Itinerary: An easy and fast way to plan your next trip

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ABSTRACT
To identify the potential usability problems of Google applications, a multi-step task was given to 20 users. On completion of the task, the users were asked to fill a survey with five questions. In all, several usability problems were identified and we suggested some solutions for the problems. In the next two months, two web applications and an android application was developed using the user suggestions. Further we conducted user tests on the three applications and conducted a post survey to collect the user experience from 60 users (20 users per solution). Finally we ran statistical analysis and used Multi-criteria decision making methods on the data to show that one of the solutions was empirically better than the other two.

Keywords
Usability studies, google maps, google search, web maps, multi-criteria decision making, ANOVA, t-test, Simple Additive Weighted Method.

1. INTRODUCTION
In everyday life, people are becoming more dependent on computer applications to do any task. As the tasks are becoming complex day by day, applications which help to support those tasks are becoming available. This has made usability more critical. Now companies are focused not only on the technology aspect of the application but also on user experience.

In the past decade, there has been a significant increase in the number of mobile apps users due to the benefits provided by the smartphones in terms of portability, location awareness, and accessibility [17]. With the increasing number of applications in the market, it is important for an application to be of superior quality in order to compete. One of the important aspect in an application is its usability; applications which are easy to install, takes less time to learn and get results, and has a simple interface, are usually preferred by the users. For an example according to netmarketshare.com 2015 [1], Google search is the world's most popular search engine with a market share of 67.49 percent as of September 2015. Google, as a contrast to its competitors, Bing and Yahoo! has kept a minimalistic interface and shows results which are more relevant to the users. Another Google application, "Google Maps" is a web mapping service which shows satellite imagery, street maps, 360 ° panoramic views of streets, real-time traffic conditions is widely used for route planning by millions of users [2].

In January, We did some studies to find the potential usability problems in Google maps. Then we conducted a survey where a multi-step task was given to 20 people. The users were suggested to use Google Maps and we identified several usability problems during the user tests. In February and March, we developed three different solutions targeting a subset of the problems. Later in March, we conducted another user test and survey to test our solutions to find the best one among them.

This paper is structured as follows. Section 2 presents some of the related works in this field. Section 3 presents the preparation work that we have done in January for identifying the usability problems. Section 4 provides the different three solutions targeting some of the usability problems found in section 3, and section 5 presents the evaluation process and results of the three solutions mentioned in section 4. Finally section 6, 7 and 8 presents the acknowledgement, conclusion and future work respectively.

2. RELATED WORK
Research on usability evaluation targeting on google applications seems to be scanty. However, several previous usability researches in relation to other web mapping sites have been carried out. Beverley (1997) studied the bene-

fit of a dynamic display of spatial data-reliability from the user's point of view with a test using map data for decision-making [8]. Harrower et al. (1997) evaluated the design elements and communication quality of Internet maps for tourism and travel in a user survey [9]. MacEachren et al. (1998) have conducted some studies with the help of map animation and interactive tools [16]. Andrienko et al. (2002) tested the learnability, memorability and user satisfaction of users with specific geo-visualisation tools [5]. Hornbaek et al. (2002) have also evaluated the usability of zoomable maps with and without an overview map [11].

Arleth (1999) studied the problems of screen map design and listed them; the map area was too small and both the legend and instructions too dominating on the screen [6]. According to the study, the design process would be more manageable if it were divided into two phases concerning the map interior, including the map elements, symbolisation etc, and the map exterior, including the tools and functions for using the map. Leitner and Buttenfield (2000) investigated the effect of embedding attribute certainty information in map displays for spatial decision support systems by having test users perform specific tasks with test maps [15]. Harrower et al. (2000) used a focus group method and structured user testing to find out how novice users understood and used the geo-visualisation tool designed to support learning about global weather [10]. Ahonen-Rainio and Kraak (2005) described a study including an iterative design with improved map prototypes and testing for visualising geospatial metadata [4].

