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Modeling Engagement with Multimodal Multisensor Data: The Continuous Performance Test as an Objective Tool to Track Flow

Authors : Mohammad H. Taheri, David J. Brown, Nasser Sherkat

Abstract : Engagement is one of the most important factors in determining successful outcomes and deep learning in students. Existing approaches to detect student engagement involve periodic human observations that are subject to inter-rater reliability. Our solution uses real-time multimodal multisensor data labeled by objective performance outcomes to infer the engagement of students. The study involves four students with a combined diagnosis of cerebral palsy and a learning disability who took part in a 3-month trial over 59 sessions. Multimodal multisensor data were collected while they participated in a continuous performance test. Eye gaze, electroencephalogram, body pose, and interaction data were used to create a model of student engagement through objective labeling from the continuous performance test outcomes. In order to achieve this, a type of continuous performance test is introduced, the Seek-X type. Nine features were extracted including high-level handpicked compound features. Using leave-one-out cross-validation, a series of different machine learning approaches were evaluated. Overall, the random forest classification approach achieved the best classification results. Using random forest, 93.3% classification for engagement and 42.9% accuracy for disengagement were achieved. We compared these results to outcomes from different models: AdaBoost, decision tree, k-Nearest Neighbor, naïve Bayes, neural network, and support vector machine. We showed that using a multisensor approach achieved higher accuracy than using features from any reduced set of sensors. We found that using high-level handpicked features can improve the classification accuracy in every sensor mode. Our approach is robust to both sensor fallout and occlusions. The single most important sensor feature to the classification of engagement and distraction was shown to be eye gaze. It has been shown that we can accurately predict the level of engagement of students with learning disabilities in a real-time approach that is not subject to inter-rater reliability, human observation or reliant on a single mode of sensor input. This will help teachers design interventions for a heterogeneous group of students, where teachers cannot possibly attend to each of their individual needs. Our approach can be used to identify those with the greatest learning challenges so that all students are supported to reach their full potential.

Keywords : affective computing in education, affect detection, continuous performance test, engagement, flow, HCI, interaction, learning disabilities, machine learning, multimodal, multisensor, physiological sensors, student engagement
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