Using Machine Learning and Superimposition Based Augmented-Reality to Provide Artistic Insight into Abstract Art

FIRE170 2019
Phillips Virtual Culture
Glen Joy

Abstract

Abstract art is an artform which many audiences have trouble understanding, appreciating, and finding meaning and beauty within. Many contemporary museums today, such as The Phillips Collection, are filled with abstract art pieces which are often overlooked by museum visitors in favor of more direct and understandable pieces.

The work described here attempts to reconcile modern audiences' lack of appreciation for such art by uniting art concepts, analysis, and artistic interpretation with modern technology in the development of a mobile AR application backed by machine learning. Such an application would enable museum visitors to scan abstract art and receive helpful insight into better understanding the piece. The goal of such an endeavor would be to increase visitor interest in such abstract pieces, encourage re-visitation, and bridge the gap between technology and art in museums.

Contents

1 Introduction

Abstract art is largely defined as an indirect representation or invisible portrayal of elements from the visible world [1]. It often masks typical understanding of our physical world with techniques of metaphorical expressionism. It is, therefore, unsurprising that many audiences may find trouble appreciating and understanding such pieces as their meanings and intentions are often hidden from plain view.

While the true meaning and intention of many abstract pieces may be solely in the mind of the artist, there are very clearly patterns of fundamental artistic techniques such as geometric patterns, shapes, symbols, color choice, brush stroke, size, textures, and other elements present in modern art, which may allude to the purpose and meaning behind an abstract piece. Many audiences, however, may have trouble identifying and associating these visual patterns and artistic elements with a solid meaning.

The following proposal attempts to help audiences identify such elements in abstract pieces and provide information into possible meanings behind their use, allowing the viewer further insight and better understanding of the piece. Such a task would be accomplished through the development of a mobile application. Using machine learning, the application would be able to detect image features which may match certain artistic elements. Using superimposition-based AR, the application will superimpose information about those artistic elements over the piece, providing the viewer with a direction in how to possibly interpret the piece.

2 Previous Work

Many current applications of AR in museum environments are often related to the problem of indoor navigation [2][3]. Other bolder applications seek to create entirely new museum experiences through the digital construction of virtual reality museums and exhibits [4][5]. Currently, it appears that very few applications help provide audience insight into physical art pieces themselves, especially through the use of feature-based inference assisted by machine learning.

Perhaps the most similar project used for audience insight for works of art was an AR-based 3D-modeling application for modeling artwork and visualizing associated music [6]. This project entailed using color data from art pieces to produce a 3D depth map of the colors within the piece. Information about the piece such as authorship and date of creation were also superimposed aside the 3D-model. In addition, using metadata about each individual piece, related music that the creator may have listened to or have been influenced by was played and was visualized by the depth of the 3D-model changing accordingly to the frequency of the music.

This work intends to be different from previously performed research by incorporating the use of machine learning. Whereas previous work presents information to the user using what is already provided, this

application analyzes data to infer and draw its own conclusions to the user.

3 Statement of Work

The developmental phases of this work can be divided in to the following categories: Preliminary research, implementation selections, dataset creation, machine learning model training and refinement, mobile application development, testing, and finally user evaluation.

3.1 Preliminary research

This phase of the development process entails the research of various artistic techniques and the principles or elements of artistic design. It will be determined which artistic choices are most commonly present in abstract pieces and their common interpretations. Research may delve into artistic concepts such as color theory.

In addition, research will also be conducted on feature-based detection in images using machine learning, which algorithms and frameworks are best for this particular endeavor, and other implementation options regarding machine learning and superimposition based augmented-reality.

Results of preliminary research conducted thus far can be found in section 5.

The expected time frame for this phase is 1-2 weeks.

3.2 Implementation selections

Based on above conducted research, specific implementation options will be selected for use for this project. This includes which machine learning algorithm will be used, how the dataset will be created, how it will be trained, what software will be used, which artistic features will the application be able to detect, etc.

