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# An Analysis on Exploring Geographical Information on Small Screen Cell Phones

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**Abstract:** Cell phones are now powerful enough to support and visualize maps, image and other complex information however screen is still small to support its portability. Exploring geographical information on small s screen is still a big challenge and one can't conceptualize and get all information at once on small screen. Overview + detail technique is common and widely used to explore large information however there are problems associated with it that is overview window hide some information from detail window and movement between two windows is not seamless. To handle these problems modified split screen technique is presented in this paper that has large overview window and provides detail window on toggle mode to provide unobtrusive behaviour and continuity while exploring the information contents on mobile screen. Experiment is conducted to compare both techniques: overview +detail and split screens. Results shows that with simple spatial tasks no differences surfaced for two techniques while with complex spatial tasks, split screens help more in exploring geographical information.

**Key words:** Geographical Information · Small Screen · Mobile Phone · Investigating · Cell Phone

## INTRODUCTION

Cell phone is now essential commodity of almost every human being and it is in much more advance shape than early age phones [1]. Its processing power, memory, level of applications and gadgets is tremendously increased over the time however its screen size is still limited to favour mobility of cell phones. This small screen of cell phones cause more effect during exploring information especially geographical information. Exploring geographical information on small screen is tedious job. Multiple zoom/pan actions need to be performed to explore and get contextual sense of the information. This situation is more highlighted when a query is posted to find some geographical information. In this case it is not possible to explore all the retrieved information received against the posted query at once on the mobile phone screen. Some part of information must goes beyond the screen and is generally called out of screen information and become not visible unless a mechanism is devised to view such information.

To overcome these situations number of techniques has been proposed, developed and still research going on to provide optimal solution to the problem. Most of techniques that are used to explore geographical information on mobile phones arrows, city lights, drag mag, edge radar, fish eye, halo, hop, multiscale zoom, overview + detail, panning, wedge, win hop, zooming [2-7] provide direct or indirect hint for existence of off-screen objects and some also provide information about its location as well. Some techniques city lights, drag mag, edge radar, fish eye, hop, multiscale zoom, overview + detail, win hop [8-13] provide an overview to assist the user in understanding the overall scenario of the maps while exploring information on cell phone screen. Techniques arrow, halo, wedge [14, 15] which provide direct hint to locate off screen objects only provides detail view and does not provide overview. Thus the user of such techniques requires extra mental concentration to recognize the contextual view while exploring off screen objects. While techniques panning, scroll and zooming techniques [8, 16, 17] does not provide contextual view however this can be achieved if the information is zoomed out to small scale. Table 1 shows detail of technique that has overview. However the techniques which provide overview have some problems. Techniques document lens, edge radar, fisheye [9, 11, 18] which provide distorted overview around detail view does not provide accurate distance information.

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Table 1: Techniques that provide overview.

| Technique | Availability of Overview |
|---|---|
| Arrow | Not available |
| City Lights | Along the borders of a window |
| Contextual Views | Contextual views |
| Document Lens | Distorted form around focus area |
| DragMag | Overview window |
| Edge Radar | Miniature view around the edge |
| Fish Eye | Distorted form around focus area |
| Halo | Not Available |
| Hop | Not Available |
| Magic Lens | Distorted form around focus area |
| Multiscale Zoom | At small scale only |
| Overview + Detail | Overview window |
| Pan | Not Available |
| Perspective Wall | Merged 2D and 3D representation |
| Scaled Arrow | Not Available |
| Scroll bars | Not Available |
| Semantic zooming | At small scale only |
| Wedge | Not Available |
| WinHop | Not Available |
| Zooming | At small scale only |

Overview + detail [8, 19] is technique commonly used to explore information on mobile phones however its small overview window laid over the detail windows hide many detail and also seamless spanning of the information is difficult in the scenario of overview + detail technique.

To handle these problems associated with overview + detail technique, modified technique is presented in this paper that has large overview window to minimize the obtrusive behaviour of overview screen laid over the detail view and providing the continuity behaviour between overview and detail view.