With the intention to improve usability, Agrawala and Stolte (2001) studied how route maps are used analysing the generalisations commonly found in hand-drawn route maps [3]. Ishikawa et al. (2005) evaluated climate forecast maps by designing an empirical study with test users and observed their behaviours in the experiment. They concluded that in many cases qualified and motivated test users failed to interpret the maps in the way that the map designer had intended [12]. Richmond and Keller (2003) carried out an online user survey to assess whether maps on tourism Websites met the expectations of users [18]. Jahn and Frank (2004) proposed an additional factor for usability attributes: information quality (IQ), which is used to describe the importance of the data needed by the user and it can help to enable data quality to be adapted in an optimal way to meet user needs [13]. Van Elzakker (2004) carried out user tests in order to investigate the selection and use of maps when users are exploring geographic data online. In their method, users carried out six to seven tasks with the sites. Qualitative data was gathered through the 'thinking aloud protocol' and questionnaires and quantitative data by measuring the total time each user was performing each task, as well as the total number of clicks [20]. Similarly, Koua et al. (2006) studied test subjects' ability to perform visual tasks in the data-exploration domain and emphasised that use and usability assessment is an important part of understanding visual methods and tools for data exploration and knowledge construction [14].

3. PREPARATION

Before starting the development of our applications, we did some preparation in January to collect data from users, which has later become the guideline of our development process.

3.1 Previous work

The study was designed to identify the potential usability problems with Google applications and gather the qualitative information to find solutions for the problems in the near future.

Several experiments were carried out in order to identify as many potential usability problems with the chosen google applications as possible. First, a typical scenario for using these types of sites was formulated: 'A friend of yours has a layover at Raleigh for 8 hours and you need to plan an itinerary and accompany with her'. Part of the evaluation was conducted as a series of user tests, with the other part consisting of the evaluation of the the applications involved in the user tests in the form of questionnaire. During the user test, we provide them with some intro notes and encourage them to "think aloud" as they do their work. On an average, the users took 30 to 40 minutes to complete this part of the survey. The questionnaire allowed the users to select from some of the common problems that we previously prepared and allowed the participants to write additional problems which were not mentioned. This helped us to get some feedback about the problems they faced during the rst part.

Altogether, 20 participants were involved and 11 evaluations (6 tasks in the first part and 5 questions in the second part) were carried out. The experiments were run in a Windows/ Linux/Mac OS environment using either desktop, laptops or phone according to the preference of the user.

3.2 Usability problems in Google Maps

According to the survey result, we found that users prefer to use Google Maps among the common Google applications. Also, by conducting the user tests, some usability problems in Google Maps have been found.

Besides the problems that had been provided in the questionnaire, participants also encountered other usability problems. Firstly Maps show no information about local school bus, which had been mentioned by two users. Five users complained that they cannot save the route. Five users mentioned they cannot mark location on the maps. Another two users pointed that it would be a good feature if integration calendar and maps can be done. Few of the user suggestions were tourist information can be shown for free outdoor places (like what would be the best time of the day and of the year to visit a lake/mountain), adding opening hours and distances in the nearby menu. One of the user pointed out that on adding more than 2 places using Maps, one has to enter the exact name of the place as it no longer provided with a results list.

3.3 Decision of future solutions

While developing the solutions, we decided to focus on the problems proposed by the users. The functionalities included marking multiple markers on the map, saving path, showing different routes for different locations and planning a complete itinerary on the maps.

According to one of the results of the survey, focusing on which device would a user prefer while doing this sort of task. About only 45% of users chose laptop while 55% of people thinks they'd rather use a smartphone. One of the users who prefered smartphones over laptop stated that smartphones are better for this kind of task as it is handy and easy to use. Another user who chose laptop over phone said that he prefers laptop when using more than one application at the same time. Also multiple tabs in a browser can be better handled on a larger screen. So, we decided to create solutions for both computer and phone; two of the solutions are based on web and the other one on android smartphones.

4. SOLUTIONS

In this section, we will talk about three different solutions responding to the usability problems found in section 3. Among the three solutions, two of them are web applications and the third one is based on Android.

4.1 Solution 1

In this solution, we implement a new web application in order to make users manage their itinerary. This solution allows users to search multiple places and select any of them as the original place or midway place or their destination. It also helps users manage their time as an itinerary application.

This application developed by HTML and JavaScript as programming language and based on Google Maps API. HTML is a markup language for describing web documents and JavaScript is the programming language of HTML and the Web. We have also used CSS to make the application visually appealing.

As for this solution, there are two parts in the application web page as shown in Figure 1. One is a map that Google Maps provide, and the other is the menu which will provide functionalities to users. There are several buttons and textboxes in the menu part. The search textbox is designed for users to input places they might go and it will be autocomplete based on the string that users input. It is convenient for users because it will reduce the number of keyboard input characters. Once they search a place, it will generate a marker on the map. The label of the marker will be an integer based on the order of the places that users searched. So users can select any place they have searched by the number in the label and the place name will be added to the table below. The first selected place will be set as the start place.

