ERCIM "ALAIN BENSOUSSAN" FELLOWSHIP PROGRAMME

Scientific Report

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Period of the fellowship	01/01/2018 to 31/12/2018

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my fellowship, I had the opportunity to conduct several experiments and to write papers (see next section) based on the data collected from these experiments. Following experiments were conducted to understand the relation between the physiological and interaction, multimodal data (Eye-tracking, EEG, blood volume pressure, heart rate, electrodermal activity, facial features, keystrokes, audio data) and the performance of the learners in the given specific task:

1. Skill acquisition with Pacman (16 participants): Data recorded – actions and audio. Predicted variable – game score.
2. Adaptive assessment (32 participants): Data recorded – Eye-tracking, EEG, blood volume pressure, heart rate, electrodermal activity, facial features, keystrokes. Predicted variable – test score.
3. Group work during a project-based course (43 participants): Data recorded – blood volume pressure, heart rate, electrodermal activity. Predicted variable – perceived usefulness, performance and satisfaction.
4. Program Debugging (on going, 40 participants): Data recorded – Eye-tracking, EEG, blood volume pressure, heart rate, electrodermal activity, facial features, keystrokes. Predicted variable – debugging score.
5. Story telling (65 participants): Data recorded – actions and audio. Predicted variable – empathy quotient.

Apart from the above-mentioned experiments, I have participated in numerous formal and informal discussions with colleagues at the Computer Science Department at NTNU, which I consider very helpful in not only designing and analysing the experiment but also in progressing my professional and personal paths.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Published Journals

1. Schneider, B., Sharma, K., Cuendet, S., Zufferey, G., Dillenbourg, P., & Pea, R. (2018). Leveraging mobile eye-trackers to capture joint visual attention in co-located collaborative learning groups. International Journal of Computer-Supported Collaborative Learning, 13(3), 241-261.

This paper describes a promising methodology for studying co-located groups: mobile eye-trackers. We provide a comprehensive description of our data collection and analysis processes so that other researchers can take advantage of this cutting-edge technology. Data were collected in a controlled experiment where 27 student dyads ($N = 54$) interacted with a Tangible User Interface. They first had to define some design principles for optimizing a warehouse layout by analyzing a set of Contrasting Cases, and build a small-scale layout based on those principles. The contributions of this paper are that: 1) we replicated prior research showing that levels of Joint Visual Attention (JVA) are correlated with collaboration quality across all groups; 2) we then qualitatively analyzed two dyads with high levels of JVA and show that it can hide a free-rider effect (Salomon and Globerson 1989); 3) in conducting this analysis, we additionally developed a new visualization (augmented cross-recurrence graphs) that allows researchers to distinguish between high JVA groups that have balanced and unbalanced levels of participations; 4) finally, we generalized this effect to the entire sample and found a significant negative correlation between dyads' learning gains and unbalanced levels of participation (as computed from the eye-tracking data). We conclude by discussing implications for automatically analyzing students' interactions using dual eye-trackers.

2. Prieto, L. P., Sharma, K., Kidzinski, Ł., Rodríguez-Triana, M. J., & Dillenbourg, P. (2018). Multimodal teaching analytics: Automated extraction of orchestration graphs from wearable sensor data. Journal of computer assisted learning, 34(2), 193-203.

The pedagogical modelling of everyday classroom practice is an interesting kind of evidence, both for educational research and teachers' own professional development. This paper explores the usage of wearable sensors and machine learning techniques to automatically extract orchestration graphs (teaching activities and their social plane over time) on a dataset of 12 classroom sessions enacted by two different teachers in different classroom settings. The dataset included mobile eye-tracking as well as audiovisual and accelerometry data from sensors worn by the teacher. We evaluated both time-independent and time-aware models, achieving median F1 scores of about 0.7–0.8 on leave-one-session-out k-fold cross-validation. Although these results show the feasibility of this approach, they also highlight the need for larger datasets, recorded in a wider variety of classroom settings, to provide automated tagging of classroom practice that can be used in everyday practice across multiple teachers.

3. Prieto, L. P., Sharma, K., Kidzinski, Ł., & Dillenbourg, P. (2018). Orchestration load indicators and patterns: In-the-wild studies using mobile eye-tracking. IEEE Transactions on Learning Technologies, 11(2), 216-229.

Orchestration load is the effort a teacher spends in coordinating multiple activities and learning processes. It has been proposed as a construct to evaluate the usability of learning technologies at the classroom level, in the same way that cognitive load is used as a measure of usability at the individual level. However, so far this notion has remained abstract. In order to ground orchestration load in empirical evidence and study it in a more systematic and detailed manner, we propose a method to quantify it, based on physiological data (concretely, mobile eye-tracking measures), along with human-coded behavioral data. This paper presents the results of applying this method to four exploratory case studies, where four teachers orchestrated technology-enhanced face-to-face lessons with primary, secondary school, and university students. The data from these studies provide a first validation of this method in different conditions, and illustrate how it can be used to understand the effect of different classroom factors on orchestration load. From these studies, we also extract empirical insights about classroom orchestration using technology.

