

Horizon – Mobile Image Search Engine

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ABSTRACT

This paper introduces *Horizon*, a mobile, multi-platform image search engine with the capability to search for personal images across users' networked hardware, online storage, and social media. A user-centered design approach was followed in order to validate the usability of this application. Results of a simulated work task user test determined that the users succeeded in the primary functionalities of image search and storage. Filtering and query reformulation were less successful due to user's technical and domain expertise and prototype limitations.

Author Keywords

Search; image search; mobile; usability.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI); Miscellaneous.

General Terms

Human Factors; Design; Measurement.

1. INTRODUCTION

With the proliferation of smartphones and tablets, many users today own several devices in addition to desktop and notebook computers. In September of 2013, Pew [1] published a study on smartphone and tablet use amongst adult Americans confirming this trend. The study found that 56% of American adults own smartphone and 35% of Americans ages 16 and older own a tablet computer. As many of these devices contain image-capturing capabilities used more and more by users in lieu of traditional digital cameras [13], users are often left with multiple corpora of images stored across multiple devices. Image collections become further scattered when one considers images stored on social media or photo sharing sites like Facebook and Flickr. With no way to

search across all platforms and devices, finding an image requires looking through image collections on multiple devices and websites. Horizon eliminates this time consuming process by allowing users to sync multiple platforms and providing a single access point to personal collections. . Harnessing geolocation and social network data Horizon creates a social, content-aware and context-aware search interface for mobile users featuring faceted search, tagging, metadata, and recommendation functionalities.

The objective of this research is to evaluate the overall usability of the proposed Horizon mobile image search application by obtaining end-to-end understanding of its' use among university graduate students. Employing a simulated work task we tested the user's satisfaction, efficiency, and effectiveness in fulfilling an information need using the functionalities and affordances of *Horizon*. These functionalities and affordances include simple text image search, search by image, faceted search, filtered search, exploratory search, storing images on cloud (Horizon albums) along with metadata, zero results search, navigation and lastly the overall look and feel of the application. A detailed explanation of the Horizon design and testing phases has been given in Sections 3, 4 and 5.

2. MOTIVATION

Managing personal collections of digital photos is an increasingly difficult task. Over a period of time, digital acquisition of pictures has become easier and storage has become cheaper ; but, at the same time the methods of access and retrieval are limited. Moreover, personal images are stored across various platforms - online storage (e.g. - Picasa, Dropbox, iCloud), social media (e.g. - Facebook, flickr, Instagram) and personal devices (e.g. - iPad, SmartPhone, PC). The difficulty of accessing these pictures stored across various platforms is the prime motivation of this research. *Horizon* provides a single point of reference

for users accustomed to storing, sharing and generating images in diverse locations.

3. RELATED WORK

Several systems have been proposed in order to address the issue of storing, querying and managing digital collections. Lim et al. [2] proposed a framework for automatic organization of personal digital photos based on analysis of image creation timestamps and image contents to facilitate browsing and summarization of images. The strength of this paper was that it did not require the end users to always store pictures using meta-data. However, the focus was on pictures taken from digital cameras only.

In another system proposed by Hare et al. [3] the challenges for exploiting image meta-data were elaborated. The system was capable of organizing personal digital photo collections based on date/time and GPS location, which are believed to become a key organizational methodology over the next few years as consumer digital cameras evolve to incorporate GPS and as cameras in mobile phones spread further. Again in this system, there was no focus drawn to the fact that in today's world, personal image corpora is spread across many devices and media.

Hare et al. [4] also went on develop another system which went beyond the simple contextual information (date/time, GPS) derived from pictures to organize and retrieve them. In this system, content-based querying was supported.

“Caliph & Emir” [5] are a pair of prototypes allowing semantic annotation and retrieval of digital photos. This work addresses the issue of a growing necessity of generating, storing and visualizing additional meta-information about the content to allow semantic retrieval. At the same time, these prototypes do not focus upon the diversity of storage of the digital photos.

Google image search [10] which is a search service owned by Google and introduced in July 2001, allows users to search the Web for image content. The keywords for the image search are based on the

filename of the image, the link text pointing to the image, and text adjacent to the image. This apart, it also has provisions to search by image or voice. Again the restricted domain of search is the Web in this case.

