

Title	遠隔学習プロセスにおける学習者のエンゲージメントに関する自動認識と分析
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Automatic Recognition and Analysis of Learners' Engagement in Distance Learning Process

Engagement is an essential component of the learning processes associated with positive learning outcomes. Measuring learner engagement in learning processes is important for providing insights for enhancing learning activities. Because the learning paradigm has shifted to enable more distance learning practices, machine learning-based automatic engagement estimation methods have been proposed as a new way to measure learner engagement. Nevertheless, most existing methods are built standalone and have yet to be integrated into actual distance learning practice. Furthermore, implementing automatic engagement estimation should ensure technological and ethical impact responsibilities.

This study aims to provide an intermediary knowledge and solution to analyse learners' engagement in the distance learning process by addressing the main research question: "How do educators or education institutions safely apply automatic engagement estimation in their distance learning process?" A systematic review is conducted to gain basic knowledge of the current trend of automatic engagement estimation in the literature to achieve this goal. The engagement types, datasets, and methods are defined and theoretically investigated. Secondly, the technical investigation to understand the basic requirement for automatic engagement estimation is done by building an engagement estimation module using deep learning methods. We introduce a design principle for end-to-end integration of real-time automatic engagement estimation in distance learning practice. Thirdly, we introduce a design principle for the ethical implementation of automatic engagement estimation so that the technology can benefit actual distance learning in practice.

From the literature review, we found that clearer engagement definitions and cues are crucial for developing an applicable automatic engagement estimation. However, there is no clear taxonomy to define engagement, especially for distance learning implementations. Therefore, we introduced a taxonomy of engagement definitions and cues, categorized the engagement datasets, and conducted method categorization, which mainly utilised machine learning-based methods. The combination of a clear definition of engagement and suitable machine learning methods allows learners' engagement during learning activities to be measured automatically, including in human-human interactions, human-computer interactions, and human-robot interactions.

Two deep learning models were experimented with, i.e., long short-term memory (LSTM) and convolutional neural network (CNN), and a publicly available engagement dataset. However, we found that classic machine learning would be the best practice, especially for real-time engagement estimation, while LSTM is less feasible for practical implementation compared to CNN from a runtime perspective. Furthermore, a framework for real-time automatic engagement estimation is proposed for implementation in distance learning practices. Furthermore, we introduce system designs and prototypes for both an asynchronous and a synchronous setting.

We propose the design of RAMALAN, a real-time engagement assessment for asynchronous distance learning, and MeetmEE (pronounced as 'meet me'), a real-time video conference integrated with automatic engagement estimation for synchronous distance learning. The MeetmEE prototype was deployed in a pilot experiment to evaluate the MeetmEE system design. A total of 20 participants joined the experiment in a one-hour meeting session with the author via MeetmEE online either as educators ($n = 13$; 65%) or learners ($n = 7$; 35%) with 60%. The participants completed two survey forms (Forms A and B) based on their roles in their affiliations. The experiment results of Form A demonstrate that most of the responses were very positive to the automatic engagement estimation concept, represented in MeetmEE. MeetmEE is favourable for 70% of the participants, where, for educators, this technology will motivate them to improve their teaching strategies and give support to their students, while students can measure their own engagement as well. Furthermore, the results of Form B showed a positive evaluation, demonstrating that MeetmEE is sufficient, particularly in scales of stimulation, attractiveness, perspicuity, and novelty. However, MeetmEE is perceived as relatively low in terms of dependability and efficiency.

Finally, the user evaluation results are considered to construct the design principle of ethical implementation. The automatic engagement estimation implementation's design principle incorporates technical and operational measures. While the current automatic engagement estimation studies focused on only the ICT point of view instead of the feasibility of the actual education process, the development of an engagement estimation design principle incorporated with its real-time application in the distance learning process is a part of the originality of this research. We believed that this contribution would be beneficial in designing a broader distance learning framework where the learners' internal state and affective factors are considered.

Keywords: Distance learning, automatic engagement estimation, emotional engagement, WebRTC, design principle.