Journal of Knowledge Information Technology and Systems

ISSN 1975-7700

http://www.kkits.or.kr

Design and Implementation of a Transparent Tablet

Jongmyung Choi*

Department of Computer Engineering, Mokpo National University

ABSTRACT

Transparent tablets have been introduced a lot of SF movies and the concept videos for future technologies. There have been researches on user interface for transparent mobile devices, but only a few researches on the implementation of the devices have been introduced. In this paper, we introduce how we develop our transparent tablet, which consists of a transparent LCD and Raspberry PI 2. This tablet is a mobile device, so that it should be small and light enough to be carried in everyday life. Furthermore, it should support the applications which run on the traditional tablets, and applications which are designed for the specific features of transparent tablets. The applications of transparent tablets are classified into three groups according to their adaptability: level 0, level 1, and level 2. The applications in "level 0" and "level 1" can provide unique services for transparent tablets, but applications in "level 2" should have the supports from hardware and system software. Applications in "level 1", such as drawing application, can be used for transparent tablets with "overlay" interaction without any modification by changing its usage scenario. Therefore, the development of usage scenarios for "level 1" and "level 2" will be the key point for the practical usefulness of transparent mobile devices.

KEYWORDS: Transparent tablet, See-through device, Overlay application, Software level, Drawing application

ARTICLE INFO: Received 29 December 2015, Revised 12 Feberuary 2016, Accepted 12 Feberuary 2016.

1. Introduction

Transparent or optical see-through tablet computers have been introduced in a lot of SF movies and some future concept videos such as

*Corresponding author is with Department of Computer Engineering, Mokpo National University, 534-729, Youngsanro-1666, Cheonggyemyeon, Muangun, Jeonnam, KOREA.

E-mail address: jmchoi@mokpo.ac.kr

Corning's "A Day Made of Glass" [1]. With the advent of transparent display, some transparent mobile devices such as Sony Ericsson's Xperia Pureness [2] and Lenovo's S800 [3] was introduced in the market. However, those devices was not so successful in the market, because they did not provide practical usefulness.

There have been some researches on transparent mobile devices, but most of them was focused on user interface or user interaction for the devices. LucidTouch[4] and tPad[5] are the representative existing researches. The existing researches introduced good user interface pattern and usage scenarios for transparent devices. However, there have been only few researches on transparent mobile device implementation or software development issues for the devices.

In this paper, we introduce transparent tablet implementation and software development for the devices by extending our previous work [13]. For the implementation, we elicit some requirements and consider design issues for the device. Our prototype tablet adopt an optical see-though LCD for its display with IR touch panel, and Raspberry PI 2 with a camera module. We also consider software development. The tablet has Linux platform, and all Linux applications run on the tablet. We classify transparent tablet applications into three groups according to their adoptability: level 0, level 1, and level 2. Our example application is a drawing application which is a typical drawing application used in desktop computer or tablet devices. Our transparent tablet allows people to overlay the transparent display on the exiting pictures and trace the lines of the pictures.

This paper consists of five sections. In the next section, we introduce other existing researches on transparent or see-through tablet computers. After then, we describe some design and implementation issues for our transparent tablet computer in Section 3. In Section 4, we introduce some software issues for transparent tablets, and finally we reveal our conclusions in Section 5.

2. Related Work

Transparent tablets have been a dream device in SF movies and in some future technologies concept videos. For example, <Figure 1> shows a conceptual transparent tablet computer in the video, "A Day Made of Glass[1]." In the concept video, a student gets the information of a deer by looking the footprints through her tablet.

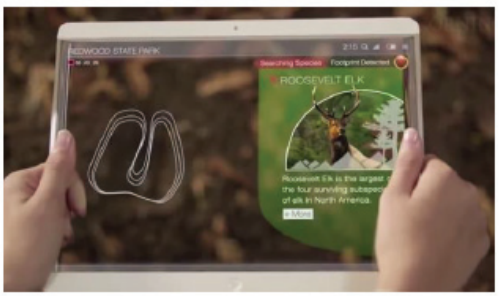

그림 1. "A Day Made of Glass" 비디오의 투명 태블릿
Figure 1. A Transparent Tablet in "A Day Made of Glass" Video

There have been researches which are related to transparent mobile devices. Those researches are categorized into three groups: the implementation of transparent mobile devices and

user interface / interaction for the devices.

