

Converting Human Movements into a Conceptual Painting based on Music Using a Motion Capture System: Action Research

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Original Article

Abstract

Introduction: Motion capturing is a concept which has been taken into consideration in recent decades and it has been used for various purposes like improving the performance of patients with motor problems and increasing motivation and creativity of users. It can also be used in film industry both in two- and three-dimensional animations. Research has shown that this system may be used to enhance creativity and intellect. The aim of this study is to use the Vicon motion capturing device to convert creative human movements into a conceptual painting with the help of music.

Materials and Methods: For cultural adaption of the system, the first chapter of "HAFTVAD" music album called "The Introduction" composed by Masoud Nekoyi and the story of Rostam and Sohrab from Shahnameh, written by the Persian poet Ferdowsi, were chosen as the musical groundwork and the scenario for this survey. A human model was trained to perform movements in accordance with the musical and fictional workarounds of the study; the model was also allowed to use self-created styles in movements in the final performance. The segmental movements of the model body were identified in the Vicon Vero system by wearing clothes equipped with reflective markers. This information was transmitted into the Unity engine, and without modeling the body's segments, different colors and brushes were defined to illustrate the path of the movements of the hands, feet, head, and heart.

Results: By defining various brushes in different colors, human movements were converted into a conceptual painting in accordance with the music.

Conclusion: This study discussed a creative process, entitled Motion Paint, which was implemented in Iran for the first time. This method can be used to make the process of exercise therapy more attractive, especially in chronic motor problems.

Keywords: Digital painting; Motion capture; Converting motion to painting; Harmonic motion

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Introduction

Digital painting is a type of virtual art that seeks to create a painting in a digital form using special tools. Various methods of digital painting include light pens and various software packages such as Photoshop (Adobe Photoshop, Berkeley, CA, USA) and Illustrator (Adobe Illustrator Berkeley, CA, USA), which can be applied as a virtual painting studio. The ultimate goal is to combine art (painting) with digital technology. This virtual art has certain features such as transparency and symmetry, and with the help of various tools used in its creation, many outputs combined by the artist with creatively can be achieved.

The first computer drawing system, Sketchpad,

was introduced in 1964 by Ivan Sutherland (1), followed by various painting software, including Corel Photo-Paint (Photopaint Corel, Corel, Ottawa, Ontario, Canada), Painter 3D (Painter 3D, Microsoft Paint, Microsoft, Redmond, DC, USA), and Photoshop. These software packages allowed users to simulate painting on computer screen. Users could use a mouse or light pen to simulate different sizes of brushes, select colors from a color palette to manipulate photos, adjust the contrast and color of images, and add special effects to the image, which often increase image quality (2).

Movement has always been one of the most important topics in scientific research. Given the

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subtlety and complexity of healthy human movements, these movements can be used as a model for other people with mobility problems. For this purpose, the Motion Capture technic can be used. Motion capture is the process of recording movements of objects or people, which is used in the military, entertainment, sports, medical applications, as well as to improve computer vision and machine vision (3). In many cases, Motion Capture is referred to as Motion Tracking, which is employed in the film and game industry to match the movements with characters, but the purpose of recording motion in filmmaking and games is often to record the actor's movements rather than his visual appearance. In this method, the animation data is plotted in a three-dimensional model so that the model performs the same actions as the actor (4).

In the study by Bevilacqua et al., a combination of music and dance of three-dimensional rhythmic movements was used using the motion capture system, and different mapping was applied between movements and music based on the indicators extracted from this analysis (5). In another study, their movements and mapping to music were analyzed (6). At the multimedia international conference, an interactive dance was used to examine the extent to which users were immersed, as well as how engaged they were with the software and how the users communicated remotely with their trainer (7). In a study, using the Vicon motion capture system, Kapur et al. tried to assist patients in identifying and correcting problems related to motor coordination through sound (8). However, human theatrical movements have not yet been portrayed in the form of a story and in a music context.

The aim of the present study is to develop a creative image and painting based on information collected from sensors that are installed in different parts of the body and play the role of a stylus. The Motion Capture system seems to be irrelevant to digital painting, but at the same time, with the help of original Iranian music in the fictional field from the myths of Iranian culture, it can embody different movements. Therefore, the study results may be able to provide a way to increase the motivation of patients with a variety of debilitating problems, so that not only participation in rehabilitation sessions would be attractive to them, but also the outcomes of treatment that are slow and gradual in many cases, would be visually understandable.

