Wired Fisheye Lens: A Motion-based Improved Fisheye Interface for Mobile Web Map Services

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Abstract. We propose a mobile Web map interface that is based on a metaphor of the Wired Fisheye Lens. The interface was developed by using an improved fisheye views (Focus+Glue+Context map). When a user wants to obtain information on both the details of the target area and the geographical relation between the present location and the target area by using existing Web map services, he/she has to scroll maps and change the scale of the maps many times. These operations result in a large cognitive cost for users. The Wired Fisheye Lens enables users to easily search an area surrounding the present location since it has the following features: 1) The Focus+Glue+Context map enables users to view both a large-scale map (Focus) and a small-scale map (Context) without changing the scales of the maps; 2) The posture sensor enables users to search for details of the surrounding area by tilting, shaking, and looking through the fisheye lens; 3) The Focus is moved by considering it to be a fisheye lens connected with the present location by a rubber wire on the map. Even if the lens approaches the edge of the screen, it can be kept within the screen by scaling down the Context as if the lens were pulled in by its rubber wire and as if the map were a rubber sheet and pulled in by the lens. As a result, the user can easily navigate through the area surrounding the present location while keeping the Focus within the map. These features enable users to find the target quickly. We developed the Web-based mobile map system that uses commercial maps that are utilized by Yahoo Japan. We confirmed the advantages of the proposed system by evaluation experiments. The new system will be able to contribute to the novel mobile Web map services with fisheye views for mobile terminals such as cellular phones.

Keywords. fisheye views, Focus+Glue+Context, Web map service, mobile maps

1 Introduction

In recent years, advanced Web map services such as Google Maps [1] and Yahoo! Maps [2] have become available. These services support not only PCs but also mobile terminals such as cellular phones and PDAs. Mobile terminals mounted with GPS, geomagnetic sensors, and acceleration sensors enable novel mobile services such as pedestrian navigations [3, 4].

On the other hand, when users want both information on multiple areas and their relation to areas such as the present location and target area, they have to switch between multiple maps with different scales and mentally form geographical relations between these maps. These operations lead to a large cognitive cost for users.

For instance, let us assume a situation in which a user searches for a landmark on a street by using a mobile map. Although it is easy to search for a target displayed within the screen, the user has to scroll and zoom the map if the target is not displayed within the screen. The user may lose sight of the present location if it becomes necessary to repeatedly scroll and zoom the map. Moreover, a small target landmark cannot necessarily be displayed when a user views a wide-area map to comprehend geographical relations. This problem becomes particularly serious in devices having small display screens.

In our previous study [5], we proposed a *Focus+Glue+Context* (we call it *F+G+C* in this paper) map based on a metaphor of a fisheye lens, as shown in Figure 1. This map enables users to simultaneously view *Focus* (detail and large-scale map) and *Context* (small-scale map). In contrast to a Focus+Context map such as fisheye views [6, 7], since *Glue* absorbs all distortion properly, an F+G+C map has no distortion in Focus and Context. In contrast to the existing fisheye views for cartographic data, where the whole region is generated by using the displacement function, in the F+G+C map, only Glue is generated by using the displacement function. Since the generation cost of the F+G+C map is low, therefore, a high-quality F+G+C map can be generated in real-time. In fact, we have begun the F+G+C map Web service that was developed in collaboration with Yahoo Japan[1].

Although Web map services are supposed to be controlled mainly by the mouse, mobile terminals on which a mouse cannot be mounted are not necessarily considered. Although touch display is a good device for controlling web maps, a user cannot control it on mobile terminals by using one hand. Then, we proposed a motion-based mobile map interface by using posture and acceleration sensors, which are popular in recent mobile terminals.

It has been proposed that a posture sensor is useful in mobile map systems. Rekimoto [8] proposed a mobile map interface in which a bird's-eye-view map can be controlled by using a posture sensor and a button. Nadia [9] proposed a mobile map interface in which a 3D map can be controlled by applying VR technologies. Since these systems cannot enable users to simultaneously view multi-scale maps, users have to grasp geographical relations from a small-scale map (Context) before they view a large-scale map (Focus). In this regard, these systems have the same problem as existing Web maps.

The purpose of this study is to propose a mobile Web map service that enables pedestrians to search areas surrounding their present location easily. We need to comply with the following requirements in order to realize this goal:

requirement 1 The focus area should be shown in detail in order to search the target area easily.

