Effortless Tool-based Evaluation of Web Form Filling Tasks using Keystroke Level Model and Fitts Law

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Abstract
Usability of interactive web forms is a critical aspect of the overall user experience. In this paper, a tool to automatically evaluate web form filling tasks is presented. The tool carries out Keystroke Level Model symbolic calculations of the time required to fill a specific web form in a straightforward and automatic manner. Moreover, it calculates the form completion time according to different interaction strategies or users' characteristics. In addition, Fitts' law is computationally realized to calculate the exact time required to move the cursor to the form elements. Preliminary case studies illustrated the tool capability to support both designers and evaluators in an efficient and effective manner.

Author Keywords
Web form design; task efficiency; automated tool; task modeling; Keystroke Level Model; Fitts' law.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): Miscellaneous; H5.4 Information interfaces and presentation (e.g., HCI): Hypertext/Hypermedia.

Introduction

Filling forms is a common and frequent task in web interaction. Thus, designing web forms that enhance users' efficiency is an important task. Existing knowledge and guidelines have mainly derived from experimental studies comparing alternative designs and usability experts' experience or observations. For instance, both the form layout and the type of elements used significantly affect the users' performance [1].

However, there are still many design inconsistencies and open questions related to web form design. Moreover, one may argue that theoretically-based approaches have had a limited impact on the on-line form design practices. Unlike desktop [13] or mobile interfaces [11, 12], GOMS [2] and its simplified version Keystroke-Level Model (KLM) [2], have been rarely used to guide web form design or evaluation.

In addition, KLM modeling without taking into account factors such as fields' position on the form layout may provide superficial results. For instance, interaction with a dropdown menu theoretically takes longer than interaction with radio buttons, mainly because of an additional point and click needed to open the dropdown menu. However, in one study the latter hypothesis was confirmed [4] and in another it was rejected [5].

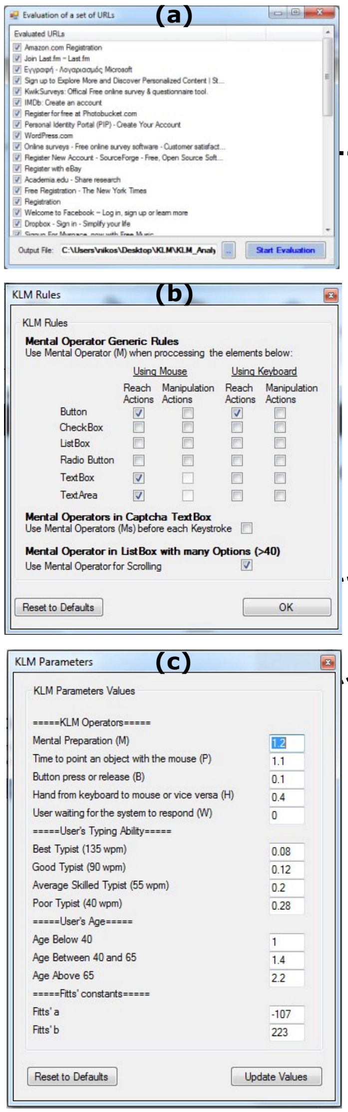
The aforementioned ascertainments illustrate the need to bridge HCI models such as KLM and knowledge derived by previous studies and practitioners' experience with suitable design and evaluation tools. To this end, CogTool [7] can produce quantitative, model-based predictions of skilled performance time from tasks demonstrated on storyboard mockups of a user interface. CogTool-Explorer [14] builds upon CogTool to predict a user's goal-directed exploratory interaction with a website.

Current modeling tools require non-trivial manual work to examine forms. In addition, if a large scale summative evaluation is needed, the evaluator has to repeat the same process without any particular assistance. Furthemore, the plethora of available functions and generic modeling nature of existing tools can overwhelm and discourage practitioners who, in most cases, need a simple tool focused on the problem at hand.

This work presents a novel tool, entitled KLM Form Analyzer (KLM-FA). KLM-FA extends the capabilities of existing modeling tools for practitioners by focusing specifically on automating the analysis of web forms. The tool functionality and usage is delineated in the next section. Then, two case studies demonstrating its usefulness both in formative and summative evaluation contexts are described.