Materials and Methods

This study was conducted in order to identify and convert human movements using Motion Capture

(Vicon Vero, Vicon Motion Systems Ltd, Oxford Industrial Park, Yarnton, Oxford, UK) with music and convert these movements into a painting in a creative style in Motion Capture Workshop, School of Multimedia, Tabriz Islamic Art University, Tabriz, Iran winter 2020. In the process of carrying out this project, examining and establishing a relationship between the moving limbs of the desired individual, the route of these movements was recorded so that in the end, these movements could be seen as a real painting.

Conceptual movement based on poetry and music:

What raised the issue in terms of conceptualization was the addition of themes and movements that were creatively designed for such projects in a completely native environment using national values. The story was based on a poem from the book Shahnameh and part of the poems of The Seven Labors of Rostam composed by Ferdowsi. This epic poem was about the story of the arrival of the protagonist named Rostam in a city called Turan. The protagonist's movements were calm and peaceful, and then the poem found a faster rhythm. The concept of movements was in the direction of expressing the content of the poem, which was composed and performed using music. In order to conform to the national values of the Iranian society, the epic music of Haftavad was used to define the movements. To better harmonize the movements with the poem, the music called "Pishvaz" from the album Haftavad composed by Masoud Nekoyi was used.

Recording movements in Motion Capture: The first step after choosing music was to select points to capture movements based on the concept and sense of the body organs. Depending on the type of music, the main organs of the body such as the head (brain) to show reason and logic, the chest (heart position) to express emotions, and the hands and legs to express the mood of the model were used. Based on the sense and concept of the music, only some points were displayed, and the character's movements were performed in a three-dimensional space without background to better induce the sensation, which was implemented in the final model in the backgrounded software.

In order to implement the project, the movements were captured by the Vicon system using 12 cameras that reflected infrared waves to the markers attached to the models clothes and received their reflections (Reflective Optical Capture). These cameras are the most accurate and flexible motion capture cameras. 53 infrared reflective markers were installed on the actor's clothes based on the Vicon marking model. The transparency and quality of the markers are very important in accurately recording the details. In addition, the speed of the cameras was adjusted to

record the smoothness of the movements. Another key component of this system was the Shogun Post software, which, in addition to interacting between the camera and markers, made it possible to process two-dimensional and three-dimensional data (9).

The system was calibrated using Vicon **active wood**, which had LEDs of a certain order. The accuracy of the information obtained depends on the type of calibration. Therefore, the active range of the camera was calibrated and determined according to the edge of the sensors. To calibrate the character, the person stood in a T form and the character was calibrated using the Shogun Post software.

After preparing and calibrating the device and introducing the model to the device, the desired music was played in the environment. Then, the desired movements were designed according to the mentioned meanings and taught to the desired model and the model performed rhythmic movements according to the content of the music and his perception of it. While performing these movements by the model, all movements were displayed on the monitor that was connected to the device. These movements included important body movements for this music, including hand, foot, head, and chest movements (expression of emotions). Digital painting was performed in a real three-dimensional space, using the motion of the limbs of a real human wearing clothes with 53 sensor points on it. All movements were recorded in the Vicon Shogun Post software, from the series of software specific to the Vicon Motion Capture system, and the data output was prepared in the Fbx format to transfer them to the Unity software (Unity Software, Unity® 2019.2.2.13 f1 <DX11>, Unity Technologies, 2019, San Francisco, CA, USA).

Mapping human movements on the Unity software using the motion capture device: Unity software is a suitable environment for combining ready-made structures with a structure through coding that can be added by a programmer. There were not enough movements in this part of the project to present a digital painting. Therefore, the captured movements of the model in the Unity space were formatted on a predefined and ready-made human character. For each movement, a specific color and brush were considered, which according to the theme, had different and distinct shapes such as circle, square, soft shape (such as brush head), sharp linear shapes (similar to pencil tip), etc. Depending on the content of the music, the desired pens and colors were assigned as visual, a particle, or an object, and textures and materials were added to them (particles were used to indicate the path of movement, and a

specific shape, texture, and material were used to show and express the characteristics of each organ). The final image was coded in the Unity software and the codes related to the delay between movements (so that they do not combine with each other), different pens, timing of movements, different colors to better show the model emotions, and the effect of music on him were written. To better specify the movements shown in different colors and brushes, the black background was used in the Unity software.

The desired virtual model was prepared using a ready-made rigging format. Since in this project, only the points and their connection were considered in the positions specific to the theme of poetry and music and the visual state of the virtual character did not have a place in the goals of the project, the definition of the direction of the makers relative to each other and the construction of human body model were abandoned, and only the appearance of the marker movements by the coded points and colors remained.