Below the search section, there is a nearby search box and a nearby search button. The first textbox is designed for users to input which place they want to "search nearby" from. Users can enter the label number on the map in this textbox. And the second one is designed to input the keyword for nearby search. We provide two recommendations here, parking and restaurant. We believe these are the most frequently used by users in their daily lives. Once users click on the nearby search, the results will show on the map as markers. Users can click on those marker labels and get information for the place and can click on add button and add it as their destination. Once add button is clicked, the other markers of this nearby search will disappear and add the place's name and drive time to the table.

In summary, this solution allows users search places and choose any of them as one of their destination, provide nearby search for every one of searched places by any keyword and make a table for users to see which contains drive time and drive distance between two places in order to let users manage their time for their journey.

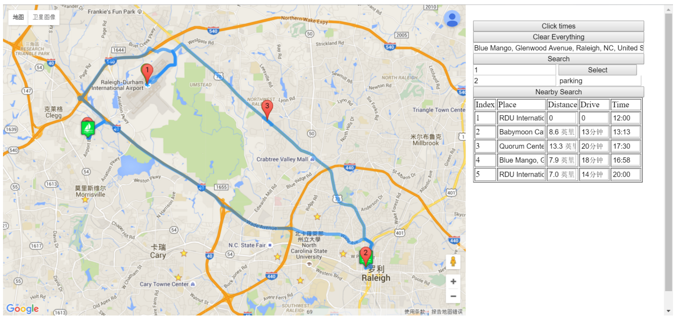

Figure 1: Screenshoot for Solution 1

4.2 Solution 2

We have used Javascript and HTML to implement our second solution as well. Depending on the results of January survey, we implement several features in the second solution in order to solve the usability problems, such as nearby parking and timeline, which are not included in Google Maps and also help to manage the itinerary.

In the second solution, instead of having the nearby textbox on the right side, we have added the nearby parking and restaurant button in the marker as shown in Figure 2. Once you have searched a place, there will be a marker on the map to show that place. Then you can click the marker, an info window will pop up and then you can click nearby parking button to show the parking places around. The add nearby restaurant function has the same operation flow with nearby parking function. By clicking the marker, it will keep the operation simple to use and make the user interface cleaner. Through marker, we also provide timeline management function. If we are interested in a place and decide to go there, we can add it into the itinerary table. In this form, we can record and manage the places like edit the arrival time and leave time for each places. Also, our application can automatically calculate the distance and drive time between each places and draw the directions on map.

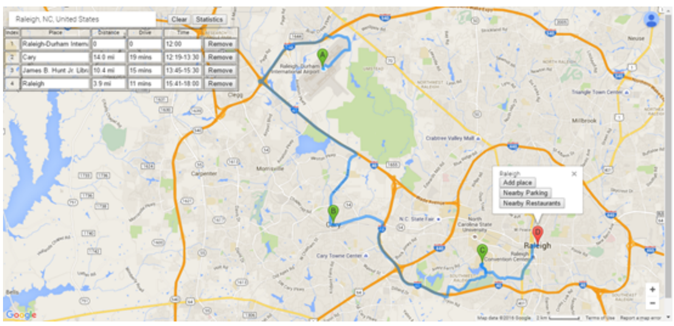

Figure 2: Screenshoot for Solution 2

4.3 Solution 3

We have used Android Studio as the tool to develop our third application and the core language for this solution is Java.

In this solution, we generated an android application which can be run on android-based devices such as phones, tablets and others. As stated in the previous section, 55% of the users preferred to use phones for this kind of activity so we decided to use Android for the third solution. Unlike the user interface of web, relied on indirect manipulation on mouse or touchpad to achieve goals, android's user interface is mainly based on direct manipulation, using touch gestures that loosely correspond to real-world actions, such as swiping, tapping and pinching, to manipulate on-screen objects, along with a virtual keyboard for text input.

In the third solution, there are two user interfaces (or activity in Android terms) in the application as shown in Figure 3. The first interface is the itinerary form where the user can add places and the times spent in each place. The second interface is a map which is provided by Google Maps Android API where the results are displayed. For example, when the user is planning for one-day trip, he/she can just provide multiple locations in the trip, depart time, and the time that he/she plans to stay in each location and then our application can show a complete itinerary in the map. This application can calculate the arrival and departure time at each location which is shown in the map interface.

