# An Efficient Document Browsing Method with Floating Diagram Window on Mobile Device

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**Abstract.** This paper proposes an efficient method to browse the document including diagrams on mobile devices equipped with touch screen. With the method, the user can pull the referenced diagram close to the referrer sentence and browse the pulled-in diagram and the document simultaneously. The pulled-in diagram is displayed in the floating window overlapping the document. Both the pulled-in diagram and the underlying document are able to be scrolled and zoomed in/out by the user independently of each other. From the experiment, it is found that the proposed method is efficient for operation on mobile devices and the method is viewed very positively by the participants.

**Keywords:** mobile interaction, document browsing, touch screen, human interface.

## 1 Introduction

It is very common today to use mobile devices like cell phones or PDAs (Personal Digital Assistant) for browsing web pages or documents. Furthermore, recent mobile devices are equipped with a high-resolution touch screen so that the user can scroll or zoom in/out with intuitive finger gesture on the screen.

While users browse a document including some diagrams, they often want to see both referrer sentence and its referencing diagram simultaneously. However, it is difficult to do so with mobile devices because of their small screen size. On such devices, users have to scroll the document to see the desired sentence or diagram. Furthermore, if they want to see the sentence and the diagram mutually, they have to scroll so often that it takes long time to browse the document. It is also time consuming operation to zoom in/out the contents to get the suitable view magnification.

This paper proposes an efficient method to browse the document including diagrams on mobile devices equipped with touch screen.

## 2 Proposed Method

Our proposed method provides a floating diagram window overlapping the document. With our proposed method, the user can pull the referenced diagram close to the referrer sentence with following manner. Firstly, he/she touches a referrer word, such as “figure x” or “table y”, on the screen, and then a string-like graphical line is drawn

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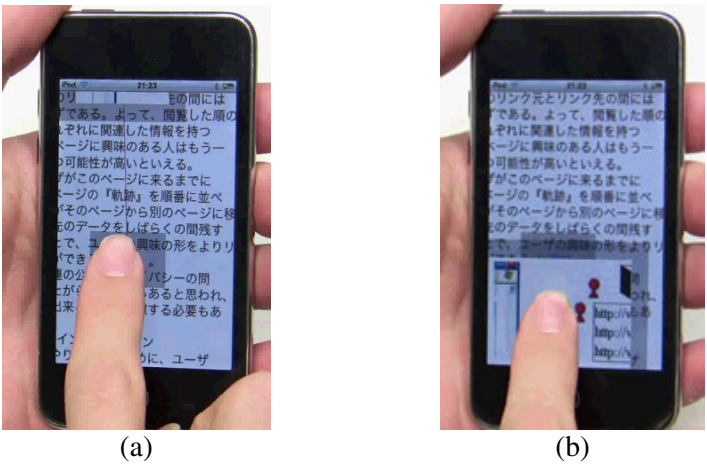
between the word and the referenced diagram. If he/she pulls the string with his/her swipe-in finger gesture, the diagram is pulled into the screen and shown in the floating diagram window. Fig. 1 shows how to pull a desired diagram into the screen.

The pulled-in floating diagram window overlaps the document. The user can touch the window's border and drag the window to desired position. He/she can also scroll or zoom in/out the diagram in the window. He/she can scroll it with swipe finger gesture and zoom it with pinch finger gesture. At the same time, with the same manner, he/she can also scroll or zoom in/out the underlying document. Both the pulled-in diagram and the underlying document are able to be scrolled and zoomed in/out by him/her independently of each other. As a result, with the proposed method, the user can browse the document and the diagram simultaneously on the small screen of mobile devices.

When the pulled-in diagram becomes to be unnecessary for the user, it can be thrown away from the screen with the swipe-out finger gesture with touching the border of the diagram window.

In order to implement the proposed method, there must be a link between the referrer word and its referencing diagram. This paper focuses on HTML documents which already have such links. It might be our future work to propose and implement a method for making a link between the referrer word and its referencing diagram in other type of document.