Horizon incorporates aspects from many of these ideas. It supports context and content aware retrieval of pictures stored in diverse locations. Apart from supporting simple text queries that is dependent upon meta-information, it additionally allows retrieval of similar photographs using image search, exploiting technologies of face/content recognition; the highlighting feature of course being the single-point of access to images across media.

4. INTERFACE DESIGN

This section focuses on the features of *Horizon* and how it addresses the single-point access issue. It also discusses the approach used to design the prototype version of *Horizon*.

One of the objectives of designing the *Horizon* interface was to make it more usable. ‘User-Centered Design’ (UCD) [6] is a design process in which the end-users primarily influence how the design takes place. Figure 4.1 illustrates the various stages of a UCD. The sub-sections elaborate on how UCD was used to realize the design, keeping in account the main features of *Horizon*.

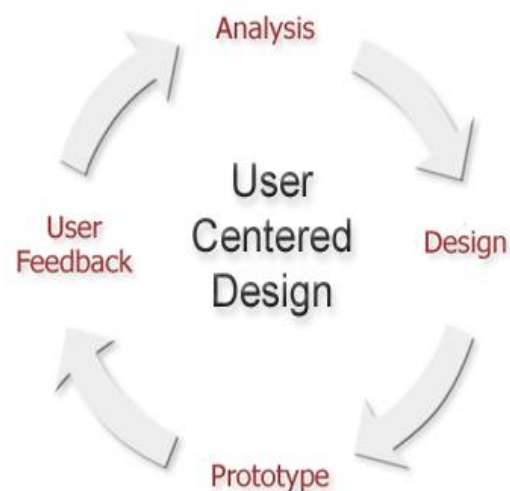


Figure 4.1 Stages of User-Centered Design

4.1. Analysis Phase

In the analysis phase, the target audience and the supported features of Horizon were realized keeping in mind the main purpose of the application.

4.1.1. Targeted Audience

Horizon's intended users are individuals who actively participate in the creation of digital content and maintain image libraries across multiple platforms. Ideal users own several devices such as an iPad, smartphone and point and shoot camera resulting in multiple image collections strewn across mobile and stationary devices. Additionally, ideal users participate frequently in pre-existing forms of image sharing and album creation such as Instagram and Facebook. Isolated albums created on sites like these further exacerbate the need for a comprehensive search tool. Horizon's capabilities are best exploited by users who have friends also engaged in these forms of image creation and sharing as it enables users to search across not only their image collections, but also friends' collections. Typical users of Horizon have relatively high domain knowledge; content driving the search is created by the user and the users' friends. Horizon's intended users also possess moderate to high technical skills and are adept at using current technologies and interfaces.

4.1.2. Supported Features

To begin with, a thorough understanding of designing a search experience on a mobile interface was obtained [7]. Mobile design solutions were kept in mind while designing the *Horizon* interface (a mobile application) which included points like having the search box within the navigation bar or the secondary toolbar, optionally having non textual input methods, viewing results with less text, options of query refining and reformulation, having minimal controls and yet serving all the necessary data on the single page.

Horizon supports a variety of search tasks [7] in a content and context-aware framework. It caters to the 'learn, lookup, investigate' philosophy of search that encapsulates exploratory search. The supported search

modes and patterns include that of Exploratory-Driven search (Explore-Analyze-Evaluate). Horizon's objective is to facilitate iterative search over multiple IR cycles in order to find the best match. It can be utilized both online and offline, across multiple platforms as mentioned earlier. With most of the pictures being shared, stored and generated via smartphones, Horizon was intended to be a mobile application.

Some of Horizon's highlighting search functionalities and supported features are listed below. These were formulated after investigating several design principles.

- Faceted Search; e.g: organize pictures depending upon categories (different sources/devices) / sub-categories (size, location, date). [8]
- General search of pictures based on meta-information - this can include picture desc tags (e.g: Halloween) / mood tags (e.g: happy) / date and time tags (e.g: Dec 31st midnight) / location tags (e.g: New York) (users are content creators; hence it is assumed that the database has searchable content).
- Search images similar to an image (e.g: if I have an image of a cat on my phone and want to find more images of cats).
- Ability to narrow results using combined text and image search, filters, sorting [7] [8]
- Query reformulation/refining in cases where search provides less / no results.
- Exploratory / serendipitous search using actionable description tags, people tags, location tags when describing a single result.
- Search across platforms by device integration over Horizon Cloud. For example, if I have an image stored on my desktop, to be able to search for it on my phone and add it to my Horizon collection that can be later accessed on my iPad.
- Recommendations by friends from friend circle - number of likes for pictures by friends on Facebook
- Information about a particular picture can be obtained - people tagged, mood tags, location, source of the picture, additional description.

