Surprise Grabber: A Co-located Tangible Social Game Using Phone Hand Gesture

Mingming Fan
Department of Computer Science & Technology, Tsinghua University
Beijing, 100084, P.R.China.
fmm08@mails.tsinghua.edu.cn

Li Tian
Academy of Art & Design,
Tsinghua University,
Beijing, 100084, P.R.China
tianli.888@hotmail.com

Xin Li
Department of Computer Science & Technology, Tsinghua University
Beijing, 100084, P.R.China.
lixinsemail@gmail.com

Yuanchun Shi
Department of Computer Science & Technology, Tsinghua University
Beijing, 100084, P.R.China.
shiyc@tsinghua.edu.cn

Yu Zhong
Department of Computer Science & Technology, Tsinghua University
Beijing,100084, P.R.China.
mina77lim@gmail.com

Hao Wang
Nokia Research Center,
Beijing, 100176, P.R.China
hao.ui.wang@nokia.com

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Abstract
Social network games (SNGs) are among the most popular games recently. Different from the asynchronous and online based SNGs, we present *Surprise Grabber* to see how tangible gesture interface could benefit the synchronous co-located social game. In *Surprise Grabber*, users control a virtual grabber's moving in 3D game to catch the gifts by using their camera phone. An efficient code running on the phone detects hand motion, delivers results to Serve PC and provides feedbacks in real time. Distinguished from online SNGs, all players stand together in front of a public display. The main results of the pilot user studies showed that: 1) Gesture interface was easy to catch up and made the game more immersive; 2) Occasionally inaccuracy in hand motion detection made the game more competitive instead of frustrating players; 3) Players were eager to share their experience by talking while playing; 4) Players' performances were obviously influenced by the collocated playing social atmosphere; 5) In most cases, players' performances became better or worse at the same time instead of random results.

Keywords
Surprise Grabber, Tangible Interface, Hand Motion, Mobile Phone, Multi-user, Social Game

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

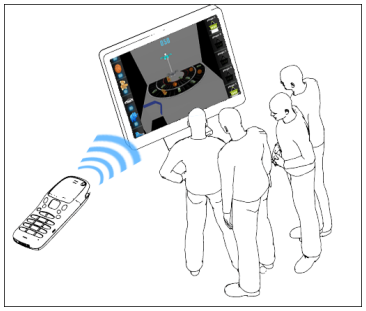

figure 1 Overview of *Surprise Grabber.* Several people compete or collaborate with each other to catch the virtual gifts in the game space by controlling the virtual grabber' position through moving their own mobile phones.

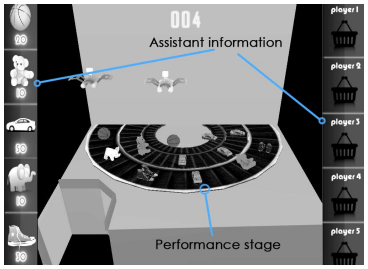

figure 2 *Surprise Grabber* Interface Design.
Center: Performance Stage with three circles full of various gifts.
Up Side: Virtual Grabbers
Left Side: Bar of Values of Gifts
Right Side: Bar of Online Players

General Terms

Design, Human Factors.

Introduction

Recent years there are more research focusing on public display interaction [2, 3]. The large public display provides a better chance for multiple users to collaborate and compete. Different from the asynchronous and online SNGs, the social atmosphere they form could give users rich feedback which deserves the attention to leverage for social game design. Direct manipulation facilities the interaction with large display. To utilize the intuitive of direct manipulation, we also employ phone hand gesture and map it to virtual grabber's motion. As for gesture interface for game, what makes our approach stand of the peers, e.g. Nintendo wii or Microsoft X-box games? First of all, surprise grabber, running on mobile phones, is self-contained and cheap. No other hardware is needed except your daily phone. Surprise Grabber can be easily deployed on public place and is more suitable for improvisational situation, like playing while shopping at mall with other pedestrians. In this regard, the game provides a new platform to make new friends.