There are two types of see-through devices in research. The first one is the tablet with an opaque display, but it allows people to see its back using the attached video camera. The most well-known system of this type is LucidTouch[4]. LucidTouch has an opaque display, but it has a camera at its back to monitor user's hands and fingers. Therefore, it allows people to show their fingers' locations in its back. <Figure 2> shows the system architecture of LucidTouch. The main purpose of the camera is to detect the locations of user's fingers.

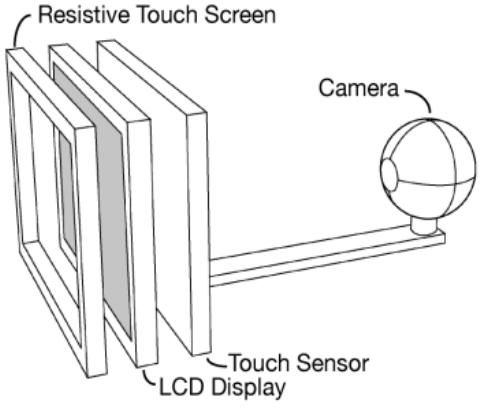

그림 2. LucidTouch 구조

Figure 2. Structure of LucidTouch

The second one is the tablets with transparent display and its typical example is tPad[5]. Juan and et al [5] introduced transparent tablet prototype with transparent LCD. <Figure 3> shows tPad, one of their transparent tablets. They implemented transparent tablets and classified user interaction techniques into four types: overlay, dual display & input, surface capture, and model-based interaction. They showed good examples of interaction methods and applications for transparent tablets.

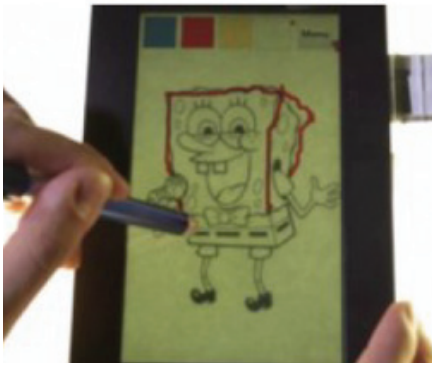

그림 3. tPad의 오버레이 인터랙션

Figure 3. tPad's Overlay Interaction

There were some commercial transparent mobile devices: Sony Ericsson's Xperia Pureness [2]. It was released in 2009, and it had a transparent 1.8 inch monochrome display. Another similar device was Lenovo's S800 model smart phone, which was released in 2011 [3].

Our system has some similarities with other transparent or see-through tablet in that people can see the back of the tablet. However, we also have some differences with other works. First, our work differs from LucidTouch, because our system adopts a transparent LCD rather than video camera display. tPad[5] is very similar to our work. However, our research focus is different from that of tPad. Our research focuses are on the issues in design and implementation of the system. <Table 1> shows our work's similarity and difference compared to other researches.

표 1. 기존 기기와 비교

Table 1. Comparison to the Existing Devices

Features	Lucid-Touch[2]	tPasd[3]	Our System
Trans-parency	No	Yes	Yes
Touch	Yes	Yes	Yes
Camera	Yes	Yes	Yes
User View Camera	No	No	Yes
Tablet Computer	Yes	No	Yes

Another related research area is transparent user interfaces. There have been researches on user interface for transparency. Eric A. Bier's toolglass [6] is a see-though GUI widget which helps people to manipulate visual objects. Wolfgang Büschel's research [7] introduced user interaction scenarios for flexible and transparent display. They proposed some new interaction patterns such as Coner Bending, Twisting, Bend-Squeeze, and Stack & Bend. Juan and et al. [8]'s another research was about Contact Augmented Reality with transparent display devices. Its prototype was tPad, and with external camera, it provided augmented reality on top of physical objects such as map and documents. Gordon [9] also introduced GUI paradigm for transparency. Juan[11] also introduced interactive transparent exhibition cases using transparent display. Furthermore, there have been some devices using transparent display. Samsung also has interests in show window application with their transparent display [12]. J¨orn Loviscach [14] introduced the concept of transparent blackboard.

3. System Design and Implementation

3.1 System Requirements

The main purposes of this project are 1) development of a transparent tablet computer, 2) validation of the use of transparent tablet in daily life, and 3) development of applications for the transparent tablet. To meet those purposes, we have some requirements for the transparent tablet.

- R1. Portability: Transparent device should be portable or carryable in daily life. Therefore it should be a kind of a hand-held device.
- R2. Computing Power: It should have full computing power, and it should be able to be used as a computing device.
- R3. Transparency: It should be transparent enough for people to see physical object through its screen.
- R4. Clear Vision: It should support clear visibility to see its content on the screen.
- R5. Easy Manipulation: It should support hardware and software facilities for users to operate it with ease.
- R6. Direct Manipulation: It should support hardware and software facilities for users to manipulate physical objects which are seen through the display.

