

U-Sketchbook: Mobile Augmented Reality System Using IR Camera

Jae Hyuck JANG*, Won Vien PARK *, Chang Geun SONG**, Sun Jung KIM**, Young Woong KO*

*Department of Computer Engineering, Hallym University, Chuncheon-si, Gangwon-do, Korea

**Department of Ubiquitous Computing, Hallym University, Chuncheon-si, Gangwon-do, Korea

jaehyok2@gmail.com, wonvien@hallym.ac.kr, cgson@hallym.ac.kr, sunkim@hallym.ac.kr, yuko@hallym.ac.kr

Abstract— In this paper, we propose the novel interface system for mobile phone using infrared pointer scheme. Our approach exploits mobile augmented reality technology using IR camera. We implemented the proposed mechanism on smartphone and applied the proposed interface to sketchbook application called U-Sketchbook. Users can draw picture on any space available and the IR camera can detect the movement of pointing device (IR-Pen). We performed several experiments to test effectiveness of the proposed system. The experiment result shows that users can easily use U-Sketchbook for multimedia application such as an image editor. The prototype can track IR-Pen within 30ms, which makes users feel very comfortable using the proposed system.

Keywords— AR(Argument Reality), IR(Infrared Ray), Mobile, U-Sketch, Smartphone

I. INTRODUCTION

As computer technology is evolved, there have emerged many mobile devices including smartphone, netbook, personal digital assistant (PDA) and cell phone. Generally most of the devices adapt touchscreen technology as a source of input. A touchscreen is well-known technology that can detect the presence and location of a touch within the display area. The touchscreen enables one to interact directly with what is displayed rather than indirectly with pointing devices.

However, the touchscreen has limitation on display size. This makes it difficult to allow users to control mobile device precisely; therefore, it is difficult to use almost all applications running on a Personal Computer such as image editor [1]. For example, mobile-phone touch screen provides a button interface for handling user inputs. The size of button and text field is very small, which makes user difficult to control the limited area of the screen. When a user tries to touch the screen using finger, it is hard to precisely input the detailed control and the user may click invalid object such as button, text field and region. Furthermore, if we try to draw a picture on the screen, it is more difficult to draw line or circle then text data. To overcome these problems, we propose an augment reality based input system using infrared camera. We implemented the proposed mechanism on smartphone and applied to ubiquitous sketchbook application called U-Sketchbook. Users can draw a picture on any space available

and the IR camera can detect the movement of pointing device (IR-Pen) easily.

In this paper, the key issue is a tracking algorithm of IR pointing device. First, we capture IR image from the IR camera by detecting IR-Pen. We can control the operations (turn on or turn off) of the IR-Pen by pushing button on the IR-Pen. Second, we convert the IR image to binary image and get rid of noise on the binary image. Finally, we try to identify objects on the image and store the location information of each objects using data structure. We performed several experiments to test effectiveness of the proposed system. The experiment result shows that user can easily use the proposed interface and U-Sketchbook. Our prototype can track IR-Pen within 30ms delay. Therefore, user feels very comfortable using the AR interface.

The remaining parts of this paper are organized as follows. In Section 2, we introduce recent works about existing touchscreen interface. In Section 3, we present the architecture of the proposed system and explain how to design and implement the system. Our implementation details and evaluation results are presented in Section 4. In Section 5, we make conclusion and discusses future research plan.

II. RELATED WORKS

The Motorola development lab has developed the program that can test touchscreen ability for smart-phones.



Figure 1. Touchscreen accuracy Experiment results

They have evaluated the recognition accuracy of recent smart-phones. As we can see Figure 1, the accuracy of each product is different each other. The reason that makes this difference depends on applications used for touchscreen, driver compatibility between operator systems, and controller chip sets types. Recognition performances showing large differences in recognition or pressure screen depending on the area.

Recently, various interface technologies are emerging that do not use touchscreen technology [2]. In figure 2, eyeSight use gesture recognition interface for smart-phone. The camera is attached to the front and rear part of smart-phone and can detect the movement of a user [3]. There is another research work using sensor based data acquisition approach [4]. With sensor input such as acceleration, we can express more information for smart-phones. However, gesture recognition and sensor based data acquisition scheme can be used only for control purpose; therefore we cannot input text data or draw an image on smart-phone.



