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A Solution for Improving Data Capture Process Aimed at Collecting Azeri Dance Data: An Action Research

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Original Article

Abstract

Introduction: The modern human is on the cutting edge of information, communication, and technology, the turning point of which is to maintain the valuable traditional and cultural data inherited from the ancestors and hand down it to the descendants. This is fulfilled via stories, dances, and activities; negligence in this regard results in loss of cultural and location-based information.

Materials and Methods: In this project, Perception Neuron device (a wearable system of nonoptoelectronics MoCap group) was utilized for capturing the data of the musical movements of the body. The captured data refers to the Azerbaijan region, known as Azeri Dance in the world. The study process contained three phases of possibility of identification, capturing and maintenance of musical movements on cultural-climatic backgrounds, endeavor at utilizing these musical movements of the body in creation of melodic and rhythmic patterns, and the game side of the study containing levels, game-based learning, player progress, and skill comparison among the players. The device was attached to a female performer with the body height of 165-170 cm according to software's default body size with fewer flaws in data. The captured data was musical movements of the famous folk tune called Tərəkəmə (pronounces as /Tærækæmæ/).

Results: The final product of the musical movements and Azeri dance was build and presented within a 3D room in Unity game engine. The player could move around and get closer to the performers in order to watch the dance and musical movements from different angles along with hearing the real music (Perfomer danced with) syncing with the movements.

Conclusion: This interdisciplinary study provided an interface for Azeri dance and rhythmic melodies using digital technology. The study can be extended to any culture from any part of the earth as well as for entertainment, medical, rehabilitation, and educational purposes.

Keywords: Motion capture; Motion data; Computer game; Georeferencing; Musical movements

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Introduction

Humans, everywhere on earth, are subconsciously tied to culture and feel it inside themselves. Rhythmic movements are part of the culture of each geographic area that is passed down from one generation to another and no effort seems to have been made to identify, understand, and maintain them. In addition to everyday routines, humans also use movements for the rhythmic understanding of music. In fact, music can be understood by humans simultaneously both in terms of sound and movement (1,2). Jensenius believes that music is created from movement, albeit not only from the movements of sound waves, but the body movements of the performer are also involved (2). Investigating behaviors and body movements after hearing different melodies (3), using movement

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to produce rhythmic sounds for entertainment and inspiration (4), the extent to which musicians use body movements when playing a musical instrument and its effect on the music played (5), and extracting piano notes by recording the musician's movements through the camera (6) can be clear examples of combined study of music and movement. In this regard, studies have been conducted in the field of rhythmic movements that help to identify these movements during the performance (3). Various studies have been conducted on the use of rhythmic movements in improving the health of people with dementia (7), Parkinson's disease (PD) (8), and even the development of social and emotional abilities (9). Capturing motor data is important, especially in sports; for example, using the algorithms and templates provided in this approach, it was possible to examine the skill level of professional athletes (10).

Reviews of related lectures including journal, books and dissertation showed no similar study on Azeri dance and its movements using a motion capture device in the creation of melodic and rhythmic patterns. Most previous investigations have focused on simple body movements (11), ballet (12), rehabilitation movements (13), and musicians' movements (5,14). In Germany, researchers designed an interactive system for a wide range of users with different abilities - with special mental and physical conditions - for entertainment and therapy (4). This software is easy to use and considering the 3 modes of room, wheelchair, and bed, almost everyone can use it to use it. Using a video motion tracking technique, the device detects motion and sends data to audio production software, converting the person's movements into audio in real-time. Of course, a similar example has been provided in Slovakia for the preservation of culture and education (15).