Those requirements should be considered at design and implementation phases to meet them.

3.2 System Design Issues

The system requirements mentioned in the previous section should be considered in the design phase. There may be several design solutions for a requirement. However, in the

design phase we should select the best solution to meet the system's purposes.

- D1. Portability: For this requirement, the tablet should be small enough to carry, and not heavy. So we determine its size to be 10 inches, because most of the commercial tablets are about the size. It also has a touch pad and a camera as the commercial ones have them.
- D2. Computing Power: For the requirement, we adopt Raspberry PI2 because it is small but has full computing power. It supports Linux operating system.
- D3. Transparency: There can be two types of see-through tablets as mentioned in the section 2: an opaque tablet with camera and an optical see-through tablet. We choose a tablet with a transparent display because it is the dream device in the movies. For the transparent display, there are transparent LCD, AMOLED, and OLED. We choose LCD because the others are not available on the market when we design the system. Transparent AMOLED or OLED with big size are on the market, but there are no ones with 10 inch size.
- D4. Clear Vision: For this requirement, we adopt the back light module. Transparent LCD does not support clear images on its screen, but the back light panel helps its clarity.
- D5. Easy Manipulation: The tablet should be easy to manipulate, so that it should support touch interface. There are several technologies for touch panel, but we adopt an IR-based transparent touch panel after considering costs and market availability.
- D6. Direct Manipulation: For direct manipulation, we adopt a camera at its back to record the scene what people see. When people see something through the tablet, the camera can identify the thing by recognizing it with the camera.

Our transparent tablet consists of a transparent display, a transparent touch panel, Raspberry PI2 computer, and a camera as shown in <Figure 4>. Because we adopt transparent display and touch panel, users can touch its display for user interaction.

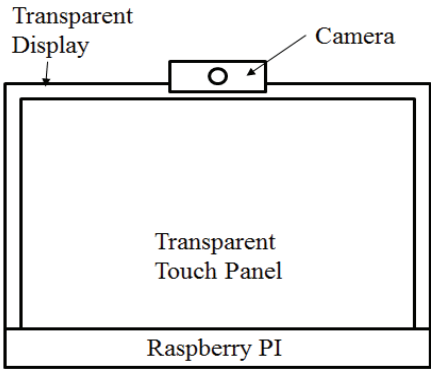

그림 4. 투명 태블릿의 개념 설계

Figure 4. Concept Design for a Transparent Tablet

3.3 Transparent Tablet Implementation

We implemented a transparent tablet with a transparent LCD, Raspberry PI2 computer, a camera, an IR touch panel, and a battery. <Figure 5> shows our transparent tablet front side.

그림 5. 투명 태블릿 전면

Figure 5. Front of Our Transparent Tablet

<Figure 6> shows the back of our transparent tablet. It shows IR touch panel board, AV board, and a switch.

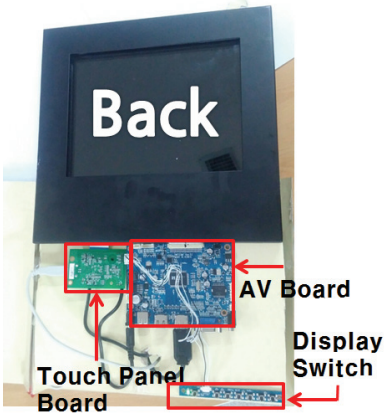

그림 6. 투명 태블릿의 뒷면

Figure 6. Back of Our Transparent Tablet

<Figure 7> shows that the tablet works as other normal tablet computers. Therefore, people are able to utilize Linux applications in this tablet.

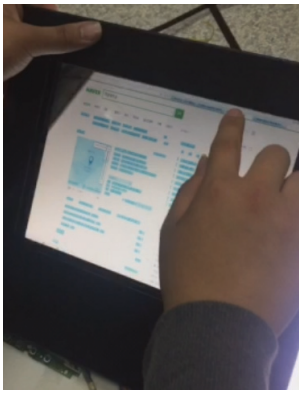

그림 7. 태블릿 사용

Figure 7. Using the Tablet

<Figure 8> shows that the tablet is transparent. User's hand is seen at the behind of the display. The LCD has low transparency, so that it sometimes requires backlight for clear view.

