Airsteroids: Re-designing the Arcade Game Using MarkAirs

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Abstract
This paper presents Airsteroids, a multi-player re-design of the classic arcade game Asteroids. The re-design makes use of handheld devices such as tablets and Smartphones and of MarkAirs, an around-device interaction (ADI) with fiducial markers that reduces occlusion on the screens and interference between users' interactions.

Author Keywords
Around-Device Interactions (ADI); fiducial markers; tablets.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – Input Devices and Strategies, Interaction Styles.

Introduction
Handheld devices are becoming very widespread and offer several advantages with respect to tabletops in terms of cost, scalability, and mobility to build collaboration spaces [8]. Despite these advantages, in these devices interaction is usually carried out via touch contacts, which, in multi-user co-located scenarios, can be the source of multiple problems. These include interference if several users try to simultaneously touch the same display, no identification of the source of a

given action, and occlusion of digital content by the participants' hands and arms, among others.

To overcome these problems, Around-Device Interactions (ADIs) could be used in these environments to enable interactions in the available 3D space above the surfaces. However, when ADIs have been implemented in the past they have either required pre-installed specialized hardware that limited the choice of where these interactions could take place, or have not been accurate enough to perform high precision manipulations of objects on the devices.

In this work, we present a re-implementation of the classic arcade game Asteroids called Airsteroids, which enables a multi-user co-located game experience. Each user brings his/her own tablet to the environment and can interact with all devices by means of ADIs using MarkAirs. MarkAirs is an interaction technique that makes use of fiducial markers tracked by the built-in front camera of these handheld devices. The user can perform several aerial gestures with the markers, which entail different behaviors to the game elements.

Related Work

Previous works have explored ADIs with tabletops. These exploit the space above the surface either to explore 3D virtual spaces (e.g., [9]) or to reach and manipulate distant elements (e.g., [1]). These high-precision tasks, however, often rely on complex hardware settings composed of several external cameras, projectors, or gloves with reflective markers like the ones used in motion capture (e.g., [7]).

Other approaches rely on embedded cameras that are installed within tabletops to recognize aerial interactions. Hilliges et al. [3], for example, use an "enhanced" tabletop and make use of hands to perform gestures in the air to manipulate 3D digital objects rendered on a tabletop. However, one of the drawbacks of their approach is that, even though hands enable natural interactions, it is not possible to identify the user who makes a given aerial interaction. To solve this problem, Gallardo and Jordà [2] propose the use of fiducial markers for such interactions. However, their approach requires expensive specially designed hardware to control the degree of transparency of the surface, so that image projection and gesture detection are interleaved. Moreover, their markers cannot be occluded for the system to work properly.

Several works have explored ADIs for handheld devices using external cameras or depth sensors with the purpose of performing 3D rotations using hand gestures around the handheld (e.g., [6]), or reducing the occlusion produced by touch contacts on the screen (e.g., [4]). These approaches allow manipulations to be performed with a certain precision but, again, require careful installation of external hardware. Others reduce the hardware complexity by making use of the built-in sensors in the tablets. Ketabdar et al. [5], for instance, exploit the magnetic (compass) sensor of the device and enable in-air interactions using magnets. Unlike optical approaches, this solution is more robust to occlusion, but it is less precise and the system is not capable of differentiating between different magnets since they do not have an encoded ID.

Interaction with MarkAirs

MarkAirs is an interaction technique performed above a tablet or smartphone conducted by handling a fiducial marker which, when in the field of view of the tablet's built-in front camera, allows a computer vision software to detect the marker and track its 6-DOF pose (position and orientation) in real-time. Markers may be attached

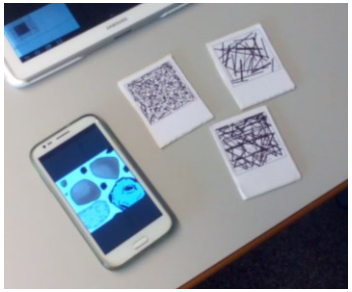

Figure 1. Markers used to perform interactions in the Airsteroids game.

to physical cards or displayed on other digital devices allowing for multi-display ecosystems (see Figure 1). Unlike other works [2], our markers consist of arbitrary drawings which are tracked by Vuforia™'s natural feature tracking algorithms. We adopted these particular markers for several reasons: First, because they can be tracked even if they are partially occluded. Second, because this system allows for a virtually infinite number of markers, since creating a new one can be achieved simply by drawing some arbitrary lines. Finally, because a marker can also be a meaningful photograph, which can be related to the digital information content that is associated with the card (e.g., if we want a card to contain a game element, the marker can be a picture of the element itself).