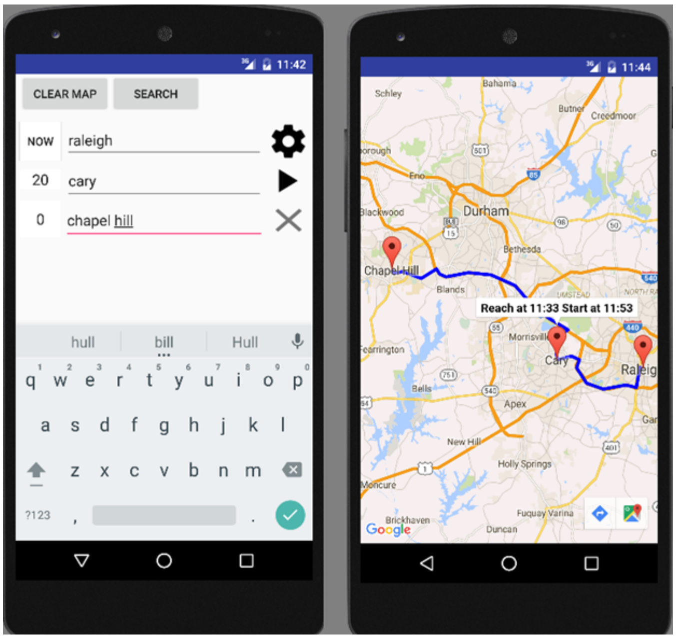

Figure 3: Screenshoot for Solution 3

5. EVALUATION

In this section we have discussed how we have decided to evaluate the three solutions.

5.1 User Test

In order to test the three solutions with different features, and to find how useful they can be in practice, we have designed an experiment to test the Google Maps with new functionalities.

5.1.1 Participant

A convenient sample of twenty participants were recruited for each solutions. Thus, we have sixty participants in total for our user test. The tests were primarily conducted in the graduate student spaces in Hunt Library and InteliMedia Lab in Engineering Building III of North Carolina State University. Other than that we visited some friend's places to conduct these tests. A significant number of the participants were in engineering related field and they had prior experience using Google Maps. Before the test, we explained each person how our maps applications work and that we have also given them several minutes to be familiar with it before test, we assume that all the participants are in the same level.

5.1.2 Procedure

The whole evaluation process consists of two parts. In the first part, a scenario was described to the users at the beginning of the test. The scenario is similar to the previous one but with less details to make it simpler because last time many users complained that the survey took "too long". The scenario was "Your friend Cara is flying from California to New York and has a layover at Raleigh for 8 hours. Her flight lands at 12pm and her flight to NY is at 8pm so she has to reach the airport by 7.30pm. She wants to visit a couple of places near Raleigh. You assume that you have taken the day off and you will be assisting her in the trip."
Following this, the test instructor gave the users one predefined task at a time, which they would try to complete by using one of our solutions and here is a work-flow for the first part tasks in figure 4. There are 5 tasks they need to complete while planning the itinerary and some important points had to be considered. For example, Cara arrives at 12 pm and leaves at 8 pm, so you need to pay much attention to time schedule because there are a couple of places to visit in the tasks. And as Cara is a fan of Museum of Natural Sciences, you should try your best to let her be in the museum as long as possible.
In order to achieve these tasks, participants need to take everything into consideration and it can maximally test the functions of applications they use. They were asked to find the restaurant by using the nearby feature but as Solution 3 didn't have a nearby feature so we suggested three options for simplicity. Also the participants were asked to search for parking near Museum of Natural Sciences using the parking nearby feature. After finishing all the tasks in the first part, the participants will be asked to fill a questionnaire. This helped us to get some feedback about whether they are satisfied with the three solutions. The users took less than 2 minutes to complete this part of the survey. In the user test, each participant only conduct one test for one solution, and this is the independent variable in the process for the reason that the performance of one participant will not cause any influence to the outcome of the test for other solutions. The dependent variables of the process are the Quantitative and Qualitative measures we obtained. The Quantitative measures primarily include measurement of time, the number of clicks and the number of input characters caused by those participants to complete the tasks. And the Qualitative measurements are the results from post questionnaire

