COMPUTER AND CONTROL ENGINEERING

CRT/DAUIN - XR-based Adaptive Procedural Learning Systems

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Context of the research activity	The research aims at developing a versatile learning framework that leverages adaptive algorithms and XR technology. This framework will enhance education in various domains through interactive and immersive experiences that dynamically adapt to learners' needs and skills. The research will explore and test the effectiveness of adaptive models from the literature, and develop software for rapid prototyping of procedural learning applications in XR ensuring scalability and efficiency.
	In many fields, such as industry, medicine and others, procedures play an important role in the smooth execution of activities and tasks. In general, a procedure is a sequence of operations or activities that follow certain rules and ultimately serve to achieve a desired result. Procedural learning refers to the process of acquiring and mastering all the skills, knowledge and understanding required to perform a particular procedure effectively. The main objectives of procedural learning can be summarized as follows. First, to provide learners with the necessary theoretical knowledge of the procedure, including an understanding of the underlying principles and concepts behind each step, as well as acquiring the practical skills they need to perform a procedure as accurately as possible. Another important goal for learners is to memorize and retain the individual steps of the procedure so that they can remember the sequence when they need to perform it. Last, learners should also master the execution of the procedure in order to minimize errors and optimize the workflow. In the field of computer-assisted learning, XR (Extended Reality) technologies are certainly a game changer. XR systems offer the possibility of providing multimedia and interactive information that utilizes contextual awareness. This enables the development of learning environments that are effective, engaging, appealing and even entertaining. This research project aims to advance the state of the art in XR-based procedural learning by tackling the following objectives: • Creating AI models that can adapt the learning content and its presentation

Objectives	based on the user's prior knowledge and progress. These adaptive learning algorithms will optimize the training of procedures in real time in different fields, ensuring high quality and efficient learning experiences. • Development of XR environments that replicate real-life scenarios with interactive elements and virtual instructors. These environments will be adaptable to various procedural training requirements, such as medical procedures, industrial processes and emergency response. • Implement systems that provide real-time intelligent feedback tailored to learners' challenges and achievements, as well as advanced and natural interaction mechanisms (e.g. natural language interaction). This will improve user engagement and the realism of training scenarios. • Implement autonomous, lifelike virtual agents that can take on different roles, from non-playable characters (NPCs) to virtual instructors. These agents will enhance the interactivity and realism of the training environment. • Develop solutions that are compatible with various XR platforms and scalable across different hardware capacities to ensure broad acceptance and future-proofing against technological advances. • Develop a framework for rapid prototyping and development of procedural learning applications featuring visual design tools for non-technical professionals to create training content and define procedures' activities, rules and constraints. This approach aims to improve collaborative development, simplify communication between technicians and domain experts, and automate the generation of software elements from visual representations. Work Plan: Phase 1 - Foundation and initial development (M1-M16) Analyze the current state of the art in procedural learning, XR-based learning and adaptive learning systems and identify gaps and opportunities. Analyze requirements and gather insights from experts in industry, medicine and other fields. Create initial prototypes of XR-based adaptive learning algorithms and conduct their preliminary testing and validation. Phase 2 - Development of a software framework for XR procedural learning (M6-M30) Design and implement a software framework for rapid prototyping and implementation of XR-based procedural learning applications. The framework will support portability and scalability across different devices and environments (from AR to VR). The framework will be iteratively extended with the following features: - intelligent real-time feedback systems tailored to learners' challenges and achievements - natural language interaction mechanisms for better usability and user engagement - autonomous, lifelike virtual agents that can act as NPCs or virtual instructors - visual design tools for non-technical professionals and domain experts to create training content and define activity graphs, rules and constraints Phase 3 - Refinement (M12-M36) Identify one or more specific use cases and with the collaboration of domain expert design and implement a training activity exploiting the developed framework. Once developed, select a group of target learners and conduct comprehensive testing of the entire system. Collect data to asses user experience and learning effectiveness of the proposed ssyem. Refine the proposed systems according to the feedback gathered and iteratively improve the solution.

Skills and competencies for the development of the activity	The ideal candidate should possess a strong background in computer science and AI, with expertise in XR technologies. Essential skills include problem-solving, creativity, asset optimization for low-end devices, and immersive user interface development. Good communication, collaboration, and scientific writing skills are also required.