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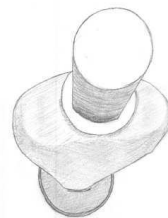
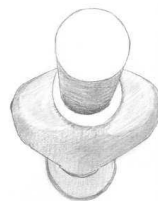
# Digitally assisted stereo drawing

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**Figure 1:** Anaglyph preview of a bottle and the resulting left and right hand made drawings.

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**Abstract**

With the increasing range of available stereoscopic rendering devices, stereoscopic images and videos are reaching the general public. Creating such pairs of images digitally from 3D content is easy to tweak and adjust. On the other hand, drawing directly stereoscopic scenes on a sheet of paper is very hard to perform. In this paper, we focus on such an interactive task where interactive 3D graphics and novel user interfaces are combined together to create stereoscopic drawings from a standard pen and paper interface. Our system is based on augmented reality, multitouch, and 3D spatial interaction, to enhance interaction with the 3D scene. The projection of the left and right views on the paper guides the users in their stereoscopic drawing task, while maintaining a high level of expressiveness. This work is a first step towards promising full applications for interactive drawing of 3D stereoscopic images.

**Author Keywords**

Stereoscopy, drawing, tangible interaction, multitouch, augmented reality, pen and paper

**ACM Classification Keywords**

H.5.1 [Information interfaces and presentation]:  
Multimedia Information Systems Artificial, augmented,  
and virtual realities

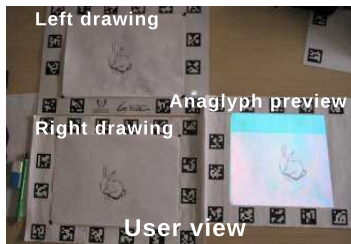
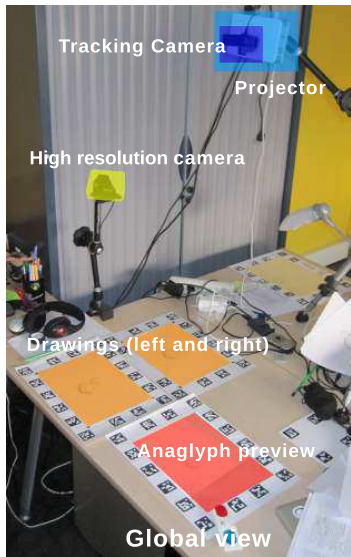


Figure 2: Setup overview.

; J.5 [Computer Applications]: Arts and humanities Fine arts

## Introduction

Stereoscopic visualization that has existed since the 16th century is currently reaching a general public appropriation thanks to recent advances of dedicated technologies. In particular, shutter glasses, polarized light, or lenticular lenses are currently widely exploited for producing stereoscopic displays dedicated to film industry, personal TVs or workstations. With such medias, users benefit from rich visualizations of 3D content that have been prepared for them, but they are generally excluded from the stereoscopic creation process. Our motivation in this work is to provide tools allowing one to create 3D pairs of images. Contrary to approaches where the full creation process is done digitally (e.g. [2]), we explore an approach where user draws directly on a sheet of paper, as they would do for standard drawings (see Figure 1). This maintains a direct link with the physical material, keeping a good expressiveness for the user. In this paper, after describing some existing tools, we describe our approach for creating stereo drawings. Then, we present some techniques used to correct the left/right disparities. Finally we discuss perspectives for enriching our tool.

## Existing techniques

According to Phillipe Coudray [3], the easiest way to create 3D drawings is to make the 3D effect as billboards. Using this technique, each part of the drawing will be on a different plane. The plane will be deeper inside the drawing when increasing the left/right disparity, and closer by decreasing it. When these techniques are mastered, the artist can create some objects going through multiple planes. Consequently the different parts will bump instead of being flat. Still, the drawings needs to be viewed using

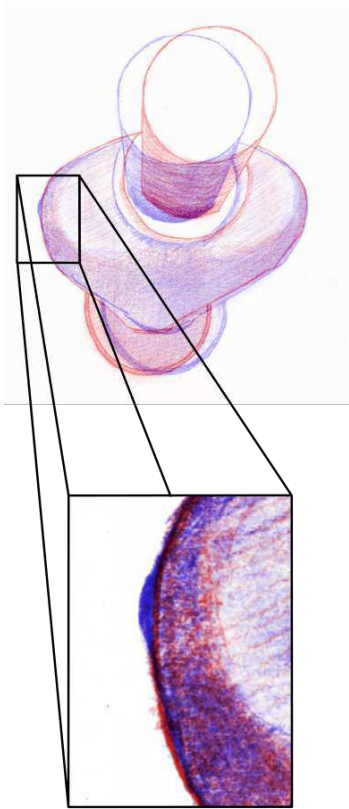
free-view methods. These methods requires the drawing to be side by side and some training for the user. Furthermore, they can be visually uncomfortable.

A stereo drawing prototype has been built by Vladimir Tamari[1]. This stereo drawing device constraints two pencils with a fixed length. It allows precise creation of two drawings at the same time. A stereoscope is included to visualize the drawing without moving the creations. Although it favors precision, the comfort of drawing can be altered by such a machine. Furthermore, the size of the drawing is constrained to the size of the device, and the form-factor of the pen can also be limited. Consequently, the range of drawings is limited in size and style.

Conversely, we use a projection and vision system where the scaling factor can be easily tweaked to the desired creation. This system guides the artist, without limiting him or her to a given drawing support and tool.