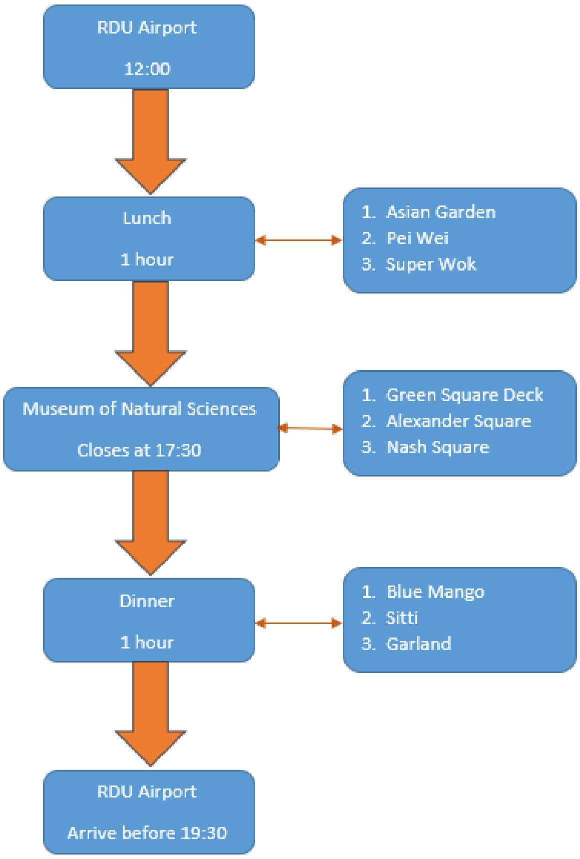

Figure 4: Procedure of user test

after the tasks.

5.2 Analysis

After we conducted the user test and post survey for the three solutions, we accumulated the results into a data sheet. The data sheet can be accessed through this link (https://goo.gl/dK5JRx). Then we ran some analysis on the data. As Dr. Menzies stated in the class that in this kind of data, median gives a better estimate than mean as an outlier can influence the mean but the median is unaffected. Further we have conducted Analysis of Variances test to find any significant difference between the groups and pairwise t-tests to find which solutions were significantly different. Finally we used Multi-criteria decision making methods to identify the best solution. First we found out the medians of all the fields which is shown in the table 1. This table can give us a basic idea about the three solutions.

Secondly we decided to plot a box-plot to compare the solutions using the five number summary - minimum, first quartile, median, third quartile, and maximum. The number of clicks, characters, total time, look and feel, complexity and functionalities are visualized using the box plots. There are showed in Figure 5-10. The comprehensive results can be found in the link:

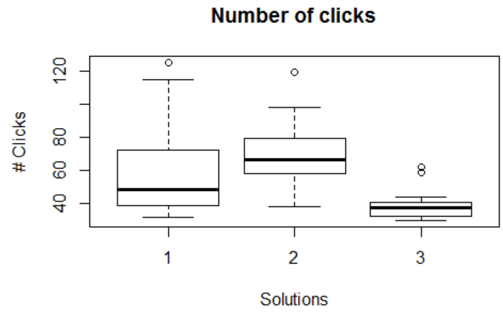

Figure 5: Device priority survey result

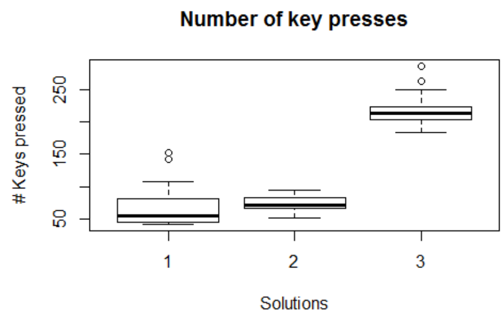

Figure 6: Device priority survey result

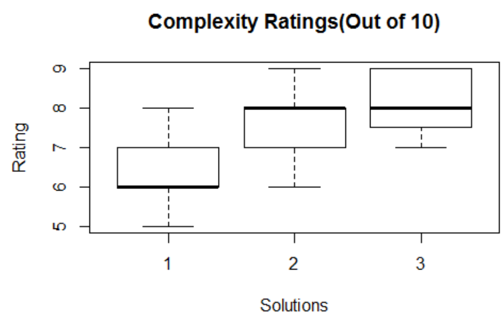

Figure 7: Device priority survey result

Solution	#Clicks	#Characters	Total Time	UI	Complexity	Functionalities
1	48.5	55	3.475	7	6	8
2	66.5	71	5.7	8.5	8	9
3	37.5	213.5	8.125	8	8	7