Surprise Grabber (***figure 1***) follows the Client-Server (CS) architecture. A public display (e.g. LCD/Projected Screen) is connected to the Server PC which is in charge of game space rendering. The client is a Bluetooth and camera equipped mobile phone, which runs a small hand motion detection algorithm. In the following parts, we will first introduce the crucial elements in game design, and then hand motion detection and multi-user management. Finally we report the design and result of two pilot user studies.

Game Design

Surprise Grabber's user interface design is showed in ***figure 2.*** The observation viewpoint is about 45 degree looking down the horizontal. In the central part, there is a performance stage, which consists of three circle running orbits. There are various and random gifts moving on the orbits all the time. Player can easily use their phone joining the game. After joining, a new grabber will appear representing this player. He can control the grabber to move around grabbing the gifts in the stage by moving phone. Different gifts are assigned with different values. More value one gift has, more difficult to be grabbed. With respect to helping players learn different gifts' values, the left column bar is designed to show the values and rolls upward periodically. The right column consists of five baskets (our system currently supports five players at the same time), which shows current joining player's status and the gift they just grab. To be specific, once a player joins in, certain basket will change its color to identify that this player has joined in. If a gift is grabbed, it will be shown in his basket for few seconds.

Once the player joins in, his phone becomes a tangible metaphor of the grabber. He can move it to the left and right, push it forward and pull it back to control the virtual grabber's 3D position. Since all gifts are moving, Players must predict their positions and move the grabber before pressing a key on phone to drop the grabber down to grab the gifts.

How to Detect Whether Grabber Catch the Gift or Not?
The capture area of a grabber is represented by a circle whose center is the position of the grabber's projection on gifts plane. The radius of circle is relevant to the gifts. Smaller radius is assigned to more expensive gift.

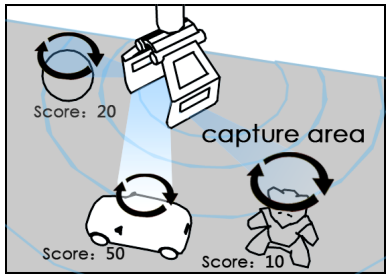

figure 3 There is a hint light illuminating from the grabber for player to evaluate grabber's

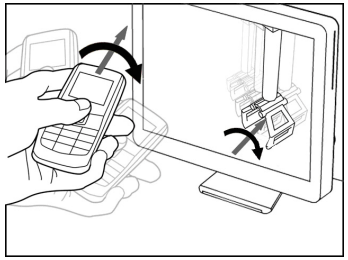

figure 4 The relation between player's real hand motion and the virtual grabber's movement.

As is shown in ***figure 3***, there is a light projecting directly down to the gift from the grabber. The light will illuminate an area on the gifts plane, from which players can infer their grabbers' current positions. However the lighting area is larger than the grabber's real capture area, so that the light does not provide exactly the accurate location information of its grabber, which pledges the entertainment of game.

Hand Motion Detection & Multiple-Users Management
All the hand motion detection is processed on mobile phone. We utilize the camera embedded on phone to detect hand's motions, which include translations and rotations. Computer Vision algorithms are used to calculate the corner points in the captured images and track them in the frames by implementing a sparse iterative version of Lucas-Kanade optical flow in pyramids. After that some mathematically algorithms are designed to deduce phone's translation and rotation (*refer to [1, 4] for algorithm details*). The server PC renders and updates the positions of each player's grabber on the screen in real time. The mapping relations between the phone and grabber are shown in ***figure 4***. Translating the phone to the left/right can move the grabber to the left/right side. Pushing the phone forward or pulling it backward can make the grabber either apart from or close to the player. *Additionally*, server PC assigns each user a unique COM port for data delivery via Bluetooth. Therefore our system could simultaneously process multiple users' data without confliction and updates all grabbers' positions in the game space without delay.

Pilot User Studies

Using hand gesture as tangible metaphor of virtual object is a special point of our game, therefore we want to evaluate how it benefits the games. The synchronous located multi-players atmosphere is another unique point, which will also be evaluated in our user studies.

Participants
11 subjects, six males and seven females, aged from 18 to 26, with various backgrounds in art, design and engineering, were hired from a local university. Quantitative studies and questionnaire were used.