As of now, the Unity platform will be used for development of this application. In addition, the application will only be available for execution on the Android operating system. Furthermore, since the application will need to distinguish artistic features within an art piece, it is expected that a classification-type machine learning algorithm will be used, however, the specific algorithm itself is yet to be determined.

The expected time frame for this phase is 1 week.

3.3 Dataset creation

In training a machine learning model to correctly identify artistic features in artwork, a training dataset must be created for the model. It is likely that a separate dataset must be created for every individual artistic feature we wish for the model(s) to detect.

This would likely entail creating a dataset full of images of other artwork which contains the features we choose to include. For example, a dataset used to train a model to detect distinguishing lines would likely contain art pieces with such distinguishing lines so that the model could learn to identify such lines when performing in our application.

The expected time frame for this phase is 2-3 weeks.

3.4 Model training & hyper-parameter optimization

Once datasets have been created, model training and testing can begin. From evaluating training metrics, datasets can be refined and model hyperparameters can be tuned for optimum performance. Model testing and evaluation will likely be conducted using standard 10-Fold Cross validation.

The expected time frame for this phase is 1 week.

3.5 Mobile application development

The core phase of the development process will be developing the mobile application. As mentioned prior, the development will likely be done using the Unity platform solely for the Android operating system.

This phase of development will further be subdivided into backend and frontend development.

The expected time frame for this phase is 3 wees.

3.6 Testing

Once a roughly working prototype of the application is developed, testing will begin on various pieces of abstract art. The accuracy to which the application correctly identifies various artistic features will be assessed, any software bugs will be identified, and it will be determined whether or not it is necessary to return to any of the previous phases of development within this Section.

Both pieces from The Phillips Collection as well as other abstract pieces will be used for testing.

The expected time frame for this phase is 1 week.

4   Preliminary research results

Research conducted thus far has explored various programs and techniques used to convert images into .csv files with color data and extracted features. Acquiring these .csv files are critical in training a machine learning model to detect such features in paintings in The Phillips Collection.

The first method researched was a software called A-VEKT Image CSV Converter [8] which is a free open-source program which enables inputted images to be decomposed into their primary colors and exported as a .csv file. There were many drawbacks found to this program. Although it extracted color data, it was not able to perform feature extraction. In addition, the program is only available for the Windows operating system while most of the work will be conducted on Mac OS. This resulted in the push to seek other alternatives.

The technique which seems to be the most promising, based on current research, is using Python and the OpenCV library [9] to generate .csv files for each painting. Not only do the generated .csv files from OpenCV contain the needed color data, but the OpenCV library also has capabilities such as line and corner detection which will prove beneficial in detecting shapes within paintings. Other methods, however, will continue to be researched.

5 Discussion

While progress has been made in determining tools for generating needed csv files for model training, research still has to be performed specifically on what particular image features are to be found in the paintings and what the artistic interpretation for those features are. It is only then where the created datasets will be of any use in developing the machine learning model.

Answers to such questions can be acquired through continued online research or inquiry with art students within the research stream as to what certain shapes and symbols may allude to in modern art. Once a set of interpretations is collected, the question becomes how can the data within the generated csv files be used to detect such features or whether capabilities in the OpenCV library can already extract such features we intend to interpret. As mentioned prior, the OpenCV library already has the capability of detecting lines and corners which may prove rather useful and be a stepping stone in the right direction.

The goal now is to continue preliminary research, specifically determining the artistic interpretations for certain visual elements and how such elements can be identified using a machine learning algorithm trained on the generated datasets.

6 Expected Outcomes

From previous engagement studies of interactive museum exhibits [7], it is expected that this application will help to increase visitor engagement, increase general interest and appreciation of abstract art forms, encourage viewers to revisit the museum, as well as possibly increase interactivity and interest of younger visitors.

Since different art pieces vary drastically in the way they incorporate artistic features, it is also expected that the developed application will not always be able to detect certain features, will sometimes detect a feature that is not present, or correctly identify a feature, however, the interpretation of the feature is not relevant to what the artist intended. All actions will be taken in an effort to minimize such errors, but no application or machine learning model is perfect.

