Map Operation Interface using Thermal Imaging Camera

Kanghoon Lee[1], Taeyoung Uhm[2] and Jong-Il Park[1†]
[1]Department of Computer and Software, Hanyang University
17, Haengdang-dong, Seongdong-gu, Seoul 139-791, Korea
[2]Center for Robotics Research, Korean Institute of Science and Technology
Hwarangno, 14-gil 5, Seongbuk-gu, Seoul 136-791, Korea
E-mail: [1]aeternalis999@gmail.com, 090607@kist.re.kr, [1]jipark@hanyang.ac.kr

Abstract: In this paper, we propose a thermal infrared image based map operation interface system that can be examined by merging a historical map and a current map. This system consists of the fusion of both maps and finger touch detection. First, the historical map is overlapping on the current map by the homography transformation. Next, finger touch detection is using a thermal camera which makes it possible to detect the residual heat generated by contact of the finger. The detected finger touch position can be interacted with two maps. In the central position, the system can be operated by overlapping the hitorical map. Therefore, the proposed system is expected to be able to effectively use in understanding the past maps and current maps.

Keywords—**Thermal Imaging Camera, Residual Heat, Fingertip Touching,Touch Detection, Thermography**

1. Introduction

When people visit to museum or exhibition, they can see historical maps. However, the visitors feel difficult to understand the historical map that corresponds to a current area. Thus, as shown in Figure 1, an interface system which able to merge historical maps on the current map will be helpful in understanding the historical map. Current maps and historical maps have different fabrication methods, and the direction reference is not the same. Therefore, for implementing the interface system, it is required a technique that can be fused to a natural current map and an old historical map.

Research to fusion by comparing the both of map information has been already actively research in the field of historical geography [1, 2]. However, these methods were needed to geographical analysis using diversified research and modern Geographic Information System (GIS) information of the current terrain changes.

For searching maps with a visitor's interaction, the fusion system is suitable for a touch-based interface. This is because they don't need to carry additional equipment, and intuitively use a finger touch in front of display systems. The finger touch based interaction has been actively studied in many fields. As a typical example, there was a visible light image-based and depth image-based research [3, 4, 5]. Visible light camera was generally convenient to use the camera system configuration. Thus, when detecting a finger using the visible light camera, the method mainly employed for matching the skin color [3]. However, this method was

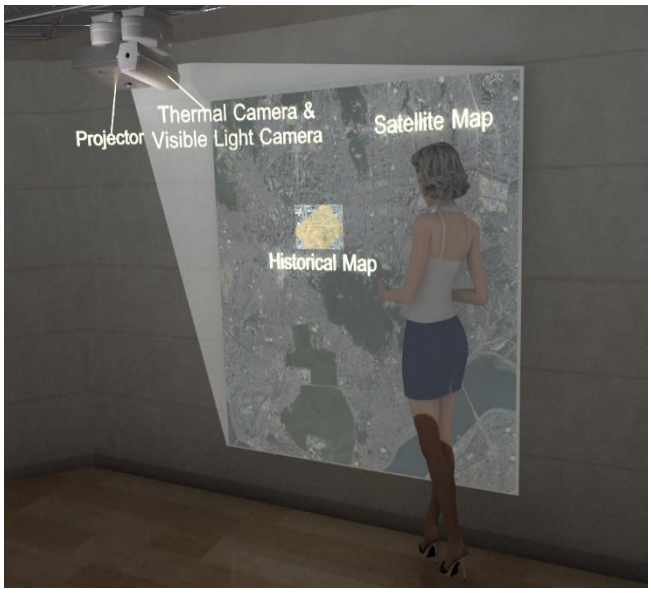

Figure 1. Examples of map operation interface system.

sensitive to changes in illuminations; the interaction range was limited in order to detect a touch of a finger. To solve these problems, in cluttered lighting environments, depth camera based robust methods were also studied [4, 5]. These methods could detect the finger and determine the contact. However, the finger was being overshadowed by the hand or arm if you bend your fingers, it is difficult to detect finger touches the depth value. In addition, due to the optical noise, the error of the depth value was generated, and it can set a contact without the touch of the finger.

To solve these problems, we employ detecting the finger touch by using a thermal infrared camera. The thermal infrared camera can detect hands and fingers in the cluttered illumination environments. Furthermore, the camera can determine the location of the touch by residual heat left from hands and fingers. Using this robust detection, we propose a practical way to fuse the two map information without any geographic expertise and map operation interface for overlapping historical and current information.