4.2. Design Phase

In the design phase, low-fidelity mockups were designed using white-board, pen and paper to incorporate the different design elements, search functionalities and features. This phase required a lot of brainstorming and was an incremental process of including the key elements of design into Horizon. The different pages, navigation between pages and interactions were decided. The general look and feel of the prototype design was realized in this stage.

4.3. Prototype

The basic prototype design that was realized at the end of the previous stage was designed in this stage using Axure - an interactive wireframe solution and mockup tool [9]. It provided us the capability of generating an interactive HTML website wireframe without coding. Some of the screens of the prototype are shown in Figure 4.3.

4.4. User Feedback

After refining the prototype design to make it more user-friendly, the wireframe was evaluated by user testing. Section 5 gives a detailed description of the evaluation methodology used. The user feedback obtained as a result of this testing was significant in further improving the design.

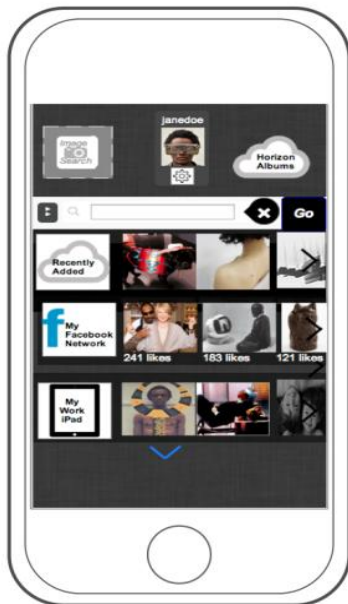


Figure 4.3 (a). Horizon Home Page

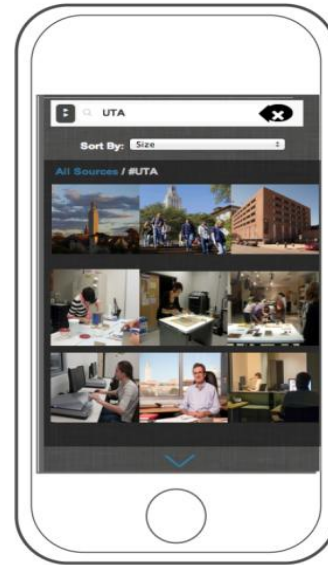


Figure 4.3 (b). Horizon Results Page



Figure 4.3 (c). Single Image – meta-information

5. EVALUATION

The objective of this research is to evaluate the overall usability of the proposed Horizon mobile image

search application by obtaining end-to-end understanding of its' use among university graduate students. The user-study designed to evaluate Horizon featured three components: a pre-test interview, work tasks and post-test interview using a convenience sampling of six University of Texas students. Each phase of the study was performed in "single-mode" as described by Kelly [11], to eliminate the influence one subject might impose on another. Additionally, different research team members were assigned to administer each phase of the study, reducing the possibility of the Hawthorne effect in which participants alter their behavior to please someone paying attention to them.

5.1 Pre-Test Interview

The pre-test interview consisted of nine questions intended to elicit necessary contextual measures from the users to determine individual differences and account for irregularities in performance. The questions focused around the participant's use of technology, specifically their familiarity with search applications, mobile devices and social networking. Users were asked about their experience with search applications advanced search features and image search as well as mobile device use, social media practices and photo management methods.

5.2 Simulated Work-Tasks

Participants were then directed to a computer where a separate research team member explained the testing process. A typed piece of paper containing the work tasks was given to each participant. Morae [12] mouse-tracking software was used to capture the participant's mouse movements throughout the tasks. Information from the Morae capture was used to determine performance measures such as efficiency, error rate and success. Researchers were instructed not to inference with the participant's performance or to help the participant in any manner. The main objective of the simulated work task was specified as *"You have been tasked with assembling a group of images to illustrate key aspects of your education at the University of Texas at Austin iSchool. The images will be circulated to potential employers to demonstrate the experiences, competencies, and strengths of our students. Please use*

the Horizon search interface to locate 8-10 images; then assemble and tag the images in a Horizon album."

