Engaging museum visitors with gamification of body and facial expressions

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ABSTRACT

In this demo we present two applications designed for the cultural heritage domain that exploit gamification techniques in order to improve fruition and learning of museum artworks. The two applications encourage users to replicate the poses and facial expressions of characters from paintings or statues, to help museum visitors make connections with works of art. Both applications challenge the user to fulfill a task in a funny way and provide the user with a visual report of the his/her experience that can be shared on social media, improving the engagement of the museums, and providing information on the artworks replicated in the challenge.

CCS CONCEPTS

• **Software and its engineering** → **Interactive games**; • **Computing methodologies** → **Computer vision**.

KEYWORDS

Cultural heritage, gamification, face pose, body pose

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1 INTRODUCTION

Gamification is the process of exploiting strategies and game dynamics into scenarios that are not a game [10]. It has already been proved to be useful to enhance skills and competences in a variety of domains such as marketing, industry training and entertainment. Certainly also cultural heritage can benefit from a gamification approach which represents an opportunity to engage visitors to museums content through the design of more entertaining, social and challenging digital learning scenarios [2, 4, 6, 8], to help museums to move from the traditional "look and do not touch" toward a "play and interact" approach. In fact, it has been observed that the availability of tools like gamified e-guides to visitors contributes to the sustainability of museums [1].

2 THE DEMO SYSTEMS

The goal of the two applications is to challenge the user to analyze and replicate artworks with their own body and face, obtaining *i)* information on the artworks that are replicated and *ii)* personalized artwork representations that can be shared on social networks.

2.1 Strike a Pose

Strike-a-pose (Fig. 1) is a web application which performs analysis and evaluation of human poses compared to poses present in famous paintings or statues. Strike-a-Pose can be made available on the visitors' phone, following the "Bring Your Own Device" (BYOD) approach that has become more common in museums since the COVID-19 pandemic [1]; the system can be used also in a dedicated environment that uses a fixed station equipped with a large screen and a camera.

The application exploits a gamification paradigm with the didactic purpose of getting users interested in works of art using fun. Once registered, the user is challenged to reproduce in sequence the poses of some artworks from the museum's collections. The skeleton of both the artwork and the visitor can be displayed on the screen in order to facilitate the user in matching the various points and segments. Matching the poses provides the descriptions of each artwork. The poses to be matched are organized in sets of challenges, e.g. challenges to replicate poses using the whole body, using only the torso (e.g. to allow also wheelchair users to interact), or any other type of challenge that is considered interesting by the museum curators (e.g. based on thematic collections). Once all the poses have been matched, the application allows the user to generate a video that can be saved for any social sharing. The video shows the user matching process and the overall interactive experience lived at the museum.

The application has been developed in JavaScript on the client side and in Python on the server side. Pose detection on the human bodies is achieved using TensorflowJS [1] detection API exploiting the pose detection model, MoveNet. MoveNet is a very fast and accurate model that detects 17 keypoints of a body. The model is used in the variant "Lightning" intended for latency-critical applications and runs faster than real time (30+ FPS) on most modern desktops, laptops, and phones. The model runs completely client-side in the browser. Server-side an SQLLite database is used to stores artworks' collections, challenges and artworks' metadata and descriptions.

*Both first two authors contributed equally to this research.

[1] https://www.tensorflow.org/js

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Communication between the knowledge-base and the interface is ensured through RESTful APIs developed in Flask [2]. The video is created server side. The interface designed for smartphones uses a vertical layout, while the one for installations has a horizontal layout, to deal with the different aspect ratios of the screens typically used in those settings.

To ensure that the coordinates of the keypoints were not related to the entire image but only to the pose, both for the user's pose and the pose of the character in the painting they have been normalized as follows: 1) the midpoint of all the segments between the keypoints is calculated; 2) each keypoint in the pose is normalized in relation to the midpoint. To test the similarity of the user's pose to the pose of the character in the painting is used an algorithm based on the euclidean distance between the set of points. The match is verified if the distance is below a predefined threshold for a certain time interval.

