SOPHOS *Search On Phones and Handhelds in One Stroke*

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Introduction

Motivation

Google processed 5,922,000,000 searches each day in 2013[1]. By 2015, Google estimates that over 50% of paid search clicks will be triggered from mobile devices[2]. Given that mobile search is expanding so rapidly, we wonder: are we searching in the most effective way possible from mobile devices?

Textual search is currently performed in two ways: manual text entry by typing keywords, and copy-and-paste from content already displayed on the device. In the first case, the procedure is very direct, constrained only by the rate of text entry on mobile devices. As improvements such as predictive text entry, optimized virtual keyboards, and voice entry continue to mature, the method will continue to become faster. In the second case, the procedure which the user is expected to follow is much more complex:

1. Select the keyword to search
2. Copy the keyword
3. Move to a search view
4. Paste the keyword
5. Trigger search

This process forces extra operations into the user's very simple mental model of the search task:

1. Select the keyword to search
2. Trigger search

With this in mind, we explore an alternative interaction technique to improve the process of mobile search on existing terms by simplifying the procedure and increasing its speed.

[1] http://www.statisticbrain.com/google-searches/

[2] http://www.marketwatch.com/story/mobile-on-pace-to-surpass-desktop-paid-search-on-google-by-end-of-2015-2014-03-19

A Gesture to Search

We propose an interaction technique for mobile and handheld devices that accelerates the user's ability to perform a web search of a one or more words in the current view. First, the user selects text using the existing text selection techniques available on the platform. Then, the user performs a *search gesture*. The application then immediately executes a web search using the current selection as the query text and opens up a web browser if it detects the gesture appropriately. If the gesture is not detected, no action is performed. The gesture can be performed using the entire screen or any subset of the screen space.

The reason for going with a gesture detection and response interaction technique was so that gestures can be performed very quickly and allows for faster mobile access [4]. It has also been established that gestures can be used to perform searches [5]. Although the context in this paper for searching is different than what we are trying to implement, the choice of gesture as an interaction technique for search had encouraging results. So with a backing of proven past experiments similar to ours, we were confident in going ahead with our idea. However, before we implemented a prototype test environment, some more thought was necessary. Gesture selection and user's acceptance of the new search technique were some of the factors that are discussed in later sections.

Gesture Selection

Taxonomy of Gestures

We designed our gesture based upon study of the taxonomy of gestures. We thought that this would help us in selecting what kind of gesture is best for the task at hand. One of the main types of gestures is the semiotic gesture [3]. A semiotic gesture is a gesture used to convey meaningful information. There are three different types of semiotic gestures as shown in Figure 1 below:

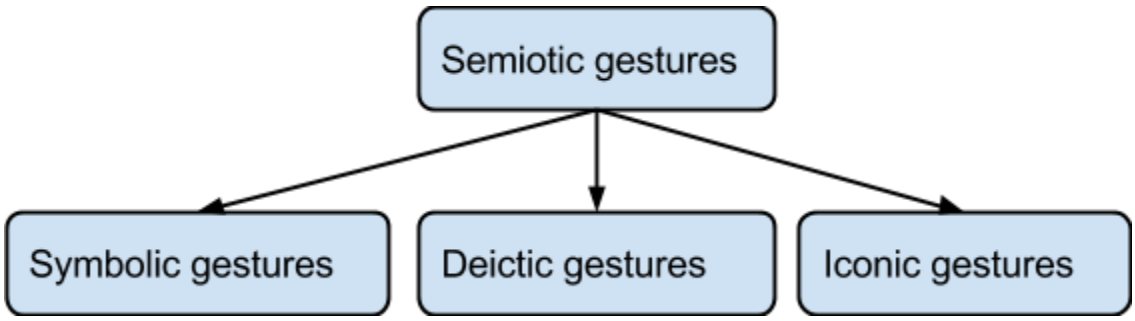


Figure 1: Taxonomy of semiotic gestures

1. Symbolic gesture: A gesture which has a unique single meaning assigned to that particular gesture. The word "Okay" in English or a Thumbs-up or Thumbs-down action are good examples of symbolic gestures.
2. Deictic gesture: A gesture which specifies a particular position of an object. The act of specifying a position of an object by saying "Put that there" while pointing the location by his hand is a deictic gesture.
3. Iconic gesture: Iconic gesture represents the a motion or an action which actually happens or exists. For example, when someone says that the plane flew like this by moving the hand in a slanting position in an upward direction.