The four work tasks given to the participants were as follows, each with increasing levels of difficulty.

Work Task 1:

- The main objective of this task is to get a feel of the application by observing the home page and navigating around as follows:
 - Identify the search box where you will enter search term to look for images.
 - Locate where you will search in Horizon by image. Horizon has a provision for image search, by either using an image from the camera roll or clicking a picture from the phone camera and searching similar images.
 - View your current Horizon albums.
 - View the pictures within the "Halloween" album.
 - The Home Page has trending or recent pictures from various sources ; for example - images recently added to your Horizon collection, pictures recently uploaded on facebook, images from your work iPad. Scroll down to view images from more sources.
 - View more images from Facebook .
 - View the account settings panel to see account options.

The work tasks below exploit the complete search functionalities, options and provisions which you can compile your yearbook album.

Work Task 2:

- In order to compile photos for your yearbook using Horizon, on the Horizon search homepage, begin by entering a search text - **"iSchool"**. Use autosuggest/autocomplete to complete the query.
- Save any two relevant results to your Horizon collection in a separate album **"iSchool"**. Optionally view your album.

- Return back to the Search HomePage or clear your previous search and start over.

Work Task 3:

- Conduct an image search by taking a picture with the camera.
- Choose a relevant result and save it to a pre-existing horizon album called ‘iSchool’. Optionally view your album.
- Continue the search, sorting the previously generated results by size
- Choose a relevant image from sorted results and save to album. Optionally view the album.
- Narrow your search by including additional text query - “computer lab work”.
- Select the first relevant image and add it to your iSchool collection.
 - You observe that one of the tags for the relevant picture is “UTA”. You wish to search more relevant pictures to UTA to use it for your album. Explore relevant results for it.
 - Instead of browsing images from all sources, filter your results to restrict relevant images only from your Facebook network and your iPhone.
 - From the filtered results, select the first relevant results from both sources and save it to your album and optionally view your album collection.
 - Clear the search and start with the next work task

Work Task 4:

- Search for “paperlabs”.
- Add the first 2 relevant results for this search, to your Horizon iSchool album

5.3 Post-Test Interview

Following completion of the work tasks, participants were directed away from the computer screen to perform a post-test interview with the third researcher. The post-test interview was designed to determine usability measures such as search experience and satisfaction. Users were also asked to describe the

applications use and the nature of their interactions with it (searching by images, text etc.).

After the completion of user-studies, the data collected was analyzed to determine results.

Pre-interview responses were compiled into a chart while performance measures were gathered from screen capture videos using Morae Manager. Due to the descriptive nature of the post-interview questions, responses varied widely therefore making the data difficult to visually represent.

6. RESULTS & DISCUSSION

6.1 Pre-Test Survey Results

All participants were current University of Texas students studying a range of topics including: computer science, information architecture, archives, web development, and information studies. Participants were relatively familiar with technology and general search applications; all participants reported using Google to find information on the web. One reported using academic databases and several reported using specific search sites such as Yelp. The majority of the participants (5 out of 6) rarely used advanced search features for general information queries. All participants cited high usage of mobile devices and 5 out of 6 owned smartphones. All participants engaged in some sort of social media (Facebook being most prevalent.) In general, most participants did not consistently manage their photos; the majority of participants reported creating albums for specific events, but not generally. 4 out of 5 participants noted they relied on the default sort-by-date feature found in most applications. (See Table 6.1)

6.2 User Observations

Footage captured by Morae was used to gather performance measures for each work task. The footage was then reviewed in Morae Manager and the chosen performance measures (efficiency and success) were demonstrated through task duration and mouse click data.