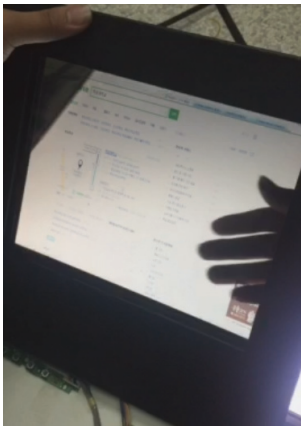

그림 8. 투명한 디스플레이

Figure 8. Transparent Display

4. Software Development for Transparent Tablets and Future Work

4.1 Software Development

Juan[5] proposed some unique interaction types for transparent tablets, and the application which adopt those interaction types should be developed. For usefulness, transparent tablets should support various applications including ordinary applications and transparent display specific applications.

We classify the efforts to develop transparent display specific applications into three groups: level 0, level 1, and level 2. Applications in "level 0" are the applications which are used as the same way that they were used in the traditional tablets.

"Level 1" applications are used in different way with new usage scenarios, but they do not require significant modification. For example, our drawing application explained later is a normal drawing application with touch events. But it can be used as a picture tracing application with the transparency feature.

"Level 2" applications are applications which adopt new interaction or input events such as dual touch. This type applications require system level modification such as hardware and operating system.

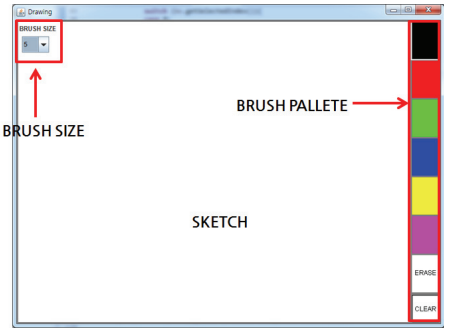

그림 9. 그림판

Figure 9. Drawing Application

We test "overlay" interaction with "level 1" an drawing application. It is implemented with Java, and it handles touch events to draw a picture. It can select colors and brush sizes. <Figure 9> shows the drawing application. This drawing application is an ordinary Java drawing application.

With the ordinary Java drawing application, people can draw a picture by tracing the original picture which is located in the back of the transparent display. <Figure 10> shows how to draw a picture by tracing the original picture.

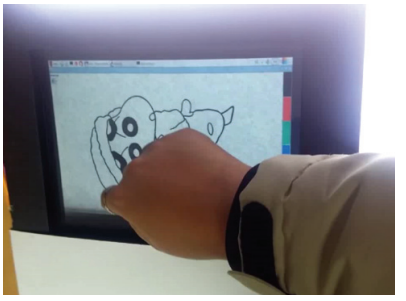

그림 10. 그림 그리기

Figure 10. Drawing a Picture with Overlay

4.2 Limits and Future Work

Our prototype system has some limits as mentioned by Simon Hill [10]: poor contrast, low transparency, energy inefficiency for strong backlight. Those limits are caused by adoption of transparent LCD. The content on the display was clear enough. Therefore, the transparent display should be bright enough to see its content clearly. In the next research, we will adopt AMOLED or OLED transparent displays. We are working on augmented reality, especially augmented reality

with user perspective view[15].

5. Conclusions

Transparent tablets have been popular in SF movies, but they are not so popular in the real market because of their low practical usefulness. However, they are in the early stage of development, and some practical usage scenarios have been introduced in research.

In this paper, we introduced some requirements and design issues for transparent tablets, and our transparent tablet prototype. We also argued that applications are important for practical usage. Therefore, we classified applications into three levels according to their adoptability to transparent tablets. Applications in "level 0" and "level 1" can be adopted to transparent tablets without modification. Just the change of usage scenario is enough to utilize the applications in transparent tablet platform. In the near future, transparent devices will be popular, and then our models will be helpful on the development of the applications.

References

[1] Corning, A day made of glass, available at https://www.corning.com/, Feb., 2011.

[2] Xperia Pureness, http://www.gsmarena.com/sony_ericsson_xperia_pureness-3015.php, Nov., 2009.

[3] Lenovo S800, http://www.gsmarena.com/lenovo_s800-4862.php, Oct., 2011.

[4] D. Wigdor, C. Forlines, P. Baudisch, J. Barnwell, and C. Shen, *LucidTouch: A see-through mobile device,* UIST'07, ACM, 2007.

[5] J. D. Hincapié-Ramos, S. Roscher, W. Büschel, U. Kister, R. Dachselt, and P. Irani, *tPad: Designing transparent-display mobile interactions,* in Conf. on Designing Interactive Systems, pp. 161-170, 2014.

