MagMobile: Enhancing Social Interactions with Rapid View-Stitching Games of Mobile Devices

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Abstract. Most mobile games are designed for users to only focus on their own screens thus lack of face-to-face interaction even users are sitting together. Past work shows that the shared information space created by multiple mobile devices can encourage users communicate to each other naturally. The aim of this work is to provide a fluent view-stitching technique to help mobile phone users establish their information-shared view. We present MagMobile: a new spatial interaction technique that allows users to stitch views by simply putting multiple mobile devices close to each other. We describe the design of spatial-aware sensor module and tailor-made magnetic sensor units which are low cost, easy to be obtained into phones. We also propose two collaborative games to engage social interactions in the co-located place.

Keywords: human-computer interaction, co-located collaboration, spontaneous device sharing, view-stitching, mobile devices, cooperative games, sensors.

1 Introduction

Because mobile phones are originally designed for personal and individual use, the interaction among mobile phone users is identical regardless of whether they are remote or collocated. Andres et al. have proposed the concept of the Social and Spatial Interactions (SSI) [Lucero et al. 2010]. Mobile phones in SSI platform can detect the spatial location between devices with wireless sensors and stitch the views into an information-shared space. Some works expand this concept to several applications such as brainstorming, photo sharing, and map-based sharing interactions [Ashikaga et al. 2011; Lucero et al. 2010; Lucero et al. 2011]. As the shared view has been created, it encourages users to communicate to each other naturally therefore enhances the social interactions.

In order to create a shared information space, past works have proposed several stitching techniques such as Bumping[Hinckley 2003], onscreen gestures

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[Lucero &Holopainen, 2011] and infrared sensors [Merrill &Maes, 2007]. However, many users are afraid to damage their phones while bumping the devices. Applying gestures frequently might be cumbersome for users and decreases gaming experience. IR sensors won't work because infrared light might be occluded by hand while users grasp the phones.

In this work, we present MagMobile: that is lightweight, lowpowered and easy to be integrated in smart phones. MagMobile enables fluent dynamic view-stitching across multiple mobile devices. Users simply put their devices close to each other then the screen views are stitching together. We use this technique and develop two co-located collaborative games that can enhance the social interaction among users who are physically sitting together.

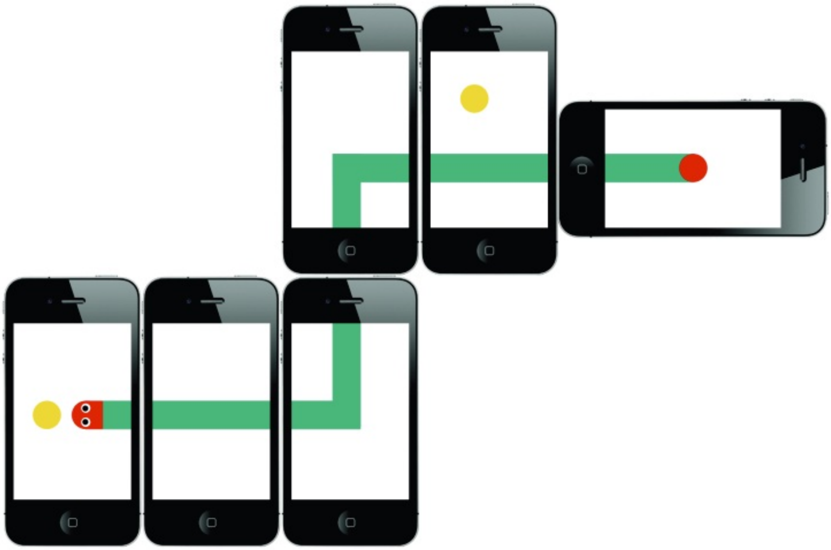

Fig. 1. MagMobile enables rapid view-stitching technique by simply putting mobile devices close to each other. We build a collaborative Snake game to demonstrate this technique.

2 Related Works

This work is related to share collocated mobile phone use and view sharing approaches.

2.1 Shared Collocated Mobile Phone Use

Andres et al proposed a SSI platform that engages phone users to collocated social interactions. They applied this interaction technique to build a MindMap prototype that supports cooperative brainstorming tool [Lucero et al. 2010]. Users can create and edit virtual notes for mind maps. Users could enlarge the scale of mind maps by stitching two devices together, the system is aware of the relative position between phones when a user applies pinch gesture on the screens. The authors further proposed Pass-them-around [Lucero et al. 2011], which is an photo-sharing prototype for mobile phone users, Pass-them- around allows user to engage collocated story-telling interactions by throwing or view-sharing digital photos between phones, this prototype also follows the SSI principles. The system supports directional communication between phones, but does not support instant short-distance view sharing mechanism. Users need apply gestures for view sharing. Ashikaga et al explored collaborative interactions for map-based applications [Ashikaga et al. 2011]. Users can share their bookmark information or synchronize the view on display. The system allows users to communicate to each other without showing their displays to other users in the process of interaction.