The KLM Form Analyzer Tool

The main objective of KLM-FA (available at http://klmformanalyzer.weebly.com) is to support design and evaluation of web forms in an effective and efficient manner. The tool employs web parsing functionality, coupled with KLM and Fitts' modeling to calculate the time required to fill a web form according to different interaction strategies (e.g. using tab to move across the elements of the web form) or users' characteristics (e.g. age and typing expertise). Figure 1 presents the main interface and functionality of KLM-FA, and a typical usage scenario of the tool follows.



First, the evaluator inputs the URL of the web form to be evaluated, or selects a previously evaluated form. Next, the evaluator selects a set of analysis preferences related to the modeled user profile (typing ability, age), usage (or not) of Fitts' law in the calculations, and hypotheses about the interaction, such as initial cursor position and whether the user moves across form elements using the mouse or the keyboard. The evaluator can also assign a predefined field type to text elements (e.g. username, email) to easily specify their number of keystrokes. The tool provides an editable list of field types that covers most of the elements used. The default typical field entry lengths rely on empirical data available in the literature and a dataset of our own with 839 registered web users' personal data (Table 1).

Next, KLM-FA runs an algorithm which includes two modules: a) *form identifier*, and b) *form analyzer*. The *form identifier* parses the HTML DOM of the URL loaded in the internal browser and finds all forms. It filters out forms that cannot be eligible for analysis (hidden) and presents a "select form" dialogue if two or more forms are available. Then, it parses the selected form, identifies and stores visible fields in an internal object-list along with their properties such as type, size and position. Currently, it cannot identify fields when either Flash or AJAX is used. However, KLM-FA provides support to manually add fields and specify their properties in a straightforward manner (e.g. click on unidentified field registers its position and size).

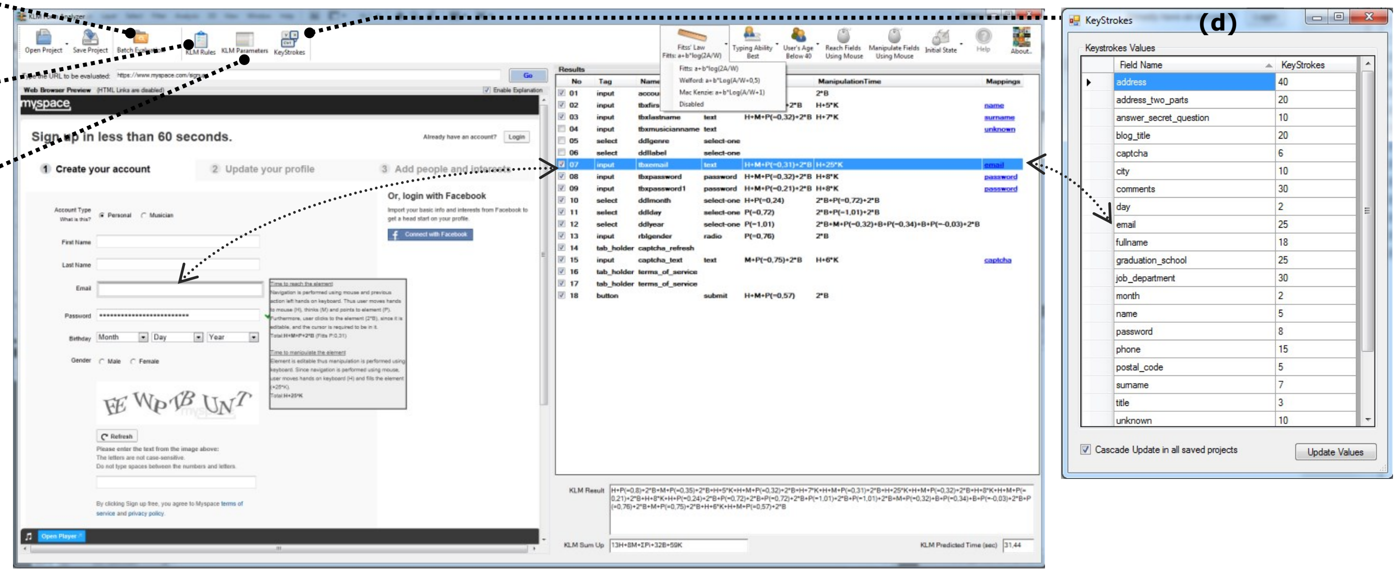


Figure 1. Overview of the KLM-FA interface and functionality: (a) Mass scale evaluation, (b) Analysis rules, (c) Analysis parameters values, (d) Extendable list of typical field types and assigned keystrokes

