ENHANCING TOUCHSCREEN INPUT VIA FINGER IDENTIFICATION

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ABSTRACT

Though there are various input ways of touch screen such as tap, double tap, gestures and multi-touch operations, input is still limited and inconvenient. In this paper, we present a method to enhance touchscreen-input modality using integrated finger identification system, through which each touch point will be given a new property or meaning by being assigned to a certain finger. It is a highly integrated method for existing display equipment with accuracy recognition performance. In addition, large programmable capacity for customization offers good interactive flexible experiences to users. Results from technical implementation show the accuracy and significantly interactive experiences of the new finger-identification platform.

INTRODUCTION

Various touch-interactive input technologies allow users to interact with computer screens and among which multi-touch technology has been widely used and brought great convenience to our daily lives. More impressive interactive characters can be achieved if we can know which finger (e.g. a thumb or an index finger) touches a screen that means with the help of finger identification, command vocabularies can be increased.

Finger identification has been studied in last decades. Some researches [1] explored technologies to distinguish fingers from different people, and yet others [2]showed methods to identify fingers from different hands. Masaaki et al. [3] designed an accelerometer 'ring' to distinguish each finger. However, these methods face problems of wire connections or assigning problems between a touch point and a certain finger. Very recently, Marquardt et al. [4] introduced a fiduciary-tagged glove to identify fingertips. Suzuki et al. [5] presented an upper camera and painted fingernails to identify a certain finger.

Focusing on the finger identification of the same hand, an integrated method for existing display equipment with accuracy finger recognition is proposed in this paper. Compared with other studies, no wire connections, highly integrated level, and the design of crossing array antennas for a better recognition performance are all contributions in terms of technical merit.

PLATFORM ARCHITECTURE

The proposed platform consists of a highly integrated finger-identification screen for sensing each finger's touch operation and spatial-temporal authentication algorithm for assigning a touch point to a corresponding finger. Using this platform each touch point will be given a new property by being assigned to a certain finger. Figure 1a shows a prototype of the designed enhanced integrated touchscreen and a system model is presented on the right. When a user's finger with a customized fingerstall touches the screen, not only a common touch position is captured but also a corresponding finger is recognized.

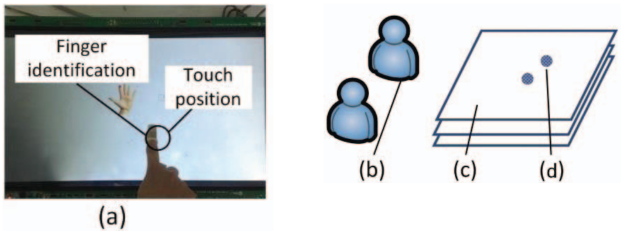


Figure 1: a prototype on the left and a design model on the right (a) a prototype of the designed enhanced integrated touchscreen (b) users (c) integrated finger identification screen (d) touching operations of different fingers.

Integrated finger identification screen

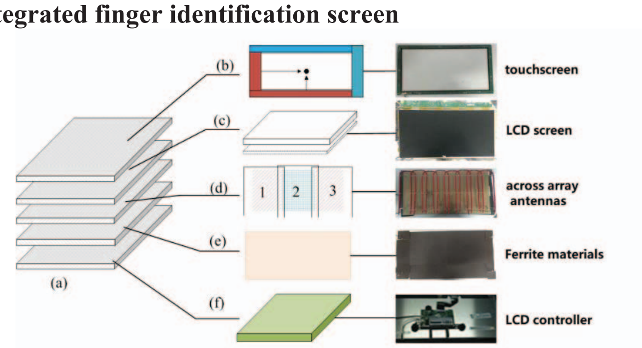


Figure 2: integrated finger identification screen (a) a 'sandwich' layer structure (b) a touch screen (c) a liquid crystal display (LCD) screen (d) crossing array antennas (e) ferrite absorbing materials (f) LCD controller board

The integrated identification screen (IFI screen) has a sandwich-like layer structure. The top layer (Figure 2b) is a general infrared touch-screen which is used for detecting touch point. The middle layer (Figure 2c) is an LCD screen without metallic shell for a displaying function. Moreover, the bottom layer (Figure 2d) is a crossing array antenna structure which is customized for detecting fingers with radio frequency identification devices (RFID) fingerstalls. Areas 1, 2, and 3 (Figure 2d) of these crossing antennas with some at-grade areas are all recognition areas, which can make sure no missing recognition happens when operating the RFID fingerstalls identification. In order to improve the identification performance and integration level of the prototype, two extra necessary layers are introduced: a layer of ferrite absorbing materials (Figure 2e) for electromagnetic interference reduction and an LCD controller circuit board (Figure 2f) for higher integration level.