Design issues

It is important that this gesture be distinct from other gestures so that different commands are not triggered when the user tries to search. It is also important that the gesture be simple and memorable so that users find it easy to use. The gesture should be easy for both left and right-handed users [1]. The gestures developed for SOPHOS are classified as symbolic gestures within the hierarchy described above. We have developed and narrowed our gestures to the three shown in Figure 2 below, which were evaluated in the user study and compared to the existing method of searching:

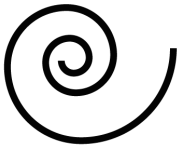
A	B	C	D
			**copy-paste to browser address bar**

Figure 2: Search methods that were evaluated.

A. Question Mark - single continuous touch top-to-bottom
B. Swirl - single continuous touch counterclockwise from outside towards center
C. Swirl - single continuous touch clockwise from outside towards center
D. Copy-paste - the existing method

Social Acceptability

Before implementing a prototype we wanted to be sure whether the user would even want to perform a gesture to search. We soon realised that users are very comfortable performing gestures on a handheld or mobile screen when compared to performing gestures in the air on a 3D plane [2]. However, we still decided to get feedback from users about which search method they preferred among the four search methods mentioned above.

Implementation

Android Gesture Builder

In order to perform the user study, we built a prototype of the gesture interface as a native Android application[3]. The Android Gesture Builder [6] allows us to define gestures by example and incorporate them into a test application. This Android-specific approach was selected over a cross platform Javascript library because the gesture builder's by-example method facilitates rapid iteration of the gesture, whereas the JavaScript library requires the development of test functions.

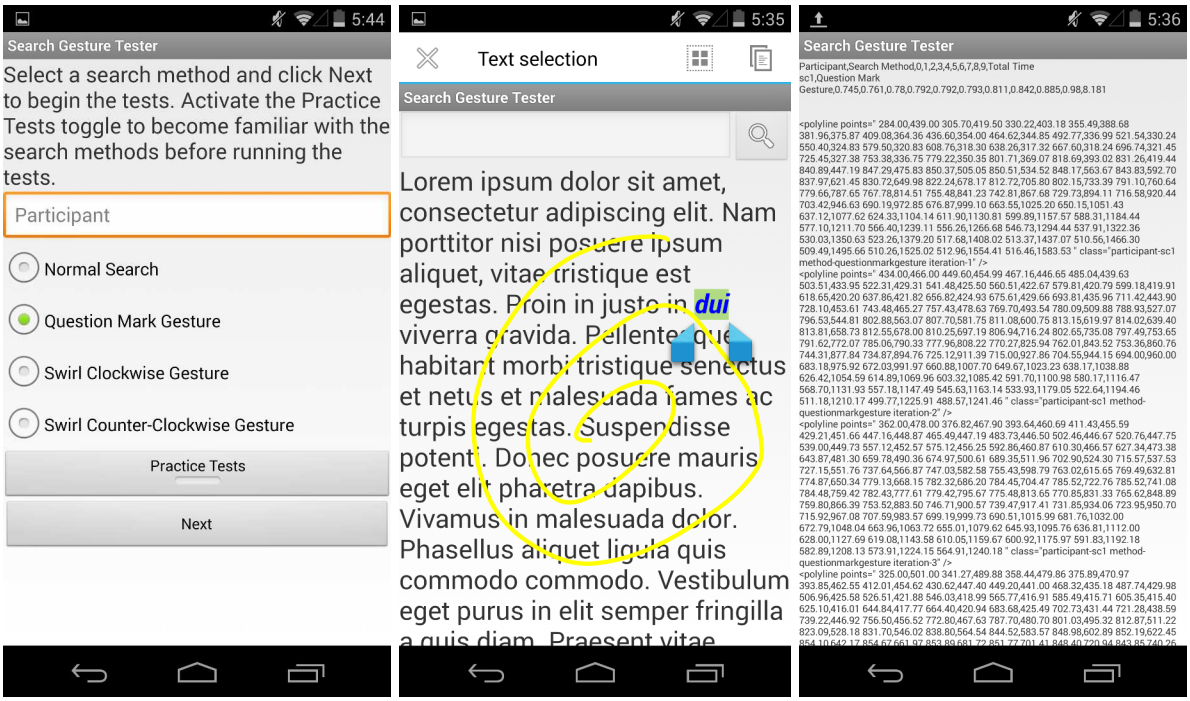


Figure 3: Screenshots of the implementation.

