Attentive, Bidirectional MOOC Learning via Implicit Physiological Signal Tracking

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Massive Open Online Courses (MOOCs) are becoming a promising solution for delivering high- quality education on a large scale at low cost in recent years. Despite the great potential, today's MOOCs also suffer from challenges such as low student engagement, lack of personalization, and most importantly, lack of direct, immediate feedback channels from students to instructors. This project explores the use of physiological signals *implicitly* collected from learners via a "*sensorless*" approach as a rich feedback channel to understand, model, and improve learning in mobile MOOC contexts. We summarize our findings in three thrusts: 1) System and Usability; 2) Understanding and Modeling Learners; 3) Interventions.

System and Usability. We designed, prototyped, and systematically evaluated AttentiveLearner [12], an intelligent mobile learning system optimized for consuming lecture videos in both MOOCs and flipped classrooms. In two 18-participant studies [10], we evaluated 1) the accuracy, speed, and subjective preferences of the tangible video control channel of AttentiveLearner; 2) the overall usability of AttentiveLeaner in a 49-minute long MOOC course. More recently, we invented and evaluated AttentiveLearner^2 [2], a multi-modal intelligent mobile learning system that uses both implicit physiological sensing via the back camera and real-time facial expression analysis via the front camera of an unmodified smartphone to improve MOOC learning.

Understanding and Modeling Learners. We systematically explored the use of physiological signals implicitly collected from learners to supplement and improve our understanding of learning activities in MOOCs and flipped classrooms. We systematically explored the detection of mind wandering (MW) [12] (24 participants), engagement & confusion [10] (18 participants), divided attention [4] (18 participants), and the dynamics of affective states [3] (22 participants) in principled research. Furthermore, we found the detection of *extreme personal learning events* and *aggregated learning events* can significantly improve the prediction accuracies in contexts where our algorithms are confident about the predictions. We also explored AtttentiveLearner technologie beyond educational contexts - we proposed AttentiveVideo [6][9], an intelligent mobile interface to quantify viewers' attention,engagement, and sentimentality toward mobile video advertisements.

Interventions. We also designed two intervention techniques, AttentiveReview [7] (32-participants) and C2F2 (Context and Cognitive-State triggerd Feed-Forward) [8] (48 participants), to directly improve learning outcomes. Overall, we found that as an end-to-end mobile tutoring system, the benefits of AttentiveReview and C2F2 outweigh side-effects from false positives and false negatives and it is feasible to improve mobile MOOC learning by adapting system behaviors from rich but noisy physiological signals.

In summary, this project trained two Ph.D. students, Xiang Xiao (Ph.D. dissertation available at [1], first job at Google Mountain View) and Phuong Pham (will defend his Ph.D. dissertation in fall 2017), generated 10 publications in places such as ACM CHI (top conference in HCI), ACM ICMI (first tier conference in HCI), ACM IUI (first tier conference in HCI), and AIED. Among these publications, we received one **best student paper award** from ACM ICMI 2016 [7], one **best paper nomination** from ACM ICMI 2015[10], and one **official press release** from CHI 2017 [5]. We also received two external grants, including one Google Faculty Research Award in 2016, and one Microsoft Azure for Research Award in 2017 for this project.

Publications (available at http://www.attentivelearner.com/research/)

1. Xiang Xiao, Improving Mobile MOOC Learning via Implicit Physiological Signal Sensing. Doctoral Dissertation, University of Pittsburgh, 2017.
2. Phuong Pham, Jingtao Wang, AttentiveLearner^2: a Multimodal Approach for Improving MOOC Learning on Mobile Devices, Poster, Proceedings of 18th International Conference on Artificial Intelligence in Education (AIED 2017), Wuhan, China, June 28 – July 2, 2017.
3. Xiang Xiao, Phuong Pham, Jingtao Wang, Dynamics of Affective States during Mobile MOOC Learning, Poster, Proceedings of 18th International Conference on Artificial Intelligence in Education (AIED 2017), Wuhan, China, June 28 – July 2, 2017.
4. Xiang Xiao, Jingtao Wang, Understanding and Detecting Divided Attention in Mobile MOOC Learning, Short Paper, Proceedings of ACM Conference on Human Factors in Computing Systems (CHI 2017), Denver, CO, May 6 – 11, 2017.
5. ACM CHI 2017 Official Press Release, "New Smartphone App for Detecting Distracted Learners in Massive Open Online Courses", May 2017.
6. Phuong Pham, Jingtao Wang, Understanding Emotional Responses to Mobile Video Advertisements via Physiological Signal Sensing and Facial Expression Analysis, Proceedings of 22nd ACM Conference on Intelligent User Interfaces (IUI 2017), Limassol, Cyprus, March 13 – 16, 2017.
7. Phuong Pham, Jingtao Wang, Adaptive Review for Mobile MOOC Learning via Implicit Physiological Signal Sensing, Proceedings of ACM International Conference on Multimodal Interaction (ICMI 2016), Tokyo, Japan, November 12 – 16, 2016. **Best Student Paper Award**
8. Xiang Xiao, Jingtao Wang, Context and Cognitive-State Triggered Interventions for Mobile MOOC Learning, Proceedings of ACM International Conference on Multimodal Interaction (ICMI 2016), Tokyo, Japan, November 12 – 16, 2016.
9. Phuong Pham, Jingtao Wang, AttentiveVideo: Quantifying Emotional Responses to Mobile Video Advertisements, Demo, ACM International Conference on Multimodal Interaction (ICMI 2016), Tokyo, Japan, November 12 – 16, 2016.
10. Xiang Xiao, Jingtao Wang, Towards Attentive, Bi-directional MOOC Learning on Mobile Devices, Proceedings of ACM International Conference on Multimodal Interaction (ICMI 2015), Seattle, WA, November 9 – 13, 2015. **Best Paper Nomination**
11. Xiang Xiao, Phuong Pham, Jingtao Wang, AttentiveLearner: Adaptive Mobile MOOC Learning via Implicit Cognitive States Inference, Demo, ACM International Conference on Multimodal Interaction (ICMI 2015), Seattle, WA, November 9 – 13, 2015.
12. Phuong Pham, Jingtao Wang, AttentiveLearner: Improving Mobile MOOC Learning via Implicit Heart Rate Tracking, Proceedings of 17th International Conference on Artificial Intelligence in Education (AIED 2015), Madrid, Spain, June 22 – 26, 2015.