uPen: Laser-based, Personalized, Multi-User Interaction on Large Displays

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ABSTRACT
We present the uPen, a laser pointer combined with a contact-pushed switch, three press buttons and a wireless communication module. This novel interaction device allows users to interact on large displays at a distance or directly on the surface with full-function of mouse. Onboard software enable the uPen system to identify different users and provide personalized services to them, such as associating users with corresponding privileges, giving access to each participant's private content (e.g., home pages, personal calendars). Additionally, with our two-step association method, the uPen system has the ability to distinguish strokes of different uPens working simultaneously and support multi-user simultaneous interaction. A prototype system has been implemented in our Smart Classroom [1]. And user studies show the benefit of using it.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces - i*nteraction styles*，*input devices and strategies*，*theory and methods*.

General Terms
Design, Human Factors.

Keywords
Large Displays, Laser Point, Multiple Users

1. INTRODUCTION
Large displays are growing more affordable and provide new opportunities for ubiquitous placement in work environments. However, most of large displays are non-interactive.

Our core idea is to augment the large display with appropriate interactive capabilities. Equipped with our uPens and auxiliary software, large displays evolve into a Large-scale Information Appliances (LIA), a new kind of information appliance that serves single users and multiple users as well. For a single user, it serves as a general information kiosk to provide personalized services. For multiple users, it identifies different users and allows them to interact simultaneously.

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Such new interactive appliance LIA bases on a novel interaction device which we call uPen. uPen is an augmented pen-like device integrated with several additional components. This device provides users ability for interacting on projected large displays with full-function of mouse at a distance. And if the display is touch sensitive, such as Smart Board [3], it enables users to directly manipulate on the surface to experience all the service.

2. THE UPEN
uPen is an extended laser pointer integrated with a wireless communication module, three buttons and a contact-pushed switch. Figure1 shows the architecture and the prototype of it.

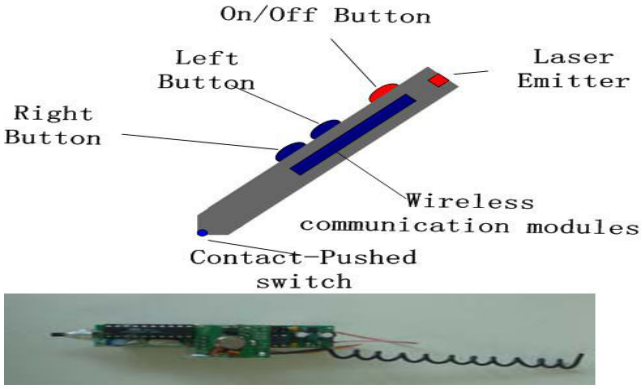

Figure1：The up is the architecture of the u-pen and the below is the inside of it.

3. INTERACTION PRINCIPLE
Based on uPen, users can easily interact with different forms of large displays, from normal projected walls to touch sensitive board (for example, the Smart Board [3]). uPen system makes these large displays serve as Large-scale Information Appliances(LIA), which support not only a single user to take over personalized service, but also serve a group of people working together.

3.1 A single user

3.1.1 Augmented mouse.
The red laser spot emitted by the uPen on the large screen is grabbed by a video camera and its position is interpreted as the location of the cursor. The Left and Right buttons on the uPen wirelessly emulate as a standard mouse's left and right buttons

respectively. Due to this powerful uPen, the user can interact with the computer in any distance with full-function of a mouse. Additionally, as the On/Off button simultaneously emits a laser beam and the uPen's ID through radio frequency, we add the ID information to the mouse event. As a result, the system has the ability to recognize who is interacting currently and it has been extended to provide personalized service.

3.1.2 Multiple displays

Smart Space usually includes a number of large displays driven by different machines. We have developed "easy-trans" mechanism to support collaborative interaction across multiple displays. Our "easy-trans" feature allows the user to seamlessly move information objects across screens with an uPen as if all of the screens were a virtual large desktop. This function is useful in the scenario of the discussion. When people were discussing about a document on a projected large display, a few minutes later, the author wanted to modify it. He can seamlessly move it onto the table display and make the modification.

3.2 Multiple users

Our system has been extended to associate each laser stroke with corresponding uPens so as to support multi-user interaction. We achieve the correct association by two-step method. The first step is to associate laser strokes with corresponding uPens and the second one is to associate laser spots with laser strokes.

3.2.1 Step One: Laser stroke to uPen.

It is the fact that when the corresponding laser stroke starts to appear on the large screen, this uPen's ID is received by the computer at the same time. If multiple uPens are being used currently, the computer receives the identities of these i-pens in same order as that in which corresponding laser strokes start to appear. For example, three i-pens (L_1, L_2, L_3) start to work in the order L_1, L_2, L_3. We identify laser strokes in the way that the laser stroke which appears firstly on the screen is generated by L_1, the secondly appearing one is generated by L_2, and the last one's ID is L_3.

After it, the rest work we need to do is to assign observed laser spots to corresponding laser strokes, which is the aim of step two.

3.2.2 Step Two: Laser spot to Laser stroke.

We find out which is the closest valid region for each observed laser spot, and associate the observed spot with the closest stork. After finding associations we update the state of each Kalman system (stroke) that was observed by the current camera. We have found that this data association technique works well in practice.

Based on it, we have developed an application named M-Drawing which allow multiple users to simultaneously draw on a public large screen with a number of i-pens and strokes are rendered with different colors according to different users.

3.3 Interaction on touch sensitive board.

The touch sensitive board such as Smart Board [3] can detect the position of the touch and interpret it as the cursor position. We added a contact-pushed switch on the tip of the uPen which allows users to directly experience our services on such touch sensitive surfaces. When uPen is pressed on the surface, the contact-pushed button on the tip is pressed down and the transmission of the ID is trigged as well. Differently with interacting on projected display wall where the cursor position is located by laser spot, the mouse's position is determined by the contact position between the uPen and the board. As a result, interactive capabilities achieved with laser beam were totally implemented on touch sensitive board with uPen. And the main advantage is that users can walk to the board and directly manipulate on it.

4. IMPLEMENTATION

A prototype of uPen system has been implemented in our Smart Space system: Smart Classroom [1].

Software to support the uPen system is based on Smart Platform [2], a multi-agent software infrastructure to support Smart Space. Smart Platform serves to provide necessary communication and coordination method. Based on it, we develop the applications necessary such as detecting laser spots, emulating a wireless mouse, identifying different i-pens, etc. A prototype of Smart Classroom has been built in Tsinghua University's Distance Learning School. Our uPen system as a part of the Smart Classroom works effectively, and teachers using our system to give a class have been very positive in their assessment of its utility and usability.

5. CONCLUSION

We used uPen, a pen-liked laser-based interaction device, to facilitate interaction on large displays. Our system has the ability to identify different users and provide various personalized service them. Unlike traditional interaction system that only suits a single user with one screen. the uPen system has evolved to support multiple users and multiple screens. A prototype system has been implemented in our Smart Classroom [1]. And user studies show the benefit of using it. In future, a large scale user study is expected to completely evaluate it.

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