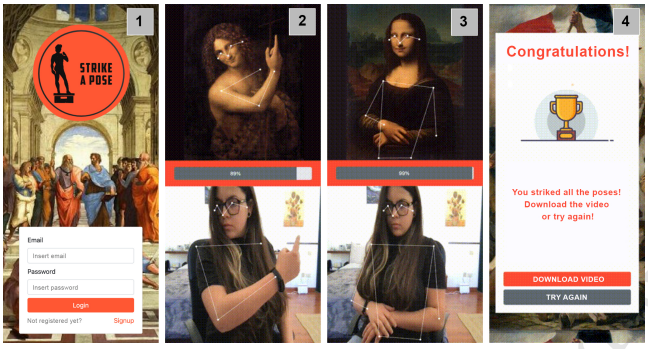

Figure 1: Strike a Pose App for smartphone. 1) Login. 2-3) The user trying to strike the pose in the painting (playing in "easy" mode, with visible skeletons). 3) Challenge completed: download the video.

2.2 Face-Fit

Face-Fit is an application developed in JavaScript and Python which provides gamification and personalization on painting, in particular portraits, adapting their visual content. The application designed both for smartphone and desktop (for museum installation) allows to replicate the pose of the head and the expression of some portraits by famous painters and transfer the face of the user on the artworks, generating a new image. The application was designed through a usability study carried out following an iterative design approach with three groups of 5 people [7]. The user places himself in front of the smartphone or installation equipped with a camera. He is presented with a series of portraits' paintings in a vertical carousel. The user can choose the artwork to match. At that point the application presents a ghost image of the user's face that the user must try to super-impose on that of the painting to find a perfect match, see Fig. 2. The ghost image solution was the result of our usability study which solved some issues related to how to keep the user at the same time concentrated on the task without losing the fun of the game. At first, in fact, we had provided some visual suggestions to find the right pose but they distracted the user from the painting and therefore from the game.

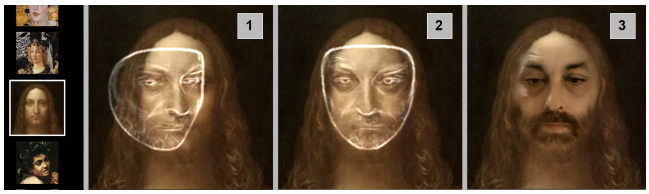

Figure 2: Face-Fit App for museum installation. 1) trying to match the pose and expression of Leonardo's *Salvator Mundi*. 2) Face matched. 3) Challenge completed: image generated.

Mediapipe library [3], which exploits Tensorflow Lite technology, was used to detect the face landmarks, using the network presented in [5] to obtain real-time execution also on mobile devices, in order to check the match of the pose and of the expression of the user's face with that of the paintings. Region of Interest, bounding boxes and coordinates of the points of the landmarks, are used to compute the rotation angles of the head with respect to the camera. The match between the pose of the user's picture deriving from the camera and the face in the painting is verified when the Euclidean distance of the 3D rotation angles is less than a predefined threshold. Then a second check is performed to compare the shapes of the three most significant features of the human face, i.e. eyes, eyebrows and mouth, detected in the two images. These features can convey the 7 universal facial expressions (anger, fear, contempt, disgust, happiness, sadness, surprise) as identified by Ekman *et al.* [3]. Image matching and face swap between the user's face and the face in the painting is obtained applying affine transformation to corresponding mesh triangles. To adapt the style of the user's image to that of the painting we use a color correction based on statistical analysis by Reinhard et al. [9]. Similarly to the Strike-a-pose app, completion of the challenges results in obtaining the generated images for social media sharing as well as unlocking the descriptions of the matched artworks.

3 CONCLUSIONS

In this demo we presented two demo applications which exploits serious gaming techniques in the context of cultural heritage. The applications can be used by children but also by adults to be enticed to discover information on works of art in any museum provided with artistic objects with human figures and faces. Full source code of the two systems will be made available on the digital hub of the EU ReInHerit project (https://www.reinherit.eu) to ease the adoption of gamified e-guides by small museums that can not afford the full development of such applications.

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[2] https://flask.palletsprojects.com/

[3] https://google.github.io/mediapipe/

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