There are three screens, shown left-to-right in Figure 3.

1. Select one of the search methods: The user selects one of the four test methods. The "Next" button advances to the gesture task screen. To perform a practice test the user may tap the toggle button to change modes, and proceed with the "Next" button.

[3] https://github.com/PushkarJ/SOPHOS

2. Perform search task: User performs the selected search method on this screen after selecting the text. If the gesture is recognized, the selected text is searched on google and a browser is opened with the search results. If the gesture is not recognized, the browser is not invoked and a error message is displayed for a certain period of time.

   For "normal" search (method D) we have added a edit text view and search button to simulate a search box on the browser. The user will hold a finger down in the search bar until the paste command is presented in a contextual menu, then use that command, and finally trigger the search by tapping the search button.

3. View Results: The results of the test are displayed in CSV and SVG readable format. The search method is indicated as well as the time required to perform each search task. The total time for all ten iterations is also shown. The user can then select restart to evaluate another search method. We will record the data after each section of the test for analysis.

Data recording

The test application records two datasets for analysis: timing data and path data. When the user first touches the screen to perform a gesture or copy-paste search, a timer is started. When the search action is triggered, the elapsed time is recorded. This data allows us to quantify the speed differences between the different methods of search.

Additionally, for methods which involve a gesture path, we record the path drawn by the user. The path is stored as a series of 64 points measured at absolute size from the screen of the Android device. This data is output as SVG polyline elements on the View Results screen, which allows us to qualitatively analyze how users perform the gestures.

We do not record the failed gesture paths (those which the recognizer did not accept). Future work which does capture these failed attempts would be useful to analyze the merits of different gestures. This study's focus is to compare gestures to copy-paste, and so that data was not crucial to our analyses.

User study

We will evaluate the effectiveness of this new interaction technique by performing user studies. The study will test each of our gesture designs and the conventional copy-and-search method. In each test, the subject will select specified text and attempt a search. We will measure the amount of time required

for each method. To check the usefulness of the test, we will measure ourselves before testing other subjects.

Practice tests

We initially discussed whether to open a web browser in response to successful gesture detection. One school of thought was by doing that we would get invaluable subjective feedback about the gesture's pleasantness. However, there was another counter argument that opening a web browser for each search task will lead to slowing down the user study. So the final outcome out of that discussion was to keep an option of practice tests where user can get the "feel" of the interaction technique by actually performing the gesture and opening of a browser. However, during the actual tests there will be small flash message (in Android terminology a "Toast" message) would give the user feedback about whether the gesture was detected or not. In the real tests, if the gesture was not detected, a different error (Toast) message would let the user know about the gesture not being detected. However, in the practice tests if the gesture was not detected the web browser will not open and no message will be displayed.

There is one more important difference between the practice tests and real tests. In practice tests the user was able to see a bright yellow color trace or halo of the gesture the user performed. If the gesture was not detected a darker shade of the yellow was visible. In real tests however, the yellow trace or halo was invisible irrespective of whether the gesture was detected or not. To enable the user to go through practice tests, on the first screen a toggle button can be seen. If the toggle button was on, the user could perform practice tests. If the toggle button was off the user could perform the real tests.

Environment

- The user will be seated at a table in a well-lit room.
- During the the test, the user will hold the smartphone in-hand.
- The smartphone used was Google Nexus 5 running Android 4.4.2(Kitkat).

Procedure

1. The user selects a search method. The user will be told which method to select each time, and the order of the methods will be randomized for each user.

2. After selecting the test method, the User will begin the test. When the user first touches the screen, the application begins timing.