Figure 2. eyeSight : Interface using the gesture recognition

III.SYSTEM ARCHITECTURE AND IMPLEMENTATION

In this paper, we propose the novel interface system for smart-phone using infrared pointer scheme. Our approach exploits mobile augmented reality technology [5,6] using IR camera. There are lots of interface researches based on augmented reality [7,8,9,10,11]. We have designed and implemented U-Sketchbook based on the proposed interface. Figure 3 shows the concept of the proposed system. By using infrared camera and LED pen, the proposed system can track infrared interface.

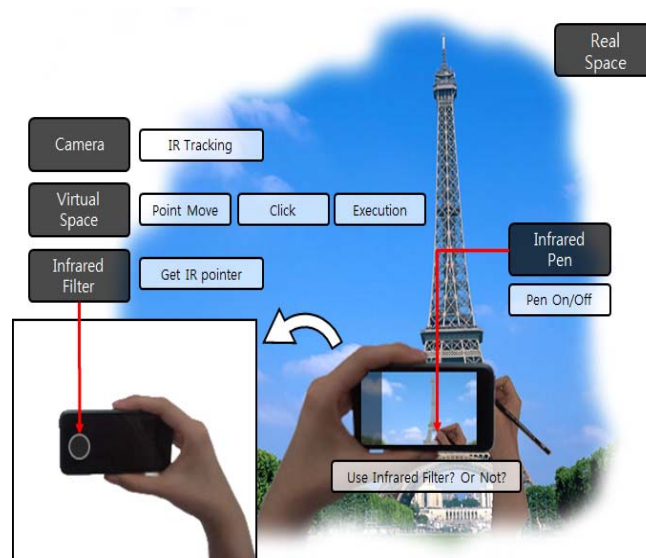


Figure 3. The conceptual diagram for the proposed system

In figure 3, real space means the camera's viewpoint. We can trace infrared pen (IR-Pen) that moves within the visible area of camera. Virtual space is a display region in which picture is displayed on smart-phone. All the activities in real space are transformed into information in virtual space. If user draws a picture in real space, the picture is displayed in virtual space. Sometimes, if user wants to generate control events such as line thickness, line color and operation change. At that time, the control menu is displayed on virtual space, and user can select the menu. Therefore, user can do lots of activities on the virtual space. Also, user can perform zoom in/out operation for virtual space by adjusting the distance between the camera and IR-Pen.

A. System Configuration

Figure 4 shows the configuration of the proposed system. The system works using smart-phone mobile device and infrared pen. We attached a negative film on the camera, which makes only infrared rays can be accepted on the system. There is a drawing area where user can draw image or input control information. The drawing area can be any place such as desk, wall, white board, and anywhere IR-LED is located..

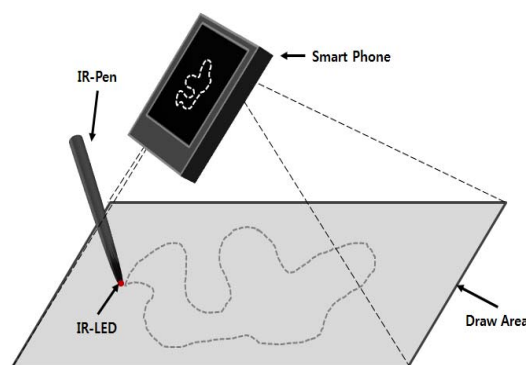


Figure 4. System architecture

The IR-Pen has an IR-LED and push button. If user pushes the button, the IR-LED emits infrared rays. If user moves the IR-Pen on the drawing area by pushing the button, the position of the IR-LED is tracked by IR camera on smart-phone. The image processing modules on smart-phone process tracking algorithm and the output is displayed on the screen. Figure 5 shows the detailed algorithm for the proposed system.

