HoloARt: Painting with Holograms in Mixed Reality

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Abstract
We propose *HoloARt*, a new media art that explores the use of holograms in mixed reality for creative self expression. We designed a system that allows the user to turn their physical environment into a canvas where digital holograms and physical objects co-exist in the real and virtual world. Users are able to virtually spray and splatter *hologram paint* on top of physical objects and surfaces as well as painting in the air by only using their hands. The content grows dynamically, following the natural movements of the user. The system is self-contained and does not require hand controllers nor positional tracking sensors on the space.

Author Keywords
Interactive Media Art; Mixed Reality; Art Exhibition; Digital Art; New Media; Holograms; Performance Art; Design

ACM Classification Keywords
H.5.m [Information interfaces and presentation]: Miscellaneous

Introduction and Rationale
The manifestation of human creativity has evolved from traditional media such as paintings or sculptures to more recently developed computer generated approaches. New modes of expression are now considered arts such as 3D

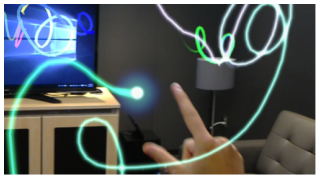

Figure 1: *Air Painting* with "Light" brush.

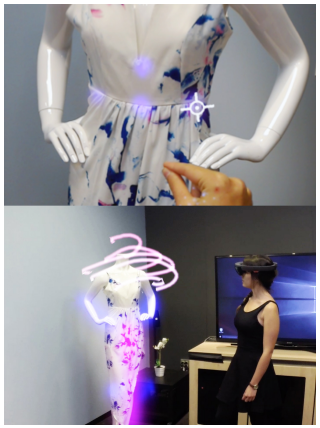

Figure 2: *Air Paint* and *Graffiti* for fashion design.

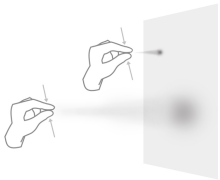

Figure 3: Pinch gestures to spray paint on a wall. Top hand: less distance, higher opacity and smaller size. Bottom: less distance, lower opacity and bigger size.

animation, computer art, video, etc. Technology has broadened the scope of New Media Art[1] and has opened the door to new forms of artistic expression and HCI.

Immersion is commonly used among artists to reach to that special state that we call "flow". A feeling outside of time that artists use to dive in the creative process. This makes Mixed Reality an especially interesting medium for art generation because it brings a level of escapism unlike any other. In the world of art the medium is defined as the material or tool that the art work is made of; such as clay in the case of ceramics. In *HoloARt* we can see the medium as a digital hologram. The content grows with the movements of the user's hand and co-exists with the physical environment. *HoloARt* is the first Mixed Reality system that allows the user to draw, spray and splatter digital paint anywhere in the "real" physical space. We create a spatial mapping of the physical space so the user can move around and use any object, surface or the air as a canvas.

Related Work

The first artists who explored the idea of painting in the air or Light Painting [2] were Man Ray in his series *Space Writing*, Gjon Mili and Pablo Picasso, who in 1949 published his series of photos *Light drawings*. Mann et al. [9] created the first "computational light painting" using wearable computational photography with an actual or simulated long-exposure light painting. Most of the efforts in HCI have been in creating real-time annotations and drawings for remote collaboration systems [5, 3, 4, 7]. *Second Surface* [6] is a collaborative Augmented Reality system that allows the user to draw and overlay content on top of the physical environment using a smart-phone or a tablet. Austin S. Lee et al. [2] created real time annotation from a tablet device onto the HoloLens [8] user's world. In this setup the scene is locked and the image is associated with the data of the space. *Tilt Brush* [1] uses Virtual Reality and external sensors to create a space in which the user is able to draw in the air. The limitation of this system is that it does not create a spatial mapping of the environment, but rather knows the position of the HMD and hand controllers relative to the coordinates of the sensors. Therefore, it needs a previous set up and requires hand controllers to know the position of the user's hand. *Tilt Brush* is designed to be an immersive system and does not allow the user to see nor interact with the physical environment. The digital content generated does not co-exist in the physical space.

The main difference between *HoloARt* and previous work is that we focus on creating a new media art that uses mixed reality and holograms for purely artistic purposes. Users are able to draw, paint, spray and splatter *hologram paint* only using their hands, without the need of a controller or a device mediating the experience. The main contributions and differences from previous work are: (1) Use of real-time spatial mapping to create art that co-exists in the physical space and matches the 3D shape/mesh of the object or surface (see Figure 2). (2) Direct manipulation between holograms and the hands. Users see how *holographic paint* comes out of their fingers instead of manipulating it at a distance or having a controller (see Figure 1). (3) Human augmented bracelet menu that is controlled by voice commands (see Figure 7).

System Description and Design

HoloARt intends to serve users that are interested in expressing themselves creatively. From professional artists that sculpt or draw to fashion designers, interior designers or novice users that just want to explore new forms of art.

[1] genre that includes artworks created with new media technologies

[2] photographic technique in which exposures are made by moving a hand-held light source while taking a long exposure photograph.

Figure 4: User is splattering paint on the ceiling and a wall. *Splatter* uses real physics to simulate how the paint reacts depending on the angle of the surface.

Figure 5: *Erase*. On the left, an eraser follows the tip of the index finger. When collided with the painting, an explosion will delete the painting selected (right image).