The remainder of this paper is organized as follows. In Section 2, the fusion method for historical map and satellite map is described. Then, the fingertip touch detection and operating interface are explained in detail in Section 3. Finally, the conclusion and suggestions for future research are given in Section 4.

† Corresponding author

2. Fusion of historical map and satellite maps

For comparing between the modern map and historical map, it may be required to overlap two types of maps in the cluttered illumination environments. Generally, image compensation with rotation and scailing is difficult to overlap two types of maps. In geography, professional imformation based overalpping is employed by high complex processing which needs specialized support. Therefore, we propose an overlapping method based on a modern map(current Seoul satellite map) and a historical maps(1936's Seoul map). The historical maps are made up into a large map by panorama.

In this paper, we use a projection of historical map on the current map using the homography transformation. The homography transformation is a linear transformation which define the relation of two image planes. As shown in Eq. 1, P and P' represent the corresponding points of the historical map and satellite map, respectively.

$$P = \mathrm{H}P' \tag{1}$$

Here, the matrix H is the homography transformation which represent linear transformation between P and P'. Then, we employ a warping the historical map by using H through Eq. (2)

$$A\mathrm{H} = A' \tag{2}$$

Here, A is a historical map. As shown in Fig. 2, it can be found a warping result by correspoinding points. The result shows that the method is appropriate for natural matching main loads and buildings include Seoul Cityhall.

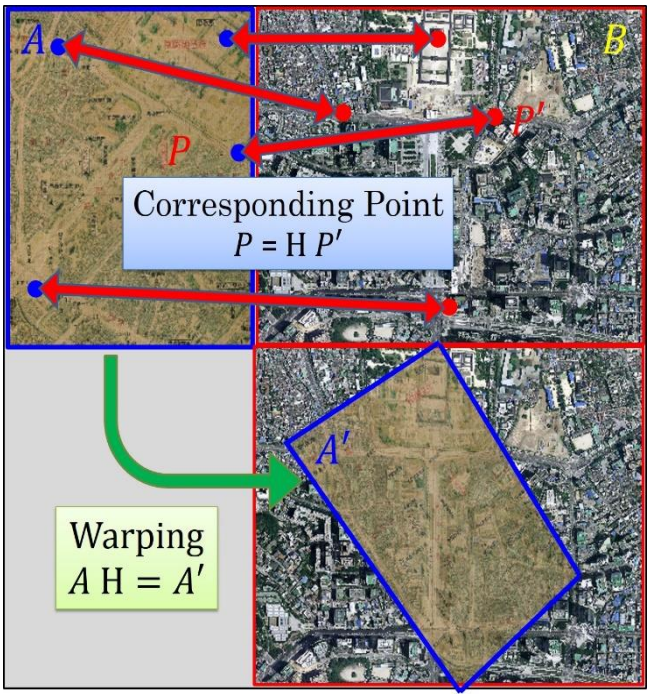

Figure 1. Corresponding Points and Warping.

Figure 2. A touch based operating system using optical equipment.

3. Fingertip touch detection

Fingertip touch based operating interface plays an important role in the interaction with digital contents. Moreover, the touch interface is easily access for display devices (e.g. smart phone). However, these devices have limitation which cannot install to various objects or spaces because that is embedded form. To overcome this limitation, we focus on a touch interface using optical equipment.

In this paper, we built a touch based operating system that consists of a visible light camera, a thermal camera, and projector, as shown in Fig. 3. A visible light camera is calculated position and direction. Then, the thermal camera is employed to detect the contact of the fingertip. As shown in Fig. 4, when the finger contacts the wall, the residual heat is generated on the surface. It is difficult to detect the touch using visible cameras and near-infrared cameras only. However, the residual heat can be showed by thermal camera. Thus, it is possible to calculate the correct contact position by segmentation the region of residual heat. This method is able to distinguish clearly intended behavior in touch interface which has reflected the tendency to use button, because that the residual heat of intended touches has a higher temperature than unintended behaviors (such as a touch mistake). This difference is defined as a threshold value for replacement existing sensitive touch interfaces.