[1] Fish-Eye powered By Emma. http://joint.alpslab.jp/fisheye/

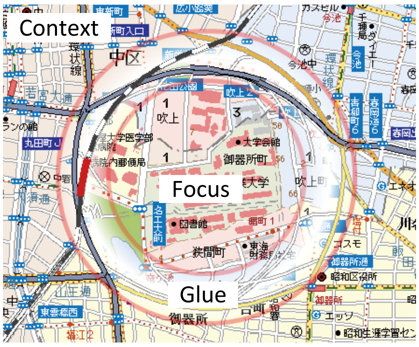

Fig. 1. Focus+Glue+Context map.

requirement 2 The direction of the focus area from the present location and the distance between them should be shown correctly so that the user can understand the geographical relation between these areas easily.

requirement 3 The present location should be shown constantly so that it is never out of sight.

requirement 4 The entire target area should be shown in order to survey the target area.

We propose the motion-based mobile Web map interface based on a metaphor of the *Wired Fisheye Lens* in order to search the surrounding area. The proposed system has the following three features, as shown in Figure 2.

feature 1 The F+G+C map enables users to view both Focus (large-scale map) and Context (small-scale map) on mobile terminals in real-time. Since in the F+G+C map, the direction of a center of any focus from any point of context as well as the distance between these two points are correct, we expect that the cognitive cost of grasping geographical relations is low (correspond to requirements 1 and 2).

feature 2 Scrolling the position of Focus by changing the posture of a mobile terminal enables users to search a target area. By automatically controlling the scale of Context to display both the present location and the focus area constantly, users can comprehend geographical relations between these regions (correspond to requirement 3).

feature 3 By shaking a mobile terminal, users can control the size and scale of Focus as required. By doing so, users can efficiently search target areas where sizes are different, e.g., a large park and a small park. (correspond to requirement 4).

In this study, we develop and evaluate a proposed system that operates on a mobile terminal.

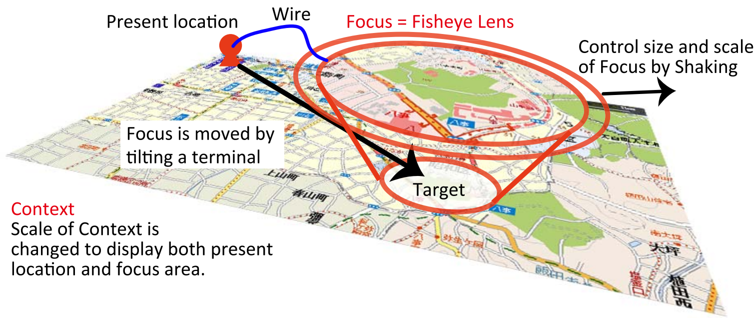

Fig. 2. Conceptual diagram of a metaphor of Wired Fisheye Lens.

2 Proposed System

In this section, we describe the Focus+Glue+Context map, a metaphor of the Wired Fisheye Lens, and system architectures.

2.1 Focus+Glue+Context Map

An F+G+C map has Focus, Glue, and Context, which are based on cognitive maps [10]. As shown in Figure 1, Focus is a large-scale map area that enables users to comprehend the details of the focus area, Context is a small-scale map area that enables users to comprehend global relations, and Glue shows the roads that connect Focus with Context. In contrast to the existing fisheye views [6], in the F+G+C map, there is no distortion in Focus and Context because Glue absorbs all distortion. Then, Glue is compressed by a large amount in the direction from Focus to Context. Major roads, rails, and the roads that run down from the area in Focus into the area in Context are drawn selectively in order to reduce the density of the roads in Glue.

In addition, in the F+G+C map, both the direction of center of any focus from any point of context and the distance between these points are correct. If the target object is centered in Focus, we can comprehend geographical relations between Focus and Context directly.

Moreover, in the F+G+C map, the calculation cost is lower than that in the existing fisheye views for maps, where the whole region has to be transformed. Although Glue must be dynamically generated according to its shape, the advantage of Focus and Context is that there is no need for dynamic generation. Therefore, by generating the Focus and Context maps in advance, we can generate the F+G+C map in real-time.

