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APPLYING HUMAN FACTORS ENGINEERING TO IMPROVE USABILITY AND WORKFLOW IN PATHOLOGY INFORMATICS

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Abstract

Human factors engineering is an underutilized approach in the design, evaluation, and implementation of health information technology. Heuristic evaluation of the usability of an interface is a ‘low-hanging fruit’ for identifying a set of relatively simple modifications to a software program that can make software easier to use. In this paper, we describe recommendations to improve the usability of a software package used to view digitized images of tissues by pathologists. Several recommendations were immediately implemented, and others are planned for future releases. The changes are anticipated to be more compatible with user expectations from interacting with similar elements in other packages, and thus easier to learn and use.

INTRODUCTION

Human factors engineering has been identified as an underutilized approach in the design, evaluation, and implementation of health information technology in general, and informatics software for treating cancer patients in particular. Heuristic evaluation of the usability of an interface is a ‘low-hanging fruit’ for identifying a set of relatively simple modifications to a software program that can make software easier to use.

In this paper, we describe recommendations stemming from applying human factors engineering to improve the usability of a software package used to view digitized images of tissues by pathologists. In March, 2016 these recommendations were presented to the software team in a series of teleconference meetings. Many of these recommendations are planned for incorporation during planned updates of other functionality over the next few years. The changes are anticipated to be more compatible with user expectations from interacting with similar elements in other packages, and thus easier to learn and use.

METHODS

In this effort, two use cases were used to identify opportunities to streamline the routine workflow: 1) viewing two images at once to identify changes over time for a patient, and 2) changing the magnification of an image to inspect trouble spots in detail. Next, a heuristic evaluation by two reviewers was conducted of all of the toolbars on the interface.

FINDINGS

For the first use case, a pathologist is identifying changes over time in the proportion of indicators of cancers, such as neuroblasts, by viewing two images from the same patient at once. In Figure 1, the typical configuration for accomplishing this task is displayed. The navigation mechanism is clicking the two selected images on the left of the large display, and the ordering of the two images (top and bottom) is determined based upon alphabetical sorting of the image file name. With this configuration, only one image can be viewed at once. There is an option for a horizontal layout within the software where the two images can be viewed at once. In order to streamline workflow for this common use case, recommendations were:

1. Automatically open with the horizontal layout view when two image files are selected for viewing as the default configuration
2. Add “File... Compare” menu selection where two image files are selected in a pop-up button after selecting the menu item that are then viewed in a horizontal configuration
3. Open the layout configuration to the last configuration which the user had selected as a default option

For the second use case, a pathologist would be analyzing one image in detail, such as in order to grade the severity of a diagnosed cancer such as follicular lymphoma. He or she would typically look at the ‘big picture’, then ‘zoom in’ to inspect a trouble spot in detail and then ‘zoom out’ in order to identify another area in which to inspect in more detail. In Figure 2, the typical configuration for accomplishing this task is displayed. In order to streamline workflow for this common use case, the primary recommendation was to have consistent ‘zoom’ interaction mechanisms across all aspects of the interface. For example, ‘zoom by dragging’ was able to be used in layered and tabbed configurations, but not with the vertical or horizontal view of an image. Therefore, having ‘zoom by dragging’ in all configurations was recommended.

Next, a heuristic evaluation by two reviewers was conducted of all of the toolbars (labeled View, File, Zoom, Tools, Overlay Shapes) and menu items. Heuristic evaluations are typically the lowest cost usability evaluation method, where a human factors or usability expert examines the interface based upon recognized usability principles. These principles are often referred to as ‘heuristics’, and a set of heuristics that are particularly applicable for health information technology are described by Wiklund and Weinger (2015). This list synthesizes similar heuristics described in Holzinger (2005), Shneiderman (1992), and Zhang and Walji (2011). The heuristics are:

- **Content Organization:** The configuration (physical arrangement, order of presentation) of information (e.g., text, graphics, charts, tables) within a screen and the degree to which it facilitates information acquisition, data entry, and control tasks.
- **Navigation:** The clarity and efficiency of movement among an application's various screens.
- **Nomenclature:** The use of familiar terms for the intended users.
- **Visual Design:** The use of graphics, color, typography, layout, and other visual elements to facilitate information acquisition, draw attention to important information, and optimize the aesthetic appeal of onscreen content.
- **Error Prevention:** Design characteristics that protect users from committing use and/or safety errors.
- **Error Recovery:** Design characteristics that help users detect and recover from use and/or safety errors, giving users a chance to check their actions and make necessary corrections before the error becomes consequential.
- **Feedback:** Indications that a user action is required, and/or information that a user action has been accepted/submitted, or otherwise is in progress. Feedback from an EHR may take visual and/or auditory forms.
- **Status Indication:** Information about system processes and progress (e.g., search is being undertaken, document is being downloaded, print job is being sent to printer), or clinical processes and progress (e.g., order status, pending tasks).
- **Internal Consistency:** The EHR employs a common set of design rules and behaviors that enable users to apply lessons learned about performing a given task with the EHR to other tasks within the EHR.
- **External Consistency:** An EHR employs a set of design rules and behaviors that are consistent with EHRs and other EHRs and software products with which a user might be familiar, such as business applications, websites, medical devices, and consumer products.
- **User Support:** The use of user interface features such as headings, prompts, alerts, tool-tips, reminders, and online help to guide users' interactions with the EHR.
- **Support for clinical decision making:** The EHR provides information necessary to make proper medical decisions and choices at the right time.
- **Affordances:** Information contained within the design element informs actions that can be undertaken with the element (e.g., "buttons" that afford pushing, accordion chevrons that afford expanding and collapsing).

- **Customizability:** Opportunities for users to adjust certain EHR characteristics (e.g., available functions, information configurations, degree of prompting) to suit their personal needs and preferences.
- **Workflow:** The efficiency with which users can perform overall EHR-related tasks, which may occur in parallel or in series with interactions involving other equipment and personnel, and the degree to which it matches users' preferred task order and established mental models.

Based upon the heuristic review, more than thirty recommendations were made for change regarding:

- Following conventions for placement of the 'close' box in the upper right of dialog boxes, use of 'gray' when a function is not available, and avoiding changes to settings when using 'toggle' across images
- Consistent placement of the company logo throughout the interface
- Moving icons needed for zooming from the View Toolbar to the Zoom Toolbar
- Eliminating a pop-up dialog box which asks users to confirm sorting files alphabetically
- Changing the default for sorting to date (newest first) from alphabetical
- Enabling clicking column titles to sort files

One recommendation was made to improve patient safety by reducing the opportunity for a 'wrong patient' error in analyzing an image:

- Automatically adding a patient identifier to screen shots in the NIST 7804-1 (Lowry et al., 2016) recommended format in the upper left hand corner of the image:

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A number of recommendations were made to the wording and icons for the toolbars and menu options. An example is that the image to the right was the icon used for "Tabbed Layout". Due to the possibility of it being confused with the notion of a folder, it was recommended to add one or more 'tabs' to the folder icon. Typically human factors engineers would recommend that a visual designer review icons and work with someone

with the expertise to redesign the icons, so the primary contribution was to identify icons and labels that might be confused with icons that are often used for standard purposes.

Recommendations to augment functionality to make the software more useful included:

- Add an option to save the output of applying an advanced algorithm to the image
- Add the ability to more easily select an algorithm to use advanced analytic capabilities on images
- Add the ability to group related advanced algorithms, particularly updates of the same algorithm
- Add the ability for the user and user's organization to 'gray out' algorithm options which 'crash' the system due to incompatibilities from failing to upgrade the algorithm's code to match software updates
- Make it clear to the user when the memory limit is being reached (typically about 12 images) and support removing images from the list.

DISCUSSION

Human factors engineering is an underutilized approach in the design, evaluation, and implementation of health information technology. In this paper, we used standard human factors approaches to identify use cases and recommendations to improve the ease of use, usability, and patient safety of a software product already on the market that is used to view

digitized images of tissues by pathologists. Several recommendations were immediately implemented, and others are planned for future releases. The changes are anticipated to be more compatible with user expectations from interacting with similar elements in other packages, and thus easier to learn and use.

In addition, cognitive task analysis can be employed to identify use cases for design and evaluation that appropriately represent the cognitive challenges of the domain. In addition to the traditional objectives of use cases of design, training, and validation studies, they also can inform the strategic selection of ‘leverage points’ to greatly increase the perceived usefulness of a particular technology. If use cases are assembled from modular components, then a ‘design seeds’ approach can be employed where components of a useful system can be adopted without needing to adopt a particular software package.

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Figure 1.
Typical configuration of displays for viewing two images at once

Figure 2.
Typical configuration for analyzing areas of one image in detail