# Virtual Spatially Aware Shared Displays

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**Abstract.** Nowadays, sharing resources over multiple devices is a common task. Some approaches consist in sharing a common workspace among users, or moving user interface elements between displays. But distributing interaction between displays is critical in cross-device environments. In this work, we present a technique for distributing content and devices in shared workspaces using cross-device displays. This technique, referred to as the virtual spatially aware technique, allows the creation of virtual shared displays and the coordination of cross-device interactions. By using this technique, we propose a method for arranging content and devices on virtual displays. We also present a prototype that supports the virtual spatially aware technique. This prototype has been built using web technologies, and it is able to run in any modern web browser.

**Keywords:** Distributed interaction · Virtual spatially aware · Shared workspaces · Content representation

## 1 Introduction

There are many approaches for the distribution of interaction among multiple devices. Albertos et al. presented synchronous interaction over shared resources in Drag&Share [1]. They provided a shared workspace which is the same for all users. Other approaches are aimed at moving user interface elements between displays according to a device's characterization [4]. But these approaches do not take into account the arrangement of cross-device displays within a shared display.

Radle et al. [3] initiated the debate about the use of spatially-aware (use of real-world spatial configurations as the referential domain) or spatially-agnostic cross-device interaction techniques. Their results showed that spatially-aware techniques are preferred by users. There is also no consensus on how to make the mapping between input and output in applications using multi-display and/or cross-device interactions.

In this work we present a technique for the design of virtual spatially-aware cross-device interaction. Using a planar technique, which is easy to match to the space [2], we propose the use of virtual spatially aware shared displays for supporting the creation of shared interaction spaces using cross-device displays.


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This new technique is based on the arrangement of devices and resources using a virtual display and distributing interaction over multiple devices. It is intended to be used to share resource interaction on multiple displays or to facilitate the set-up of multi-display screens.

## 2 Arranging Content on Virtual Spatially Aware Shared Displays

The use of virtual spatially aware shared displays allows the management of devices and resources in a common interaction area. This is achieved through the use of virtual elements that represent devices and resources that are virtually arranged on the virtual display. This arrangement might depend on physical or logical conditions.

Figure 1 shows a virtual display on which multiple resources are shared among multiple devices, which are represented by a semi-transparent gray square with a number representing their ID. The device will display the resources according to the representation of the virtual display. For example, the device with ID 122 will show the picture of a graph. These representations can be moved freely within the virtual display to show other resources or to make compositions with other displays. For example, real displays which are represented by IDs 102, 107, 112 and 117 are arranged as one big display. Therefore, they will show the area of the virtual display as a real and larger display, with the corresponding resources on it.

A support tool has been developed to support the virtual spatially aware shared displays. This tool allows the management of virtual displays, devices and content. In the following figures the virtual display is shown within a green square, device displays are in a pink square, and resources are shown within a blue square. Mapping between virtual and real elements is represented using arrows.