2.2 A Metaphor of Wired Fisheye Lens

Although the F+G+C map has several advantages, it has a problem in that ordinary people may not easily control the map. For instance, the F+G+C map has six degrees of freedom: users have to independently control the position (x- and y-axes), size, and scale of the Focus; the width of the Glue; and the scale of the Context. Therefore, users need to perform complex operations to control the F+G+C map in a suitable manner. This problem becomes particularly serious when users have to view multiple maps by changing scales. In order to easily control the F+G+C map, we need to develop intuitive operation methods that do not require the control of these parameters.

Therefore we propose the Wired Fisheye Lens metaphor to control the F+G+C map easily. This metaphor enables users to control the F+G+C map easily as if the Focus were the lens put on the paper map. The proposed system can be used to realize a metaphor of the Wired Fisheye Lens, as shown in Figure 2 and Figure 3, in order to search maps visually. This metaphor is based on a fisheye lens that connected with present location by a rubber wire is on the map. This metaphor enables the three following operations that correspond to features stated in section 1:

Look Users can view a large-scale map through the fisheye lens (correspond to feature 1).

Roll Users can scroll the position of the Focus by tilting the mobile terminal. In other words, the Focus is moved by considering it to be a fisheye lens connected with the present location by a rubber wire on the map. Even if the lens approaches the edge of the screen, it can be kept within the screen by scaling down the Context as if the lens were pulled in by its rubber wire and as if the map were a rubber sheet and pulled in by the lens, as shown in Figure 4 and Figure 10. As a result, the user can easily navigate through the area surrounding the present location while keeping the Focus within the map.(correspond to feature 2).

Shake By shaking the fisheye lens on the map, the size or scale of the fisheye lens can be changed (correspond to feature 3).

By tilting the mobile terminal, the fisheye lens (Focus) is moved. As shown in Figure 3-a, the fisheye lens can move freely unless the wire is stretched. However, when the wire is stretched, the lens protrudes from the display, and the wire generates an elastic force, as shown in Figure 3-c. When the elastic force exceeds a threshold and the Focus is moved out of the screen, the Focus (fisheye lens) is shown within the display by scaling down Context (map), as shown in Figure 4. In other words, Focus is moved as though there is a force F that rolls the fisheye lens and an elastic force K that pulls in the map according to gravity g, as shown in Figure 5.

2.3 System Architecture

The proposed system that we developed is based on a client-server model. This system consists of a Web map server and a mobile terminal that has a geo-magnetic sensor and an acceleration sensor built-in, as shown in Figure 6. We consider a mobile terminal consisting of a small tablet PC, PDA, and cellular

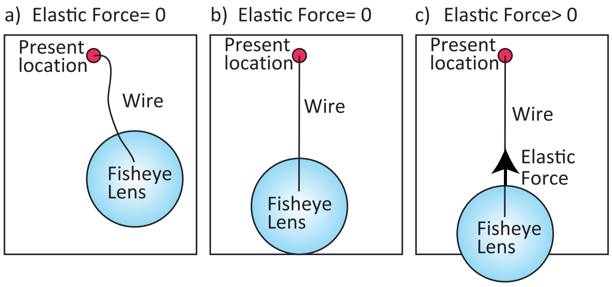

Fig. 3. A metaphor of Wired Fisheye Lens. a) Wire is slack. b) Wire is just stretched. c) Wire is stretched further.

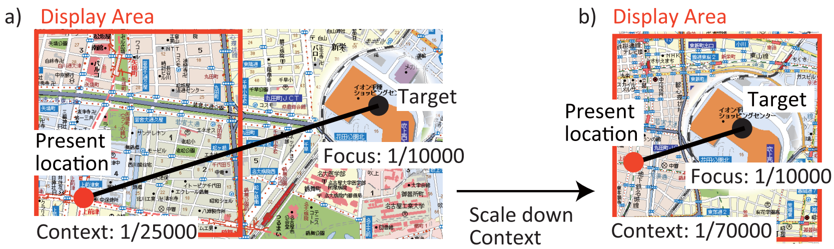

Fig. 4. A mechanism for displaying both the present location and Focus. a) Focus protrudes from the display. b) By scaling down Context, Focus and present location are displayed.

phone. A map is displayed in the Web browser using Adobe Flash technologies. The Web map server was developed by using Java Servlet.

We utilized a six-axis geomagnetic/acceleration sensor [2], which is a popular sensor for cellular phones. This sensor outputs three-axis posture data (roll, pitch, yaw) and three-axis dynamic acceleration data (ax, ay, az), as shown in Figure 7. In other words, we can recognize the direction, tilts, and accelerations of the terminal mounted with this sensor. These data are mutually independent.