The idea of this study includes three steps: 1) feasibility of identifying and maintaining rhythmic movements in cultural-climatic contexts, 2) trying to turn these movements into melodic and rhythmic patterns, and 3) applying videogame frameworks for purposes such as motivation, entertainment, and training. Additionally, two main characteristics were considered as innovations. First, the use of Azeri rhythmic movements to capture movement data that no similar study was found in this field, and second, the use of these rhythmic and musical movements in the design of melodic and rhythmic patterns, which was the main innovation of this study, and in the second stage, the performance will be presented by the authors to the general public and the scientific community in the future studies. Therefore, the present study is carried out to record Azeri rhythmic movements and use it in the creation of melodic and rhythmic patterns with the possibility of real time analysis of rotational angles of the limbs.

Materials and Methods

The present project was conducted in the Motion Capture Laboratory, Faculty of Multimedia, Tabriz Islamic Art University, Tabriz, Iran. The first data of Azeri rhythmic movements were captured and analyzed by the authors in February 2019 using the Perception Neuron device. To improve the motion data capture process, this process was repeated several times during the year and the last output that is under investigation for the second phase of the study was recorded in February 2020.

Azeri dance: The data of the desired rhythmic movements in this study belong to the northwestern regions of Iran or Azerbaijan, called Azeri dance. The rhythm of the Azeri dance movements and the power and speed of its performance has long been considered by the people and is considered as a kind of martial dance (16,17). These movements can be performed based on "arrangement by master" or "impromptu". These movements are thought to have taken on meaning from long ago; As for each social activity, a kind of dance was performed with rhythmic movements and a certain melody, with the selected names containing special meanings (18); for instance, the "Xan Çoban" dance which is an example of Azerbaijani folk dances belonging to a tribe that was engaged in shepherding and animal husbandry. These movements are a reflection of a shepherd's daily work, and an old example of these movements has been uploaded by the Media Center of Khazar University, Baku, Azerbaijan, on YouTube (19).

Moreover, the "Cəngi" dance is performed with a sword and a shield, the movements of which represent a kind of battle scene (16,18), but unfortunately, some of the movements of these dances are completely forgotten (taken from interviews with experienced performers of Azeri dance who have reached the stage of coaching).

However, in most cases, the type of movement of men is similar to that of an eagle (in Azeri: Qartal), and when men perform it, they move their chest forward and straighten their shoulders, and with these movements, they try to express courage, strength, balance, firmness, and freedom. Unlike men, women perform more subtle movements that indicate their softness and tenderness, and a symbol called a dove (Azeri: Göyərçin) has been introduced for it. On the other hand, the rhythm of performing the movements

depends on the rhythm of its music, and this makes the performance of movements by men more intense and faster (18).

Introduction of motion capture device and its special software: Motion capture can be employed in health, entertainment, sports, and art projects. There are various devices for recording and collecting motion data, such as Vicon, Shadow, Qualisys, and Perception Neuron.

In this study, due to the lack of data on Azeri rhythmic movements in the previous databases, it was necessary to collect primary data. First, a simpler device, i.e. the Perception Neuron (Perception Neuron V1.0 Motion Capture System, Noitom Ltd., Miami, Florida, USA) was utilized (Figure 1), which is among the wearable systems from the non-optoelectronics classification (20).

Figure 1. Items of the motion capture device, along with a power bank and a router used in the study

After the first step, the Vicon device will be used in the second step, which is a more advanced version of motion capture devices with infrared cameras. The Perception Neuron device is a prototype of its kind, which has a total of 33 neuron positions, and its items include the hub or switch as the main core, 32 neurons placed in boxes made of special alloy and resistant to electricity and magnetism, 9 main neuron positions that can be connected with an elastic strap and 2 additional positions, an additional piece of interface wire to connect additional positions, a wearable vest containing 6 embedded neuron positions, three pairs of gloves (the first pair without a neuron position, the second pair each with two neuron positions, and the third pair each with 9 neuron positions), a piece of interface wire to connect to a computer, a piece of interface wire to receive input current from the power bank, a piece of wire to calibrate neurons, bags for storing items, and a portable protective case. Figure 1 demonstrates the motion capture device items, along with the power bank and router used in this experiment.

