# Real-World Drag'n'Drop – Bidirectional Camera-based Media Transfer between Smartphones and Large Displays

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**Abstract.** Investigating intuitive and seamless approaches for sharing files between smartphones and large displays is an increasingly relevant research challenge. In this paper we introduce a novel promising interaction technique called 'Real-World Drag'n'Drop': Using a smartphone as a see-through device, locally or remotely stored files may be directly dragged onto a distant screen targeted through the viewfinder and vice versa. Following the well-known basic metaphor, our technique allows for the precise selection, transfer and placement of files across devices. The presented fully functional prototype demonstrates the feasibility and benefits of this new approach.

**Keywords:** Smartphone, media sharing, drag'n'drop, large screen, interaction, augmented reality

## 1 Introduction

Over the last years, large flat screens have become ubiquitous in both private and public environments. While private screens used for home entertainment come with dedicated remote controls, smartphones as our everyday companions have been identified as feature-rich input devices especially for public screens while enabling a variety of innovative screen interaction techniques (cf. Ballagas et al. [2]). Besides the traditional use case of remotely controlling a screen (e.g., enabling interactive presentations on a public screen in a shopping window), the simple, intuitive, and seamless sharing of media between the mobile device and the remote screen is a promising application and a challenging research topic.

In this paper, we introduce a novel technique called 'Real-World Drag'n'Drop' for bidirectionally transferring content between a smartphone and a large screen. We combine the well-known original drag'n'drop action with the so-called 'Smart Lens' metaphor to enable the visual shifting of items across devices. In analogy to its desktop counterpart, 'Real-World Drag'n'Drop' offers the advantages of precise selection and arrangement of items of interest.

## 2 Handheld-based Screen Interaction

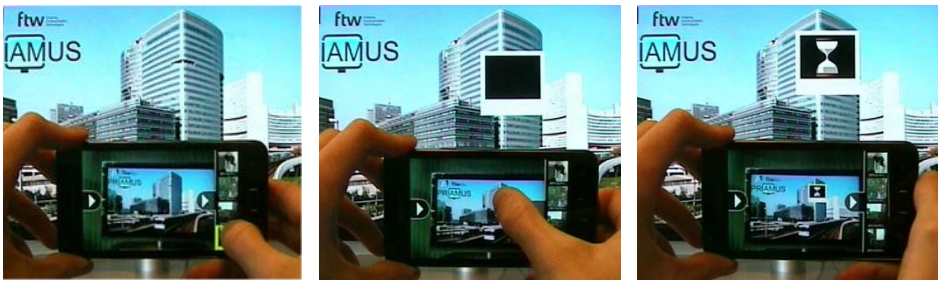
'Real-World Drag'n'Drop' is based on recent advances in camera-based mobile interaction with large screens using real-time visual feature detection. Boring et al. [4] were amongst the first researchers investigating the interaction with mobile live video. Their 'Touch Projector' enables the dragging of photos between multiple remote displays over the camera view of a smartphone. Baldauf et al. [1] presented a related research prototype which forwards touch events on a smartphone display to a targeted remote screen utilizing natural image features. Herbert et al. [5] presented another system for visual screen interaction based on natural image features. However, their prototypical non-mobile setup did not include a smartphone but was based on a webcam. A sharing concept related to 'Real-World Drag'n'Drop' was first introduced by Kruppa and Krüger [6]. They suggest to 'physically plug a handheld PC in front of a large display' while 'the large display device would simply export the part of its display, that is now hidden by the handheld, to the handheld' to achieve a see-through effect. The content transfer is initiated when an object is dragged in the display part visible on the handheld. A camera-based smartphone approach for fetching content from a screen is 'Shoot & copy' [3]. Photographing an icon of interest on the screen, the icon is identified and the corresponding content is downloaded to the device.

In contrast to these previous approaches, our concept of 'Real-World Drag'n'Drop' is based on a well-known operation and enables bidirectional content transfer using one basic metaphor. Further, it features the precise selection and arrangement of items of interest and represents a practical solution not requiring any further hardware.

## 3 Real-World Drag'n'Drop

We implemented a fully functional prototype to illustrate this novel media sharing concept. The interface of our mobile application (cf. Figure 1 and 2) consists of a full-screen camera viewfinder and two overlaid file galleries (one containing photos, one for office documents) for demonstration purposes. These translucent file galleries can be slid in and out and vertically scrolled to browse through the files. This interface enables drag'n'drop operations between two different reference systems: the traditional 2D mobile display and the remote screen in 'real-world' 3D space via the viewfinder.