In addition, to prevent unexpected behavior, this sensor does not output data until a user pushes the *sensor button*, as shown in the lower left corner of Figure 8. A prototype system is shown in Figure 8.

3 Proposed Method

In this section, we propose the algorithms of the Roll and the Shake operations.

3.1 Roll Algorithm in Wired Fisheye Lens

In the Roll operation, a user can scroll a map simply by tilting a mobile terminal toward the direction in which the user wants to move. In addition, the scale of

[2] Aichi Micro Intelligence AMI603SD.

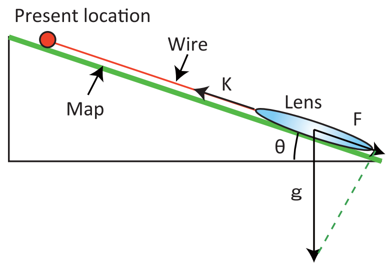

Fig. 5. Forces in Wired Fisheye Lens.

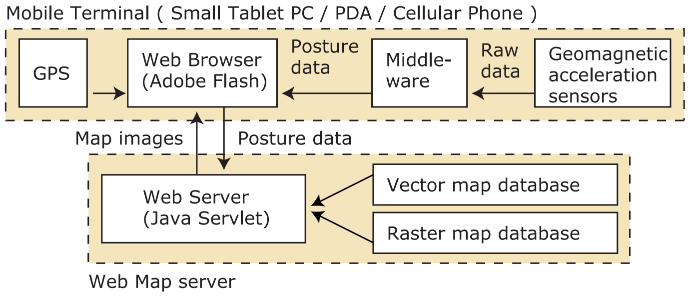

Fig. 6. System architecture.

Context is automatically changed according to the distance between the present location and focus area in order to display both the present location and the focus area on the screen. However, if a large-scale map is displayed on a small screen, we cannot comprehend the details of map in general. Then, we put a Focus (a fisheye lens) on the map to show detail of focus area.

In specific, we developed the system as follows. As shown in Figure 9, let us define a tilt angle in the direction of dip of a terminal as t, where $t > 0$. And let us define a unit direction vector in the horizontal direction of dip of a terminal as R. $th1$, $th2$, and k are constants, where $k > 0, 0 < th1 < th2$.

1. The present location and Focus are displayed in the center of screen, as shown in Figure 10.
2. When t is larger than $th1$, Focus is moved toward the direction of tilt of the terminal. Then, an area in the direction of tilt is displayed as shown in Figure 10-b.
3. When t is larger than $th2$ and Focus touches a border of the screen, as shown in Figure 10-c, the scale of Context is reduced stepwise. The far area in the direction of tilt is displayed as shown in Figure 10-d.
4. By repeating steps 2 and 3, an area further in the direction of the tilt is displayed, as shown in Figure 10-e.
5. When Focus is displayed around the center of the screen and t is smaller than $th1$, the scale of Context is reduced stepwise.

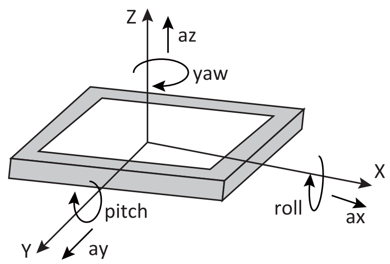

Fig. 7. Outputs of geomagnetic/acceleration sensor. Three-axis posture data (roll, pitch, yaw) and three-axis dynamic acceleration data (ax, ay, az) are output.

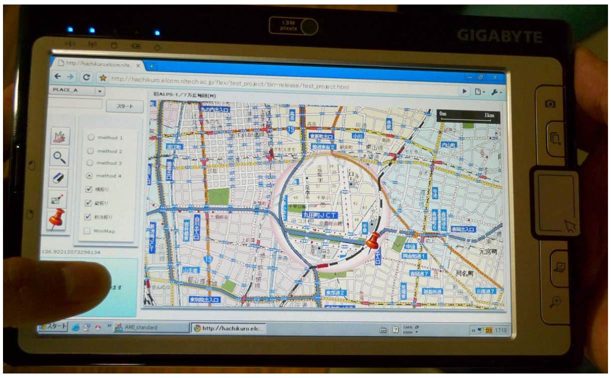

Fig. 8. A snapshot of the prototype system.