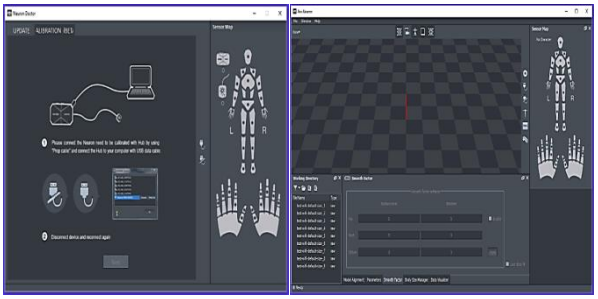

Figure 2. AXIS Neuron program environment (right), neuron calibration section in Dr. Neuron program (left)

The software of the device, called AXIS Neuron (AXIS Neuron 3.5.24.2740 Stable) has been provided by the manufacturer of the device and is available on its official website which can be easily downloaded and installed. The version used in this experiment, when installed on a computer, provides the user with two software; the main software called AXIS Neuron (Figure 2, the right hand picture), and the secondary software called Neuron Doctor for calibrating neurons (Figure 2, the left hand picture); Of course, the secondary software was previously part of the main software.

Initial preparation and connection method: First, the device was placed in an isolated environment, preferably in the laboratory environment. No one near the device was allowed to carry metal items or objects with electricity and magnets, cell phones, wired mice, and wired keyboards. The device had to be as far away from the power supply as possible. Furthermore, it was better for the person to whom the device is connected to wear a cotton garment to prevent the generation of static electricity. The vest was then put on by the individual, and after tightening the vest straps, the exact position of the neurons was corrected.

The arm and thigh positions were located in the same direction on either side of the body and could be placed higher or lower depending on the size and physical proportions of the person, but the knee neurons were located below the knee and on the tibia; However, in a study conducted in Hong Kong, the knee positions were moved above the knee, contrary to the device instructions (21). This is thought to be performed based on the need to improve calculations and reduce limb error, but in the present study, the position of the knee neurons was located exactly below the knee.

There are three general ways to connect a neuron perception device to a computer. The first method, or wired and online connection, is used for the device recognition by the computer. In the first method, the

person to whom the device is connected is placed near the computer and connected to the computer and AXIS software via a hub using an interface wire approximately 1 meter long. In the second method, by removing the interface wire and replacing a power bank that is placed in the pocket and a router, the connection to the computer is established wirelessly. In the third method, the device does not actually connect to the system, but offline and independently, with the help of a power bank that is placed in the pocket and a Secure Digital (SD) memory card can perform data collection. Of course, the important point is that the existing device could not use the third method because it was the first version. For a better understanding, the advantages and disadvantages of all three methods are presented in table 1. In the present study, the second method, "wireless and online", was selected to collect motion data.

Motion data capturing process and how to improve it: After connecting the motion capture system, a preliminary mapping of the position of the detected sensors to the three-dimensional model is performed by the software. In some cases, some neurons may have problems. Additionally, some may not be detected, in which case the program will send a warning message. To solve such problems and improve the data capture process, a step-by-step solution is provided for the device, which can be seen in figure 3.

One of the weaknesses of this device was the lack of a debugging system. Figure 3 shows a flowchart of how to deal with this problem. To ensure the recognition of all neurons, the way the light-emitting diodes (LEDs) flashed on the neurons was examined to see if they were in the "working" or "standby" state. On the right side of the AXIS program was a sensor map (Figure 2 on the right) by checking which the status of neurons was examined. The green and yellow indicated the best and moderate states for each neuron, respectively, and defective neurons lit up red, and unrecognized neurons were displayed as off. In the case of the off and red light for the neurons, the troubleshooting steps were performed as shown in figure 3. During the process, there was a step called "20Hz and standby mode" that required the rate of LED flashing on the neuron to detect. For this purpose, the table embedded in the AXIS program was used in the help section or its image in the digital manual of the device.