3. The user will select the indicated text marked in ***bold italics and blue*** by a long press until highlighting is visible, then dragging to position the ends of the selection correctly.
4. The user then will use one hand to perform the search gesture (or copy-paste method).
5. If the gesture is recognized, the application ends timing and records the data. If the gesture is not detected the user must continue attempting the gesture until it is successfully recognized. Because text selection does not differ between methods, we do not check whether the user selected the text that was highlighted or some other text.
6. The screen refreshes with a different text marked in the same way as before.
7. Steps 2-6 are repeated until all ten tasks have been performed.
8. The results will be displayed for the just-tested search method. It contains as explained before in the data recording section the path data that helps us detect the way the user moved his finger while performing the gesture along with the timing data that includes the timing data for each instance of the user performing the search method. The data collected is copied and pasted in a notes application for further analysis.
9. The user then clicks Restart and repeats steps 1-8 until all four methods have been tested.

Each user will perform the tests in the same order to account for learning effects among users. The tests involve selecting a single word, which is placed at different locations on the page in each test iteration.

Study Participants

Seven subjects were tested during this user study. 6 were right-handed and 1 was left-handed. There were 5 females and 2 males. The majors of the subjects were computer science, information systems, 3 industrial design, 1 computer design and 2 information security.

The age range was from 20-25 years, with a mean age of 21.3 years. Everyone was very confident in their experience with computers (mean of 4.9 on a likert scale from 1 to 5 with 1 being strongly disagree and 5 being strongly agree). The mean for experience with touchscreens was also a mean of 4.9 on the likert scale. Mean for experience with android was 3.7 and experience with gestures was a mean of 4. Our participants were generally young adults and extremely experienced with technology. This does create some bias in our results.

Results and Observations

As described above, the test application measured both the time to search and the gesture paths for each of our seven users in ten test cases for each method. Below we outline the results and observations collected from this user study.

Time to Search

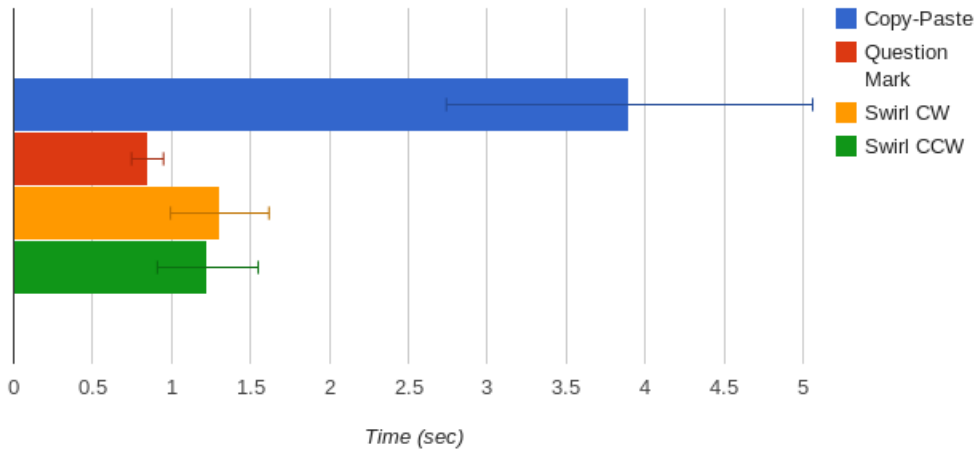


Figure 4: Comparison of the average time to perform a search.

Figure 4 summarizes the time spent to perform searches using each method. We can see a pronounced difference in the speed of the traditional copy-paste method compared to the three gesture methods that were tested. Copy-paste was approximately three times as slow as the gestural methods, suggesting that our initial intuition towards simplifying the procedure is correct.

Method	Average	St. Dev. Absolute	St. Dev. Percentage
Copy-Paste	3.900	1.160	0.2974

Question Mark	0.8475	0.1012	0.1194
Swirl CW	1.305	0.3121	0.2392
Swirl CCW	1.229	0.3191	0.2597

Figure 5: Average and standard deviation of search times.

We also observe that the standard deviation of the time spent searching is significantly less for the question mark gesture than for any of the other methods. When considered relative to the average time taken to search, as shown in Figure 5, the question mark gesture's standard deviation is half of the deviation of the other gestures and the copy-paste method. It is unclear why the question mark gesture's times are more consistent than the other methods. Future study comparing a greater variety of gestures may reveal the cause of these variations.