2.2 View Sharing Approaches

In order to achieve view-sharing mechanism, some works designed stitching gestures. Pass-them-around [Lucero et al. 2011] use pinch gesture on two device screens to stitch them together. Stitching system [Hinckley et al. 2004] asks user to draw a continuous line across different screens of devices. By analyzing the path between two devices, system could estimates the relative position between two devices. However, gestures are not suitable for collaborative tasks with fast interactive process such as cooperative games or other tasks that require continuous interactions. Applying gestures frequently might be cumbersome for users and lower down the fluency and continuity of interactive process. Gesture-free techniques can overcome this problem. In order to know the spatial information between devices, Kris et al. proposed a V-scope system [Luyten et al. 2007] to support wireless 3-dimensional location tracking by "time-of-flight" technique. Three-towers in V-scope system send infrared signals to a personal device and receive an ultrasonic back signal sent back by the device. Vscope system then calculates the 3-dimensional location of each phone. Users can treat their phones as a window above a virtual space and brows the shared digital information. However, V-scope needs an extra signal tower and force users to stay inside the sensing zone. Ken proposed bump technique that user can simply bump their devices to connect each other [Hinckley 2003] by using built-in accelerometer sensor. However, as the smart phones are expensive, many users are afraid to damage their phones while bumping the devices. Siftables[Merrill et al. 2007] is a playful distributed TUI blocks. Each Siftables equips four IrDA on each side face for sensing other neighboring blocks. Once two blocks are align together, they can communicate with each other and know the relative positions. This technique is low-cost and easy to deploy. But the character of infrared light might be occluded by hand while user grasps the phone. To avoid this situation, we use magnetic sensors for MagMobiles, which can still sense magnetic force precisely even when there is an obstacle in front of it.

3 System Design

In this section we present the design process of the MagMobile. When users want to share their views, they simply put their phones close to each other. The view will expand to both displays in less than half a second, which is sufficient for speedy view sharing applications such as playing games. Moreover, user can sense attractive force-feedback during the view-stitching process.

3.1 Basic Concept

To allow users re-arrange their shared-information as quick as possible, sensor based solutions were adopt in our prototype. We decided to use magnetic sensors and magnets to implement our sensing mechanism. The reason we adopt magnetic solution is because magnets are low-cost and magnetic force has the character of penetrability, thus the magnetic value can be sensed even the user's hand cover the magnets. In the early implementation of our prototype, we tested electronic compass embedded in a smart phone to sense the neighboring magnetic field. But build-in electronic compass can only detect one magnetic value for each axis in 3D space, which is insufficient to sense multiple mobile phones at the same place. Furthermore, we found that if there are multiple magnets nearby the built-in electronic compass, the signal output from the compass will be unstable. As a result, we decided to use Hall Effect sensors to sense the magnetic field.

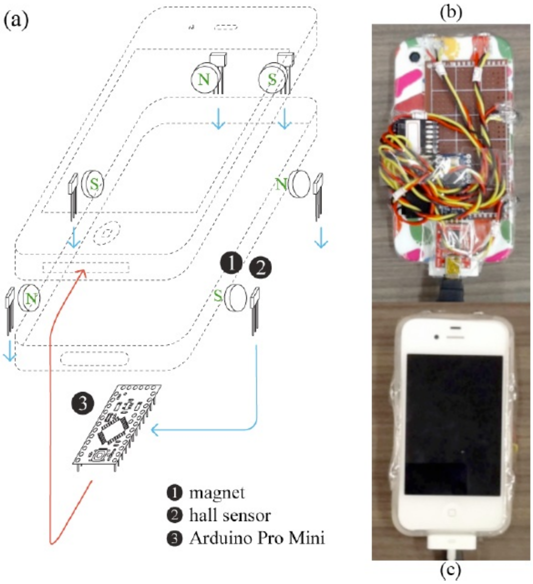

Fig. 2. (a) The design of sensor module: We attach 6 sensor units (magnet + Hall Effect sensor) on a sleeve case, (b) the backside, and (c) the front side of the MagMobile