Horizon Pre-Testing Interview Results

PARTICIPANT	AREA OF STUDY	EXPERIENCE w/ SEARCH APPLICATIONS	USE OF ADVANCED SEARCH	FAMILIARITY w/ IMAGE QUERIES	FREQUENCY OF MOBILE USE	MOBILE DEVICES USED	MOBILE DEVICE ACTIVITY	SOCIAL MEDIA USE	DIGITAL PHOTO MANAGEMENT
1	Web Dev	Google, computer search	Rarely	Not familiar	High	Go-phone (no smart phone)	Text, Camera	Facebook - no tagging	Photo (some grouping)
2	Info Arch	Google (frequently), Yelp, Maps, IMDb	25% of the time	Not familiar	Very High	iPhone	Text, Call, Social media, banking	Instagram, Twitter	iPhone (some grouping) Instagram
3	PHD Info Studies	Google, Yelp, Bing	90% of the time	Yes, Google	Very High	Android, iPad	Games, Email, Social Media, Web Browsing, Map	Facebook, Twitter, Flickr, Yellow Frog, Picasa	Flickr
4	Archives	Google, Academic Databases	Rarely for Google, 90% for Academic Databases	Aware of but hasn't used	Very High	Android, iPad	Email, Web Browsing, Podcasts	Flickr (rarely), Facebook (daily)	Photo (some grouping), Facebook (no grouping), Phone (no grouping)
5	Archives	Google (frequently)	Rarely	Not familiar	High	iPhone, iPad	Email, Text, Social Media, Weather, Web Browsing	Facebook, Instagram	Adobe Lightroom (tagging)
6	Comp Sci	Google (frequently)	Never	Not familiar	High	Laptop, Smartphone	Text, Camera, Email, Games, Web Browsing, Social Media	Facebook, Instagram (not often)	Dropbox Google Drive

Table 6.1 Pre-Test Survey Results

6.2.1 Task 1

Task 1 involved introducing participants to Horizon's homepage and basic sections of the application. Users were asked to identify the image search box, a pre-existing album in Horizon and to view more photos on the Horizon homepage via horizontal and vertical scroll. Participants experienced varied success with Task 1. Several participants achieved only partial success mostly in part to the limitations of the prototype; often correct areas were clicked upon but not precisely enough to trigger the prototype. This can also be attributed to the high number of mouse clicks for a relatively simple task (See table 6.2.1, figure 6.2.1).

6.2.2 Task 2

Task 2 was a medium difficulty task involving a simple image retrieval using text search. Participants were then asked to save the selected image to a new album in Horizon. All participants successfully completed the task at around 2 minutes.

6.2.3 Task 3

Task 3 required participants to use a combination of Horizon's simple and exploratory search features as well as image management tool. Participants conducted an image search, sorted results, reformulated queries, searched by tags and filtered results. Amongst those who did not successfully complete the search, most difficulty was experienced with searching by image tags and filtering results.

6.2.4 Task 4

Task 4 was of moderate difficulty and involved query formulation through a suggestion on the application's "No Results" page. While one participant was able to successfully complete the task, having successfully completed Task 3, other participants were unable to complete this task as there unable to complete the final steps of Task 3.

Participant	Time Taken (min:sec)	Mouse Clicks	Completion Success	End-to-end task completion	Interesting Observations
1	3:26	31	Partial Success	Did not view more pictures (scroll down)	1. Took some initial time understanding the interface. 2. Was only asked to identify image search box but tried using it and hence was confused (most time spent here). Eventually, used browser back button to get back to home page and complete steps of the task.
2	2:25	98	Success	Completed all sub-tasks.	1. Was only asked to identify image search box but tried using it and hence was confused (most time spent here). Eventually, used browser back button to get back to home page and complete steps of the task. 2. View more pictures from facebook - was not clear to use to scroll right
3	2:25	34	Success	Completed all subtasks	Was only asked to identify image search box but tried using it. But navigated back to the homepage without browser back button.
4	2:35	15	Partial Success	Did not scroll down	Understood the interface well
5	3:12	23	Partial Success	Did not scroll right	1. Was only asked to identify image search box but tried using it. But navigated back to the homepage without browser back button. 2. View more pictures from facebook. Tried scrolling right, but was not patient enough to wait to get the hand over the scroller.
6	2:02	29	Success	Completed all tasks	Was only asked to identify image search box but tried using it. But navigated back to the homepage without browser back button.