Roadmap for the remainder of this paper is as follows: In section 2 research methodology is described, whereas Section 3 and 4 highlights overview + detail and split screen techniques respectively. Section 5 is about implementation of proposed technique followed by section 6 that underpin results. Finally section 7 conclude the topic.

**The Research Methodology:** Three stage processes - design, implementation and evaluation is used as research methodology to accomplish the work underpinned in this paper.

In the first phase, design to improve the existing traditional overview + detail technique is presented with all the necessary consideration about the proposed split screen technique. Design of technique is implemented in the second phase. The implementation is done using Flash software with the help of built in action Script language on the Windows platform. Flash is used to develop the interface of prototype for the split screen technique. This software is used in number of previous related studies for the purpose of evaluation of visualization techniques [15, 10, 21].The action script language which comes coupled with flash is used to implement the logic of main algorithm as well as data logging procedure.

In the final stage implemented technique is evaluated by comparing it with traditional overview +detail technique. For evaluation purpose user testing is performed for both techniques for comparative analysis. After critical study of literature regarding tasks required for the study, closest, order and locate tasks are selected. Tasks made as practical and meaningful as possible for the user. Task duration time, errors rates and user preference evaluated while performing the tasks by the users during the study.

**Overview + Detail Technique:** This technique has the detail view window with a smaller overview window at the bottom of the screen. Both windows are tightly coupled, i.e. performing an operation performed on one window immediately transfers to the other one. The overview featured a field-of-view box that represents current displayed detail view. Users could either pan on the overview by dragging the field-of-view box, or jump to another position by tapping the overview window outside the box. The field-of-view box then automatically moved to the pen position. Overview + detail technique widely used in the current applications such as Google maps, but certain problems has been reported by [8, 14, 19, 22-24]. An experiment is performed on overview + detail technique [22] which elaborated that both direct manipulation of the object in the overview and manipulation of objects by highlighting in the overview have a positive effect on user performance in terms of task completion time however recognition of spatial configuration of targets is difficult to achieve in traditional overview + detail.

**Split Screen Technique:** To explore information and make maximum availability of queried objects on the small screen of cell phone split screen technique is designed and implemented. This technique undertakes improvement for the unobtrusiveness and continuity of the information contents available on the screen by dynamically avoiding hindrance. Split screen technique designed by considering: 1) avoid hindrance, 2) maximize object availability and 3) provide an additional distance cue.

- *Avoiding hindrance*: Hindrance of the detail view by overview is resolved by separation of display of detail view and overview using technique of split screens.
- *Maximizing the availability*: To locate queried information over the screen of cell phone, each split screen aid users.
- *Distance estimation*: The split screen laid on the overview to facilitate approximation of the distance between the two queried information.

**Split Screens Layout Algorithm:** The algorithm select number and size of split screens in proportion with the scale of information contents resulted from the query posted by the user. Scale of resultant information is computed dynamically to estimate the number of split screens and thus size of split screens and to enable the toggle mode to shift between overview and detail view.

**Scale of Queried Contents:** Scale of information retrieved against the query parameters, may vary with the number of retrieved objects and distances between these objects. When the query is posted, coordinates of the returned objects are fetched from the database and then latitude and longitude of objects are sorted in order to find minimum and maximum latitudes and longitudes. Such latitudes and longitudes are then used to find the upper, lower, left and rights limits with the help of "haversine" equation as in (1)

$$a = \sin^2(\Delta\varphi/2) + \cos(\varphi_1).\cos(\varphi_2).\sin^2(\Delta\lambda/2)$$
$$c = 2.\text{atan2}(\sqrt{a}, \sqrt{(1-a)})$$
$$d = R.c \quad (1)$$

where $\varphi$ *is latitude,* $\lambda$ *is longitude, R is earth's radius (mean radius = 6,371km)*

Using these limits bounding rectangle is formed at the suitable scale. Limits of bounding rectangle is enhanced from extreme positions as surrounding information may also be needed by the user. To facilitate the user 10% of the screen size of the cell phone added up to the bounding rectangle to find the information extents.