3.2 Hardware Settings

We use UGN3503 series Hall Effect sensors which are ratiometric linear Hall Effect sensors. According to the spec of UGN3503, UGN3503 series Hall Effect sensors are sensitive and precise enough to track the small changes in magnetic flux. An Arduino pro mini is used to read the sensor values in our prototype, which transform the output voltage of sensors to a digital value, which is ranged in 1024 levels, from 0 to 1023. Fig. 2 shows our latest prototype, which is composed of six UGN3503 series Hall Effect sensors, six 10x1.5 mm cylindrical magnets, and an Arduino pro mini into one sleeve case. We stick a Hall Effect sensor and a magnet into one unit, so the unit could release magnetic force while sensing the change of neighboring magnetic field. We attach six units around the sleeve case (left, right and top). Each side is attached two units. The directions of the magnetic pole are arranged as Fig. 2a. All units are connected to Arduino pro mini. The signal processor reads the sensor values and sends them to a smart phone. Fig. 3 represents four possible spatial arrangements between two phones. The magnetic attraction force augments the feeling of stitching mechanism.

We integrate the magnetic module with an iPhone, and test the functionality of the internal digital compass, gyroscope, and accelerometer. All of them work normally. The magnets used in our prototype won't affect the performance of build-in sensors because their magnetic field strength is too weak. We have not attached the units to the bottom of sleeve case because our prototype now has to be linked to a computer as a relay station. This limitation will be eliminated in the future when the sensor module is integrated into mobile phones.

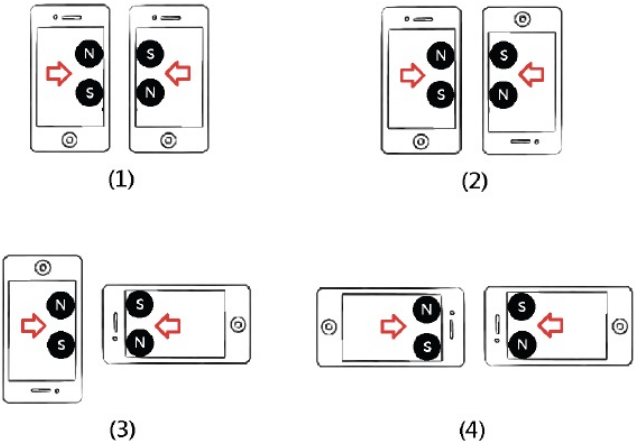

Fig. 3. Four possible spatial arrangements are all attracted to magnets. The magnetic attraction force augments the feeling of stitching between phones.

3.3 Stitching Mechanism with MagMobile Modules

The magnetic data read by Arduino are used to estimate the distance between two phones. We did an experiment to collect the data and build a lookup table for the spatial relationship between sensor module. We put two devices close in various distances and directions (see Fig. 3), and record sensor values of each unit. Fig. 4 shows the results of the experiment. At the beginning of synchronize mechanism, sensor values of a unit is calibrated by using the lookup table we built. Then the changes of sensor values are used to be the indicator of the distance between mobile phones. To judge if there is any device is getting closer in a certain direction or not, we simply accumulate the changes of sensor values on one direction. If the accumulated value is larger than a threshold, the phone assumes that there is another device nearby and stitches the screen views. Currently our prototype can sense three directional stitched position (i.e. left, right, and top), but it could sense more precise stitched position if we add more Hall Effect sensors on each side. (Fig. 7) Each module sends those stitched position to a server when the stitching edge has been detected. The server is written in Python 3. Our next plain is to run the server directly on the phone to eliminate the external server. Fig. 5 represents a view-stitching demo when two phones get close together.

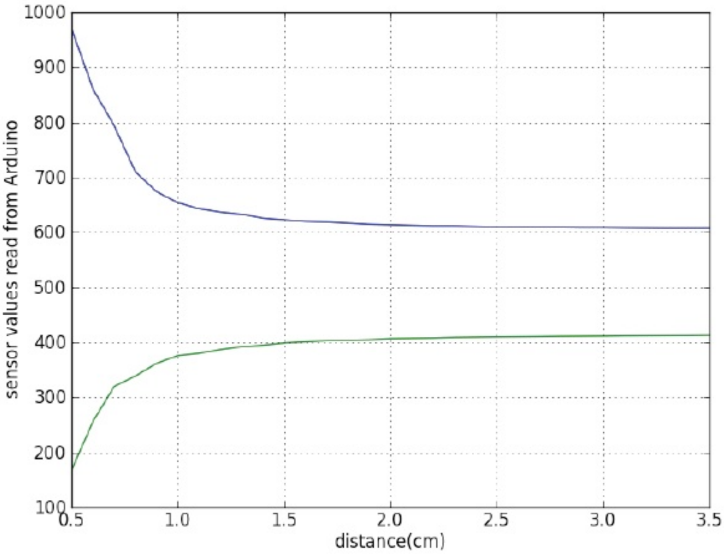

Fig. 4. The magnetic data between two phones in the distance from 0 to 3.5 cm. The blue curve represents the average sensor values of N-pole-outward unit, and another curve represents S-pole-outward unit.