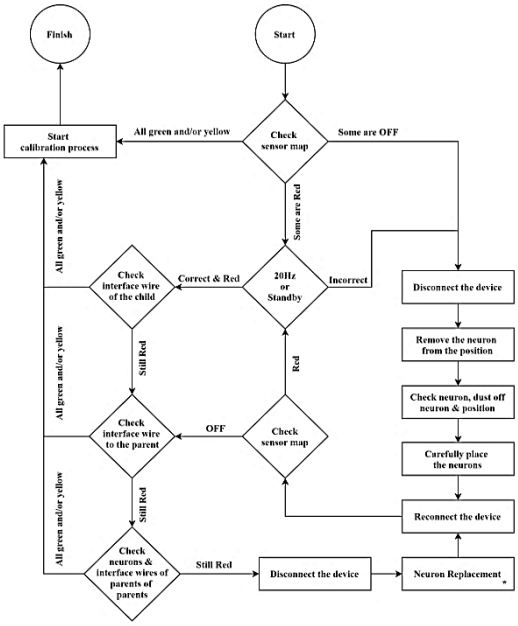

Figure 3. How to solve the problem of connection and failure to recognize neurons until reaching the calibration stage

Table 1. Comparison of connection methods of the motion capture device

Method	Items	Advantages	Disadvantages
First	Interface wire	Fast and easy connection Ability to see in real-time on the computer while performing	Restrictions on movement and the inability to rotate and run
Second	Power bank Router	Range of motion and the ability to rotate and run Ability to see in real-time on the computer while performing	Need to a power bank to supply power to neurons and hubs Need to router configuration
Third	Power bank Memory card	Range of motion and the ability to rotate and run	Need to a power bank to supply power to neurons and hubs Possibility of error due to the impossibility of real-time observation while performing movements

To perform the troubleshooting steps, all neurons were labeled and their location was determined, which was placed in a list next to the device in the laboratory. This helped researchers diagnose errors in the device and showed which neurons and which positions were defective. The path described in this process was necessary to reach the calibration stage and to capture the data with high quality. Also, in the neuron switching step [symbol (*) in figure 3], if the desired result could not be achieved by switching neurons, the neuron position was replaced by one of the additional positions mentioned in the device introduction section. The noteworthy point was that the two additional positions could only be used for the arms, thighs, legs, and feet.

After solving the problems and before starting the calibration step, the body size of the person was selected (after accurate measurements, the desired specifications could be recorded in the system). After the calibration step, the performer was asked to move all the joints of her body one by one so that if there was a problem with the mapping to the model, it could be fixed before recording the data. Then, the data capture process was performed.

In Azeri dance, men's dance has a faster speed and is performed more powerfully. This causes the neurons to move and get out of calibration during the capture process. To solve the problem, these movements will be recorded in the second stage of the study with a more powerful device called Vicon, but the main challenge of the present study was the lack of a system for error detection that was compensated using the steps specified in figure 3 and by trial and error methods.

The data were captured based on the performance of Azeri dance for Azeri folk music as "Tərəkəmə" (Latin pronunciation: /Tærækæmæ/), which was performed by a female performer as "referenced professional performance". The tempo of this music was relatively slow, and it was in 6/8 meter, and the default mode of the AXIS software with a height of 165-170 cm was selected to perform the data capture process, based on the height and body proportions of the performer.

Results

After calibrating the system, the motion capture began and was repeated several times. Finally, data from the body movements of performance of an Azeri folk dancer were captured using the motion capture system and is currently under study for implementation in the second and third stages of the study. Several different postures of the performer are depicted in figure 4.