Structures of antennas have great impacts on the identification accuracy of RFID tags. Generally, turns and width of the rectangular antennas were explored and results show that single coil and 8 cm are the best choices for this prototype system. Moreover, by adopting a crossing structure of two adjacent antennas, a wakeless recognition near the wireframe area of a single coil is avoided, which achieves a larger recognition area when the vertical distance between antennas and tags is less than 1 cm.

Spatial-temporal authentication (STA) algorithm

An STA algorithm is proposed to assign a touch position to a certain object. So a certain touch operation is assigned to its upper touching objects.

Algorithm 1:Spatial-temporal authentication (STA) algorithm

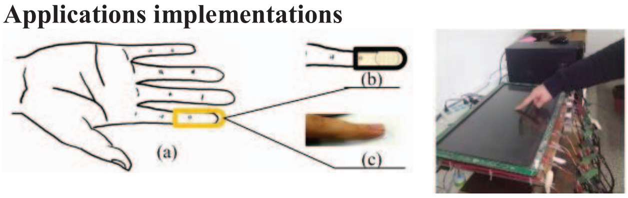
Input: $P(x,y)$
Output: $P(x,y)$, F_p and Corresponding $F_p(C\text{-}F_p)$
Initial: $P(x,y)=0$, $t=0$, $F_p=0$, $C\text{-}F_p=0$, P_s, P_t,
Touches detection: **if** ($P(x,y)$) **then**
    $t = t_1$;
Spatial authentication: **if**($\| P(x,y) - P_{ant}(x,y)\|_2 < P_s$) **then**
        Opening antennas to detect fingers
        F_p = ID.
        $t = t_2$.
Temporal authentication: **if** ($|t_1 - t_2| < P_t$) **then**
    $C\text{-}F_p = F_p$;
    $P(x,y) = P(x,y)$;

where $P(x,y)$ and $P_{ant}(x,y)$ is the position of touch position and antennas respectively, F_p is the identification (ID) of fingerstall, $C\text{-}F_p$ is the corresponding ID of that touch position. t is the triggering timestamp of touch operation and identification operation, and P_s and P_t is threshold of spatial and temporal authentication respectively.

The STA algorithm has two main steps: spatial authentication and temporal authentication. Firstly, it is a spatial-authentication. When a touch operation for RFID tags is triggered $(P(x,y) \neq 0)$, a timestamp t_1 of the touch operation will be stored. Then only two nearest antennas ($\| P(x,y) - P_{ant}(x,y)\|_2 < P_s$) below this touch position are activated to detect RFID tags within detection fields of these two antennas. After that, for all detected objects, the object of the closest time using stored timestamps ($|t_1 - t_2| < P_t$) is the latest joined object and will be assigned to this touch operation, which is called temporal-authentication. After the STA algorithm, touch points are assigned to their upper touching object and can operate other commands using internal RFID information. In the prototype, the implementation of the STA algorithm can deal with multi-touch operation whose time interval is larger than 250ms (P_t=250ms) and spatial interval is larger than 2.5 cm (P_s=2.5cm). Obviously, both of these two values can be decreased and performance can be improved by using more powerful RFID sub-system.

EXPERIMENTAL RESULTS

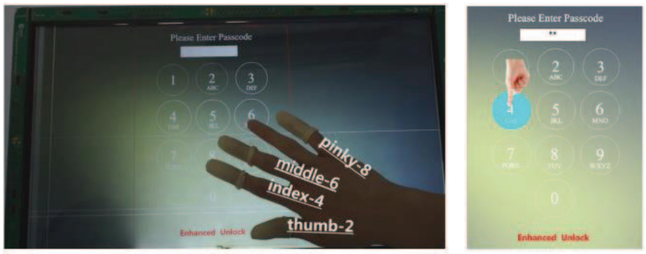
Applications implementations



(d)

Figure 3: extended touchscreen and plastic fingerstall containing RFID tag (a) a hand with a RFID tag fingerstall in index finger (b) schematic (c) a practical size of a finger (d) actual extended touchscreen architecture.