Table 1: Medians

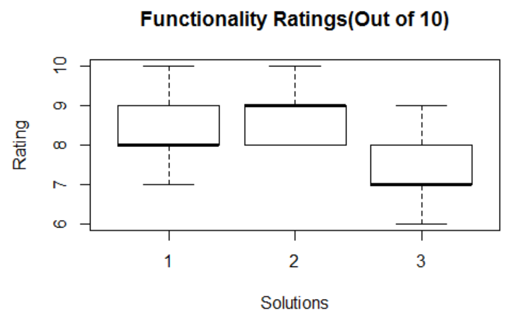

Figure 8: Device priority survey result

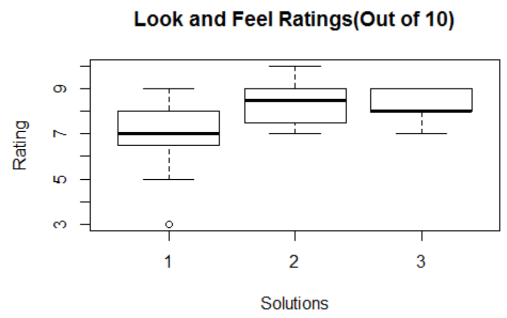

Figure 9: Device priority survey result

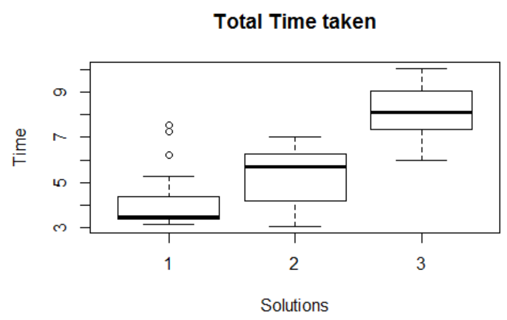

Figure 10: Device priority survey result

5.2.1 *Number of clicks*

The box plots shows there is much difference in the number of clicks between the medians and variances among the solutions, especially among solution 3 and the other two. Then we conduct Analysis of variance test which showed significant differences among the three groups: $F(2,60)= 12.552, p< 0.000$. Subsequent pairwise t-tests showed that solution 3 required significantly less number of clicks than the others: $t(23) = 3.2$, $p = 0.003$ (Solution 1); and $t(26) = 6.4546$, $p < 0.000$ (Solution 2). This can be attributed to the fact that in solution 1 and 2, the users had to click on the maps for adding the place whereas that feature was not present in solution 3 thereby reducing the number of clicks.

5.2.2 *Number of key presses*

The box plots shows there is much difference in the number of key presses between the medians among the solutions, especially among solution 3 and the other two. The ANOVA test showed significant differences among the three groups: $F(2,60)= 233.95$, $p< 0.000$. Subsequent pairwise t-tests showed that solution 3 required significantly more number of key presses than the others: $t(35) = -16.115$, $p < 0.000$ (Solution 1); and $t(27) = -23.796$, $p < 0.000$ (Solution 2). The auto-complete feature was not implemented for Solution 3 so the users had to type the entire name of the places which resulted in the more number of key presses in solution 3.

5.2.3 *Total Time*

The box plots shows there is much difference in the total time spent between the medians among the solutions, especially among solution 3 and the other two. The ANOVA test showed significant differences among the three groups: $F(2,60)= 57.852, p < 0.000$. Subsequent pairwise t-tests showed that solution 3 required significantly less number of clicks than the others: $t(37) = -10.341$, $p < 0.000$ (Solution 1); and $t(38) = -7.7086$, $p < 0.000$ (Solution 2). As the auto-complete feature was absent in solution 3, the users often had trouble locating the places in the map so the total time was significantly more for solution 3.

5.2.4 *Others*

The post survey was used to compare the "look and feel", complexity and functionalities of the solutions. As the users did the user test on only one of the applications, the results are independent of the other solutions. In general (from the box plot), the users rated solution 2 the highest and solution 1 the least in the context of look and feel. In terms of complexity the users found solution 3 the least complex and solution 1 the more complex. The reason for it might be many users found it confusing to enter the numbers from the map to add on to the itinerary. Finally the post surveys signified that the users liked the functionalities of solution 2 the most and solution 3 the least.