Algorithm 1 realizes steps 2, 3, 4, and 5, where P is the present location, F_P is the center of Focus, C_S is a scale of Context, W is the width of the screen in the screen coordinates, $isDisplay(F, P)$ is a function that returns true if both Focus and the present location can be displayed on the screen, and $relocate(F, P)$ is the function that moves Focus in order to display both Focus and the present location on the screen.

This method has the advantage that users can view a detail of a far area at the same time as confirming geographical relations from the present location. Since the direction of a center of Focus from any location of Context and the distance between these points is correct in the F+G+C map, we expect that users can comprehend geographical relations easily.

3.2 Shake Algorithm in Wired Fisheye Lens

If Focus is too small to view the whole target region, users can view it easily by increasing the radius of Focus. Further, if the scale of Focus is too small to view details of the target, users can view it by increasing the scale of Focus. We propose a mechanism by which users can control the size and scale of Focus by shaking a mobile terminal.

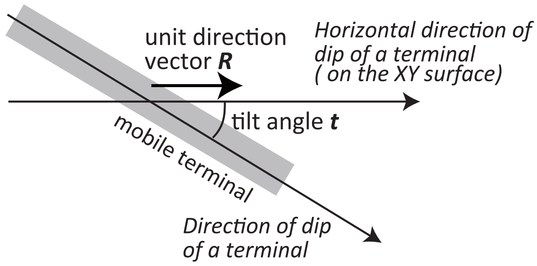

Fig. 9. Tilt and direction of a mobile termnail.

Algorithm 1 Roll algorithm

```
loop
  if isDisplay(F,P) then
    if th1 < t then
      F_P ⇐ F_P + kt · R
    end if
  else
    if th2 < (F_P − P)/|F_P − P| · tR then
      scaleDown(C_S)
    end if
  end if
  if t < th1 and |F_P − P| < W/2 then
    scaleUp(C_S)
  end if
  relocate(F,P)
  update map
end loop
```

In specific, we developed the system as follows:

1. When a sensor outputs acceleration to the right, the radius of Focus increases stepwise. When a sensor outputs acceleration to the left, the radius of Focus is reduced stepwise.
2. When a sensor outputs forward acceleration, the scale of Focus increases stepwise. When a sensor outputs backward acceleration, the scale of Focus reduces stepwise.

Here, the scale of Focus is larger than that of Context.

Although users can control the radius of Focus, how to define the radius of Focus is a problem. Although the radius of Focus should ideally be defined according to the shape for the target area, it is difficult. Thefore, we simply utilized the switching method in which the radius of Focus is alternated between 100 pixels and 240 pixels.

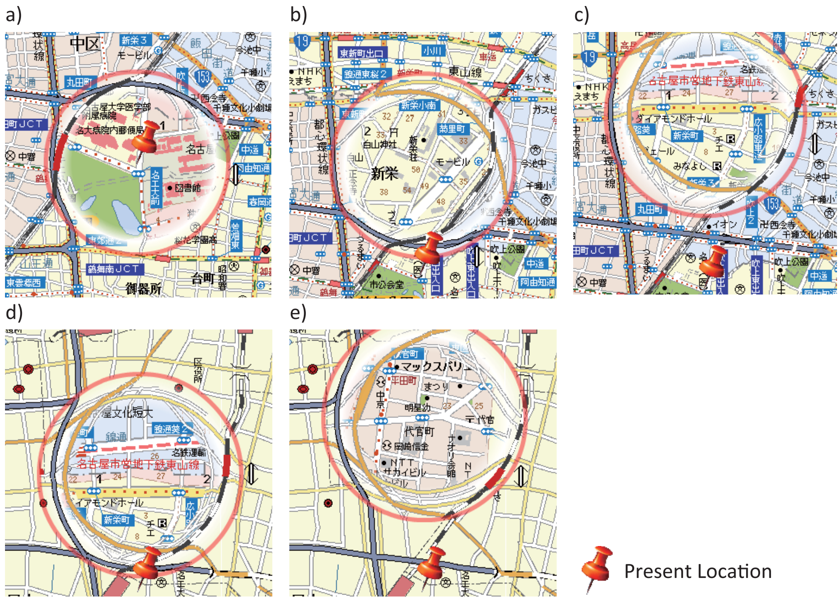

Fig. 10. Procedure for displaying the far area; in a), b), and c), Context is a 1:70000 scale map, and Focus is a 1:25000 scale map; in d) and e), Context is a 1:110000 scale map, and Focus is a 1:25000 scale map.