Field type (Length)	Source/Comment
City (10)	http://goo.gl/6uCoQ
Email(25)	http://goo.gl/8aw8n
Password (8)	Cazier & Medlin (2006)
Surname (7)	U.S. Census Bureau (USA surnames)
Year (4)	Fixed
Title (3)	Median of {Mr, Mrs, Miss, Ms, Dr, Rev, Sir, Lady, Lord, Dame, Prof}

Table 1. Extract of KLM-FA field types and default expected keystrokes. Assigned values rely on empirical data in the literature. Full list at the KLM-FA website.

	Mouse-based	Keyboard-based
Mean	33.64	23.25
SD	13.54	11.46
Min	14.12 (LinkedIn)	5.92 (LinkedIn)
Max	62.25 (Flickr)	46.48 (Google+)

Table 2. Average KLM-FA calculated completion times (in sec) for 16 signup forms of popular social networking websites (young user, good typist is assumed)

Subsequently, the *form analyzer* takes as input the fields' object-list, the evaluator's analysis preferences and a set of analysis parameters related to KLM and Fitts' law calculations. Based on empirical data [10, 15], the tool provides a set of default values for the analysis parameters (KLM operators, typing ability and age adjustments), which can be easily modified through appropriate dialogues. The MacKenzie-Shannon formula and constants [13] for the Fitts' law is the default selection for modeling pointing device movement time. However, given the lack of consensus on the Fitts' formula [3], the tool offers additional options (e.g. Welford's formulation [13]) and it is also easy to add further formulas or modify constants values.

For each field the *form analyzer* produces the sequence of required actions (KLM operators) to first reach it (ReachTime) and then manipulate it (ManipulationTime). This distinction enables flexible modeling of various user interaction strategies (e.g. tab-based navigation). Finally, the KLM-FA algorithm sums up the results of each analyzed element and produces a sequence of operators and the predicted form completion time for the provided analysis preferences and parameters.

The output of the tool is an interactive web form preview synchronized with a results list: when an element is selected in the web form preview it is highlighted in the results list and vice versa. Depending on the evaluation scenario, any element can be excluded from the analysis. To this end, one can uncheck it from the results list and the tool updates the calculations in real time. Furthermore, KLM-FA provides an option that elaborates the underlying KLM calculations for each element (tooltip in Figure 1). In this way, the user of the tool can trace step-by-step the KLM modeling analysis by simply selecting the sequence of the form elements either in the web preview or in the list.

Each evaluated form can be saved and/or subsequently modified. In addition, KLM-FA can employ mass scale summative evaluations by selecting a set of saved projects (Figure 1-a). Then, the tool runs an analysis of all the selected forms using the same settings for all projects and saves the results in an XML file.

Experience using KLM-FA: Two Case Studies

Two case studies dealing with design and evaluation issues in signup web forms demonstrated the usefulness of our tool. In both studies, the following assumptions were held constant: a) the user's hand began on the mouse and the cursor's initial position was at the upper–left corner of the webpage, b) the user was a good typist and aged below 40, c) system response time was negligible, d) tool defaults for all analysis parameters (e.g. field entry lengths) were used, e) Fitts' law calculations were enabled in KLM-FA.

Benchmarking web forms

Signup forms are meant to collect data required for user authentication and information related to marketing or other business goals. However, they should not require too much time to complete, as this may discourage users from registering to the website. A key question in this context is what is a "good" time for completing a sign-up form? Of course, the answer largely depends on the website domain and goals.