In the thermal camera images, the pixel distribution of residual heat represents a circle or an eclipse. Thus, we employ Blob Detection algorithm for detecting the distribution [6]. After detecting the region of residual heat, we can find a contact presence with a touch position for the operation interface. Then, the interface calculates a visible coordinate using relationship between a visible camera and a thermal camera. Next, the relationship between a projector and a visible camera is employed for computing a projection image coordinate. Finally, the historical map by warping

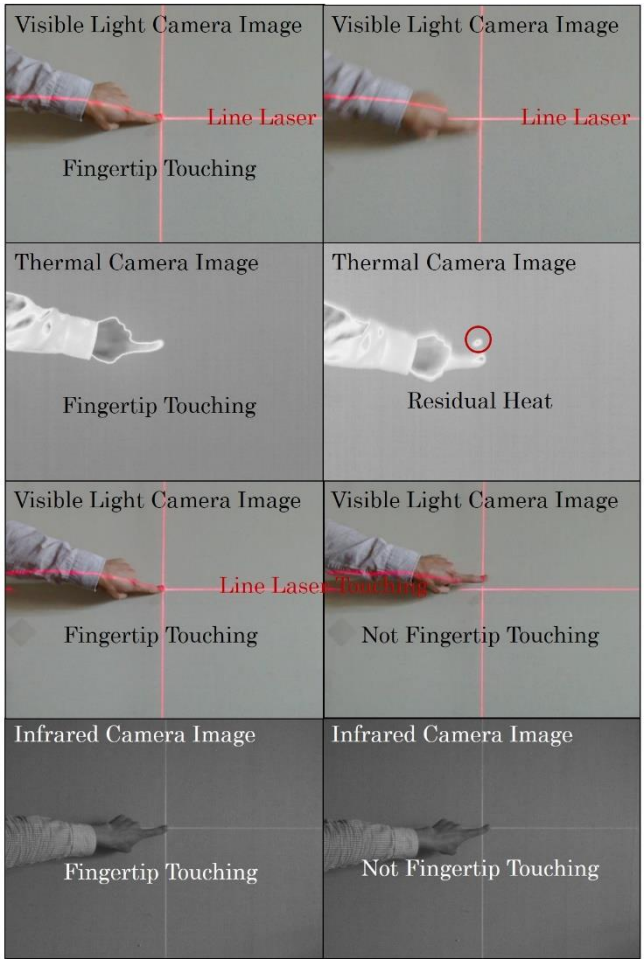

Figure 4. Fingertip Touch and Residual Heat.

(explained in Section 2.) has been resized to fit in the current satellite map for the same coordinates. Fig 5 shows the projection image; upper image is a current Seoul satellite image, and lower image is a historical image by warping.

When touch a finger to the desired location in the projected satellite map of the plane wall, the system detects the touch position using a thermal camera. Then, the historical image which corresponds to the touch potion is projected. Fig 6 shows the overview of the proposed map operation touch interface.

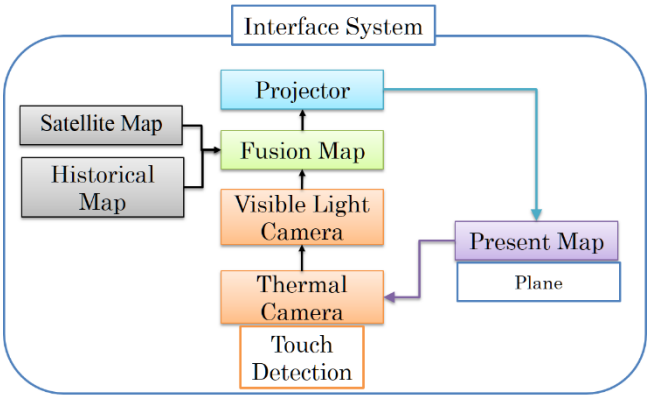

Figure 3. Overview of the proposed system.