4 Experimental Result

We performed experiments on the proposed system. The subjects were 20 university students. The window size of the system is 800 x 400 pixels, which is a popular size in Japanese mobile phones. We use the surrounding areas A (Kyoto station), B (Nara station), and C (Hakata station). Each area is a famous Japanese sightseeing area. The subjects search the locations of the three facilities in each area. In this experiment, to simplify the problem, we only utilize the 1:25000 and 1:70000 scale maps. Although the 1:70000 scale map provides users with only outlines of parks, a 1:25000 scale map provides users with the names and locations of structures within the park. In specific, users have to perform the following series of tasks many times: search candidate parks using the 1:70000 scale map and confirm the details of each park using the 1:25000 scale map. The area of the search range is within 1600 x 960 pixels in the 1:70000 scale map. The default radius of Focus is 100 pixels.

We used the GIGABYTE M704 mobile terminal. The frame rate of this system is 4 fps, which is also confirmed to work appropriately in the communications zone of the cellular phone network in Japan (FOMA, 3Mbps).

In this experiment, we compared method 1, method 2, and method 3.

method 1 Users can scroll normal maps by tilting the mobile terminal. As shown in the lower right corner of Figure 11, a small 1:500000 scale map

Fig. 11. An interface in method 1; the map in the lower right corner has a scale of 1:500000 ; the scale of context is 1:70000.

enables users to comprehend geographical relations. Users can also switch between the 1:25000 and 1:70000 scale maps by shaking the terminal. (existing method)

method 2 Users can control the F+G+C map by Look and Roll operations, as shown in Figure 12. (sub-system of the proposed method)

method 3 Users can control the F+G+C map by Look, Roll, and Shake operations as shown in Figures 12 and 13. Users can alternate the radius of focus between 100 pixels and 240 pixels. (proposed method)

We measured the time required by users to search for three structures within the parks around the present location for each method. The number of parks in each area is listed in Table 1. We categorize parks as follows. A park that lies within a Focus of radius 100 pixels is known as a small park, a park that lies 70% or more within its Focus is known as a medium park, and parks bigger than medium parks are known as big parks.

In addition, the subjects record the direction of the found structures from the present location as well as the distance between the two points. We consider the counterbalance to avoid the influence of the experimental order of area and method. We performed a total of 60 experiments, for three regions per subject. Subjects practice using the system for 5 minutes before each experiment.

Let us compare methods 1, 2, and 3.

First, Figure 14 shows the average times required to find the target object in each method. In the case of *All* area, the time required in method 2 was 23% less than the time required in method 1, which was statistically significant at the 5% level. However, the difference between methods 2 and 3 is not statistically significant at the 5% level. We think that this result is influenced by area A for the following reason. Although area A has many small parks but no big park, areas B and C have some big parks, as listed in Table 1. In addition, although method 3 is effective for an area that has big parks, such as areas B and C, method 3 is not effective for an area that has many small parks, such as area A, as shown in Figure 14-A, B and C. Since a large Focus compresses Glue area significantly and parks in Glue can not be displayed, users could not locate some

Fig. 12. Interfaces in method 2 and method 3; the radius of Focus is 100 pixels; the scale of Context is 1:70000, and the scale of Focus is 1:25000.

Fig. 13. A interface of method 3. Size of radius of Focus is 240 pixel. Context is 1:70000, Focus is 1:25000.

small parks within Glue in area A when method 3 was used. In fact, in the case of areas B and C, method 3 involved 39% less time than method 2, which was statistically significant at the 1% level. In total, method 3 is approximately 2 times faster than method 1 in areas B and C. Therefore, these results suggest that method 3 is more effective than method 1 and method 2 for areas B and C.

Next, Figure 15 shows the rate at which users found the target objects until specified times (1 min, 2 min, ..., 8 min) for areas B and C. Only approximately 70% of target objects could be found within 3 minutes when methods 1 and 2 were used; in contrast, over 90% percent of target objects could be found when method 3 is used. This result suggests that method 3 is superior to methods 1 and 2.