(a) (b)

**Fig. 1.** With the proposed method, (a) a user can touch a referrer word on the screen and (b) pull the referenced diagram into the screen with swipe finger gesture

## 3 Experimental Evaluation

The purpose of experiment is to examine the performance of the proposed method to browse the document including some diagrams on mobile devices. The proposed method is compared with a conventional method described below.

### 3.1 Compared Conventional Method

With a conventional method for browsing the document on mobile devices with touch screen, users can simply scroll the document with swipe finger gesture and zoom in/out it with pinch finger gesture. Our proposed method is compared with this conventional method experimentally.

### 3.2 Prototype System

Both proposed and conventional methods are implemented on the Apple's iPod touch (3rd generation, 8GB memory). Its screen resolution is 320 by 480 pixels but top of 20 pixels are used as the status bar. Thus the resolution for displaying the document is 320 by 460 pixels.

In the prototype system of the proposed method, the resolution of floating diagram window is 320 by 230 pixels and the width of each border is 30 pixels. Thus the resolution for displaying the diagram is 260 by 170 pixels. The width of diagram display area is a little bit narrower than that of document display area. The height of diagram display area, on the other hand, is less than a half of the height of document display area so that the user can read the underlying document around the floating diagram window.

### 3.3 Procedure

Ten participants were recruited from our university. They were undergraduate and graduate students (nine male, one female). A repeated measurements within-subject design is used for the experiment.

In the experiment, each participant was asked to hold the mobile device and to tap the start button on the screen. Then a HTML document with some figures was shown on that screen. The participant was asked to find two questions in the document and to answer orally one by one. In order to answer each question, he/she must see the figure referred in the question. After he/she answered both questions, he/she pressed the hardware stop button below the screen.

Task completion time, the elapsed time from pressing start button to pressing stop button, was measured. Subjective evaluation was also done with a questionnaire after each task.

## 4 Results and Discussions

Through the experiment, all participants answered all questions correctly. This means that both methods allowed users to browse the document without serious problems.

### 4.1 Task Completion Time

From the experiment, as shown in Fig. 2, it is found that the task completion time with the proposed method was 28.5 seconds and was slightly shorter than that of conventional method (30.5 seconds). However, there was no significant difference between them ($t(59) = 1.983$, $p = 0.052$).

In order to analyze the task completion time in detail, we classify the time into two categories. They are a browsing time and an operation time. The browsing time is time to see the document or the figure with no operation. If there is an operation, such as scrolling or zooming, it is considered as the operation time.

With this classification, it is found that, as shown in Fig. 3, the operation time with the proposed method was 5.5 seconds and was significantly shorter than that with the conventional method (10.8 seconds, $t(59) = 4.6709$, $p < 0.01$).

Talking about the browsing time, there was no significant difference between two methods. In our prototype system of the proposed method, as mentioned before, the resolution of diagram area was less than that of document area. Especially, the height of diagram area was less than a half of the document height. With this prototype system, the size of pulled-in figure was adjusted to that of the floating window so that it was sometimes smaller than the size of figure with the conventional method. In such case, it might take a little bit long time to browse the figure. This might be one reason why there was no significant difference about the task completion time between two methods.

These results mean, anyway, that the proposed method is more efficient than conventional method for operation on mobile devices.

### 4.2 Subjective Evaluation

Fig. 4 shows the results of the subjective evaluation about ease of learning and ease of operation. From this figure, it is found that both methods were easy to learn and to operate. This means that the participants viewed the proposed method very positively.

It might be easy for participants to learn the operation of conventional method because the number of operation was so few, they were zoom in, zoom out, and scroll. Furthermore, participants were already familiar with such operation. Talking about the proposed method, it was also easy to learn the operation. This might be also caused by a few operations to learn. A few participants also commented that the pulled-in manner of the proposed method was very intuitive and easy to learn.