KLM-FA was used to provide an answer to this question in the context of social networking websites. A KLM expert unfamiliar with our tool used it to produce

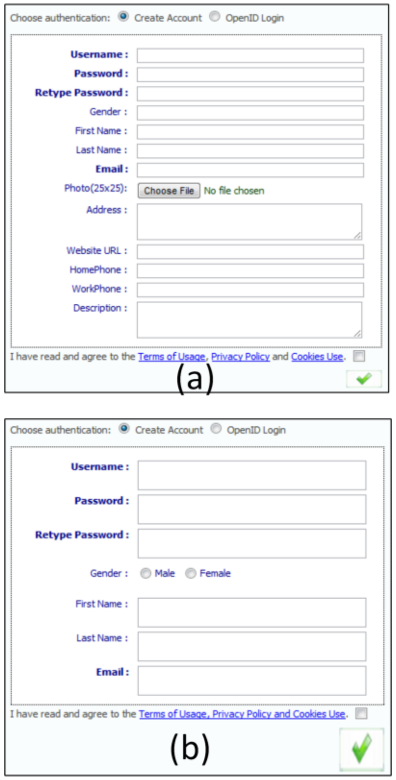


Figure 2. The signup form of a Web-based computer-supported collaborative learning service: (a) Original form, (b) Redesigned form using KLM-FA. In sum, the webmaster chose to reduce the total number of elements, increase the dimensions of some elements, replace a textbox with radio buttons, and use one link for the terms and conditions instead of three.

benchmark data by calculating the completion time for 16 signup forms of popular social networking websites (Table 2). The process required approximately 30 minutes, less than two minutes per evaluated form.

Given such benchmark data, one can then convert task completion times for her specific form, either calculated with KLM-FA or measured through user testing, into percentile ranks and make meaningful comparisons or set data-driven usability goals. Furthermore, additional benchmark data adapted to various user profiles (e.g. elderly users, poor typists), can be instantly produced using the tool batch evaluation functionality.

Supporting decisions during web form redesign
In this case study, the signup form of a web-based computer-supported collaborative learning service (Figure 2-a) was redesigned. The webmaster of the service was provided with KLM-FA and was asked to make changes that would improve users' signup time. He had no previous experience with HCI models or our tool. An observer took notes about his actions and performed a brief semi-structured interview at the end of the session to get his views on the tool.

The webmaster experimented with changes in the total number of fields, in fields' dimensions and tried design alternatives (e.g. radio buttons instead of textbox, one link for terms and conditions instead of three). Figure 2-b shows the redesigned form that he proposed after using KLM-FA. The new design resulted in a decrease in the KLM-FA calculated signup time of 55.8% for mouse-based (from 60.02 to 26.53 sec) and 60.6% for keyboard-based interaction (from 31.48 to 12.40 sec).

In the interview, the webmaster reported that the tool "was intuitive and easy to use" and that it can be a "valuable asset to effective form design". He also provided insight on both improving current functionality (e.g. project handling) and adding new one (e.g. drag-and-drop movement of fields updates results).

Conclusion

While there are other excellent general modeling tools such as CogTool [7], KLM-FA is characterized by increased simplicity and automation. By focusing on web form design and evaluation, KLM-FA minimizes the required effort, thus increasing the chances of its adoption in actual practice. As a result, practitioners can rapidly evaluate alternative web form design approaches using a variety of scenarios.

Moreover, KLM-FA can also be helpful in the KLM research area as a massive analysis tool that can produce benchmark data of form completion times for specific web domains. Finally, educators who attempt to teach KLM concepts to their audience are expected to be benefited as well. The tool enables the step-by-step tracing of the modeling and can aid students in understanding the entire process through examples.

Investigating the effect of KLM-FA adoption on the learning outcome, while educating students in KLM, constitutes a future research goal. In addition, we plan to conduct studies that compare KLM-FA form completion predictions with user testing data. Additional future research goals are to carry out mass scale summative evaluations for various web site domains and incorporate enriched models of KLM and Fitts' law by taking into account additional operators [6] or stochastic models of errors [16].

Despite the advantages of the presented automated approach, it only addresses task efficiency which is one aspect of the web user experience. Other tools that automate different aspects of web design are also available [8, 9]. However, all such approaches should be used in conjunction with user-based methods.

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