In addition, Table 2 lists the number of the Shake operations in each method. In contrast to method 2, method 1 and method 3 have to do the Shake operation by shaking the mobile terminal. Since the Shake operation is the operation that users change the size of Focus or the scale of the map consciously, the cognitive cost of that is bigger than the Roll or the Look operations. Therefore, the number of the Shake operation is one of the barometers of the cognitive cost for users. Then, we compare the number of the Shake operations for each method. Method 1 involves 20.5 shake operations which change the scale of the maps on average.

Table 1. Number of parks for each area.

	small parks	medium parks	large parks	Total
area A	19	2	0	21
area B	13	0	3	16
area C	6	2	3	11

Table 2. Number of Shake operations for each method.

	area A	area B	area C	All area
method 1	22.4	19.2	19.8	20.5
method 2	0	0	0	0
method 3	16	7.4	5.8	9.7

In contrast to method 1, method 2 involves no operations and method 3 involves only 9.7 shake operations related to the size of Focus. These results suggest that proposed methods enable users to find the target with lower cognitive cost than method 1.

Moreover, Figure 16 shows human errors in recognition of the direction of the target areas from the present location and the distance between the two points. There is no difference between methods 1, 2, and 3, which are statistically significant at the 5% level. Although methods 2 and method 3 have distortion in Glue, these results suggest that the cognitive cost of the F+G+C map is approximately the same as that in the normal map. Furthermore, we have to comprehend geographical relations in order to find the target quickly; Figure 14 suggests that it is easy to grasp geographical relations by using method 3. We will confirm the detailed cognitive cost associated with geographical relations in a future study.

Finally, we used the following questionnaire with a 5-stage Likert scale for areas B and C. Note that 5 denotes strongly agree, and 1 denotes strongly disagree.

Usability Is this method easy to use?
Viewability Is this map easy to view?
Connectivity Do you feel that there is no gap between the 1:25000 scale map and 1:70000 scale map?
Stress Do you feel stress when using the system?

Figure 17 shows the result of questionnaires. In terms of Usability and Viewability, method 3 is superior to method 2, which is statistically significant at the 5% level. This result suggests that the Shake operation is effective. Although methods 2 and 3 involve Glue, which is too compressed, method 2 (4.0) and method 3 (3.8) are superior to method 1 (3.3) in terms of Connectivity. The Stress in each method is not so good (2.7 or less on an average) because the experimental task is too complex, i.e, finding the target object within a short time. Therefore, all numbers are 4 or less on an average.

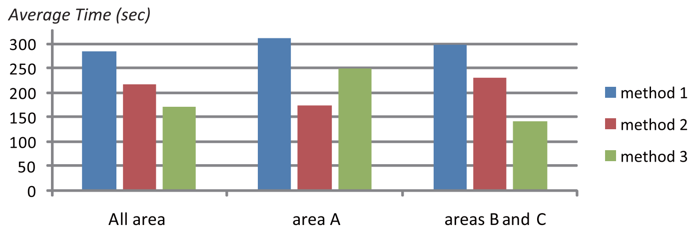

Fig. 14. Average time required for each method.

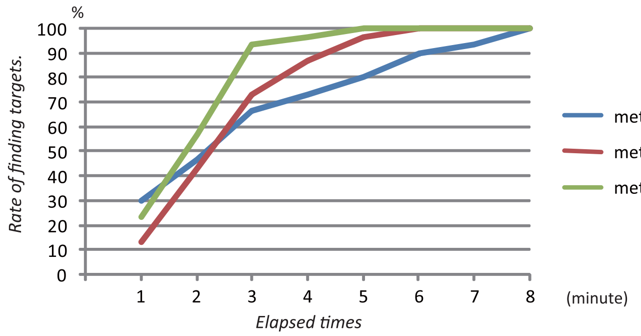

Fig. 15. Rate of finding targets until specified times for each method.

Although the F+G+C map is utilized in method 3, which is not common, in short, this method has a significant advantage compared to methods 1 and 2 in terms of both the elapsed time and the questionnaire results. In particular, the Shake operation is effective for areas B and C. However, we found that there is a problem in the Shake operation leads to small structures being ignored. To solve this problem, we have to control the sizes of Focus and Glue such that they are as small as possible. We will have to propose a method to do so in our future study.