**Suitable Visualization Scale:** To structured and conceptualize the design process of proposed research, we surveyed mobile device users about their usage of map in mobile devices. Our main goal was to understand user's attitude toward the use of maps in the mobile devices. 50 participants from different organizations were participated in this survey. Survey was conducted with the help of questionnaire to get an overview of scale of maps they prefer while using the maps in the mobile phones. The resulting replies by the users suggest that most of the people (58%) like the view of maps/geographical information on the large scale. However exact suitable scale to be select from the range of large scales depend on processing power and screen size of cell phone and availability of necessary geographical information.

**Number of Split Screens:** Number of split screens is proportional to the suitable scale of information. A check is performed to see whether information extents exceed the limit of cell phone screen if displayed on suitable scale or not. If information extent is in approximate to the size of cell phone screen then no split screens are generated. However if information extent exceeds the limit, then information is virtually divided according to suitable visualization scale and split screens are rendered over the information.

**Toggle Mode:** Split screen technique provides detail view and context view using the toggle mode and helping to minimizing the effect of hindrance of overview layout over the detail view. Toggle mode facilitate quick shift the between the two views (overview, detail view).

**Size of Split Screen:** Size of split screen is integrated with the production of number of split screen against the extent of information according to the suitable scale.

**Implementation:** Design of split screens implemented in Adobe Flash CS4 and Action Script 3 as a prototype and then tested to compare its effectiveness.

- Hypothesis: Hypotheses for testing prototype were the following:
  H1-Both visualizations would be equally effective in term of task duration time and error rate for the simple closest and locate tasks.
  H2-Split screen technique would allow users to complete the order task comparatively faster than overview + detail technique.

- Participants: 12 participants took part in the prototype evaluation. Most of them were well aware of mapping functions especially navigation. None have previously used split screen technique and two have used overview +detail technique before.

- Apparatus: The experiment conducted using a standard desktop computer. Display characteristics (resolution and colours) set to simulate of size 240 x 320. Standard two-button mouse used as input. All maps represented similar kind of geographical area.
- Interfaces: Split screens limited to four for simplicity and toggle mode was achieved with the help of keys from 0 to 4. Suitable scale selected as 15,000 due to limitation of necessary information to test the technique and screen size.
- Tasks: The tasks considered partially inspired and adapted from related studies [3]. Participants were educated to complete each task as quickly as possible while maintaining reasonable accuracy as well.. During the evaluation, each participant has carried out total 12 tasks, out of which 6 tasks belong to split screens and 6 tasks belong to overview +detail. Total 144 tasks performed.

- *Task Complexity:* In all tasks, objects spread at different distances on all four sides of the view. In any task orientation of objects have similar complexity for two visualizations techniques. For different number of objects for example 5 or 8, the task complexity differentiates. Task complexity measured with the help of objects distances from the user position which considered as center of screen. The tasks which had similar complexity had equal distances from the user position with the tolerance of ± 5%. Objects distance calculated with the help of "haversine" equation as in (1) mentioned above.

- *Closest Task:* This task reflected in majority of past evaluations studies to tackle the off screen object location problem [5]. In this task participant designate which off screen/on screen object closest to the user location? In this task, users provide their answers by clicked on the graphical symbol displayed on screen representing the closest off screen object.
- *Locate Task:* This task judge accurate location for off screen objects. In this task, participants provide their answers by clicked at the estimated location technique of the off-screen objects for overview + detail technique and pick the estimated location directly in the split screen technique.
- *Order Task:* This is a comparatively difficult task and evaluates the distance of all off screen objects. In this task participant order all off screen objects according to the increasing distance from the user location. In this task, users provide their answers by click in distance order on all graphical elements associated to off screen or on screen objects.

**Procedure:** Training session facilitate participants about the nature of study, technique to be used (split screen or overview + detail) and the associated evaluation tasks to be performed. Initially two demonstration tasks corresponding to the two different task types to let participants make acquainted with the conditions undertaken. Participants instructed to start the evaluation test actually after training session. Once these tasks completed participants completed ranking of techniques according to their preference. All tasks (including demonstration and evaluation tasks) presented via an on-screen dialogue window. Each task commenced with the participant clicking the "Read Task" button, which displayed instructions related to the task. After understanding, participant wanted to begin the task, clicked the "Start Task" button. This displayed required window (split screen or overview + detail) immediately. On completion of the task participant clicked the "End Task" button. The participant then proceeded to the next task by once again clicking the "Read Task" button if desired to do so.

