learner, obviously exhibiting a certain level of intelligence.

Intelligent, automated, adaptive dialogue between a learner and a software tutoring agent may be implemented in a learning management system at different stages:

- *Assessment:* through automated grading that provides the learner with feedback after and assessment (quiz, exam, etc.) has completed. It simulates the behavior of a human tutor, and helps assess learners' knowledge, analyzing their answers, providing feedback and proposing personalized training plans, mostly in an asynchronous context. Automated grading is cheap, quick and without human bias, however it has serious limitations when applied to essay-type content assessment [14].
- *Content Creation: "Smart content" creation*, from digitized guides of textbooks to customizable learning digital interfaces, are being introduced at all levels, from elementary school to corporate environments [6].
- *Content Delivery*: intelligent tutoring systems have seen a tremendous amount of progress in recent years [7]. Recent advances in Artificial Intelligence (AI) have enabled dialogue management frameworks like Artificial Intelligent Dialogue Agent (AIDA) [12].

Integration of intelligent, adaptive and automated dialogue in popular Learning Management Systems (LMS) (e.g., Docebo, Adobe Captive Prime, Desire2Learn, Moodle, Looop, SkillCast, etc.) is still lagging behind. Most LMSs improve interaction through concepts like *gamification,* and enable learner's self-management and enhanced visualization of learning progress, however dialogue is pushed to the peer or tutor level.

IV. INTELLIGENT AUTOMATED FACILITATORS

The main purpose of an automated facilitator in an e-Learning environment is dialogue facilitation for learning. Most facilitator systems rely on speech recognition and/or text analysis and interpretation.

The industry has implemented a variety of natural language ChatBots and voice-recognition modules trough projects like Apple's Siri, Google Now, Microsoft's Cortana, IBM's Watson. LMS environments like Khan Academy, YouTube, Coursera, Lynda, and other massive open online courses (MOOCs) are growing in popularity, however they are still lagging behind in terms of intelligent dialogue creation. Many of these tools suffer from the lack of the immediacy and motivational qualities of personal interaction with a human. However, the effort to improve is ongoing with the goal of powering the intelligent dialogue inside a multitude of devices and digital services (e.g., Viv labs [15]) along the "intelligence becomes a utility" slogan.

Among the notable ongoing research projects in automated, intelligent facilitator's development, Mika [16] provides learners feedback and hints based on the learners' background knowledge and the learner's problem solving strategy. University of Southern California Institute for Creative Technologies is leading for a few decades research efforts in delivering Virtual/Mixed Reality based intelligent *avatars* that act as facilitators for different tasks using the "*Virtual Classroom"* paradigm. The *SimCoach* project [17] for example, implements a virtual human (avatar) support agent that facilitates intelligent dialogue with military personnel and family members to seek information and advice related to their healthcare. Moreover they have expanded the avatar facilitator approach to other areas like: STEM education, CANVAS project [18] and PAL3 [19], a

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system for delivering education materials and intelligent dialogue via mobile devices, to provide on-the-job training and support lifelong learning.

Projects like TLE TeachLivE™ [20] , reverse the coin, and explore Mixed Reality classrooms with simulated learners that provide tutors the opportunity to develop their pedagogical practice through intelligent dialogue in a safe environment that doesn't place real learners at risk [21]. European Union research efforts (e.g., iTalk2Learn [22]) emphasize the importance of intelligent dialogue through interdisciplinary projects that aggregate expertise from machine learning, user modeling, intelligent tutoring systems, educational psychology and mathematics.

V. CONCLUSION

The dialogue is an essential component of any human activity, and it is fundamental for any type of interaction. Particularly in education, its importance is amplified by the fact that knowledge transfer occurs in the process of social interaction through intelligent dialogue.

Artificial intelligence has been "*married*" with education for more than 30 years [23]. Personalizing teaching, learning 21st century skills, life-long and life-wide learning will spawn many AI based applications, targeted at new forms of intelligent dialogue design and development involving human senses beyond audio and visual. However care must be taken, to train teachers on how to balance their competences between the new, AI driven, intelligent dialogue systems and the traditional class activities.

Haptic ("tactile") interfaces [24] and Web3D [25] have recently been employed in e-Learning prototypes to enhance intelligent dialogue as well as to widen the communication channel. With the rapid evolution of technology, the 3D and haptic sense, seem poised for immediate adoption into virtual facilitators, embodied like virtual humans, for intelligent dialogue tailored to each learner.

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