4. Papavlasopoulou, S., Sharma, K., & Giannakos, M. N. (2018). How do you feel about learning to code? Investigating the effect of children's attitudes towards coding using eye-tracking. International Journal of Child-Computer Interaction.

Computational thinking and coding for children are attracting increasing attention. There are several efforts around the globe to implement coding frameworks for children, and there is a need to develop an empirical knowledge base of methods and tools. One major problem for integrating study results into a common body of knowledge is the relatively limited measurements applied, and the relation of the widely used self-reporting methods with more objective measurements, such as biophysical ones. In this study, eye-tracking activity was used to measure children's learning and activity indicators. The goal of the study is to utilize eye-tracking to understand children's activity while they learn how to code and to investigate any potential association between children's attitudes and their gaze. In this contribution, we designed an experiment with 44 children (between 8 and 17 years old) who participated in a full-day construction-based coding activity. We recorded their gaze while they were working and captured their attitudes in relation to their learning, excitement and intention. The results showed a significant relation between children's attitudes (what they think about coding) and their gaze patterns (how they behaved during coding). Eye-tracking data provide initial insights into the behaviour of children, for example if children have difficulty in extracting information or fail to accomplish an expected task. Therefore, further studies need to be conducted to shed additional light on children's experience and learning during coding.

5. Sharma, K., Chavez-Demoulin, V., & Dillenbourg, P. (2018). Nonstationary modelling of tail dependence of two subjects' concentration. The Annals of Applied Statistics, 12(2), 1293-1311.

We analyse eye-tracking data to understand how people collaborate. Our dataset consists of time series of measurements for eye movements, such as spatial entropy, calculated for each subject during an experiment when several pairs of participants collaborate to accomplish a task. We observe that pairs with high collaboration quality obtain their highest values of concentration (or equivalently lowest values of spatial entropy) occurring simultaneously. In this paper, we propose a flexible model that describes the tail dependence structure between two subjects' entropy when the pair is collaborating. More generally, we develop a generalized additive model (GAM) framework for tail dependence coefficients in the presence of covariates. As for any GAM-type model, the methodology can be used to predict collaboration quality or to explore how joint concentration depends on other cognitive operations and varies over time.

Published Conferences

1. Sharma, K., Olsen, J. K., Aleven, V., & Rummel, N. (2018). Exploring Causality Within Collaborative Problem Solving Using Eye-Tracking. In European Conference on Technology Enhanced Learning (pp. 412-426). Springer, Cham.
2. Sharma, K., Mangaroska, K., Trætteberg, H., Lee-Cultura, S., & Giannakos, M. (2018). Evidence for Programming Strategies in University Coding Exercises. In European Conference on Technology Enhanced Learning (pp. 326-339). Springer, Cham.
3. Håklev, S., Sharma, K., Slotta, J., & Dillenbourg, P. (2018). Semantically Meaningful Cohorts Enable Specialized Knowledge Sharing in a Collaborative MOOC. In European Conference on Technology Enhanced Learning (pp. 370-384). Springer, Cham.
4. Jermann, P., & Sharma, K. (2018). Gaze as a Proxy for Cognition and Communication. In 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT) (pp. 152-154). IEEE.
5. Sharma, K., Papavlasopoulou, S., Giannakos, M., & Jaccheri, L. (2018). Kid Coding Games and Artistic Robots: Attitudes and Gaze Behavior. In Proceedings of the Conference on Creativity and Making in Education (pp. 64-71). ACM.
5. Mangaroska, K., Sharma, K., Giannakos, M., Trætteberg, H., & Dillenbourg, P. (2018). Gaze insights into debugging behavior using learner-centred analysis. In Proceedings of the 8th International Conference on Learning Analytics and Knowledge (pp. 350-359). ACM.
6. Ozgur, A. G., Wessel, M. J., Johal, W., Sharma, K., Özgür, A., Vuadens, P., ... & Dillenbourg, P. (2018). Iterative Design of an Upper Limb Rehabilitation Game with Tangible Robots. In ACM/IEEE International Conference on Human-Robot Interaction (HRI) (p. 187).
7. Olsen, J., Sharma, K., Aleven, V., & Rummel, N. (2018). Combining Gaze, Dialogue, and Action from a Collaborative Intelligent Tutoring System to Inform Student Learning Processes. International Society of the Learning Sciences, Inc.[ISLS].
8. Sharma, K., Mangaroska, K., Giannakos, M., & Dillenbourg, P. (2018). Interlacing Gaze and Actions to Explain the Debugging Process. International Society of the Learning Sciences, Inc.[ISLS].
9. Pappas, I., Sharma, K., Mikalef, P., & Giannakos, M. (2018). Visual Aesthetics of E-Commerce Websites: An Eye-Tracking Approach. In proceedings of Americans Conference of the Information systems (AMCIS)
10. Mikalef, P., Sharma, K., & Pappas, I. (2018). Social commerce and consumer search behavior: An eye-tracking study. In Proceedings of the Hawaiian International Conferences on System Sciences.
11. Thelisson, E., Sharma, K., Salam, H., & Dignum, V. (2018). The General Data Protection Regulation: An Opportunity for the HCI Community?. In Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (p. W36). ACM.
12. Giannakos, M., Sharma, K., Martinez-Maldonado, R., Dillenbourg, P., & Rogers, Y. (2018). Learner-computer interaction. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (pp. 968-971). ACM.
13. Lee-Cultura, S., Mangaroska, K., & Sharma, K. (2018). Adult Perception of Gender-Based Toys and Their Influence on Girls' Careers in STEM. In International Conference on Entertainment Computing (pp. 407-410). Springer, Cham.
1. Gaze-Driven Design Insights to Amplify Debugging Skills: A Learner-Centered Analysis Approach (2018) *Journal of Learning Analytics,* 5(3), 98–119. **Mangaroska, K., Sharma, K., Giannakos, M., Trætteberg, H., & Dillenbourg, P.**