B. IR Tracking Algorithm

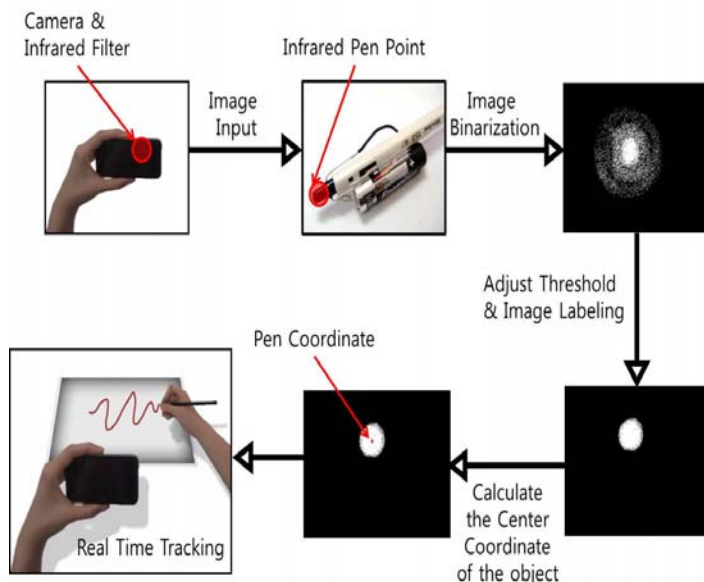


Figure 5. Infrared extract algorithm

As shown in Figure 5, it shows the processing stage of the proposed system. First, the camera module is initialized and smart-phone displays the current drawing area on the screen. Second, the camera detects IR-LED and captures the image. After adjusting threshold and image labelling, it calculates the centre coordinate of the object. Finally, current position of IR-LED is displayed on the screen. However, during the converting stage where the input image is converted into binarization image, noise can be occurred depending on the environment. The binarization is a process where each pixel in an image is converted into one bit and we assign the value as '1' or '0' depending upon the mean value of all the pixel. If the value is greater than a mean value then we assign '1' as the value otherwise '0'. To remove noise, it needs an additional calculation process that sets threshold and remove noise. This is not a big problem in case of the single object. However, in the case of multiple objects in one area, it needs to distinguish calculation each independent single object from the multi objects. Distinguished object performs that extract center coordinate of each object. We can find location information of objects and save the information with data structure. With coordination information obtained through this process, we can trace the location of infrared object, and find the point where user is pointing on display with location information that user moved infrared pen. Also, we can use the event

through the button on the infrared pen. However, it is hard to remove noise of infrared image totally because of illumination change according to the experimental environment. Therefore, it needs to set the dynamic threshold value follows the current environment. In this experiment, we set up the threshold value manually, and we will conduct the threshold value dynamically in future.

IV. IMPLEMENTATION AND PERFORMANCE EVALUATION

Figure 6 shows the implementation result. We adapted well-known mobile device using Android platform. The platform has the camera capabilities supporting up to the 30 frame/sec. If the tracking algorithm can be finished less than 30ms, it is possible to display the tracking result with very precisely without missing deadline for processing algorithm. In experiment result, by increasing the number of points, we tested the tracking capabilities for the proposed system. We made a filter that can recognize infrared ray only and attached it in front of the lens because smart-phone camera lens does not recognize infrared ray. Smart-phone is easy to move, users adjust the distance of camera recognition area randomly, and we found that we can solve limited work area which is disadvantage of smart-phone using the camera attached smart-phone. The infrared LED is attached at the end of pen equally common pen and the battery was equipped inside the IR-pen for easy to use.

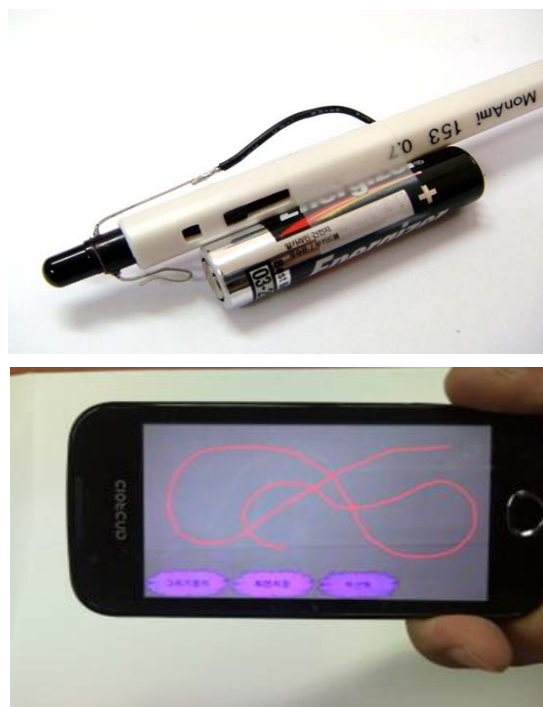


Figure 6. System implementation screen

Smart-phone based interface system aims to improve processing speed and increasing recognition more than existing interface system. Therefore, in this paper, we conduct the performance evaluation of infrared pointing processing

calculation. Figure 7 shows that measured time to calculate the coordinate of infrared pen. We did not test for the mobile phone because we have no testing tools for evaluating the performance of mobile phone. However, we can evaluate the performance of IR camera, because the capability of web camera is much similar to smart-phone camera. The mobile device camera support up to 30 frames per second, therefore we have experiment using web camera to support the same frame on the desktop. To support the smooth image for users, we should find the coordinate of infrared pointer within 30ms when calculating the coordinate of infrared pen. As a results, we could be calculated all of the coordinates within 30ms at least 30 infrared LED. We check that we can find smoothly the coordinates of infrared pen in the mobile phone.