Fig. 5. Two phones with MagMobile module (left). They can detect magnetic change in short distance and stitch screens (right). Each blue dot on the screens represents magnetic force sensed by a sensor unit.

4 Applications

MagMobile stitching technique enhances the fluent dynamic view-stitching in the collaborative game and increase body interaction among collocated users. Here we propose two applications(games) to demonstrate the realistic scenarios of the use of MagMobile sensor modules.

4.1 Collaborative Snake Game

We redesign the classic Snake game to a collocated collaborative game that supports 2~6 players. The game starts while all devices connect to a local wireless network. Like a classic snake game, the game picks one device as a start point. User can use swipe gesture to direct the snake's direction. The gold are randomly showed in different players' device. So users have to move their phones and rearrange the relative position quickly to collect gold and avoid obstacles. (Fig. 1)

4.2 Collaborative Tower Defense Game

Tower defense is a very popular game genre on touch devices. Base on the rules of traditional tower defense, we added collaborative factors into games. The map is not limited by a tiny mobile display. By putting multiple mobile devices together, the piece of map can be stitched into one large map. Players need to re-arrange their phones to generate a better path on the map dynamically. (Fig. 6)

As the game starts, a map shows different path on every smartphone and the defense towers are randomly located on the map to attack the enemies. At the beginning of each round, enemies will randomly appear on one of the smartphones, and then start to move through the path on the map.

Players have to extend the path by stitching their phones so the defense towers can eliminate more enemies and get more scores. As the enemies go from one phone to another, when the enemies pass to the next phone, the previous phone is free to take

Fig. 6. Collaborative Tower Defense Game: (a) The path expands while two phones stitching together. (b) If there is no other phone be stitched in the end of the path, the enemies escape and decrease the player's life point.

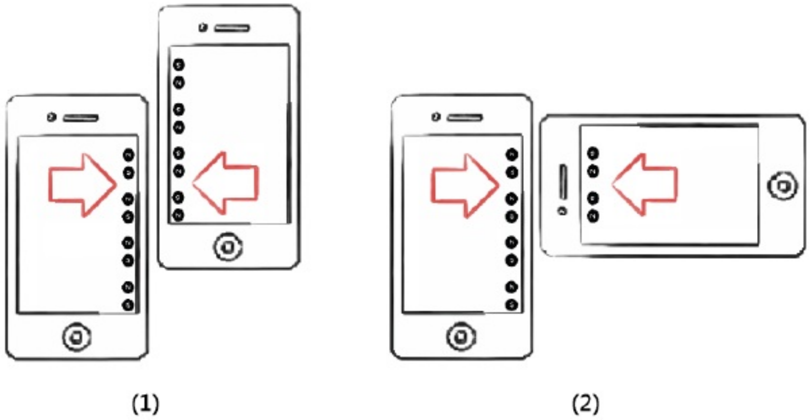

Fig. 7. Increase the sensor units around the edge to expand views between mobile devices in a various way

away and change a new path to be stitched in the next round. If the enemies move to the end of the path or the edge of the screen, the enemies will escape and decrease player's life points. When the life points decrease to zero, the game is over.

In the game design, players are required to team up with each other and use their phones to create a bigger map and a better path to win the game. Thus the game encourages the social interaction and provide more fun for players who are sitting together.

5 Conclusion and Future Work

In this paper, we provide a rapid view-stitching technique to build the information-shared space and encourage users to engage co-located social interactions. We present a prototype: MagMobile, which contains magnets and magnetic sensors to sense the spatial relationship among multiple mobile devices. The main contribution of this work is to provide a fluent view sharing mechanism by just putting devices close to together. Furthermore, MagMobile is low cost, low power consumption and easy to be integrated to mobile phones. We design and implement two collaborative games that support the view-stitching interactions to demonstrate the realistic scenarios of the use of MagMobile sensor modules.

In the future, we plan to conduct a user study to observe the user's behavior with our technique in co-located collaborative interactions. We plan to discover the possibility about magnet force feedback between devices. For example, users will feel attracted force if the phones are allowed to be stitched and feel repulsive force conversely. On the other hand, we will try to increase the density of the sensor units, we plan to combine an Npole- outward unit and an S-pole-outward unit into a pair, and then the number of relative spatial arrangements will be increased. (Fig. 7).

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