A one-dimensional ANOVA analysis of the data recorded from this study finds an f-ratio of 89.13. The 99 percent confidence threshold for the dataset is an f-ratio of 3.853, so we are very confident in the significance of the difference between copy-paste and gestural search methods.

Gesture Paths

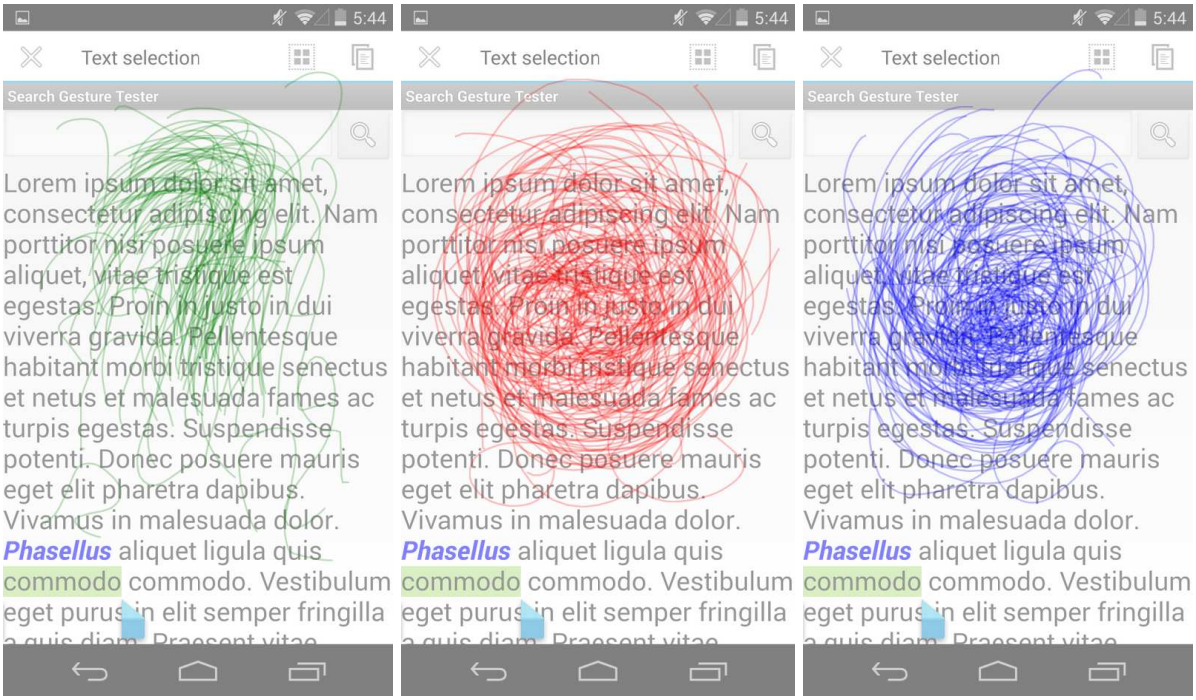


Figure 6: Gesture paths by method: question mark, clockwise swirl and counterclockwise sw

Gesture paths were recorded for the three gestural search methods. As shown in Figure 6, the users all drew gestures in the middle of the phone screen, with little variation of position between the different tests, despite significant variation in the location of the highlighted search term.

We had originally supposed that users would attempt to draw the gestures near the search term, since they are not tied to any controls on the screen, as the copy-paste gesture is. However, informal observations during several of the user studies showed that users encountered difficulties where the gestures would reach the edge of the display before completion in the practice tests, and so they avoided that method in the recorded tests.

The Nexus 5 smartphone that was used as test hardware in this study has a screen diagonal of 4.95 inches. As a result, the highlighted text was often close to one or more screen edges. Future work should investigate gestural search invocation on larger form factor devices, such as tablets, to determine if gestures do occur closer to the search terms where it is more feasible.