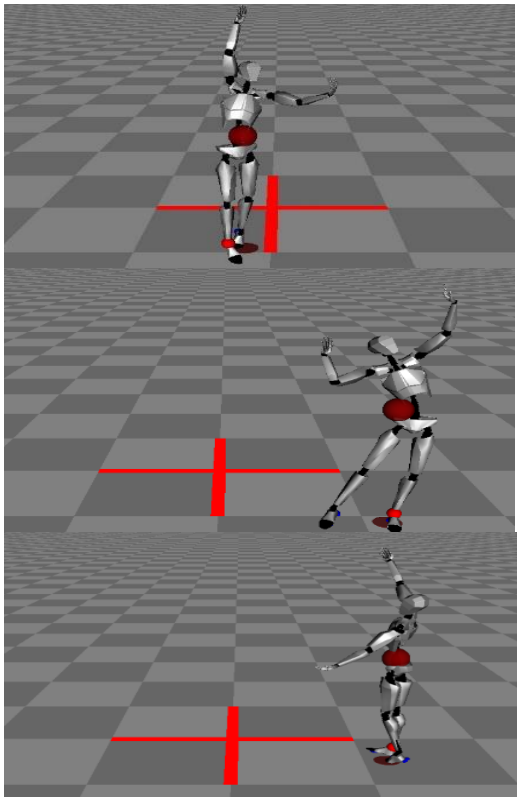

Figure 4. Images of the data captured by the motion capture device in the AXIS environment

Then, the data obtained were analyzed and the best ones were transferred to the Unity game engine environment version 2017 (Unity 2017.2.0f3, Unity Technologies, San Francisco, United States) in FBX format to get the output of the first phase of the project. Furthermore, the two models were utilized to map motion data, one of which was related to the AXIS program avatar and the other was downloaded for free from the Mixamo site (https://www.mixamo.com/). After reviewing the obtained motion data, a suitable output was prepared to run in the Unity game engine and the final settings were applied to adjust the data on the model. The final output was created as an executable file according to figure 5; so that the person is placed in a three-dimensional virtual environment and can move like in a computer game in the environment and closely observe and examine how rhythmic movements are performed on the three-dimensional model, besides, he can hear the music with which the rhythmic movements are performed, which are synchronized with the model movements. This file was intended to run on the Windows operating system. Moreover, its video output is available for

public viewing on the author's channel on YouTube (https://youtu.be/kku8vt5apvw).

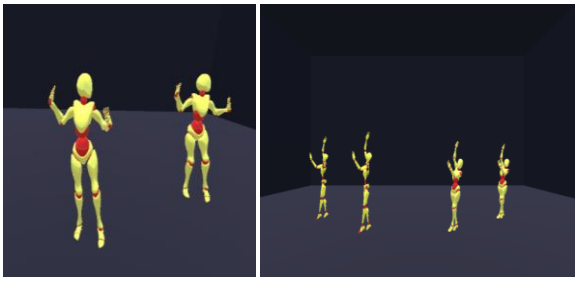

Figure 5. Output environment and mobility in the environment

Discussion

The present investigation was aimed at converting Azeri musical and rhythmic movements to melodic and rhythmic patterns. This study was defined in three stages. The present report was the implementation of the first stage to capture the rhythmic movement of Azeri dance and identify its components. At this stage, a program containing Azeri rhythmic movements was prepared for the Tərəkəmə music piece, which can be run in the Windows operating system environment and allows the user to be as close as possible to each of the performers in the three-dimensional space and observe their rhythmically aligned movements with the background music from different angles. It is hoped that in the second phase of the study, the appropriate output will be provided for most of the popular operating systems. Additionally, for the third stage and the educational aspect of the study, the involvement of virtual reality (VR) can be considered to improve the interactive education.

This study was conducted for the first time in Iran for Azeri dance. Moreover, studies have shown that a similar study has not been conducted worldwide to record and report the traditional-climatic rhythmic movements of Azeri dance in the creation of melodic and rhythmic patterns. However, in a similar sample to preserve and teach Slovak Folk Dances (15), a three-dimensional environment was designed for displaying four dances and its training has been compared to training via video recordings, with the results indicating a slight improvement in the learning process.

