Detect User Confusion using Eye Tracker and Machine Learning Methods

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Abstract

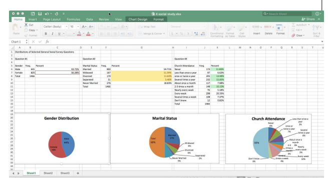
Confusion is known to hinder user experience. Many researchers leverage eye tracker to discover the mental process conveyed by eye movements. This project explores the possibility of using machine learning methods to find the patterns of confusion using eye tracking, and hope to answer the question: Can eye movement reveal confusion? If so, what eye movement features are the best indicator of confusion? The hypothesis of this project is that these two patterns are possible confusion predictors: the concentration of gaze and fixation points on areas of the interface and the relative positions between the cursor and gaze points. An experiment simulating a social study is designed to collect participants' eye data. Two versions of feature data are generated: the Euclidean distances of gaze, fixation, and cursor position and the standard deviation of gaze, fixation, and cursor position in a five-second windows. A 60% to 40% data split training is used. A K-Nearest Neighbor model classifies the first feature set with 60% of accuracy with kappa statistics of 0.14. The KStar model classifies the second feature set with 53.5117% of classification accuracy with kappa statistics of 0.07. Both models are not significant enough to produce meaningful result.

Background

Eye tracking is a research technique for the researcher to understand where and when one is seeing and how one shift the gaze from one place to another[1]. Many researchers use eye tracker to conduct usability research to make users less confused. Lalle et al. found that the model built from Random Forest can predict confusion based gaze features[4]. Mouse activities are also found to predict confusion[5]. When performing visual search, users will backtrace missing items in the menu[2] and leads to a denser distribution of gaze. When users feel uncertain when using a software, they tend to fixation for a longer period[3]. Based on these work, a gaze and cursor based feature may predict confusion .

Experiment Design

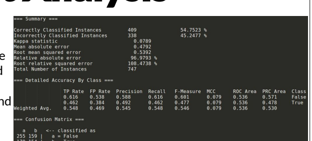
I designed eight tasks divided into small executable steps to simulate the data processing in a social study. The aim is to collect the gaze, fixation, and cursor data when subjects get confused. A GazePoint GP3 eye tracker is used for the experiment.Subjects perform calibration before the experiment. They verbally reports confusion when they cannot find the location of buttons in a correct sequence when performing assigned. I time the steps of each task and label the time interval as confusion if receiving report. Then data is collected after the experiment

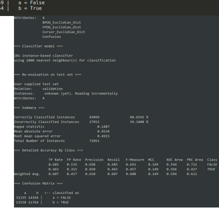


Method and Result Analysis

Ten participants joined this study. Only data from 8 subjects are used due to lost data. A data processor is written using Python to generate Feature Set 1 using time intervals and eye tracker generated data using a 5 second window. Feature Set 2 is made by manually labeling the eye tracker generated data. Both feature sets use the x and y coordinate data of gaze, fixation, and cursor position. Feature Set 1 uses the squared sum of the standard deviation of the x and y coordinate of the selected features. Feature Set 2 use the euclidean distance from the top left corner of the screen.

I applied IBk algorithm on Feature Set 1 and K* algorithm on Feature Set 2. Both algorithms are provided in WEKA. The classification accuracy using K* on Feature Set 1 is 57% with kappa statistics of 0.7. The classification accuracy using IBk on the Feature Set 2 is 60% with kappa statistics of 0.14. Although the IBk model is better than the K* model, the low kappa statistics of both models indicates that both models are insignificant.





Conclusion and Future Work

No significant result has been found in the time span of this project. Eye tracking data were collected and analyzed. Two feature sets are generated to train models to recognize confusion. The best performing model is built by the IBk algorithm, which reached 60 of classification accuracy and kappa statistics of 0.14. Since kappa statistics is too low to be meaningful, I conclude that the model has no sufficient accuracy to predict confusion.Since no real meaningful result is found in this project, I need to work on additional features, update the experiment method, and improve the data processing.

References

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