Hand Gesture Tangible Interface Evaluation
In order to explore the usability of gesture interface in game design, we tried to answer following questions in our experiment: 1) Is hand gesture tangible interface a good metaphor for 3D game? 2) Is the gesture interaction easy to learn? 3) Is the hint light design helpful for players to get a better 3D space sense? 4) Since our gesture interface is not 100% accurate, is it suitable for such 3D game? Will the false recognition affect user's experience? Before the formal test, participants were asked to warm up by practicing the phone gesture interface. 9 of them tried approximately 1 minute while the other 2 took about 6 minutes. We did not tell the participants the hint light before the test but asked them to grab as many scores as possible. The formal test lasted for 1 minute for each user. Their final scores were recorded.

We analyzed the data (***figure 5***) and interviewed the participants after the test and got the following conclusions: 1) Hand gestural interface is quite easy to learn. Users (10 and 11), who spent only a few more minutes in the warm up phase, achieved much better performance than the others. 2) User 2, 10 and 11, who had better scores, stated that they all noticed the hint light and tried to catch the gifts by predicting the

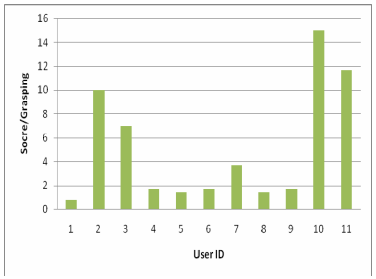

figure 5 Scores players achieved per grasping by using phone.

figure 6 two participants competed with each other.

possible positions of gifts through hint light. User 3 did not notice the light at first but after user 2 told her about light during the test she also achieved better score. 3) All of them told us that hand gesture interface made the game very immersive and they could get the relatively correct 3D space sense. 4) 9 of them also expressed that the occasionally inaccurate gesture operations made them more eager to control the game and instead of frustrated, they learned from the failed experience.

Social atmosphere's influence on user's performance
Social atmosphere here refers to the atmosphere formed when different users play together. How the social atmosphere influences players' performance in this co-located mobile tangible game is our goal of this study. Eight of the previous eleven subjects were recruited again in this test. They were divided into four groups randomly with each group two users. Each user played along for one round and competed with another one in the group for another round. The test lasted for one minute for each group. (***figure 6***)

From data (***figure 7)*** and discussions with players, we found that: 1) All participants' performances were influenced by the social atmosphere. 2) Most subjects (three out of four groups) performed better or worse at the same time than they played alone. 3) Player 3 to 6 all got better results from competition by trying more times than playing alone. 4) Player 7 and 8 reported that they all chose to grab the higher valued gifts, meanwhile they also disturbed the competitor by obstructing his grabber using their own one, which finally resulted in both worse performances.

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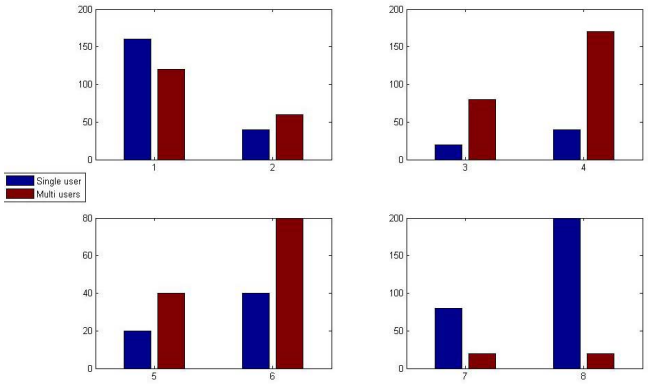

figure 7 The X-axis means user's ID and Y-axis means the score achieved. Blue (Red) means the single-user (competing) mode.

Conclusion

In this paper we present a co-located mobile game *Surprise Grabber*. Users could easily use mobile phones to join the game via Bluetooth. Through the pilot user studies, we find Surprise Grabber is attractive for its natural gestural interface and social engagement. We also conclude several valuable experiences for co-located mobile tangible social game design.

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