Table 6.2.1 User Observations of Task 1

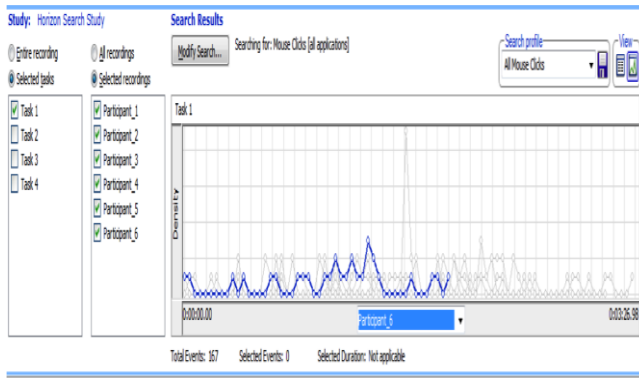


Figure 6.2.1 Task 1 Activity Chart Depicting Mouse Clicks vs Time

Participant	Time Taken (min:sec)	Mouse Clicks	Completion Success	End-to-end task completion	Interesting Observations
1	2:07	28	Success	Completed All	1. Could not get the 'saved' pop-up window to close. 2. Did not use auto-suggest.
2	1:46	40	Success	Completed all sub-tasks.	Could not get the 'saved' pop-up window to close.
3	2:13	34	Success	Completed all subtasks	Did not save the relevant results in order of listing.
4	1:23	23	Success	Completed all subtasks	Did not use auto-suggest.
5	2:01	38	Success	Completed all subtasks	Completed with ease.
6	2:30	42	Success	Completed all subtasks	Completed with ease.

TABLE 6.2.2 USER OBSERVATION OF TASK 2

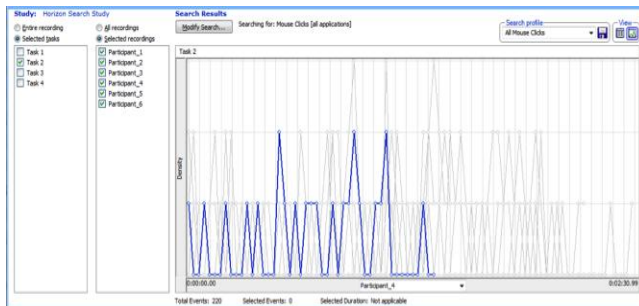


Figure 6.2.2 Task 2 Activity Chart Depicting Mouse Clicks vs Time

Participant	Time Taken (min:sec)	Mouse Clicks	Completion Success	End-to-end task completion	Interesting Observations
1	5:33	110	Success	Completed All	1. Took a lot of time in completing all steps. 2. Took a lot of time in finding filters.
2	4:07	87	Success	Completed all sub-tasks.	Had a hard time in understanding the image search purpose. Could not understand the results page.
3	4:42	66	Success	Completed all sub-tasks.	Understood the purpose well.
4	7:14	85	Partial Success	Unsuccessful in sorting, narrowed search using text, search by tag, filtering	1. Did not observe the results on sort by size. 2. Did not observe tag 'UTA' for the image. Hence did not achieve success and was confused.
5	5:02	86	Partial success	Search by tag in image, filtering	Did not observe tag 'UTA' for the image. Hence did not achieve success and was confused.
6	4:53	89	Success	Completed all tasks	Was slow but careful and observant.