Figure 3d shows an overview of the prototype. Another part of this mechanism for finger identification is the use of a small plastic fingerstall containing an RFID tag. As Figure 3a shows, an index finger wears a plastic fingerstall that holds a small RFID tag. Figure 3c shows a practical example of wearing this tag fingerstall touching this platform. The tag size is 1.5cm x 3.5cm. It has a 64-bit unique identifier and an 8-bit data storage format identifier in internal chips and both of these units can be used for assigning a tag to a finger. When a finger with a RFID tag touches the screen, the touch point is assigned to the corresponding finger.



(a) (b)

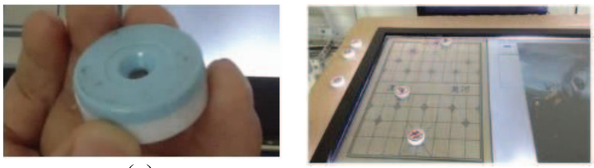
Figure 4: PIN-Finger Authentication (a) finger assigning information (b) schematic

Though input of a PIN is such a common method for daily touch operations, others can easily learn the password if a user is not careful. So, in this case, a PIN-Finger Authentication is developed which means that users should input the correct password (0-9) with its correct assigned finger.

An example for the common PIN is ’2-4-6-8’, and a new PIN-Finger password is ’2(index)-4(middle)-6(ring)-8(pinky)’. Therefore the complexities of these two different types of pins are O (10^4) and O (4^4*10^4) respectively. Due to the additional assigned finger, the complexity increases with exponential growth.

Potential identification applications for multi-touch

Not only fingers can be distinguished, but also other objects with RFID tags can be identified. With the combination of identification system and multi-touch technologies, more convenient user experiences can be achieved by a combination of computer-aided performances and real direct-touch experiences. For example, desktop chess or card games can be benefited.



(a) (b)

Figure 5: Enhanced Chinese Chess (a) a real Chinese chess (b) three chesses pieces.

Figure 5 shows an enhanced Chinese chess example. The real Chinese chess pieces are employed with a round RFID tag sticking to their bottom for identification (Figure 5a). As Figure 5b shows, several chess pieces are placed on the chessboard and the corresponding virtual chess generated under each real Chinese chess piece. When the real chess piece moved to another position, the virtual chess piece under the real chess also moved to same position. So, by this new enhanced Chinese chess application, not only the performances of identification of multi-touch events are analysis, but also the wide usage of this system is demonstrated.

Performance analysis in multi-touch environments

In the prototype, the recognition range of a RFID antenna is 1cm upon antenna plane. The range is larger than the thickness of LCD plane and touch plane, which means that fingers can be read efficiently. As for the distance issue, inactive fingers cannot trigger either touch events or RFID recognition events when fingers are held over the touch display plane shown curled up.

When it comes to multi-touch scenarios, these multi-touch events can be divided into two types: (I) multi-touch events of non-neighboring fingers, (II) multi-touch events of neighboring fingers. Considering the STA algorithm and the crossing-antenna array, the TYPE I multi-touch events of different fingers can be distinguished by the size of the antenna. For these TYPE II multi-touch events, whether the distinction of different fingers can be done or not is determined by the difference of time intervals of adjacent fingers’ touch events. Here the minimum value of the difference is the time period when two opened neighboring antennas successfully read fingers. The latency time of multi-touch responses is 250ms which is enough to task many multi-touch events.

What’s more, the performance of RFID readers can be improved by efficient circuit designs. The size of antennas can be scaled down by emerging technologies, such as printed circuit board antennas. This means the recognition performance can be improved in the future which does not affect our designs.

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CONCLUSION

In this study, a method is presented to enhance touchscreen input using integrated finger identification system. Each touch point is given a new property by being assigned to a certain finger. Results of the integrated screen implementation show it is a highly integrated method for existing display equipment with acceptable recognition accuracy. And large experiments show the efficiency of the STA algorithm for assigning. Also results from the practical applications show accuracy of the prototype and yield impressive interactive experiences with the proposed finger identification platform.

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