Submitted

1. Coding activities for children: Coupling eye-tracking with qualitative data to investigate gender differences (Accepted with minor revisions) *Computers in Human Behaviour* **Papavlasopoulou, S., Sharma K., Giannakos, M.**

2. Utilising interactive surfaces to enhance learning, collaboration and engagement: Insights from learners' gaze (Under review Round 2*) Journal of Computer Supported Collaborative learning* **Sharma. K, Leftheriotis I., Giannakos M.**
3. Coding Games and Robots to Enhance Computational Thinking: How Collaboration and Engagement Moderate Children's Attitudes? (Under Review) *Journal of Child-Computer Interaction* **Sharma K., Papavlasopoulou, S., Giannakos, M.**
4. Multimodal Data as a means to Understand the Learning Experience (Under review) International *Journal of Information Management*. **Giannakos, M., Sharma, K., Pappas, I., Kostakos, V., Velloso, E.**
56. Digital Storytelling for good with Tappetina Game (Under review) *Journal of Entertainment Computing*. **Javier Gomez, Letizia Jaccheri, Manolis Maragoudakis, Kshitij Sharma**
67. An Alternate Statistical Lens to Look at Collaboration Data: Extreme Value Theory (Submitted). *International Conference on Computer Supported Collaborative Learning 2019*. **Sharma, K., Olsen J.**
7. Towards Automatic and Pervasive Physiological Sensing of Collaborative Learning (Submitted). *International Conference on Computer Supported Collaborative Learning 2019.* **Sharma, K., Papas, I., Papavlasopoulou, S., Giannakos, M.**
8. Detecting Synchronous Collaborative Writing Strategies through Bottom-Up Analysis (Submitted). *International Conference on Computer Supported Collaborative Learning 2019.* **Håklev, S., Olsen, J., Sharma, K., Sanchis, L.M., Shengzhao, L., Knight, S.**

Work in progress

1. Building Pipelines for Educational Data: Using AI and Multimodal Analytics to Explain Learning in Adaptive Self-Assessment (British Journal of Educational Technology)
2. Exploring Causality within Collaborative Problem Solving Using Eye-tracking (IEEE Transactions on Learning Technologies)
3. An fsQCA approach to explain learners (IEEE Transactions on Learning Technologies)
4. Information Flow and Cognition affect each other: Evidence from Digital Learning (Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies - IMWUT)
5. Gaze-Driven Design to Enhance Learning Experience: Advancing the Intermediate-Level Knowledge Basis (Transactions on Computer Human Interaction)
6. Teaching How to Look: Displaying Teacher's Gaze in MOOC Style Videos (Journal of Computer Assisted Learning)
7. A New Lens for Looking at MOOC Data to Predict Student Performance (Journal of Internet and Higher Education)

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. FabLearn, Trondheim, Norway, 18th June 2018.
2. International conference on Interaction Design and Children, Trondheim, Norway, 19th – 22nd June 2018.
3. International conference of the Learning Sciences (Festival of learning), London, UK, 23rd – 27th June, 2018.
4. European Conference on Technology Enhanced Learning, Leeds, UK, 3rd – 6th September, 2018.
5. Norwegian Informatics Conference, Svalbard, Norway, 18th – 20th September, 2018.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

For my REP, I chose to go to the "Centrum Wiskunde and Informatica" (CWI) Amsterdam. At CWI I visited the Distributed and Interactive Systems group led by Dr. Pablo Cesar. There I had detailed meetings with Dr. Cesar and his team, especially with Dr. Abdallah El Ali. I also gave a talk about my research titiled "Looking through versus Looking at: Exploring gaze patterns while problem solving". We have planned one collaborative experiment with multimodal sensors and capturing the affective state of the learners in individual and collaborative settings. The main research questions to be answered using this experiment are:

1. Can we profile learners based on individual physiological patterns?
2. Do specific individual physiological patterns correlate with the personality factors given by Big 5 traits? Can we predict those traits from physiological data?

The planned task is to require learners watch a video individually and then collaboratively create a concept map about what they learned in the video lecture. The findings of this experiment are planned to be submitted in the International journal of Mobile, Wearable, and Ubiquitous Technology mid next year.