Mini-Course in Eye Movement Analysis with Hidden Markov Models (Summer 2019: 8/12-16, 2-5pm)

Classroom and Time: Intensive Sessions, at Social Sciences 609 (社科研 609 教室)
Instructor: Antoni Chan (陳萬師, abchan "at" cityu.edu.hk) Office: Social Sciences 515
Office Hours: After class or by email appointment
Instructor: Janet Hsiao (蕭惠文, jhsiao "at" hku.hk) Office: Social Sciences 515
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Introduction:

In many daily life activities, eye movements provide strong clues about underlying cognitive processes. For example, patients with cognitive deficits have atypical eye movement patterns. People's eye movement behavior before decision making reveals their preference. Thus, eye movement has become an important measure in the broad research fields on human behavior.

Recent research has reported substantial individual differences in eye movements during visual tasks. Nevertheless, most of the current analysis methods do not adequately reflect these individual differences. In addition, they focus on spatial information (fixation locations) whereas temporal information (transitions among fixation locations) is typically overlooked. In view of these issues, Chuk, Chan, and Hsiao (2014) have developed a novel eye movement data analysis method, Eye Movement analysis with Hidden Markov Models (EMHMM), which summarizes each individual's eye movement pattern using a hidden Markov model (HMM; a type of machine learning model for time series data), including person-specific regions of interest (ROIs) and transition probabilities among the ROIs. Individual HMMs can be clustered according to similarities to discover common patterns, and the similarity between individual patterns can be quantitatively assessed through machine learning methods. This similarity measure then can be used to examine associations between eye movement patterns and other behavioral, cognitive, or neuroscience measures. This method has now been applied to different types of visual tasks across different fields and made discoveries thus far not revealed by other methods. New methodologies for more complex cognitive tasks have also been developed, including using switching HMMs for tasks involving cognitive state changes such as a decision-making task, and using the machine learning algorithm co-clustering for tasks involving stimuli with different feature layouts such as a visual search task.

In short, the EMHMM methodology allows us to summarize, quantitatively assess, and compare individual eye movement patterns across stimuli and tasks, and

examine how they are associated with other measures. The Matlab Toolbox for EMHMM is available at http://visal.cs.cityu.edu.hk/research/emhmm/. This mini-course aims to introduce the use of eye tracking technology in experimental research and how to conduct eye movement data analysis using the EMHMM methodology, so that students can use it in their own research.

Structure and Activities:

Please bring your own laptops, and install Matlab and Statistics Toolbox before class. Make sure you fully charge the laptop before each class since there are few outlets in the classroom. The mini-course consists of 5 three-hour classes, as outlined below:

1. 8/12 (Mon) 2-5pm: In the first half of the class, we will introduce current methods in eye movement data analysis to illustrate the advantages of the EMHMM method using face recognition research as an example. We will also briefly introduce EMHMM with co-clustering and Eye Movement analysis with Switching Hidden Markov Models (EMSHMM) so that students can choose to use them for their projects. In the second half of the class, we will provide an EMHMM Matlab Toolbox tutorial with sample data for students to practice using the toolbox on their own laptops.
2. 8/13 (Tue) 2-5pm: In the first half of the class, we will present an EMHMM simulation study and provide recommendations for using EMHMM in experimental research. In the second half of the class, students will be provided with a sample experiment file in Eyelink Experimental Builder and learn to develop their own mini experiment.
3. 8/14 (Wed) 2-5pm: In the first half of the class, we will introduce EMHMM with co-clustering using a scene perception task as an example with a short tutorial. In the second half of the class, students will collect data for their mini-experiment for the project presentation on the last day.
4. 8/15 (Thu) 2-5pm: In the first half of the class, we will introduce Eye Movement analysis with Switching Hidden Markov Models (EMSHMM) using a decision-making task as an example with a short tutorial. In the second half of the class, students will perform data analysis for their mini-experiment and prepare for the project presentation on the last day.
5. 8/16 (Fri) 2-5pm: Project presentation

Recommended Readings:

Chan, A. B., & Hsiao, J. H. (2018). EMHMM Simulation Study. http://arxiv.org/abs/1810.07435

Chan, C. Y. H., Chan, A. B., Lee, T. M. C., & Hsiao, J. H. (2018). Eye movement patterns in face recognition are associated with cognitive decline in older adults. *Psychonomic Bulletin & Review*, *25*(6), 2200-2207.

Chan, C. Y. H., Wong, J. J., Chan, A. B., Lee, T. M. C., & Hsiao, J. H. (2016). Analytic eye movement patterns in face recognition are associated with better performance

and more top-down control of visual attention: an fMRI study. *Proceeding of the 38th Annual Conference of the Cognitive Science Society* (pp. 854-859).

Chuk, T., Chan, A. B., & Hsiao, J. H. (2014). Understanding eye movements in face recognition using hidden Markov models. *J. Vis.*, *14*(11):8, 1-14.

Chuk, T., Chan, A. B., & Hsiao, J. H. (2017). Is having similar eye movement patterns during face learning and recognition beneficial for recognition performance? Evidence from hidden Markov modeling. *Vision Research*, *141*, 204-216

Chuk, T., Chan, A. B., Shimojo, S., & Hsiao, J. H. (2016). Mind reading: Discovering individual preferences from eye movements using switch hidden Markov models. *Proceeding of the 38th Annual Conference of the Cognitive Science Society* (pp. 182-187).

Chuk, T., Crookes, K., Hayward, W. G., Chan, A. B., & Hsiao, J. H. (2017). Hidden Markov model analysis reveals the advantage of analytic eye movement patterns in face recognition across cultures. *Cognition*, *169*, 120-117.

Hsiao, J. H., Chan, K. Y., Du, Y. & Chan, A. B. (2019). Understanding individual differences in eye movement pattern during scene perception through hidden Markov modeling. *Proceeding of the 41th Annual Conference of the Cognitive Science Society*

Zhang, J., Chan, A. B., Lau, E. Y. Y., & Hsiao, J. H. (2019). Individuals with insomnia misrecognize angry faces as fearful faces while missing the eyes: An eye-tracking study. *Sleep*, *42*(2), zsy220.

Instructor Information

Antoni Chan is a world-leading expert in probabilistic models for time series data analysis and pattern recognition. He has published in several high-profile machine learning and computer vision journals, including *IEEE Trans. on Pattern Analysis and Machine Intelligence* and *the Journal of Machine Learning Research*. He is currently a Senior Area Editor for *IEEE Signal Processing Letters*, and served as an Area Chair for ICCV'15, '17, and '19.

Janet Hsiao is a world-leading expert in using eye tracking and computational modeling methods to understand human cognition. She has published in several high-profile cognitive science journals including *Psychological Science* and *Cognition*. She is currently an Associate Editor for *Cognitive Science*, and has served on the Program Committee for the annual meetings of the Cognitive Science Society since 2016.