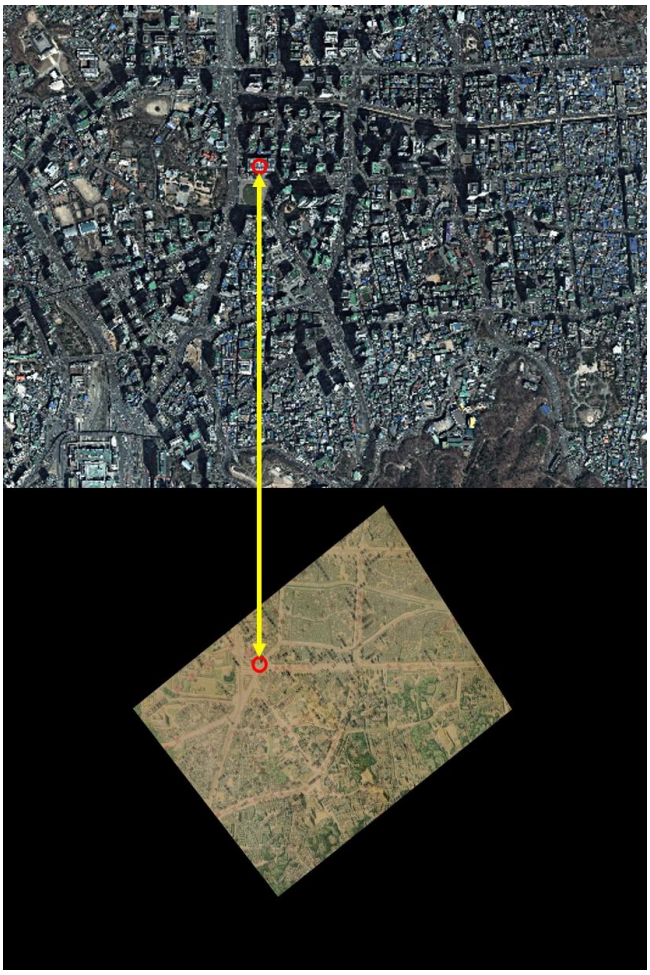

Figure 5. Projection images.

In the proposed system, the historical image is projected to a predetermined area around the detected position. The wide heat range of the thermal camera can occur to detect no residual heat region (e.g. hands, fingertips, etc.). Moreover, the temperature of residual heat is lower than temperatures of hands and fingers. Therefore, we fixed experimentally the range of the thermal camera from 29 to 31 degrees Celsius.

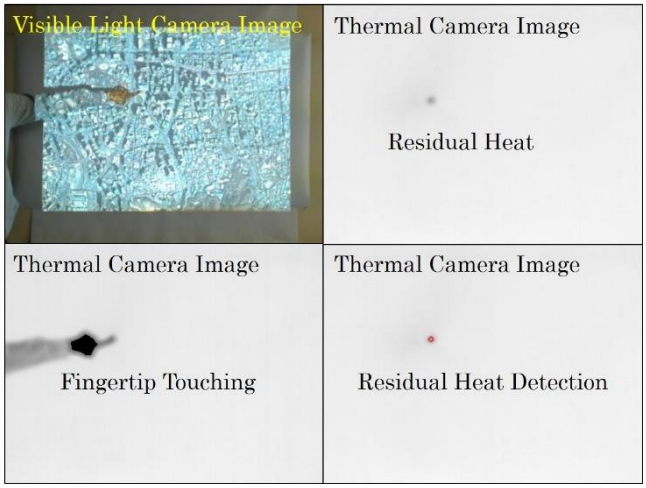

Figure 4. Fingertip Touching and Residual Heat Detection.