To transfer an item from the mobile to the screen, the user targets the desired screen through the viewfinder and selects an item from one of the galleries by touching it (Figure 1a). As soon as the item is dragged from the local gallery onto the live view, the remote screen is notified about this newly initiated transfer. When the item is dragged on the live view and moved over a 'real-world' drop area on the screen, a placeholder for the item to be transferred is shown on the screen (Figure 1b). This placeholder moves accordingly to the drag gesture on the mobile touch display to highlight the remote drop destination. When the user drops the item onto the screen (i.e., raises the finger over the screen shown on the live view), the actual file transfer is started and visualized by an hourglass image on the screen (Figure 1c). As soon as



**a)** Selecting a file from the gallery.

**b)** Precisely dragging the file onto the screen

**c)** Dropping starts the actual content transfer.

**Fig. 1.** Transferring media from the mobile to the screen.

**a)** Long pressing an item on the screen

**b)** Dragging the appearing overlay icon.

**c)** Dropping the icon at the local file gallery.

**Fig. 2.** Transferring media from the screen to the mobile.

the file transmission is completed the file is visualized on the screen - in case of an image using a respective thumbnail, else using a suitable preview image.

As mentioned above, one of the major benefits of this concept is its bidirectional applicability: our technique also allows dragging an item shown on the screen to a specific dropping location on the mobile device. To distinguish from dragging items on the remote screen, we utilize long presses to start a 'Real-World Drag'n'Drop' operation: When a screen item is touched via the viewfinder for 500 milliseconds (Figure 2a), a respective overlay icon on the mobile indicates the availability of transferrable content (Figure 2b). This icon can then be dragged onto one of the galleries and precisely dropped there at a specific location (Figure 2c). After the dropping the actual transfer is started and visualized by an hourglass at the handheld side. Dependent on the configuration of the screen application, items are either copied or moved to the mobile device, i.e., their preview images stay or disappear at the screen.

## 4 Implementation

Our latest prototype framework consists of a mobile application for Android smartphones and a C# application for the computer hosting the screen. To enable the

transformation of local touch coordinates to screen coordinates, the screen application periodically sends screenshots to the mobile device via WiFi. At the mobile side, we apply a combination of SURF feature detection and Optical Flow feature tracking (Lucas-Kanade method) using OpenCV for Android to calculate the transformation matrix from the camera frame and the received screen image. For sending information about dragging operations and files to be transferred we use TCP sockets.

## 5 Conclusion and Future Work

In this paper, we presented 'Real-World Drag'n'Drop, a novel interaction technique for sharing files between a smartphone and a large screen. Extending the well-known drag'n'drop operation, this technique enables the intuitive bidirectional content transfer between devices as well as the precise arrangement of items.

Based on our current framework we plan to investigate additional use case prototypes along with careful user evaluations in future. Further, we will investigate the requirements for fully markerless interaction with multiple adjacent screens for city-scale deployment.

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## References

1. Matthias Baldauf, Peter Fröhlich, and Peter Reichl. Touching the untouchables. In *Adj. Proc. Pervasive'10*, 2010.
2. Rafael Ballagas, Jan Borchers, Michael Rohs, and Jennifer G. Sheridan. The smart phone: A ubiquitous input device. *IEEE Pervasive Computing*, 5, 1, pages 70–77, 2006.
3. Sebastian Boring, Manuela Altendorfer, Gregor Broll, Otmar Hilliges, and Andreas Butz. Shoot & copy: phonecam-based information transfer from public displays onto mobile phones. In *Proc. Mobility'07*, pages 24–31, 2007.
4. Sebastian Boring, Dominikus Baur, Andreas Butz, Sean Gustafson, and Patrick Baudisch. Touch projector: mobile interaction through video. In *Proc. CHI'10*, pages 2287–2296, 2010.
5. Leigh Herbert, Nick Pears, Dan Jackson, and Patrick Olivier. Mobile device and intelligent display interaction via scale-invariant image feature matching. In *Proc. PECCS'11*, pages 207–214, 2011.
6. Michael Kruppa, and Antonio Krüger. Concepts for a combined use of personal digital assistants and large remote displays. In *Proc. SimVis'03*, pages 349–361, 2003.