Table 6.2.3 User Observation of Task 3

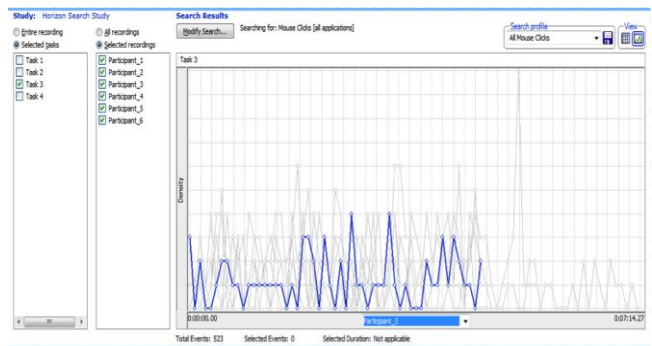


Figure 6.2.3 Task 3 Activity Chart Depicting Mouse Clicks vs Time

Participant	Time Taken (min:sec)	Mouse Clicks	Completion Success	End-to-end task completion	Interesting Observations
1	1:05	26	No success	Did not complete	Prototype issue: Was on the wrong page, where query reformulation was not routed.
2	0:45	26	No success	Did not complete	Prototype issue: Was on the wrong page, where query reformulation was not routed.
3	1:23	24	Partial Success	Did not know what to do with the query-reformulation and hence lost flow.	
4	2:08	29	No success	Did not complete	Prototype issue: Was on the wrong page, where query reformulation was not routed.
5	1:58	28	No success	Did not complete	Prototype issue: Was on the wrong page, where query reformulation was not routed.
6	0:22	26	Success	Completed all tasks	Was slow but careful and observant.

Table 6.2.4 User Observation of Task 4

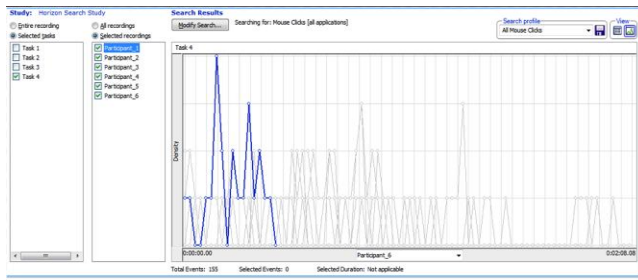


Figure 6.2.4 Task 4 Activity Chart Depicting Mouse Clicks vs Time

6.2.5 User Observation Summary

Overall users were able to complete the majority of tasks using Horizon. Most difficulty experienced by participants can be attributed to prototype limitations and the compounding nature of the work tasks; difficulties experienced in task 3 made task 4 impossible to complete.

6. 3 Post-test Interview Results

During the post test-interview, 4 out of 6 participants described their experience using Horizon in a positive manner describing it in terms such as “pretty cool”, “quick, easy and organized.” When asked about the application’s use, all participants were able to correctly describe Horizon’s conceptual model and recall the tasks they had been instructed to perform and the goals of those tasks. When asked about their feelings using the application two participants cited mixed feelings; while the application was initially easy to navigate, midway during task three they grew “frustrated.” Both participants cited an inability to locate search filters and return to the home screen as the source of frustration. One participant remarked that her album had “been deleted” indicating that prototype limitations and user familiarity with prototype behavior could account for some “frustration” experienced.

6.3.1 Look and Feel

Users described the interface as simple and intuitive. The clear standard icons aided in navigation,

but uneven application lead to confusion. Primary application functions--photo search button and search bar--were easily located.

6.3.2 Suggested Improvements

Navigation: The lack of a consistent home button or back button was cited by the majority of participants as a significant issue with the application. Additionally, as the application was designed for iOS, the inability to make use of the iPhone gestures greatly limited navigation.

Filters: 4 of the 6 participants cited issues with the application’s filters. Two participants were unable to locate the filters at all and one participant remarked that there were “a lot” of filters, implying too many filtering options. Another participant expressed uncertainty regarding which filters were “on” and which were “off” as the app’s default “off” toggle switch features a green background.

Design: One participant remarked that the use of blue text on black background could be difficult to read for users with low vision or other accessibility issues. This apart, the option for query reformulation that popped up in a yellow window was not appealing to one participant, who felt like it was more confusing than helpful.

7. Prototype Limitations

The prototype for Horizon was constructed in Axure wireframing software. The result was a relatively high-fidelity prototype which had deceptively limited interactivity. As each interaction had to be structured separately, the work tasks were developed to guide the user into specific pages and onto specific links. Some flexibility was built in--for example links to save a image and sort were simultaneously active.

Nevertheless, the process of building a collection as stipulated in the work tasks was created in effect by a Wizard of Oz situation--where the collection was not actually produced using software but modeled in pre-designed static HTML pages. For example, when the subject added images to a collection called iSchool and then hit the icon for save they would be sent to a

linked page that displayed the saved image and was titled iSchool.