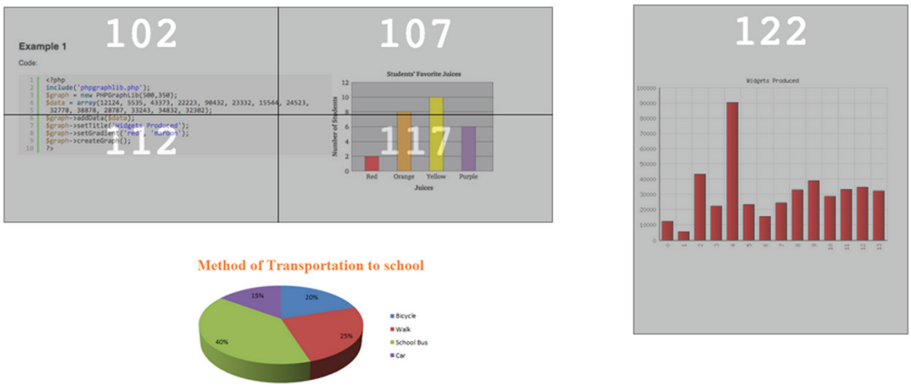


**Fig. 1.** Virtual display sharing resources among multiple devices

Figure 2 shows a scenario with a computer managing the virtual display and other devices (laptop, desktop pc and mobile phone) connected to the virtual display. It is worth pointing out that on the computer that manages the virtual display there are two browsers representing devices connected to the virtual display. There are no limitations on the location of virtual or device displays. Both systems work over web technologies and only require a modern browser to be run. Devices are connected through a browser to the virtual display.

Figure 3 shows how resources are managed using a virtual display. The set-up consists of two displays connected to two computers and another computer that hosts the virtual display. The resource in the virtual display is an image, but it can be any web resource. The devices on the virtual display are arranged so that the image is between them. As a result, the image generated by the two displays corresponds to the arrangement on the virtual display. The image is within a blue square, both on the real multi-display and in the virtual set-up. In addition, any interaction with the image on the virtual display or on the connected devices will be reflected across the entire environment (e.g. the movement of the image on any device).

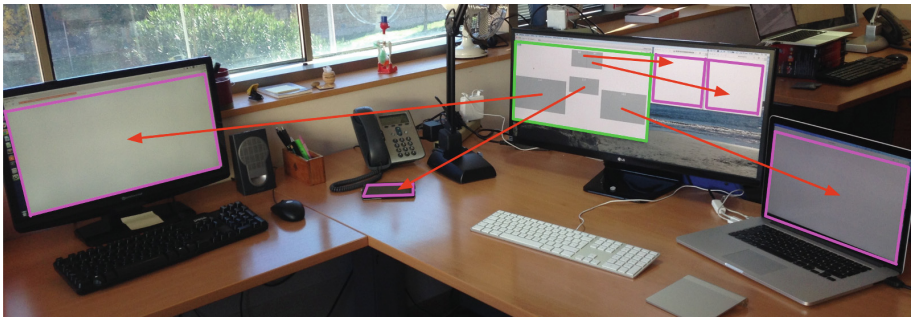

**Fig. 2.** Mapping between devices and the virtual display

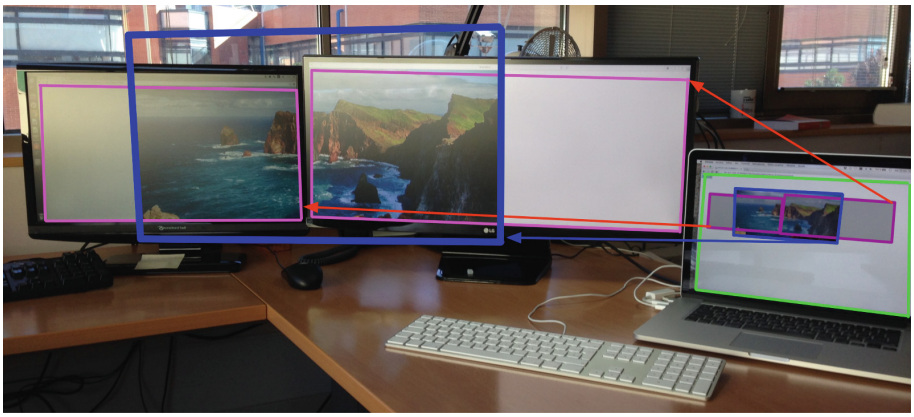

**Fig. 3.** Two displays arranged on the virtual display showing a resource

## 3 Conclusions and Future Work

In this work we have presented a tool for supporting the virtual spatially aware shared displays interaction technique. This technique allows the arrangement of content and devices on a virtual display. It supports cross-device interactions. As future work, we will continue with the development of the support tool. This development will allow us to perform an analysis of more sophisticated interaction techniques within the system and also, among others, the study of the impact of positioning devices on the virtual display according to their real position in the physical world.

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