5 Related Work

The Focus+Context method [11, 12], which was proposed by Furnas, is an effective method for visualizing large-scale information. This method enables a user to view the area of interest (Focus) and overall structure (Context) together by reducing data of the Context based on the degree of the interest (*DOI*). Applying the Focus+Context method to network maps, the fisheye-views method [6, 7] allows the user to zoom in to a part of a network map, like a fisheye lens. This method generates the map by using a displacement function. In addition, Skopik [13] validated the memorability of fisheye views-type network maps. Since the main purpose of these studies is to propose the visualization methods of the fisheye views, in contrast to our method, these studies have not considered the mobile interfaces using posture sensors.

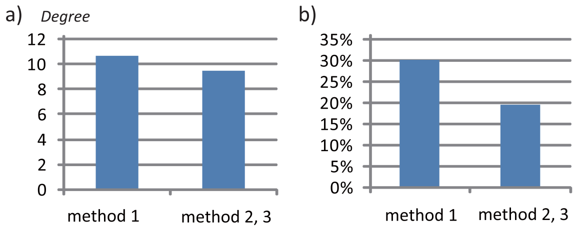

Fig. 16. Average errors in recognition of the direction and distance . a) Direction errors (degrees) , b) Distance errors (percent)

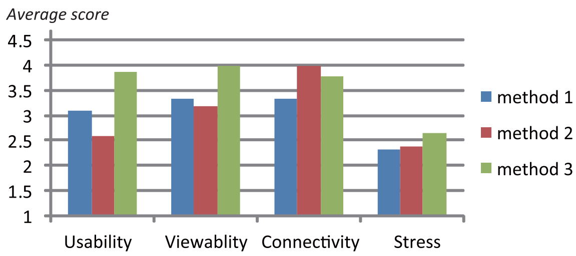

Fig. 17. Results of questionnaire for each method. Note that 5 denotes strongly agree, and 1 denotes strongly disagree.

In some studies, a map was controlled in the mobile terminals by using posture sensors. Rekimoto [8] proposed a mechanism that enables users to select and zoom target area in a bird's-eye-view map by tilting a mobile terminal by pushing a button. In contrast to the fisheye map or F+G+C map, in this mechanism, a user has to search for a target area using a wide-area map before he/she views a detailed map of the target many times. Although Harrie [14] proposed the variable-scale method of presenting geodata for personal navigation using small-display mobile devices by applying a variable-scale mapping function, they did not propose a control method of mobile maps. Gutwin [15, 16, 17] proposed a method that enables users to view Web pages by using the Focus+Context method in a mobile terminal. Because Web pages for PC are not developed for small displays, in this method, the zoom in the focus area increases and that in the context area decreases. Although users can view Web maps by using this mechanism, this interface does not consider the characteristics of maps.

In addition, there have been many studies on variable scale maps. Fairbairn [18] proposed a variable scale map that progressively zooms up from the periphery to the center of the map. Guerra [19] proposed digital tourist city-maps that transform variable scale maps according to grids. Takahashi [5] proposed the Pull method that pulls in faraway map objects by transforming a map according to grids. Although these methods can transform a map freely, they do not consider the problem of the degree of interest (DOI), unlike the Focus+Context method.

Moreover, there are some navigation methods based on camera metaphors. Guiard [20] and Fukatsu [21] proposed a method for navigating objects by using camera operations such as pan, zoom, and tilt. These mechanisms cannot be used to control multi-scale maps.

6 Conclusion

We proposed a novel mobile map interface based on a metaphor of the Wired Fisheye Lens. This method enables users to effectively search for areas surrounding a location by using Look, Roll, and Shake operations. In particular, we obtained the following results by developing and testing the proposed system. First, it was found that the proposed method enables users to find targets approximately 2 times faster and by half operations than the existing method. Second, it was found that the Shake operation—the operation by which users can interactively switch the size of Focus—is particularly effective for searching areas that include both large parks and small parks. It follows from these results that the proposed method is superior to the existing method.

However, the following tasks must be completed in the future. We have to propose the method for controlling the size of Focus according to the shape of the target object properly. Since Glue is significantly compressed, we have to propose a method for displaying objects in Glue properly. Moreover, in order to enable more complex operations, we will discuss combination with touch displays. Furthermore, from the viewpoint of the cognitive map, we will examine the usability of the proposed system.

In addition, we will develop a system that can operate in a common cellular phone such as an iPhone [3], and we will make this system available. Our system will be able to contribute to the novel mobile Web map services with fisheye views for mobile terminals.

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