Test subjects succeeded in smoothly navigating this prototype to perform the basic functionalities of search and retrieval. Mouse clicks were fairly high, however, this is likely due in part to limitations of the prototype--it was necessary to click a few times to get to the actual link. We had not anticipated the large number of subjects who, when faced with a task to filter or reformulate their query actually sought to go "home" rather than continue forward from their current position. As a result, test subjects who veered too far from the work-tasks found themselves on pages that did not reflect their entries. The prototype mobile application was hosted in a Google Chrome browser that displayed the outline of an iPhone 4S with the app located inside. When faced with the requests in task #3 to filter by a tag, 5 of 6 users sought to head back or go home to do this filtering. Several even used the browser back button to do so. When they found themselves "lost" in the prototype, frustration increased and inability to successfully complete the subsequent query reformulation.

This result illustrates that even prototypes need to provide a consistent route to the home screen from results pages for users who prefer to return home to reformulate queries. Given that the simulated work task method required users to be fairly independent in their conduct, prototypes need to accommodate users with diverse cognitive styles. This result also supports research on user cognitive styles that suggests that field-dependent or serialist users may not possess the ability to reframe questions in the process of search, preferring to simply re-execute a known methodology rather than shift mid-process. [7] Finally, the prototype limitations suggest that even on mobile platforms, unfamiliar users need to be provided with sufficient navigational tools to enable multiple search routes.

8. IMPACT OF USER EXPERIENCE

The user sample represented a diversity of subject (image storage) and technical (iOS mobile app users) skills. The tasks required the subjects to employ all the features and functionalities of the search engine--beyond the level that some might normally use outside

of the test. It is no surprise then that the Morae and survey results demonstrated a bell curve of sorts where one user found the functionalities and filters insufficient, two thought they were excessive, and four found it just right. Improvements to the navigation and filter design, as well as a few accessibility-minded changes (removing the blue on black text) to the look and feel of the application, are warranted to ensure that all users can perform basic functionalities. With these small changes, Horizon could successfully occupy the sweet spot between excess functionality and over-simplicity; satisfying a need for a meta image search and organization among users of multiple devices and social media services.

9. FURTHER RESEARCH

The Horizon mobile image search application opens up several avenues for further study in both information retrieval and user experience. By coupling image-based and text-based search, Horizon attempted to attract both visual and verbal learners, however, our results suggest that switching between methods of visual analysis and textual analysis was disorienting to users. Future usability studies might wish to conduct A/B testing on purely visual search models of Horizon and purely textual search models. The limitations of the prototype, as discussed above pointed towards current discourse in the field of cognitive styles and information seeking-behavior.

Most current models suggest that individuals fall somewhere on a continuum of cognitive styles, for example almost no one is entirely a holist or serialist.

Purposely faulty prototypes might be a deceptive way to address more accurately how individuals handle problem-solving in a digital search space.

Furthermore, by allowing the prototype errors to play out over the course of the study, we gained a much more true-to-life model of user behavior. Further study on a larger sample size, might reuse this prototype to examine learnability and emotional responses to search.

The population used for this study reflected a much more highly-educated and technically savvy demographic group than the average smartphone user. It is entirely possible that our results were impacted by an independent variable that shaped visual perception and search behavior for female graduate students. Research to test the hypotheses generated by the

research should expand to include a more reflective sampling of broader smartphone users and image-organization area experts. One might surmise that the mental model of Horizon--aggregating images from both hardware and online sources--could pose a challenge to non-digital native users or late in life adopters of smartphone technology.

10. CONCLUSION

Usability research on the mobile image search engine Horizon demonstrated that users appreciate aggregated image streams and can navigate basic search and retrieval using both image-based and text-based search with high levels of success. Creating albums and organizing images was conducted with little difficulty. Survey, interview, and Morae results consistently registered the same points of success and challenge among users, with the exception being the amount of functionality. Tasks #3 and #4, featuring filtering and query reformulation were largely unsuccessful with only one test subject successfully completing all tasks. Results are not conclusive as to whether the other users would have been able complete all the tasks given a more fully-functional prototype. Nevertheless, the prototype limitations did provide an opportunity to analyze user cognitive styles and to consider user search behavior opening up opportunities for continued research.

ACKNOWLEDGMENTS

We thank all the subjects who graciously participated in the study and provided helpful comments. Thanks is also due to our Projects in HCI classmates as well as the iSchool lab staff for aiding in the use of Morae and in producing the posters. A final thanks should be given to Prof Gwizdka for leading the class, providing guidance at key intervals, and supporting our research trajectory with enthusiasm.

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