We also see that users tended to draw the gestures large enough to span most of the width of the screen. Our gesture recognition is not limited to large gestures, but we hypothesize that users drew large gestures to minimize their own likelihood of mistakes. This agrees with the apparent larger size of the swirl gestures in comparison to the question mark gestures, given that the swirls were viewed as more challenging by the users (see below).

Questionnaire

At the conclusion of the study, the users responded to a brief questionnaire (included in full at the end of this document). In addition to the demographic information described above, users provided reactions to the search methods that were tested. These reactions are summarized in Figure 7.

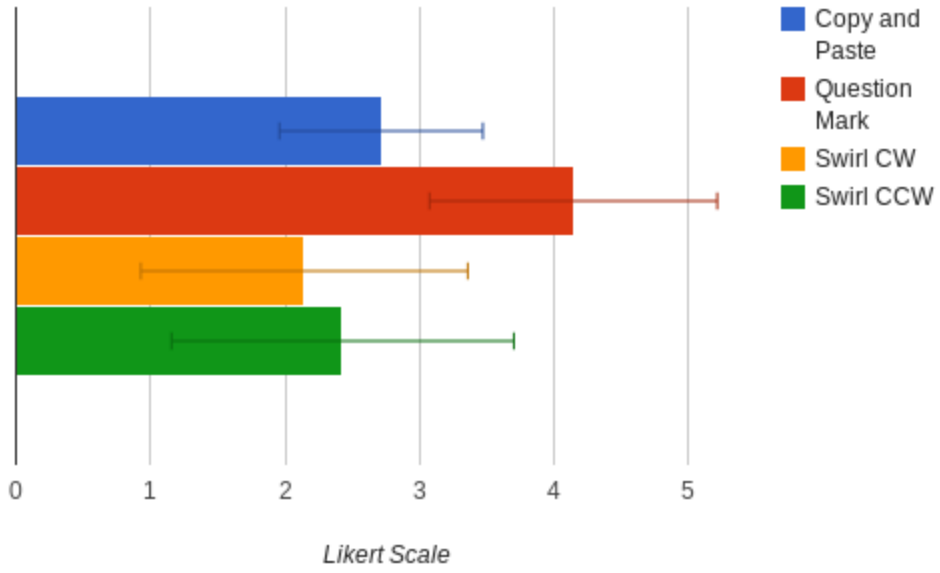


Figure 7: Users' reactions to the search methods (higher is better).

Users approved of the question mark gesture by a significant margin over all three other search methods. We were surprised to discover that users preferred the copy-and-paste method over the swirl gestures, even though the gestures were still much faster than copy-and-paste. We theorize that the complexity of the swirl gestures led users to prefer the familiar copy-and-paste method. During the study, users repeatedly became frustrated that the swirl gestures would not recognize successfully; however, no frustration with the question mark gesture or the copy-and-paste method was observed.

We also asked users to identify their familiarity with the methods. As expected, users were very familiar with copy-and-paste and very unfamiliar with gesture invocation of search. The high approval of the question mark gesture in light of users' lack of expertise with it is encouraging.

Future Work

Potential future work could include exploring other gesture designs and refining the already-developed gestures. Although we have chosen our three test gestures based on the most common results from a survey asking what people would want as a gesture to perform a search on selected text given to our class, we should still examine other potential gestures.