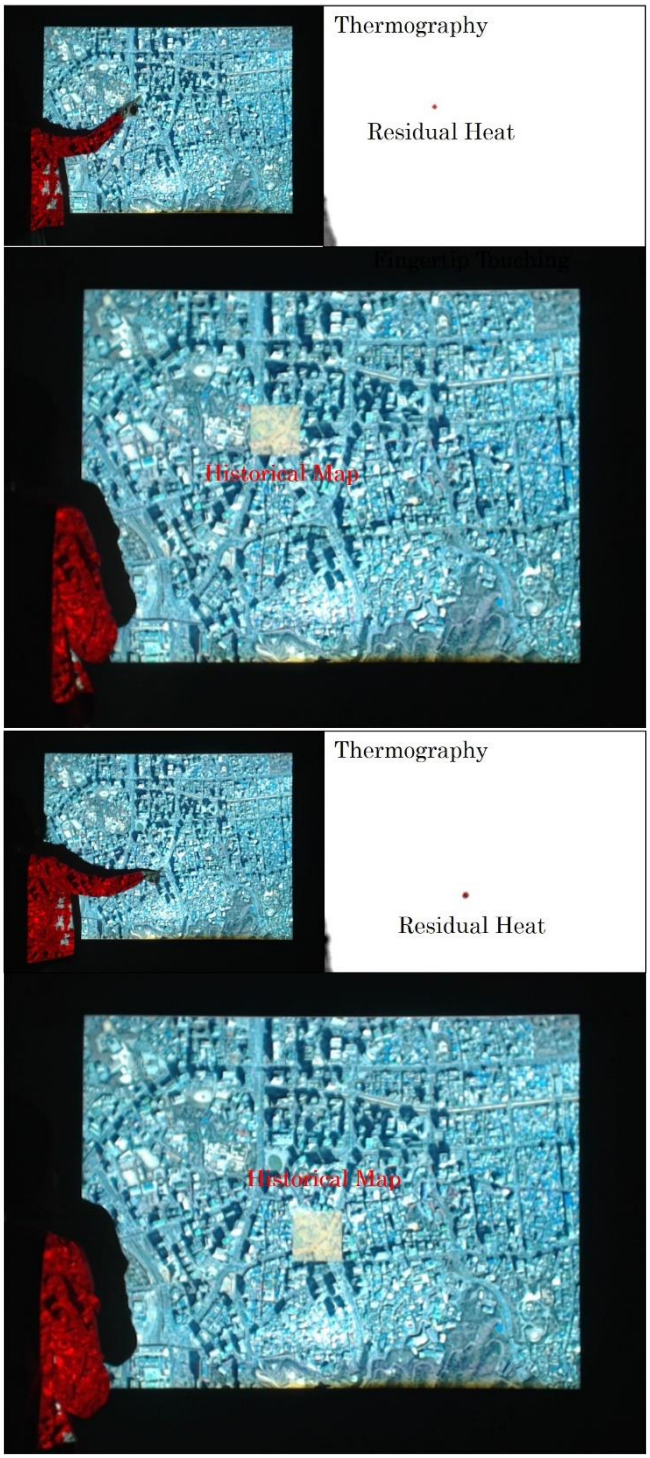

Figure 5. The results of the map operating interface.

The proposed system implemented in indoor environments and room temperature; 20 to 28 degrees Celsius. The results show the touch scene and the detected region of the residual heat in a thermal camera image, as shown in Fig. 7. Fig 8 shows the results of the map operation interface by fusion of a historical image and current image.

4. Conclusions

In this paper, we propose a thermal image-based map operation interface that can be investigated by the natural fusion of the historical map and the current map. This system can detect a correct intended touch position by analyzing a thermal image. Moreover, the implemented system offer to effectively understand two types of maps from different eras. As the results, the proposed interface can be easily interacted with digital contents.

There are some improvements required for natural operating. The system has to wait for detecting the residual heat until detract finger from the touched surface. For improvement, we conduct to merge a depth camera. In the future, we try to implement various touch behaviors based interaction. Therefore, the interface will be expected to provide a practical solution for natural operating system.

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References

[1] B. Jenny, L. Hurni, “Studying cartogramphic heritage: Analysis and visualization of geometric distortions,” Computers & Graphics Vol. 35, no. 2, pp.402-411, 2011.

[2] C. Balletti, F. Guerra, “Image matching for historical maps comparison,” e-Perimetron, Vol. 4, no. 3, pp.180-188, 2009.

[3] Kane, S., Avrahami, D., Wobbrock, J.O., Harrison, B., Rea, A.D., Philipose, M., LaMarca, A., “Bonfire: a nomadic systems for hybrid laptop-tabletop interaction,” ACM symposium on User interface software and technology, pp. 129-138, 2009.

[4] Hilliges, O., Izadi, S., Wilson, A.D., Hodges, S., Garcia-Mendoza, A., Butz, A., “Interactions in the air: adding further depth to interactive tabletops,” ACM symposium on User interface software and technology, pp. 139-148, 2009.

[5] Andrew D. Wilson, “Using a depth camera as a touch sensor,” ACM International Conference on Interactive Tabletops and Surfaces, pp. 69-72, 2010.

[6] Tony Lindeberg, “Detecting Salient Blob-Like Image Structures and their Scales with a Scale-Space Primal Sketch: A Method for Focus-of-Attention,” International Journal of Computer Vision, Vol. 11, no. 3, pp. 283-318, 1993.