**Data Logging:** For each participant, prototype also logged task duration time and clicked points to evaluate error rates.

## RESULTS AND DISCUSSION

Results of based on task duration time, error rate and participants' preferences carried out with the help of three tasks i.e closest, locate and order tasks for two information exploring techniques (split screen and overview + detail) are presented as follows.

**Task Duration Time:** Task duration time is calculated between the laps of clicking the "Start Task" button and clicking the "End Task" button. In the order task, task duration time includes user action of analyzing the objects, deciding which objects are closest and which are farthest to the user location, possible order of the objects with respect to the their distances from the user location and clicking the objects one by one in the order. In the locate task, task duration time includes user action of analyzing the objects and clicking the object at desired location. In the closest task, task duration time includes

user action of analyzing the objects, deciding which object is closest to the user location and clicking the closest object. It is assumed that participant will go through the task as quickly as possible. This assumption is based on the fact that the procedure is already demonstrated to them with the help of demonstration tasks and they have read the instruction of tasks to be carried by clicking the "Read Task" button before the start of task.

Figure 1 illustrate the summary of mean task duration time (in seconds). Techniques are abbreviated as SS (for Split Screens) and OD (for Overview + Detail). Mean time is represented by seconds and standard deviation is represented by seconds within brackets.

Summary of tasks duration times shows that task duration times for split screen technique and overview + detail technique are 16.64 sec and 19.09 sec respectively for closest tasks that suggest that both the techniques behave equally in term of task duration time. Moreover, task duration times for split screen technique and overview + detail technique are 15.01 sec and 12.33 sec respectively for locate tasks that also suggest that both the techniques perform comparative in term of task duration time. It is further added that task duration times for split screen technique and overview + detail technique are 50.97 sec and 58.52 sec respectively for order tasks that imply that split screen technique perform slightly faster comparative to overview + detail technique in term of task duration time.

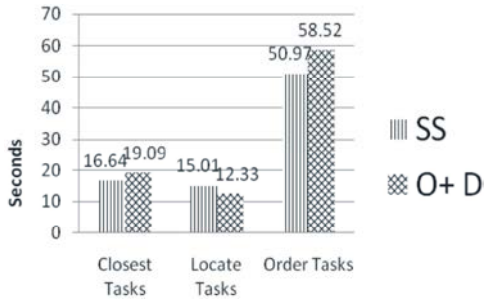


Fig. 1: Summary of task duration times

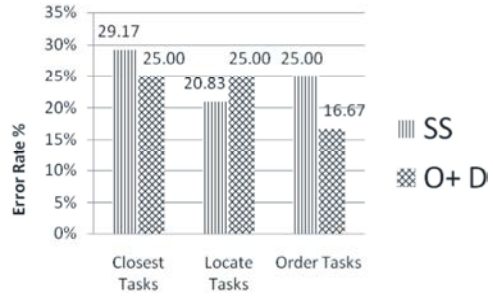


Fig. 2: Summary of error rates

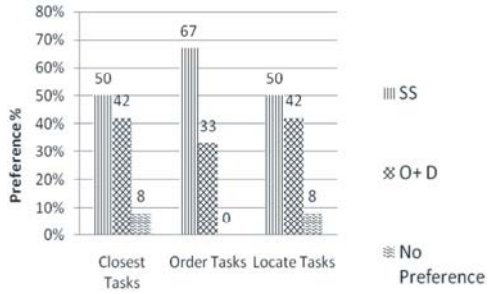


Fig. 3: Summary of participants' preference

**Error Rate:** Error rate is calculated based on the user input during the tasks and their percent correct performance was analyzed. In the order task, error rate is estimated by the percentage of correct order of off screen objects submit by the users. In the locate task, error rate is estimated by the percentage of correct answer for the object location submit by the users. Similarly in the closest task, error rate is estimated by the percentage of correct answer for the closest objects submit by the users.