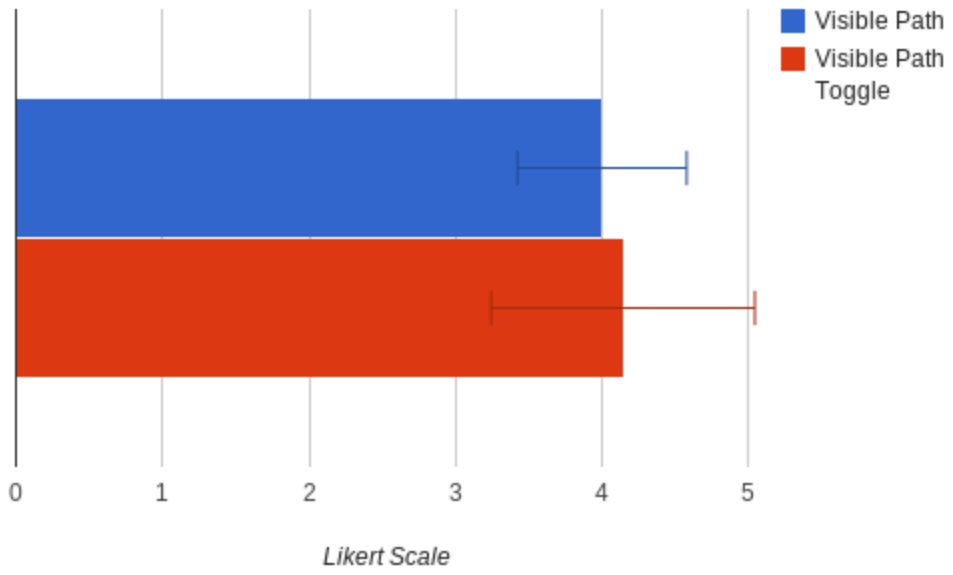


Figure 8: User desires to see gesture path traced while gesturing.

We also found that users wanted feedback on their gesture - some wanted to be able to see exactly what they were drawing. Others wanted to be able to toggle the visibility of the gesture path according to their own desires. The mean rating on a likert scale from 1 to 5 with 1 being strongly disagree and 5 being strongly agree, was a 4 for how much people wanted the drawn gesture to be visible. The mean rating was 4.1 for how much people wanted to be able to toggle the visibility.

We would like to compare the speed of search gestures to the speed of searching from a pop-up menu (see Figure 9) that would appear after holding down a finger over selected text.

Figure 9: A contextual pop-up menu providing a search function.

We would also want to consider accessibility, such as how each gesture would impact disabled or injured people. We should conduct tests that measure ease of performing each gesture on people with different injuries or disabilities. Perhaps there are other gestures that are easier to perform for disabled people. We predict the swirl gesture would be particularly difficult for disabled people to perform, but the question mark gesture should be reasonably easy since it's similar to a scrolling gesture, which is one of the most basic and simplest gestures to perform. We would probably compare the gestures to other techniques such as voice control and the traditional copy-paste method.

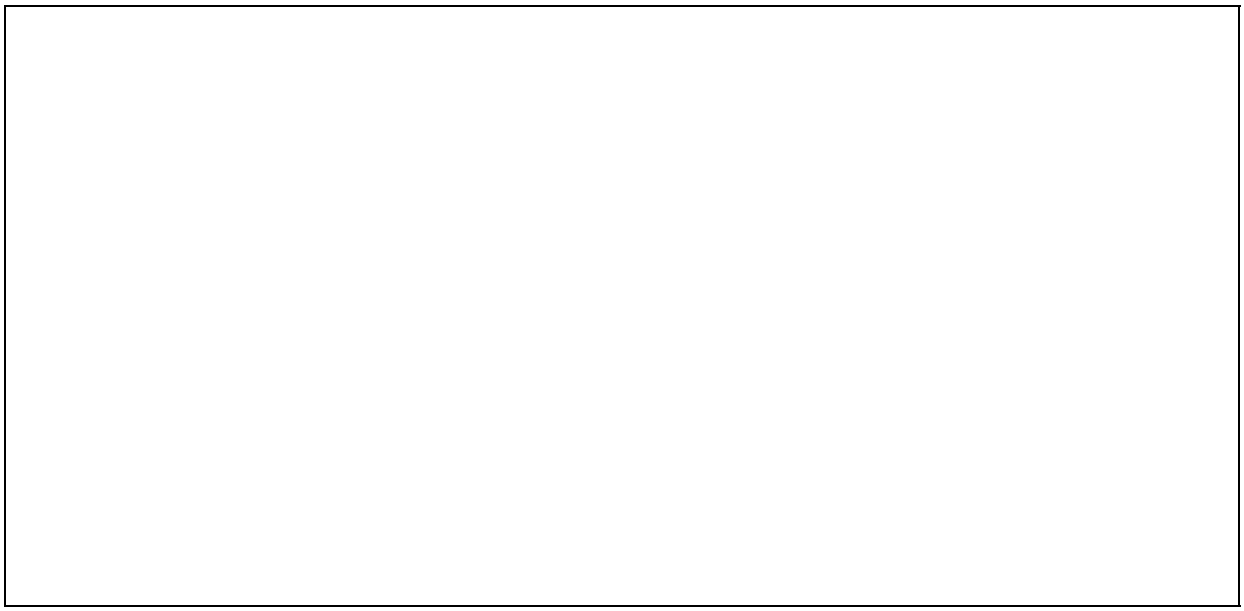
User Test Script

Thank you for agreeing to participate in this user study to measure the effectiveness of scrolling techniques for navigating to information in a document. You will not receive any compensation, monetary or otherwise, for your participation in this study. If you become uncomfortable with any of the tasks you are asked to perform, you may stop the test and leave at any time.