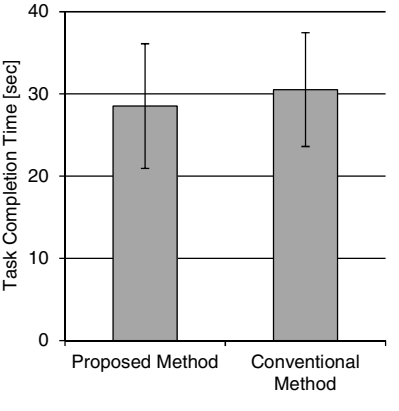



**Fig. 2.** Task completion time

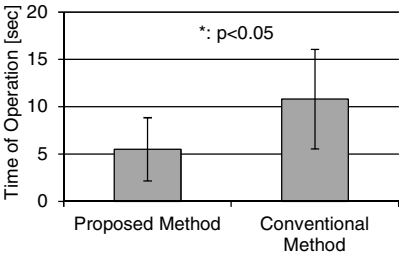



**Fig. 3.** Time of operation

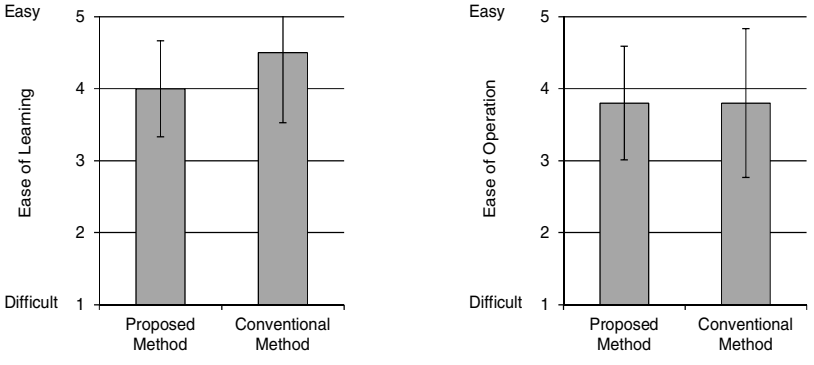



**Fig. 4.** Subjective evaluation. (a) Ease of learning. (b) Ease of Operation

The manner of operation with the proposed method was similar to that of conventional method. This might be a reason why there was no difference between the proposed method and conventional method about the ease of operation. Furthermore, some participants highly evaluated the proposed method because they could decrease the number of scrolling to see the figure and the document mutually.

Some participants complained that the border width of the floating diagram window was too narrow that they sometimes could not touch them as they wanted. They claimed to widen the width. However, to widen it makes the size of diagram smaller and might increase the difficulty of browsing the diagram.

## 5 Related Work

In order to improve the navigation on small screens, Igarashi et al. propose the speed-dependent automatic zooming. In this zooming, the view automatically zooms out when the user scrolls rapidly so that the perceptual scrolling speed in screen space remains constant [2]. Ishak et al. propose content-aware scrolling (CAS), an approach that takes into account various characteristics of document content to determine scrolling direction, speed, and zoom [3]. Both methods can improve the scrolling

speed but they don't focus on browsing both referrer sentence and its referencing diagram mutually and efficiently.

Web pages are typically designed with the desktop screen in mind and can be hard to read on small screens. There are many studies to overcome this problem with adapting the original web page to the small screen. Summary Thumbnails [4] provides an enhanced thumbnails view with text fragment. Ahmadi et al. propose a method that automatically adapts a desktop presentation to a mobile presentation with generating a set of small subpages [1]. However, with these kind of adaptation, it should be hard to read referrer sentence and its referencing diagram mutually.

## 6 Conclusion

In this paper, an efficient method to browse the document including diagrams on mobile device is proposed and evaluated experimentally. From the experiment, it is found that the proposed method is efficient for operation on mobile devices. From the subjective evaluation, it is also found that the proposed method is viewed very positively.

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