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ORIGINAL ARTICLE

Augmented Reality in astrophysics

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Abstract Augmented Reality consists of merging live images with virtual layers of information. The rapid growth in the popularity of smartphones and tablets over recent years has provided a large base of potential users of Augmented Reality technology, and virtual layers of information can now be attached to a wide variety of physical objects. In this article, we explore the potential of Augmented Reality for astrophysical research with two distinct experiments: (1) *Augmented Posters* and (2) *Augmented Articles*. We demonstrate that the emerging technology of Augmented Reality can already be used and implemented without expert knowledge using currently available apps. Our experiments highlight the potential of Augmented Reality to improve the communication of scientific results in the field of astrophysics. We also present feedback gathered from the Australian astrophysics community that reveals evidence of some interest in this technology by astronomers who experimented with Augmented Posters. In addition, we discuss possible future trends for Augmented Reality applications in astrophysics, and explore the current limitations associated with the technology. This Augmented Article, the first of its kind, is designed to allow the reader to directly experiment with this technology.

Keywords Data Analysis and Techniques · Tutorial

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1 Introduction

The market for camera-equipped smartphones and tablets has been rapidly expanding over the past few years. Although not marketed as a primary use-case, these widespread devices have all of the hardware required to enable Augmented Reality (AR) applications (Papagiannakis et al. 2008). We define AR as the combination of live images with virtual layers of additional content. Our definition follows Azuma (1997), with the exception that we do not restrict the additional content to 3D models, but also include other types of content, such as images, sounds, and videos. The principle of AR, in which virtual content is added on top of a real environment, is not to be confused with Virtual Reality, where the environment is mostly or totally virtual (Milgram and Kishino 1994; Azuma et al. 2001). There exist two distinct types of AR, which differ in the way that the virtual layer associated with a given environment is identified: location-based AR and image-based AR (Cheng and Tsai 2012). In the case of location-based AR, applications rely on the spatial position and orientation of the device to select and display location-relevant information. For image-based AR, applications use image recognition algorithms to trigger the display of relevant content over a recognised physical pattern. In this article, we focus on image-based AR applications. NASA's *Spacecraft 3D* is one example of such an application, where users can overlay 3D models of various spacecraft on top of a specific target image.[1] AR is not restricted to smartphones and tablets, but is also compatible with a wider range of hardware, such as head-mounted and head-up

[1]The Spacecraft 3D app is free to download. See NASA's website for more information. http://www.nasa.gov/mission_pages/msl/news/app20120711.html.