Results

The final image was a completely creative painting perceived by the model (user) of the music and story of the poem. By playing the music in the environment, the model was asked to perform movements in accordance with the music in the form of rhythmic movements based on the instructions given. At this stage, some movements were added by the model to the predetermined movements. The model performed the rhythmic movements in accordance with the style and story of the music. The beginning of this music had a slow trend to show the theme of Rostam's arrival in Turan City. At first, the atmosphere was very beautiful from the point of view of the character (Rostam) and these states could be seen in his behavior. To convey the same feeling with the music, the model performed a calm and ornate gesture to induce a sense of happiness in which the foot movements and steps on the ground were subtle and pleasant and showed the involvement of all his senses (Figure 1).

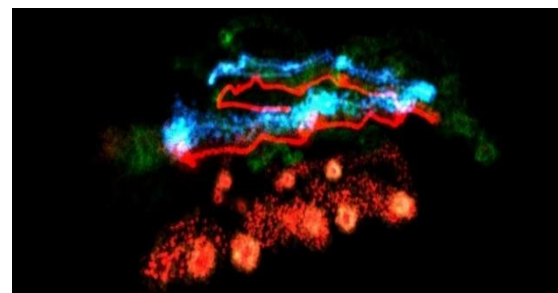


Figure 1. Illustration of all pens embedded in sensory organs

At this point, foot movements and walking on the ground were important; he had steady yet calm and peaceful steps that were exhibited by the rhythmic movements of the model. Delicate and soft pens were used to preserve the concept of calmness and peace present in the music and poetry. Due to the concentration of music and the design of the movements, the pens used in the feet of the character were clearer, and the pens of this section were identified with colors that were more calm (Figure 2).

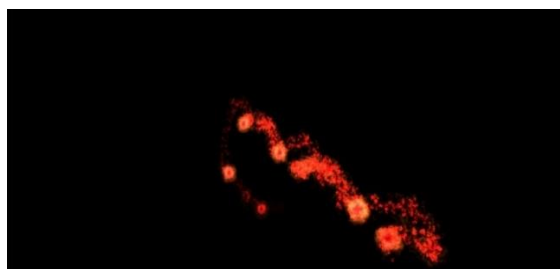


Figure 2. Path designed by foot movement

The character's previously calm movement gradually gave way to anxiety and hesitation, which was accompanied by unsteady steps; because in this part of the poem, Rostam was faced with a decision to do or refrain from fighting. Wisdom commanded attack and movement for battle while his heart and soul were not ready. Hence, the model's movements were designed as skeptical movements. The model showed this hesitation with a slight change in his movements. The pens used for this part of the model's movements, according to the content of the poem, also had sharper lines and a progressive movement rhythm. Moreover, the pens were executed on the head and heart with contrasting colors (Figure 3).

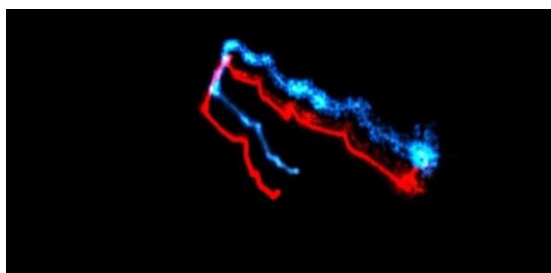


Figure 3. Path designed by head and heart movements

At the end of the music, which showed the superiority of reason over emotion, a battle broke out between Rostam and Sohrab. The model movements were faster with his feet hitting the ground, indicating

the violence of the theme. At this stage, the pens of the section related to the head of the model were activated and more visual superiority compared to other sections was observed. The pens had sharper, darker colors to represent war and bloodshed, as well as the domination of reason over emotion. In this part, the music ended with a retro rhythm (Figure 4).

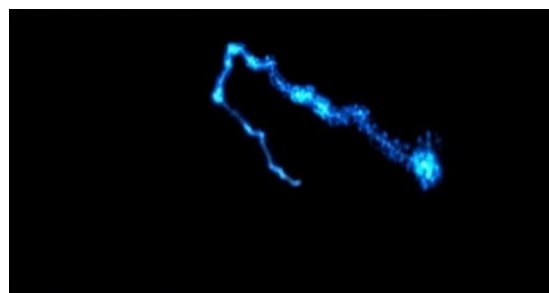


Figure 4. Path designed by head movement

In parts of the music, the expression and meaning of which involved several organs, a different picture was created with the recorded paths. For example, with the involvement of the hands and head, a specific theme of music was induced (Figure 5).