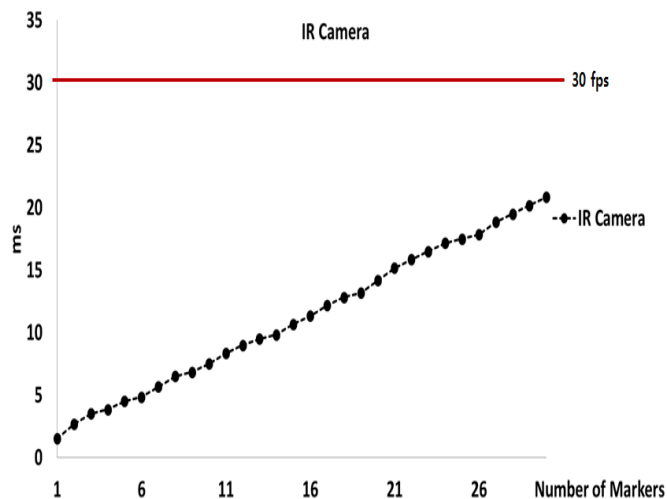


Figure 7. Infrared pointer tracking processing speed

We also measured the limit of drawing space for the proposed system by increasing distance between camera and the object. As you can see in the figure 8, we measured the size of view displayed on the camera.



Figure 8. Infrared pointer tracking processing speed

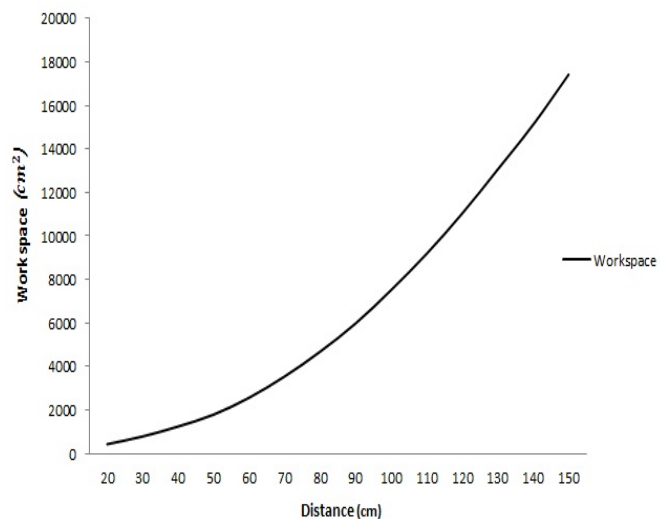


Figure 9. The workspace size depending on distance

The experiment results are shown in figure 8. As shown in the graph, we get the workspace that is proportional to square according to the distance if the camera distance away from the ground or objects. Therefore, user can adjust and use any space they want regardless of the workspace of display size.

V. CONCLUSIONS

Touch screen technologies are widely used as the basic input for mobile devices. However, for smartphones, touch screens have been utilized as a simple device that merely process text data. It has been considered an inappropriate multimedia input device for one to use design applications, such as painting, due to its narrow touch screen space, which makes it inconvenient to draw pictures.

In this study, we propose to enhance this weakness by using infrared approach on a smartphone's input interface. The usage of infrared approach will allow for quick and accurate operations without facing any space constraints. In this paper, we provide a detailed description of the design and implementation of a smartphone user interface using infrared pointing device. Additionally, using experimental results, we prove that our proposed approach is more convenient and efficient than traditional touch screen approaches used in smartphones. We presented how to trace the infrared pointing and infrared interface system instead of existing touch-input interface. The proposed system using the infrared pointer can improve that control the smart-phone more accuracy and limited workspace rather than existing touch interface. Through the test, we find that the infrared interface system provide better processing speed and recognition, and can set up the workspace through distance control between the camera and subject.

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