[6] E. A. Bier, M. C. Stone, K. Pier, W. Buxton, and T. D. DeRose, *Toolglass and magic lenses: The see through interface*, Proc. of SIGGRAPH'93, ACM, pp. 73-80, 1993.

[7] W. Büschel, A. Viergutz, and R. Dachselt, *Towards interaction with transparent and flexible displays*, Proc. of CHI'13, 2013.

[8] J. D. Hincapié-Ramos, S. Roscher, W. Büschel, U. Kister, R. Dachselt, and P. Irani, *cAR: Contact augmented reality with transparent-display mobile devices*, Proc. of 3rd ACM Int'l Sym. on Pervasive Displays, 2014.

[9] G. Kurtenbach, G. Fitzmaurice, T. Baudel, and B. Buxton, *The design of a GUI paradigm based on tablets, two-hands, and transparency,* Proc. of CHI'97, pp. 35-42, 1997.

[10] S. Hill, *Clearing a path: why we aren't using transparent phones*, TechRadar, May, 2014, available at http://www.techradar.com/news/phone-and-communications/mobile-phones/clearing-a-path-why-we-aren-t-using-transparent-phones-1251012/1, May, 2014.

[11] J. D. Hincapié-Ramos, X. Guo, and P. Irani, *Designing interactive transparent exhibition cases*, Proc. of 3rd Int'l ACM

workshop on Personalized Access to Cultural Heritage, ACM, 2014.

[12] J. Vincent, *Samsung's transparent and mirrored displays look like optical illusions,* The Verge, http://www.theverge.com/2015/6/10/8756355/samsung-transparent-mirror-oled-displays, Jun., 2015,

[13] J. M. Choi, and H. R. Kim, *Design of a transparent tablet computer,* Proc. of ISIS, 2015.

[14] J. Loviscach, *Turning a graphics tablet into a transparent blackboard*, SIGGRAPH, 2011.

[15] M. Tomioka, S. Ikeda, and K. Sato, *Approximated user-perspective rendering in tablet-based augmented reality*, Proc. of Int'l Symposium on Mixed and Augmented Reality, pp. 21-28, 2013.

투명 태블릿 컴퓨터 설계 및 구현

최종명

국립목포대학교 컴퓨터공학과

요 약

투명한 태블릿은 공상과학 영화와 미래 기술 컨셉 영상 등에서 많이 등장하며, 미래에 널리 사용될 디바이스의 하나로 많은 주목을 받았다. 현재까지 투명 태블릿의 인터페이스에 대한 연구는 많이 진행되었지만, 태블릿 구현에 관련된 연구는 많이 발표되지 않았다. 본 논문에서는 투명 LCD 디스플레이와 라즈베리파이 2 결합한 투명 태블릿을 개발한 내용을 소개한다. 이 태블릿은 휴대할 수 있는 크기와 무게를 가져야 하며, 충분한 컴퓨팅 파워를 가져야 한다. 또한 투명 태블릿의 실용적인 유용성을 위해서는 전통적인 소프트웨어를 충분히 지원하면서, 투명 태블릿 고유의 특징을 활용한 기능을 지원할 수 있어야 한다. 투명 태블릿 소프트웨어는 기존 소프트웨어와 차이점에 따라 레벨0, 레벨1, 레벨2로 구분하였다. 레벨0과 레벨1은 응용 소프트웨어를 그대로 혹은 일부 수정으로 투명태블릿 고유의 서비스를 제공할 수 있지만, 레벨2는 이벤트 처리 등을 위해서 하드웨어 혹은 시스템 소프트웨어를 수정해야 한다. 기존 태블릿 혹은 컴퓨터에서 사용되던 그림판 응용프로그램은 투명 태블릿의 Overlay 형태의 사용 시나리오를 변경함으로써 프로그램은 변경하지 않고도 투명 태블릿 고유의 기능을 제공할 수 있는 레벨1 응용프로그램이다. 따라서 "레벨1"과 "레벨2"를 위한 사용 시나리오를 개발하는 것이 투명 모바일 디바이스의 실질적인 유용성을 위한 키포인트가 될 것이다.

Acknowledgments

Following are results of a study on the "Leaders in INdustry-university Cooperation" Project, supported by the Ministry of Education.

Jongmyung Choi received the Bachelor's degree, Master's degree, and Ph.D. in Computer Science from Soongsil University, South Korea, in 1992, 1996, and 2003 respectively. He is currently a professor in the Department of Computer Engineering, Mokpo National University, South Korea, since 2004. His research interests are human computer interaction, social computing, and e-textbook.

E-mail address: jmchoi@mokpo.ac.kr