Figure 2 illustrates the summary of mean error rates (in percentage). Mean error rates are represented by percentage and standard deviation is represented by percentage within brackets. Techniques are abbreviated as SS (for Split Screens) and OD (for Overview + Detail).

Summary of error rates shows that error rate for split screen technique and overview + detail technique are 29.17 % and 25 % respectively for closest tasks that suggest that both the techniques behave equally in term of error rate. Moreover, error rate for split screen technique and overview + detail technique are 20.83 % and 25 % respectively for locate tasks that also suggest that both the techniques perform comparative in term of error rate. It is further added that error rate for split screen technique and overview + detail technique are 25 % and 16.67 % respectively for order tasks that imply that split screen technique slightly outperform overview + detail technique in term of error rate.

**User's Preferences:** Participants were prompted to record their preferences about the two information exploring techniques by designating a score of 1 or 2. Furthermore they were also asked to score 0 if they do not want to prefer any of the two techniques.

Figure 3 illustrates the summary of mean participants' preference (in percentage). Techniques are abbreviated as SS (for Split Screens) and OD (for Overview + Detail). Mean participants' preferences are represented by percentage.

Summary of participants' preference shows that participants' preference for split screen technique and overview + detail technique are 50 % and 42% respectively for closest tasks, in addition to 8% for the participants who do not prefer any technique in such task. Moreover, participants' preference for split screen technique and overview + detail technique are 50 % and 42% respectively for locate tasks, in addition to 8% for the participants who do not prefer any technique in such task. It is further added that participants' preference for split screen technique and overview + detail technique are 67 % and 33% respectively for order tasks that imply that split screen technique is preferred more than overview + detail technique in these tasks.

## DISCUSSION

According to first hypothesis [H-I], in the closest task, we expected overview + detail and split screen to be equally effective in terms of error rate, as both provide more powerful means to accurately find the closest off-screen objects (a visual representation of the configuration of objects in the first case, larger overview window in the second case). We also expected the number of objects to have no effect on the results because users could focus on each object independently of the others to find out its location and were given no time pressure to finish the task. Additionally regarding first hypothesis [H-1] in the Locate task, no technique has a significant benefit over the other irrespective of the strategies adopted by the participants to complete the task (traverse screen to recognize the particular split screen portion in split screens technique, scam the overview window to recognize the dot in the viewfinder in overview + detail).

According to second hypothesis [H-2], in the order task users were considerably slower with overview + detail than they were with split screens technique. This task can be considered as a complex version of closest task, as it demands participants to recognize the closest off screen object, then the closest among the remaining off screen objects and so on up to the farthest off screen object. Likely possible reason of these results is that it is easier for users to scan through the larger overview window as in case of split screen technique than to compare the distances of dots from the viewfinder in a small overview window in case of overview + detail technique. This confirmed already existing drawbacks of small overviews in the overview+ detail technique, for which we presented the technique of split screens which has larger overview window. It is noted that there was practically no difference in the mean times between 5-objects and 8-objects conditions with the two techniques. However significant effect of number of objects on error rate, is noted which greatly increased as the number of off-screen objects increased.

## CONCLUSION

Generally speaking, the results of the study illustrate that both the information exploring techniques behave equally to help users in executing various spatial tasks that involves visualization of off-screen objects. In particular, we found that split screens is a rather handy solution for the off-screen objects problem and is more effective than overview + detail when the user wants ordering of off-screen objects according to their distance from the user position (as in the order task).However, minor difference exists between the two techniques when users required finding of off screen objects that were closest to the user position (as in the closest task).The two techniques seem to be evenly good solutions when the location of individual off-screen objects is required to be estimated. Designers of mobile applications that support activities in which the user needs to gain spatial awareness of the information space (e.g., decision support systems, geographic information systems) have instead no simple choice. As we saw in the results, choosing the wrong technique for a certain task impacts user performance. Finally, we found that a small increase in the number of off-screen objects negatively affects user performance particularly in error rate especially in the case of overview+ detail, while it has a negligible effect in terms of task completion time.

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