Evaluation of a Finger-Motion Adaptive Algorithm through Human Subjects Testing

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Introduction

Braille reading is a complex process involving finger-rubbing actions across Braille letters for the stimulation of appropriate nerves, and intricate finger-motion patterns across the letters both from left to right and right to left. The right-to-left movement of the finger, known as “reversal,” is crucial as it not only enhances stimulation of nerves for correctly reading the letters, but it also allows one to re-read the letters that were missed in the first pass. In this poster, we report experimental results on the feasibility of an algorithm that can render a machine to automatically adapt to reversal gestures of one’s finger. Through Braille-reading-analogous tasks, the algorithm is tested with thirty sighted subjects that volunteered in the study with signed consent under approved IRB. We find that in the presence of the finger motion adaptive algorithm (FMAA), subjects’ performance metrics associated with the tasks have significantly improved as supported by statistical analysis, showing strong promise for the transition of the algorithm to Braille reading devices.

Method

FMAA is inspired by the frequently changing finger dynamics of visually impaired people during Braille reading. Mechanical and digital experimental setups used to test the algorithm are shown in the picture below.

To maintain the connection of this study with Braille reading, Braille-analogous tasks were designed requiring sighted subjects to perform certain “tracking” activities by interacting with the machine/device with their fingers at speeds consistent with Braille reading. The performance metrics in the tasks were chosen as the percentage of accomplished tasks in a given time, and accuracy.

In experiments with the mechanical device, subjects are asked to track some curves drawn on a paper wrapped around a disc that either rotates at a constant speed or at speeds adaptive to the subject’s horizontal finger motion. The same task is also presented to subjects using a touch screen, which provided us to record subjects’ finger motions.

Results

Experiments with Mechanical Setup

In the experiments with the mechanical setup, subjects performed better in the presence of FMAA. Curve coverage percentage for different experimental conditions and NASA TLX results are presented in the picture below. Statistical analysis showed significant difference between curve coverage percentages, which was higher in the presence of FMAA. In the pictures, NAA stands for the experiment where FMAA was inactive, and AA stands for the experiments with FMAA.

Experiments with Touchscreen

In the experiments with the touchscreen, subjects are asked to complete the tasks in 4 different experimental conditions: FMAA inactive (NAA), FMAA active (AA), FMAA active at increased speed (AA+), and FMAA inactive at increased speed (NAA+). Here, in order to calculate subjects’ performance in terms of the curve coverage percentage and accuracy, nearest search algorithm is used to find the points on the actual curve that are the closest to the path tracked by the finger (see above figure).

Experimental results for curve coverage, accuracy and NASA TLX surveys are presented below. Results indicate that subjects performed significantly better in AA+ when compared to other conditions.

Future Work

- Human subjects testing of FMAA with visually impaired people
- Tuning of FMAA for efficient Braille reading

References


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2. Mechanical and Industrial Engineering Department