5.3 Best Solution

The previous section shows that the Solution 3 users took significantly less number of clicks, more number of key presses and more time than the other two solutions to finish the

same user test. However we didn't find any significant differences between solution 1 and solution 2.
Now we can assume that less clicks, less key presses and less time taken to do the same task is better. Then again more user grades for each of look and feel, complexity and functionalities is better. Our aim is to identify the best solution among the three from the collected data, so we have used Multi-criteria decision making methods on the median values to compare the solutions. We have employed Simple Weighted Additive Method which is the simplest and the most often used multi-criteria decision analysis method for evaluating a number of alternatives in terms of a number of decision criteria.
The method [7] is based on weighted average. If a MCDA [19] problem is defined on m alternatives and n decision criteria, such that W_j denotes the relative weight of importance of criterion C_j and a_{ij} is the performance value of alternative A_i when it is evaluated in terms of criterion C_j , the total importance of alternative A_i is defined as:

$$A_i^{SAWM-Score} = \sum_{j=1}^{n} (W_j a_{ij}) \, \forall i = 1, 2, 3, ..., m$$

SAWM works only with benefit criteria that is, the higher the values are, the better it is. As the user test criteria contains both benefit as well as cost criteria (that is, the lower the values are, the better it is) and so convert the cost criteria to benefit criteria and normalize the matrix using the equations: When the indicator is of the type more is better, we have:

$$\bar{R}_{ij} = 1 - \frac{R_j^* - R_{ij}}{R_j^* - R_{*j}} = \frac{R_{ij} - R_{*j}}{R_j^* - R_{*j}} \, \forall i, j$$

When the indicator is of the type less is better, we have:

$$\bar{R}_{ij} = 1 - \frac{R_{ij} - R_j^*}{R_{*j} - R_j^*} = \frac{R_{*j} - R_{ij}}{R_{*j} - R_j^*} \, \forall i, j$$

Here R_{ij} outcome achieved by the i^{th} system when is evaluated according to the j^{th} indicator; R_j^* = optimum value of the j^{th} indicator (ideal value); R_{*j} = worst value achieved by the j^{th} indicator; $\bar{R}_{ij}$ = normalised value achieved by the i^{th} system with respect to the j^{th} indicator.
We have considered equal relative weight of importance for all the criteria. The final results obtained from SAWM is shown in Table 2. When all the 6 criteria are considered, Solution 2 has resulted as the best alternative whereas Solution 3 has scored the least. This can be attributed to the fact that users rated Solution 2 higher than the other solutions and also it ranked second in number of clicks, number of characters and total time. On the other hand Solution 3 scored the least in 3 of the 6 criteria thereby resulted to be the worst solution. All the results and images are available in this link. https://goo.gl/qNIfX5

Solution	1	2	3
SAWM results	3.121	4.421	2.667

Table 2: SAWM Results

6. ACKNOWLEDGEMENT

We would like to thank Dr. Tim Menzies and the teaching assistant Shaown Sarker for giving us valuable advice in implementing the project. We would also like to thank the students who took part in the user test and post-survey.

7. FUTURE WORK

The android solution didn't have the nearby feature which can be implemented. Some of the users complained of the complexity of the web applications and probably the a better user interface can reduce the complexity. The users liked the automatic calculation of time in the itinerary. So that can be implemented in Solution 1 as well. Though they were satisfied with the functionalities in these applications, some users were overwhelmed with the complexity of the applications. So, according to the feedback from our user tests for all of the three solutions. The future work for this project is to finish the automate computing time for users to fill up the time-line, better user interface and make the application simpler to use.

8. CONCLUSION

In the month of January, we read several research papers on usability tests on different applications. Then we decided to do the survey on Google applications as it is used by millions of users throughout the world and several of its applications provide an API to develop over their applications. Subsequently we prepared a multi-step task and an accompanied survey where the users can provide their feedback. The survey proved to be really helpful as we found several usability issues with Google search and maps. Then we discussed about the problems the users faced and came up with three solution. In the month of February and March we developed three solutions. The first two solutions were developed using HTML and JS whereas the third solution was developed in Android Studio using Java. Then the users used our applications to conduct a similar user test and we noted the user experience. Finally we proved empirically that solution 2 provided the best overall user experience.

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