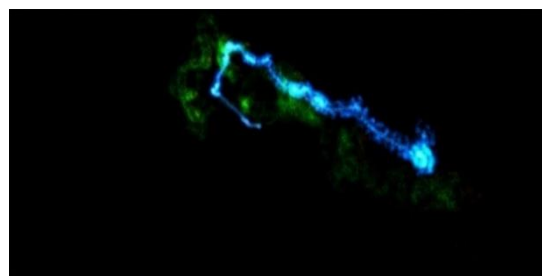


Figure 5. Path designed by hand and head movements

Additionally, by changing the angle of view relative to the drawn paths of movement, the concept and sense created could be changed in the three-dimensional environment (Figure 6).

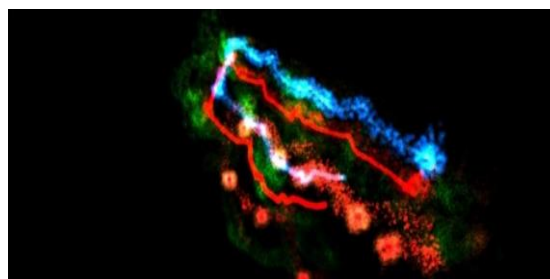


Figure 6. Path designed by all organs by changing the angle of view

Discussion

Today, the application of technology to help people and also to increase their motivation and creativity in various matters is very important. Technology and music help users improve their creativity and thinking ability. In this project, the model's movements were depicted as a digital painting, and a new process called Motion Paint was invented. The process addressed in this study was carried out for the first time and completely creatively in Iran. It should be noted that in other studies, this procedure has not been considered in this way and according to the concept of movements based on the desired music, and the output has not become a conceptual painting. In previous similar works, only the conversion of music of any kind into meaningless movements has been mentioned (10).

In today's advanced world, different sciences and arts are no longer used separately, but it is tried to combine the different arts and science fields in some way and by integrating them with each other, the aim is to achieve more important outcomes and goals. These combinations include the combination of music and rhythmic movements based on song, and the conversion of these movements into a creative painting and image, as discussed in the present study.

The findings of the present study regarding the human movement capture with the help of music can be used as a model to increase creativity and also, to create a suitable environment for solving the problem of patients with mobility disorders and increasing mobility and social interaction in children with autism spectrum disorder (ASD). Furthermore, the innovations of the present study include the beneficial use of motor organs, as well as the conceptualization of these movements according to the desired music. The study outputs can also be used to benefit from computer games as a model and help improve the movements of children with ASD.

Limitations

The system used in the present study was accompanied by some limitations due to the space occupied and the need for a fixed location to install the cameras, and the limited space prevented the user from moving freely and restricts him to the environment. Besides, the special clothing that each user must wear to capture the movements is a time-consuming task, and the end result of the work is shown to the user after the movement capture and a long process, transferring the data to the Unity software, and its execution. In addition, due to the lack of proper calibration at the beginning of the

work, some areas may not be identified and there may be a problem at the end of the work and in the transfer to software section.

Recommendations

In future studies, it is suggested that artificial intelligence be used in the field of digital art and music with different content. Moreover, it is better to use the results of the present study in computer games that increase the movement of users, especially children.

Conclusion

Motion Paint is the acronym for the creative process introduced in the present study, in which users perform creative movements after wearing Motion Capture clothes and listening to the related music. Then, using the Unity software and considering different brushes for each organ (brain, hand, feet, and chest) and showing the different logics of these organs, these movements create a conceptual and creative painting. According to the image or the final painting produced, one can perceive the purpose and concept of the desired music and the conceptual and creative movements of the user.

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Authors' Contribution

Marjan Behrouzpour-Baghmisheh: Study design and ideation, providing study equipment and samples, manuscript preparation, specialized manuscript evaluation in scientific terms, confirmation of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments; Fatemeh Rezaei: Software

analysis and charting, manuscript preparation, specialized manuscript evaluation in scientific terms, confirmation of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments; Aylar Fakherian: support and cooperation services in implementing the project, manuscript preparation, specialized manuscript evaluation in scientific terms, confirmation of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments; Yoones A. Sekhavat: study design and ideation, support, executive, and scientific services of the study and corresponding author, manuscript preparation, specialized manuscript evaluation in scientific terms, confirmation of the final manuscript to be sent to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflicts of interest. Dr. Yoones Sekhavat attracted the budget for conducting basic studies of the paper from the School of Multimedia of Tabriz Islamic Art University and has been working as an assistant professor at this university since 2014. Marjan Behrouzpour-Baghmisheh, Fatemeh Rezaei, and Aylar Fakherian have been students of the Master of Computer Arts at the School of Multimedia of Tabriz Islamic Art University since 2018.

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