Airsteroids

Airsteroids consists of a re-design of the classic arcade game, where a ship must destroy some asteroids coming at it before they crash. In our version, several players arrange some tablets on a surface (see Figure 2) and they use different markers with the MarkAirs infrastructure to handle the different game elements. There is no need to touch the screen nor pop up any contextual menus that could occlude the interface. In the proposed demo game there are three types of markers:

- *Ship controllers*: Each one of these markers represent a ship of a specific color for a given player. The marker's XY position and yaw rotation are mapped to the ship allowing it to move around the digital world and cross between surfaces. When the marker is brought down (closer to the tablet), it causes the ship to shoot.
- *Asteroids factory*: These markers allow the user to place some asteroids on any tablet by means of an up/down gesture. Once an asteroid is placed, it starts moving with a given speed and a random trajectory.
- *Property modifiers*: Modifier markers control specific properties of some game elements. For example, to modify the speed at which the asteroids move (bringing the marker up speeds up the asteroids, whereas bringing it closer to the device slows them down); others can make a spaceship undestructible during a given time span; etc.

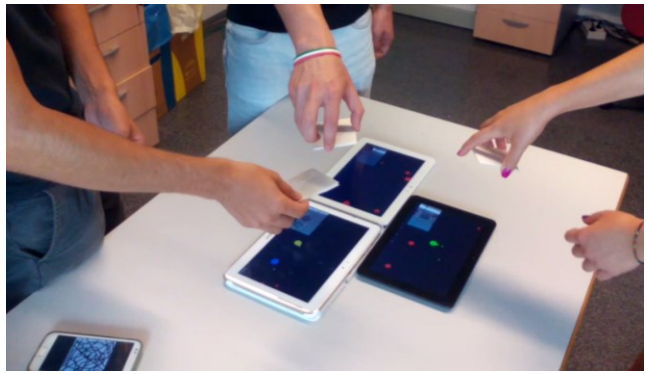

Figure 2. Several users playing Airsteroids

Conclusion

In this paper we presented Airsteroids, a re-implementation of the Asteroids game using MarkAirs, an ADI technique using fiducial markers. Airsteroids is an example of a multi-player multi-device game that can enable social/collaborative behaviors. We illustrate the ways in which using aerial interactions can reduce occlusion and interference among several users' actions, which is a problem that can occur in similar scenarios where only touch interactions are available.

As future work, we intend to conduct an experiment with real players during the ITS'15 demos session in order to obtain information about the social interactions and collaborative behaviors that emerge during the course of the game. In this evaluation up to 6 co-located tablets will be used and the game will be available for download to enable ITS attendees to participate in a massive multi-player Airsteroids experience.

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References

1. Amartya Banerjee, Jesse Burstyn, Audrey Girouard, and Roel Vertegaal. 2011. Pointable: An in-air pointing technique to manipulate out-of-reach targets on tabletops. *Proc. of ITS'11*, 11–20. http://doi.org/10.1145/2076354.2076357
2. Daniel Gallardo and Sergi Jordà. 2013. SLFiducials: 6DoF markers for tabletop interaction. *Proc. of ITS'13*, 401–404. http://doi.org/10.1145/2512349.2514914
3. Otmar Hilliges, Shahram Izadi, Andrew D. Wilson, Steve Hodges, Armando Garcia-Mendoza, and Andreas Butz. 2009. Interactions in the air: adding further depth to interactive tabletops. *Proc. of UIST'09*, 139–148. http://doi.org/10.1145/1622176.1622203
4. Brett Jones, Rajinder Sodhi, David Forsyth, Brian Bailey, and Giuliano Maciocci. 2012. Around device interaction for multiscale navigation. *Proc. of MobileHCI'12*, 83–92. http://doi.org/10.1145/2371574.2371589
5. Hamed Ketabdar, Kamer Ali Yüksel, and Mehran Roshandel. 2010. MagiTact: Interaction with mobile devices based on compass (magnetic) sensor. *Proc. of IUI'10*, 413–414. http://doi.org/10.1145/1719970.1720048
6. Sven Kratz, Michael Rohs, Dennis Guse, Jörg Müller, Gilles Bailly, and Michael Nischt. 2012. PalmSpace: Continuous around-device gestures vs. multitouch for 3D rotation tasks on mobile devices. *Proc. of AVI'12*, 181–188. http://doi.org/10.1145/2254556.2254590
7. Nicolai Marquardt, Ricardo Jota, Saul Greenberg, and Joaquim A. Jorge. 2011. The continuous interaction space: Interaction techniques unifying touch and gesture on and above a digital surface. *Proc. of INTERACT'11*, 461–476. http://doi.org/10.1007/978-3-642-23765-2_32
8. Roman Rädle, Hans-Christian Jetter, Nicolai Marquardt, Harald Reiterer, and Yvonne Rogers. 2014. HuddleLamp: Spatially-aware mobile displays for ad-hoc around-the-table collaboration. *Proc. of ITS'14*, 45–54. http://doi.org/10.1145/2669485.2669500
9. Martin Spindler, Sophie Stellmach, and Raimund Dachselt. 2009. PaperLens: Advanced magic lens interaction above the tabletop. *Proc. of ITS'09*, 69–76. http://doi.org/10.1145/1731903.1731920