Automatic 3D Modeling of Artwork and Visualizing Audio in an Augmented Reality Environment

Elijah Schwelling
University of Maryland
College Park Maryland USA
eschwell@umd.edu

Kyungjin Yoo
University of Maryland
College Park Maryland USA
kyoo@umiacs.umd.edu

ABSTRACT

In recent years, traditional art museums have begun to use AR/VR technology to make visits more engaging and interactive. This paper details an application which provides features designed to be immediately engaging and educational to museum visitors within an AR view. The application superimposes an automatically generated 3D representation over a scanned artwork, along with the work's authorship, title, and date of creation. A GUI allows the user to exaggerate or decrease the depth scale of the 3D representation, as well as to search for related works of music. Given this music as audio input, the generated 3D model will act as an audio visualizer by changing depth scale based on input frequency.

CCS CONCEPTS

• **Applied computing~Media arts** • Computing methodologies~ Mesh models • Information systems~Information retrieval

KEYWORDS

art museum, 3D model generation, audio visualization, music, education, augmented reality

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1 INTRODUCTION

In the age of hand-held technology, digital content is accessible anywhere, and at any time. This is a fact that traditional, non-digital hubs of content and expression, particularly art museums, must account for; though audiences past adolescence still appreciate art museums, many museums struggle to engage younger audiences, who seem to gravitate towards interactive digital content rather than stationary art displays. This is unfortunate, as it has repeatedly been demonstrated that arts education can greatly benefit a child's academic and personal development [1]; a child or adolescent's visit to an art museum can be quite educational and formative. As such, the central idea behind this project is to provide art museum visitors supplemental augmented reality content that makes visitors more engaged without interfering with or being separate from their appreciation for traditional art forms. Augmented reality (AR) technology allows the user to view artwork in a real-world museum setting and engage with informative digital content simultaneously. The first main feature of the application is to automatically generate abstract 3D representations of 2D artwork. Previous studies have explored using AR to display 3D content in an educational context with positive cognitive results [2], but limited efforts have gone towards applying this concept to art museums. The second main feature of the application is an automated solution for matching any given artwork to related works of music. There is potential cross-influence between visual artists and musical artists active during the same time and region, so such a feature should prove historically educational in this regard. In addition, showcasing related music could contribute an additional dimension of entertainment to an experience typically devoid of sound.

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2 METHODS

2.1 Automatic 3D Model Generation

The first feature (3D model generation) works as follows. The user scans artwork with their camera, and it is recognized using Vuforia's [3] cloud recognition service. We attach a URL pointing to a digital image of the artwork as well as basic information about the artwork's origins as metadata to each image target in Vuforia's server, and once the artwork is scanned by the user, this image and information is passed from the server to the application's model generation system and Vuforia-based AR GUI (Figure 1). This cloud-based solution allows for any museum to use the application simply by providing basic information and digital scans of each artwork to a server. We generate a 3D model from the image by taking the greyscale value of each of its pixels as that pixel's height value. These height values are stored as the z-axis position of each vertex in a new mesh, where the x-and-y-axis positions of the vertex are determined by the x-and-y-axis positions of the pixel in the original 2D image. Methods commonly used for in-game terrain generation were used to implement this concept in Unity3D [4], an engine for creating 3D applications. In Unity3D, meshes may only have up to 65000 vertices. To account for this, we resize the input image using built-in bilinear filtering functions in Unity3D before model generation. Once the mesh is generated, it is rendered over the scanned painting in the real-world camera view, and the depth scale of the model is controlled by the user with a simple GUI slider (Figure 2). The authorship information is also displayed adjacent to the mesh; appropriate positions in real-world space for each piece of information are calculated at runtime based on the size of the resultant mesh to account for different painting sizes and aspect ratios.

Figure 1: The AR view after scanning a printout of a painting on a black table, which displays the model with unexaggerated depth and basic authorship information.

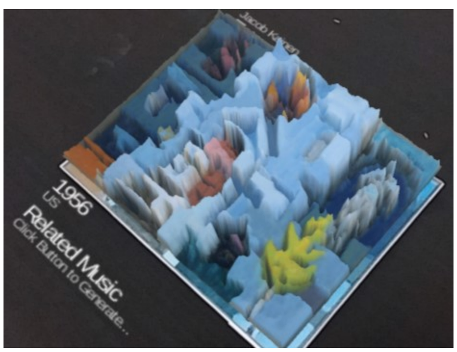

Figure 2: The AR view after the depth slider has been brought nearly halfway up.

2.2 Matching Artwork with Music

The second feature (music matching) also works immediately after a user's scan. Using the authorship information stored in the image target's metadata, the application searches an online database of music to determine what music the visual artist might have been exposed to, and we communicate that insight to the user in an educational manner with the AR GUI. The online database in question, MusicBrainz [5], has a REST-based API that allows applications to query for popular music releases based on criteria including date and location of release. When the user presses the search button in the AR GUI after scanning an artwork, the application performs a query for music releases from the same year and location. These results are displayed adjacent to the work along with the authorship information (Figure 1) and can be browsed using another button on the AR GUI. The generated model responds to audio input by augmenting its depth scale based on frequency. We divide audio input into eight frequency bands using elements of fastfourier transform analysis. The depth scale augmentation is directly correlated to the sum of all the frequency bands at each frame while the audio plays; exaggerated input frequency results in exaggerated depth.

4 RESULTS AND CONCLUSION

This paper detailed a solution for making museum visits more engaging and interactive using automatic abstract 3D modeling and the matching of related visual and musical art. Using Vuforia's cloud recognition service and MusicBrainz' open music database, we were able to implement a solution that requires minimal manual setup on the part of an interested museum; all information required can simply be uploaded to a database and scraped by the application. With greyscale height data and Unity3D's mesh system, we generate 3D representations of 2D artwork automatically, and use these representations to visualize audio. Using MusicBrainz' database, we perform queries at runtime using authorship information to find related works of music. These features were consolidated in a simple user-friendly mobile application which uses an AR user interface, so that any museum could easily allow their visitors to use the application to view their collection in an engaging manner through the application. In the future, it might be more demonstrative of the relationship between visual art and music to use specific audio frequencies from retrieved music to exaggerate specific features in the artwork's model. In addition, it might be beneficial to add more authorship information to each artwork's metadata.

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