Exploring Users' Perceived Activities in a Sketch-based Intelligent Tutoring System Through Eye Movement Data

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1 Introduction

Intelligent tutoring systems (ITS) empower instructors to make teaching more engaging by providing a platform to tutor, deliver learning material, and to assess students' progress. Despite the advantages, existing ITS do not automatically assess how students engage in problem solving? How do they perceive various activities? and How much time they spend on each activity leading to the solution? In this research, we present an eye tracking framework that, based on eye movement data, can assess students' perceived activities and overall engagement in a sketch based Intelligent tutoring system, "Mechanix" [Valentine et al. 2012]. Based on an evaluation involving 21 participants, we present the key eye movement features, and demonstrate the potential of leveraging eye movement data to recognize students' perceived activities, "reading, gazing at an image, and problem solving," with an accuracy of 97.12%.

Keywords: Intelligent tutoring systems; Eye tracking; Perception

Concepts: •**Computing methodologies** → **Perception;**

2 Background and Experiment Design

Mechanix is a sketch-based ITS; it allows students to solve static problems by drawing planar truss and free body diagrams. Mechanix automatically evaluates a student's solution against a hand-drawn answer provided by the instructor. The interface of Mechanix is shown in Figure 1. We designed an experiment to investigate the use of eye movement data for classifying users' on-screen activities. We incorporated an eye tracking framework into Mechanix, enabling it to track and record eye movement data as the users solve truss problems. We used "The Eyetribe" tracker at 30 Hz to track users' gaze. The experiment involved 21 participants with ages varying from 22 to 30 years (μ=25). Each user solved three truss problems during the experiment. As shown in Table 1, while solving a problem a user engages in broadly three different activities, and each gaze data point was labelled as one of the three activities, based on the panel in which it was located. In total, we received gaze data from 63 trials, of which 58 were valid.

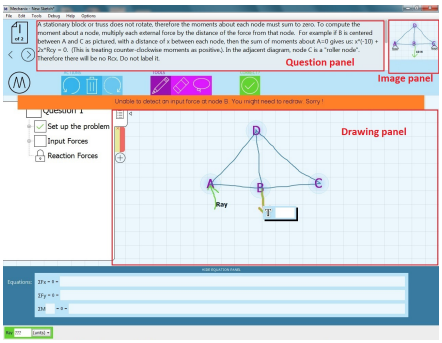

Figure 1: *Mechanix Interface*

Table 1: *Panels on Mechanix and the associated activities*

Panel	Activity
Reading Panel	The user is reading the question
Image Panel	The user is gazing at the reference image
Drawing Panel	The user is solving the problem by sketching and visually analyzing the sketch

3 Data Analysis, Results, and Conclusion

To compute feature values, we clustered the data points into two sets: 1) Fixation set, and 2) Saccade set. A *fixation set* is formed by consecutive fixation points, and a *saccade set* is formed by consecutive saccade points. Based on these two sets, for each activity (table 1), we computed five feature values: 1) Mean Fixation Distance (MFD), 2) Mean Saccade Distance (MSD), 3) FixationSpeedX, 4) SaccadeSpeedX, and 5) DilationSpeed. Furthermore, we removed highly *correlated* features, and performed *Recursive Feature Elimination* to find the minimal set of features. We found that MFD and MSD achieve a fairly high accuracy in classifying the activities. *MFD* is the average distance between two consecutive fixation points; *MSD* is the average distance between two consecutive saccade points. Lastly, we performed 10 fold cross validation to measure the accuracy on the same dataset, but with multiple classification models, by using only MFD and MSD as the features. **RandomForest classifier** achieved the highest accuracy **97.12%** with an f-measure of **0.97**. Classification accuracies of other models are: *Multi-class Classifier 96.55%, J48 96.55%, and NaiveBayes 95.98%*. In conclusion, an ability to accurately recognize students' perceived activities in a sketch-based ITS (Mechanix), using a minimal number of features, provides an opportunity to transform ITS into more adaptive agents for contextual assistance. Furthermore, we hypothesize that features MFD and MSD are independent of the target application and the layout of interface elements in recognizing users' activities. Hence, to test our hypothesis, we need to conduct further experiments on multiple sketch-based ITS.

References

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