SIGCHI Outstanding Dissertation Award: Assignment Problems for Optimizing Text Input

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ABSTRACT

Text input methods are an integral part of our daily interaction with digital devices. However, their design poses a complex problem: for any method, we must decide which input action (a button press, a hand gesture, etc.) produces which symbol (e.g., a character or word). With only 26 symbols and input actions, there are already more than 10^{26} distinct solutions, making it impossible to find the best one through manual design. Prior work has shown that we can use optimization methods to search such large design spaces efficiently and automatically find a good user interface with respect to the given objectives [6]. However, work in the text entry domain has been limited mostly to the performance optimization of (soft-)keyboards (see [2] for an overview). The Ph.D. thesis [2] advances the field of text-entry optimization by enlarging the space of optimizable text-input methods and proposing new criteria for assessing their optimality. Firstly, the design problem is formulated as an assignment problem for integer programming. This enables the use of standard mathematical solvers and algorithms for efficiently finding good solutions. Then, objective functions are developed, for assessing their optimality with respect to motor performance, ergonomics, and learnability. The corresponding models extend beyond interaction with soft keyboards, to consider multi-finger input,

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novel sensors, and alternative form factors. In addition, the thesis illustrates how to formulate models from prior work in terms of an assignment problem, providing a coherent theoretical basis for text-entry optimization. The proposed objectives are applied in the optimization of three assignment problems: text input with multi-finger gestures in mid-air [8], text input on a long piano keyboard [4], and – for a contribution to the official French keyboard standard – input of special characters via a physical keyboard [3]. Combining the proposed models offers a multi-objective optimization approach able to capture the complex cognitive and motor processes during typing. Finally, the dissertation discusses future work that is needed to solve the long-standing problem of finding the optimal layout for physical keyboards, in light of empirical evidence that prior models are insufficient to respond to the diverse typing strategies people employ with modern keyboards [1, 5]. In summary, the thesis advances the state of the art in text-entry optimization by proposing novel objective functions that quantify the performance, ergonomics and learnability of a text input method. The objectives presented are formulated as assignment problems, which can be solved with integer programming via standard mathematical solvers or heuristic algorithms. While the work focused on text input, the assignment problem can be used to model other design problems in HCI (e.g., how best to assign commands to UI controls or distribute UI elements across several devices [7]), for which the same problem formulations, optimization techniques, and even models could be applied.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; *Keyboards*; *HCI theory, concepts and models*; • **Applied computing** → *Multi-criterion optimization and decision-making*.

KEYWORDS

Computational interaction, optimization, text entry

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SPEAKER'S BIO

Anna Maria Feit is a postdoctoral researcher at ETH Zurich interested in the area of computational interaction. Her research focuses on the use of computational optimization methods to design and adapt user interfaces, making use of techniques from operations research, machine learning, and mathematical modeling. Among other interfaces, she is particularly interested in text input methods and has conducted many studies to better understand how people type. Her Ph.D. work formed an important contribution to the development of the French keyboard standard to-be-released in 2019

and changed our understanding of modern typing behavior. Anna has published several papers at CHI, DIS, and TOCHI which received two honorable mentions from CHI. Her work was featured many times in TV shows and radio programs, as well as large newspapers and online magazines (the Guardian, Washington Post, among others). She was a teacher at the ACM Summer School on Computational Interaction (2015, 2017) which she also organized in 2016. She has served on the MobileHCI Program Committee and is a frequent reviewer for SIGCHI and other conferences and journals. Anna has received her Ph.D. in 2018 from Aalto University, Helsinki, where she worked with Antti Oulasvirta in the User Interfaces group. She also holds an M.Sc. and B.Sc. in Computer Science from Saarland University, Germany.

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