Nevertheless, it is expected that the development of such an application would drastically change the way technology is incorporated into museums and would bridge the gap between both the machine learning and mixed-reality fields as well as the digital and physical worlds.

7   Evaluation Plan

The seventh and final phase of the development process is evaluation. The evaluation process will be divided into both peer evaluations and user evaluations.

Peer evaluations will entail sharing the final application amongst other researchers who were not involved in the development process for this project. These will be other researchers in the research stream. Since these researchers are those with similar technical skillsets, their evaluations will provide crucial technical feedback for the application and will highly influence any backend or implementation related changes.

User evaluations will entail sharing the final application amongst those in the general public. These will likely be students at the University of Maryland who are not in the research stream, however, it would be preferred if the users were real visitors at The Phillips Collection. It is assumed these users do not have such technical expertise as the researchers in the stream and thus their evaluations will focus on items such as usability/ease of use, emotional response, enjoyment, etc.

Evaluations for both of these groups will be used to make further updates to the application and possibly revisit earlier phases of development as mentioned in Section 3.

The evaluations will likely be administered in the form of a Google Form with various types of questions regarding overall experience with the application.

8   Conclusion

Abstract art is an often misunderstood, under-appreciated, and often criticized art form. Its lack of popularity amongst the public can likely be attributed to the difficulty in understanding such pieces. This research proposal has presented a solution in creating a superimposition based augmented-reality mobile application which uses machine learning to detect, identify, and interpret common artistic features within pieces of abstract art and present the user with possible meanings and interpretations in an effort to better the user's understanding. It is expected that such an application will help to foster visitor engagement, interest, and appreciation of art within museums.

9   References

[1] Britannica, T. E. (2015, December 22). Abstract art. Retrieved April 19, 2019, from https://www.britannica.com/art/abstract-art

[2] Damala, A., Cubaud, P., Bationo, A., Houlier, P., & Marchal, I. (2008). Bridging the gap between the digital and the physical:design and evaluation of a mobile augmented reality guide for the museum visit. *Proceedings of the 3rd International Conference on Digital Interactive Media in Entertainment and Arts - DIMEA 08*. doi:10.1145/1413634.1413660

[3] Tillon, A. B., Marchal, I., & Houlier, P. (2011). Mobile augmented reality in the museum: Can a lace-like technology take you closer to works of art? *2011*

IEEE International Symposium on Mixed and Augmented Reality - Arts, Media, and Humanities. doi:10.1109/ismar-amh.2011.6093655

[4] Wojciechowski, R., Walczak, K., White, M., & Cellary, W. (2004). Building Virtual and Augmented Reality museum exhibitions. *Proceedings of the Ninth International Conference on 3D Web Technology - Web3D 04*. doi:10.1145/985040.985060

[5] Hall, T., Schnädelbach, H., Flintham, M., Ciolfi, L., Bannon, L., Fraser, M., . . . Izadi, S. (2001). The visitor as virtual archaeologist. *Proceedings of the 2001 Conference on Virtual Reality, Archeology, and Cultural Heritage - VAST 01*. doi:10.1145/584993.585008

[6] Schwelling, E., & Yoo, K. (2018). Automatic 3D modeling of artwork and visualizing audio in an augmented reality environment. *Proceedings of the 24th ACM Symposium on Virtual Reality Software and Technology - VRST 18*. doi:10.1145/3281505.3281576

[7] Haywood N., Cairns P. (2006) Engagement with an Interactive Museum Exhibit. In: McEwan T., Gulliksen J., Benyon D. (eds) People and Computers XIX — The Bigger Picture. Springer, London

[8] A-VEKT Image CSV Converter [Computer software]. (2015) Retrieved from https://www.avekt.com/en-us/Software/ImageCSV

[9] OpenCV-Python [Computer software]. (2013) Retrieved from https://opencv-python-tutroals.readthedocs.io/en/latest/index.html