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Design and Evaluation of Model-based Optimized Touchscreen Keyboard for Older Adults with Dyslexia

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INTRODUCTION

In this work, we focus on developing touchscreen text-entry interfaces, specifically focusing on finding the optimal touchscreen keyboard interface which can capture variation among the older adults with dyslexia. The major contributions of this work are: (1) development of a design space for text-entry interfaces, (2) design and initial evaluation (including model-based simulation) of the keyboard interface suitable for older adults having dyslexia, and (3) observe the effect of the proposed keyboard on able-bodied older adults' performance compare to the QWERTY layout. In a broader sense, our work serves as an initial attempt to build a psychological foundation that could support the touchscreen text-entry interface design.

TOUCHSCREEN KEYBOARD DESIGN APPROACH

This work leverages model-based UI optimization approach to design ability-based interfaces ([1]). Application to ability-based design critically builds upon the formulation of objective functions in such a way that individual differences in sensorimotor abilities can be expressed as part of the model parameters which defines the objective function. We explored the framework proposed by Sarcar et al. [1] to express individual differences as parameters of a simulation-based cognitive model (parametric approach). This work further extends ability-based design and modelling approaches (first implemented by Gajos et al. [2] to capture text input performance difference due to variable abilities (e.g., tremor or reading difficulty).

The parametric model-based interface optimization approach leveraged here has five steps: (1) defining design space and objective function, (2) building a parametrizable predictive model of user behavior, including strategy adaptation, (3) acquiring parameters to describe abilities of a user group, (4) constructing an efficient combinatorial approach to solve the task and (5) testing the robustness of the design to differing assumptions (e.g., change in parameters or task).

USER EXPERIMENT AND PRELIMINARY RESULTS

To judge the efficacy of the proposed layout, we conducted real text typing experiment with four older adults. We conducted main text transcription tasks with two keyboards: baseline QWERTY and proposed keyboard. We recorded each action details of the transcription task through an event log and extracted typing speed (in words per minute) and error rate (calculated as Minimum String Distance (MSD)). We collected subjective impressions from the participants about the experiments through short discussions with them after the study.

The preliminary study results showed that the average text entry rate was significantly lower for the proposed layout (3.98 WPM) compared to the QWERTY (6.75 WPM), in case of dyslexic older adult participants. Also, the average total error rate for them was not much higher for QWERTY (29.75%) than the proposed layout (7.48%).

Dyslexic participants expressed positive feeling about the proposed interface: P1 said "*I spent less time in correcting the wrongly typed word from the prediction list of the non-QWERTY layout as after typing 1-2 characters, the correct word appeared in the prediction list and then I found and selected it right away. Of course I know that I will not get much benefit for a shorter-length word, but as per the experiment, I usually made mistake in the longer-length words.*" Overall, for both the participants, the addition of more candidate words in the prediction list, bigger sized character, and prediction list word buttons, and color changes based on typed character chunks affected their text input performances.

FUTURE WORK

In the future, we will conduct experiments with older adults having reading disabilities and from the results (1) tune the model parameters using the inverse modelling [40] approach, (2) incorporate more design parameters (from Table 1) in exploring the design space and (3) perform a study for 5 days with both able-bodied and impaired older adults to observe their learning effects while using the proposed and QWERTY keyboard layouts. We yet focus on understanding the efficacy of computationally designed interfaces, compared to traditionally designed user interfaces and this will be a demanding future direction.

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