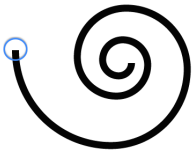
Please read all of the instructions provided in this script before beginning the test. During this test you will perform four different tasks which are intended to assess searching selected text on an Android phone. The order in which each technique is tested has been assigned ahead of time. Each test is expected to take approximately fifteen seconds. After the conclusion of the final test, you will be asked to fill out a brief questionnaire.

You will be testing an interaction technique for mobile devices that accelerates web searches based on selected text in the current view. First, you will select text using ordinary text selection techniques. Then, you will performs a search gesture. The application will then immediately execute a web search using the current selection.

What gestures would you want to use to search for selected text in Google? Explain your reasoning. Draw here:



You will now test 3 different gestures and the traditional copy-and-paste method of searching.

A	B	C	D
copy-paste to search bar			

A. Question Mark

Make a single continuous touch top-to-bottom.

B. Swirl

Make a single continuous touch clockwise from outside in.

C. Swirl

Make a single continuous touch counterclockwise from outside in.

D. Copy-and-paste by holding down finger to select text, pressing the top right square button to **copy**, and then tapping the search bar to **paste**

You may familiarize yourself with the gestures by activating the "Practice Tests" toggle on the menu screen. When using the search method in practice mode, an actual google search will be triggered when the gesture is completed. You will see the gesture you perform traced in a bright yellow color. However, this feature is turned off during the actual tests.

After you have finished practicing, please begin the tests. For each method, you will perform the search test ten times. First, select the blue word by pressing over it until the selection highlighting appears. Next, perform the search method as described above. If the gesture is recognized, the application will advance to the next test. If the gesture is not recognized, a message will appear at the bottom of the screen. Please perform the methods as quickly and accurately as possible.

After the final test, the application will present results data. Please allow me to record the data before moving on to the next gesture.

You will test the four methods in the following order:

1. _____
2. _____
3. _____
4. _____

Questionnaire

1. Please write your current age.

_____ Prefer Not to Disclose

2. Please write your current major.

_____ Prefer Not to Disclose

3. Please indicate your sex.

_____ Prefer Not to Disclose

4. Please indicate the hand you used to control the scrolling devices during the tests.

Left Hand Right Hand Prefer Not to Disclose

6. Please indicate the hand you normally write with.

Left Hand Right Hand Prefer Not to Disclose

Please indicate whether you agree or disagree with the following statements.

7. I am an experienced computer user.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

8. I am an experienced touchscreen device user.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

9. I am an experienced Android phone user.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

10. I am experienced interacting with applications by using gestures.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

11. I often perform searches in a manner similar to Method A (question mark gesture). 

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

12. I found Method A (question mark gesture) pleasant to perform. 

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

13. I often perform searches in a manner similar to Method B (clockwise swirl gesture). 

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

14. I found Method B (clockwise swirl gesture) pleasant to perform. 

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

15. I often perform searches in a manner similar to Method C(counter-clockwise swirl gesture). 

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

16. I found Method C (counter-clockwise swirl gesture) pleasant to perform. 

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

17. I often perform searches in a manner similar to Method D (copy-and-paste).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

18. I found Method D (copy-and-paste) pleasant to perform.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

19. I would love to see the system, trace my gesture visibly for Method A, B, C like in the practice test.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

20. I would like the system to give me control to turn on/off gesture tracing for Method A, B, C.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Prefer Not to Disclose

Thank you for participating in this study. Please write any comments in the space below.

References

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    b. http://android-coding.blogspot.com/2011/09/gestures-builder-create-your-gestures.html