## Proposed system.

Our system is based on PapARt [7], which allows interactive manipulation of 3D scenes directly on a paper sheet. The paper sheet is surrounded with markers that are filmed by a dedicated camera. The registration is done using ARToolkitPlus. A projector is calibrated with the camera, using Audet *et al.* [4] method. This allows the correct projection of digital content directly onto the paper sheets. Hence, the artist can directly interact with the 3D content by moving the paper, in a tangible fashion. In addition, a depth camera is used to detect finger input on the paper, as well as 3D spatial input above the surface. This way, the artist benefits from multitouch gestures as well as 3D gestures to interact with the content. These input modalities can be used to rotate, translate, and scale 3D objects, to modify the



**Figure 3:** Details on an undesired left/right disparity. The left image, in blue, is shifted on the right, in order to match at a good depth.

point of view, or to modify the light source (see [7]). With PapARt, the artist first manipulates the 3D scene to obtain the desired rendering, then, he or she uses it as a tracing paper, *i.e.* using the projection like an art projector.

We extended the PapARt approach to enable 3D stereoscopic drawing. The 3D scene edition and visualization is now performed using a stereoscopic rendering, in our case using an anaglyph rendering. This is illustrated in Figure 1. Using this, the artist has a preview of the two drawings to create, one for the left eye and one for the right eye. Then, the left image is projected on a paper sheet, and the right image on another one.

#### *Realtime reprojection and adjustment*

The difference between the left and right image have to be consistent for depth perception [6]. Furthermore, the drawings should be as similar as possible for the sharpest parts. Consequently, we created a tool to reproject the left rendering on the right drawing area, and vice versa. By shifting the projection on the left or on the right, the artist can examine different parts of the piece of art and correct parts of the drawings if necessary.

Consequently, the artist can draw the same line for both the right and left views, and compensate the copying errors, as illustrated in Figure 3. To achieve this, we use a high resolution camera in order to get a clear view of the drawing. Figure 4 contains two anaglyph captures taken during the refining process, at the beginning and the end of it.

#### *Realtime stereoscopic visualization*

The two drawings can be captured by the high resolution camera. They can be combined to create a stereoscopic view, in our case, an anaglyph view. Alternatively, using a

dedicated screen or a stereo projector, the artist could see the stereo drawing with true colors. This realtime visualization capabilities enables the artist to spot the differences between the drawings. He or she can correct them directly, or by using the technique described above.

In summary, we use projected images as the basis for the creation of drawings. Then in order to improve these drawings, our system offers the user to visualize the resulting stereo drawing as well as tools to ease the correction. In the next section, we propose some more advanced tools to ease the creation of stereoscopic drawings.

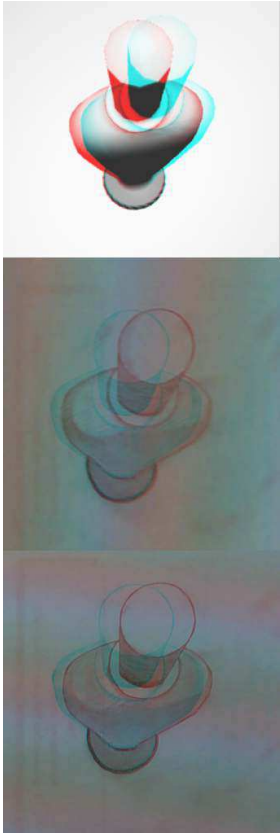
## **Perspectives**

### *Automatic detection of disparities*

In the current prototype, the drawings are based on two projections, one for each eye, of a 3D object. As each image has depth information, it can be used to track the depth disparities. The disparity error can be displayed onto each drawing, for example using color codes. The main advantage of this automated detection is that it can be used to correct the drawings, thus decreasing the visualization sickness such as headache or nausea that came from a bad stereoscopic scene.

### *Shape perception with stereoscopic drawings*

We conducted some preliminary tests with different amateur artists, and different skill levels. Novice artists used the projected shading without adding shape information. The curvature of the object is badly represented. Conversely, a user who had taken drawing courses did the shading following the object's curvature. From one drawing to another, the stereoscopic experience is very different. The monoscopic shape perception created by stylized shading seems to have an important



**Figure 4:** Anaglyph view during corrections, images taken from the high resolution camera. Top: anaglyph projection. Middle: before corrections. Bottom: at the end of the edition.

influence for the depth perception of the stereoscopic scene. Shape representation tend to lead to a better depth perception, which is not really surprising. Thus some studies could be conducted on shape and depth perception with stereoscopic drawings. It would provide guidelines for the artist, on how to create stereoscopic depth with other means than left/right disparities.

#### *Creation from an existing 2D drawing*

The creation of a stereoscopic drawing may rely on an existing drawing instead of a 3D object. In order to take full advantage of our tools, the user could use automatic [5] or semi-automatic depth retrieval method. He or she could set the depth of different part of the images, and a depth map would be generated. As a consequence, from a left image, a right image can be generated automatically. As the generated image will contain some occlusions errors and deformations, the tool can indicate the regions where the projected image may be incorrect.

### **Conclusion**

In this article, we introduced a new tool to assist the creation of stereoscopic drawings. The user can manipulate a 3D object, and display a stereoscopic view of it. He or she can then draw it on the paper. We proposed some tools to enable an easy correction of left/right disparities, by overlapping images or providing an anaglyph preview. Furthermore, by using the depth information from the generated images or by creating a depth map, one could automatically assist the artist by indicating left/right disparities.

Finally, stereoscopic drawings can provide an impressive bump effect as well as billboards effects. Further studies on the effects of shading, and the perception of shading

pattern differences could enable the creation of higher quality stereoscopic pieces of art.

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