Although capturing movements in various sports (10,22,23), rehabilitation studies (13,24), and physical disorders such as gait (25,26) is a widely used approach in today's world, music is also a broad, exciting, and highly valuable issue in areas such as dance therapy (7-9,27) and rehabilitation (24,28,29). These two important issues were considered together in the present study. The motion capture subject was investigated in the first stage (present study) and data sonification for these recorded movements will be used in the second stage and in the creation of melodic and rhythmic patterns.

In most cases, the ultimate goal is to motivate and facilitate patients' rehabilitation, earn more money, or avoid wasting individual or large expenses. In the present study, for the first time in Iran, the issue of capturing movement was considered from an artistic-cultural perspective and it was employed to preserve a national heritage and extend it to future generations. The fact is that technology and all human achievements aim to turn the process of life into a more enjoyable and beautiful way, and art as a manifestation of this beauty, cannot be unaffected by the advancement of technology. In the present study, a groundwork was provided for the user to be able to observe the delicate and skillful movements of Azeri dance in three dimensions and from any desired angle, think about it, and imitate it in a self-learning way, an opportunity that may not be easily available to modern man in today's busy life.

In this study, the first steps were taken to revive and preserve a part of Azeri culture and traditions that can be developed in different parts of Iran or even the world. Also, the ability to collect motion data and provide a motion database can be useful for researchers in the fields of medicine, psychotherapy, rehabilitation, music, video games, and entertainment.

Limitations

The present study was only a report on the implementation of the first phase of the research project on recording rhythmic movements in Azeri dance and did not include information on the second and third phases. In the second phase, the obtained data will be studied and then, using this data, the creation of melodic and rhythmic patterns will be performed. In the third phase, the game framework such as defining game levels, applying educational dimensions, determining the scale to check the player's progress, and also comparing the skills of the two players will be applied.

Recommendations

According to the findings of the present study and experimental work with the Neuron Perception motion capture device, it is suggested that in future studies a system or algorithm be designed to optimize the motion data obtained by improving the animation Key Frame keys, reducing file loads, and automatically

detecting and correcting motion defects. This system can also be used for research and entertainment purposes by designing and developing VR games using VR headsets and motion capture gloves. Furthermore, a comprehensive and statistical study to record the physical proportions of Iranians and different ethnicities for use in the calculation of motor data to evaluate changes due to various diseases or incorrect motor and walking habits will be useful.

To develop the present research project, the final findings of this process will be applied to a larger process such as "impromptu" data. Moreover, by creating a statistical community with an appropriate number and statistical tests, users' reactions can be analyzed in different ways. Finally, a location-based database of all cultures in different parts of the world will be created, which is a kind of cultural map, and in addition to containing a cultural layer for different parts of the world, it can identify a layer of different diseases and include medical data of people in different parts of the world.

Conclusion

This interdisciplinary study provided a ground for Azeri dance art and rhythmic and melodic creations with the help of computer technology. This research project can be effective in studying dances and body movements and collecting data from various regions not only in Iranian culture but also in every other cultures, and can also be used for entertainment, treatment, rehabilitation, and education purposes.

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Authors' Contribution

Afsaneh Yadaei: Study design and ideation, study support, executive, and scientific services, providing study samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Mohammad Reza Azadehfar: Study design and ideation, study support, executive, and scientific services, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Behnam Alizadehashrafi: study support, executive, and scientific services, providing study equipment, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest. Dr. Behnam Alizadehashrafi is an assistant professor and faculty member at the Faculty of Multimedia, Tabriz Islamic Art University and Dr. Mohammad Reza Azadehfar is a full professor and faculty member at Tehran University of Arts, Tehran, Iran. Afsaneh Yadaei has been a master student of Computer Arts, Computer Games Production since 2017 at the Faculty of Multimedia, Tabriz Islamic Art University.

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