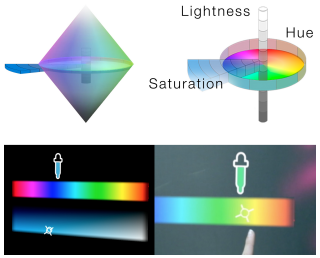

Figure 6: 3D color representation based on HLS. Lightness at the vertical axis and saturation radially outwards to the hue (top image). Bottom images are 2D representations with RGB values and lightness.

The interaction and design principles defined are the result of an exploration inspired by real artistic techniques such as painting and photography.

The user is able to *Air Paint*, *Graffiti*, *Splatter*, *Edit*, *Erase* or choose the *Color* of the art work.

The aesthetics and interaction used for *Air Painting* resemble the photographic technique of Light Painting. 3 dimensional representations of different textures are created in real time using mixed reality. Transparencies and superimposition of the textures on top of the physical space can easily be achieved by moving the index finger around the physical space. Users draw using the tip of their index finger and air tap to stop or start the drawing (followed by a "click" sound as if it was a retractable pen). The results vary among users, the drawings are usually not logically structured, but it is rather a result of the movements and "flow" of the person.

Graffiti or *Surface Painting* lets the user spray on objects, walls and any type of surface. Users can spray paint by holding the thumb and index finger together (pinch gesture) or holding the index finger down. A target cursor follows user's hand position and is projected at the predicted destination of the sprayed paint. The distance between the hand and the surface it is directly proportional to the size of the spray and inversely proportional to the opacity of the paint (see Figure 3). These type of hand gestures and spray have been designed to mimic real graffiti techniques that artists use.

Users can splatter paint by pointing with inertia towards surfaces. The size of the splat is proportional to the velocity of the user's movement and is affected by gravity. If the user throws paint with more force, the splatter will be bigger (mimicking the technique used by artist when splattering paint with a brush). If the user splats paint on the ceilings, some of the paint will fall down with because of gravity (see Figure 4).

Aside of the different mediums we described above, we created some basic tools such as *Edit*, *Erase* (Figure 5) and *Color*. The user can delete paintings by hovering the eraser on the painting while a sound feedback and particle explosion happens. *Edit* lets the users grab and move paintings. The user can grab a painting by pinching it and then move it while holding the gesture. A subtle change on the opacity provides feedback to the user when the painting is selected. Finally, the *Color* tool lets the user pick the color of the painting. We experimented with 3D and 2D color pickers (see Figure 6).

We designed a bracelet-menu that augments the user's forearm and provides an intuitive interaction technique that does not depend on a controller. The menu has a hierarchical layered interface that is designed so as to fit on top of the forearm as if it was a set of bracelets (see Figures 7, 8). The design of the menu has been placed strategically on the forearm so as not to be seen while the user is painting. Because of the limited field of view provided by the Hololens, the bracelet is not displayed when the user paints, splatters or sprays paint. In this manner, the user has both the convenience of an easy access to the menu by just looking slightly down to the forearm and the advantage of not being distracted if painting. For the same reason we choose voice commands for selecting tools and brushes.

Implementation

HoloARt has been created using the Hololens HMD [8]. We use its built-in sensors to create a map of the space and track the hand position of the user. The user can move freely without the need of using hand controllers nor be-

Figure 7: Bracelet Menu with *Splatter* selected. The white rectangle shows the field of view of the Hololens.

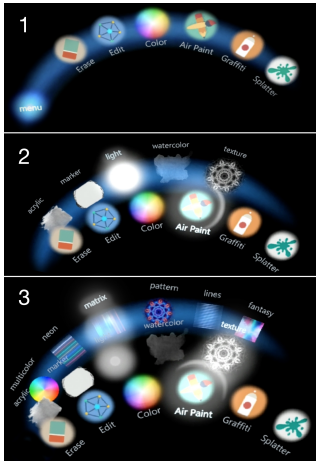

Figure 8: Mixed Reality capture of the of the bracelet menu (disabled video capturing). The images show the navigation hierarchy. (1) Initial menu. (2) *Air Paint* tool and "Light" brush selected. (3) *Air Paint* tool, "Texture" brush and "Matrix" type selected.

ing in a predefined room or setting up external sensors for positional tracking. For *Air Paint* we create real-time procedural meshes that follow the index finger position of the user. We use Z-sprites (also called billboards) that are constrained to face the camera/user's point of view all time to create an effect of 3D. These procedural meshes consist on image quads, in the case of *Graffiti* these image quads are superimposed one on top of each other to create the desired effect of increased amount of sprayed paint. In the case of *Graffiti* and *Splatter* a Raycast between the center of the hand position and the collided surface is created to determine the trajectory of the paint. Thanks to the spatial mapping and Raycast we can detect the angle of the collided paint and make the animation of the painting follow the angular degree of that surface.

The index finger position and the forearm is estimated from the center of the hand. The menu is constantly billboarding the camera so as to be always looking at the user. To reduce delay between the index finger and the painting, we use 2D textures instead of 3D models. This reduces the computational power needed by the Hololens. We take advantage of the illusion of depth and use 2D textures that look 3D because of its illuminated circular shape and the billboarding effect (see Figure 1).

Conclusion

We envision that in future versions of HMD, Virtual and Augmented Reality will be integrated in a unique headset and Mixed Reality will become the ultimate medium for *HoloARt*. Emerging trajectories in art will include these types of technologies as new forms of artistic expression. In this paper and exhibit we introduced *HoloARt* with three different techniques or "sub-mediums", (1) *Air Paint*, (2) *Graffiti* and (3) *Splatter*. We believe that in the future, other techniques will flourish such as (4) *Hologram Sculpting* or (5) *Color-Picking* the physical environment.

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