BalletVR: a Virtual Reality System for Ballet Arm Positions Training

Ricardo R. Barioni
Voxar Labs, Centro de Informática
Universidade Federal de Pernambuco
Recife, Brazil
rrb@cin.ufpe.br

Willams Costa
Voxar Labs, Centro de Informática
Universidade Federal de Pernambuco
Recife, Brazil
wlc2@cin.ufpe.br

Alessandra Aleluia
Mustic, Centro de Informática
Universidade Federal de Pernambuco
Recife, Brazil
aaa6@cin.ufpe.br

Veronica Teichrieb
Voxar Labs, Centro de Informática
Universidade Federal de Pernambuco
Recife, Brazil
vt@cin.ufpe.br

***Abstract*—In a ballet studio, the teacher plays an important role in the process of learning positions and movements. However, there are occasions where the student needs to practice while the teacher is unavailable. In this situation, the student has no orientation and is likely to create bad habits during training, which may lead to worse results than before. In this work, we present the BalletVR, a Virtual Reality Kinect-based application for guiding ballet dancers through the practice of basic ballet arm positions. The results show our system's potential to be used by students as an alternative for autonomous ballet basic positions training.**

***Index Terms*—Virtual reality, Human computer interaction, Graphical user interfaces, Application software**

I. Introduction

In the context of ballet performing and dancing, there is a habit from dancers to practice their ballet steps and positions by themselves, since that ballet teaching is not available most of the time. However, there are several issues to this approach: dancers are likely to bad habits, like arms positioning and postural correctness, which may lead to worse results than before. Not only that, self-guidance may lead to higher chances of getting injured [1].

Many ballet dancers address this problem by watching videos of other people performing and try to repeat their movements and positions. However, this approach does not give to the practitioner any information about the correctness of their movements, neither gives any feedback on how to fix them. Not only that, it is very important for a ballet performer to have self corporal awareness; considering that, it is critical to give visual feedback at all times, in order to strengthen the memorization of the positions and steps to be performed.

In parallel to that, the emergence of low cost motion capture technologies brings the opportunity to explore pose analysis in different scenarios; from teaching how to play a musical instrument [2] to physiotherapy rehabilitation [3] [4] [5] [6] [7], motion capture has shown its potential to create systems that not only guide users through their process but also provide coherent and convenient feedback. There are several accessible high-end RGB-D sensors like the Microsoft Kinect, Intel RealSense and Orbbec Astra which provide human pose estimation in real-time, and can be used in interactive applications.

With respect to the set of applications that are possible to be conceived by using motion capture information, Virtual Reality (VR) emerged as a great option for conceiving interactive immersive environments and is an effective method for giving feedback about ballet positions guidance on the fly [8].

In this paper, we present the BalletVR: a VR system for guiding ballet dancers through learning and practicing positions. We focused on guiding basic arm positions, proposed by École Française, which consists of five basic positions (first, second, third, fourth and fifth), which can be visualized in Figure 1. In our system, we also present gamification features, in order to make the process of training more engaging, challenging and motivating [9] [3].

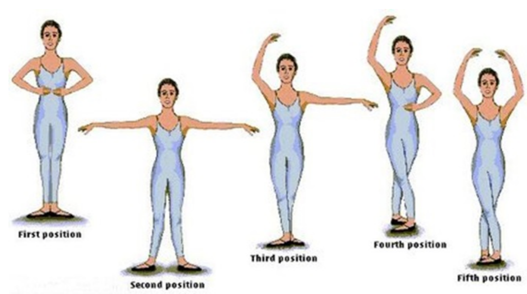

Fig. 1. Basic ballet positions, proposed by École Française.

This paper is structured as follows: first, we present state-of-the-art methods and works for analyzing ballet positions and movements, applications for providing guidance of these activities, as well as general technologies for human pose estimation and tracking, which can be applied in contexts regarding activities. Second, we describe BalletVR, its fea-

978-1-7281-5434-3/19/$31.00 ©2019 IEEE
DOI 10.1109/SVR.2019.00018

tures, and approach for the position analysis. Third, we provide details about the evaluation of the system with potential users, followed by results and feedback/suggestions from users. At last, we conclude the study and provide future work directions.

II. Related Work

Recently, many research areas have been addressing the challenge to overcome technical issues regarding VR applications, like rendering, data visualization, natural interaction, and many others [3]. This work took a closer look in two research areas: the usage of human pose estimation in VR applications and the development of tools for guiding ballet dancers (or beginners) through learning ballet positions and movements correctly.

A. Pose Estimation

Many research works have been done to address the challenge to obtain human poses in real time. In recent years, some propose the usage of deep learning approaches to extract human pose information by only using RGB cameras content [10] [11] [12], which can be potentially used in many VR applications. However, these approaches still require the user to have high-performance computers, usually containing a Graphics Processing Unit (GPU), which are not commonly available and are expensive for common users. However, there are RGB-D cameras which can address this problem and can be used in many scenarios, like games , physiotherapy [3] [4] [5] [6] [7], home automation [13], tutoring systems and in movements assessment context [14] [9].

One of the most used off-the-shelf RGB-D sensors for these type of applications is the Microsoft Kinect; firstly, it was developed to be used in Xbox games. However, it is used in many different applications. The second version of Kinect is capable of providing 25 human body joints in the 3D space, for each human in its field of view. Not only that, it can provide the user with a depth map from the environment, where each pixel contains a value regarding its distance to the camera. Also, this sensor provides all this information at a rate of 30fps, which is acceptable for VR applications.

Considering that, [9] provides a system that allows users to record physical movement sequences and share them so that others can access and perform as well. Also, the system guides the user by using a series of stages, in which gradually follow the quality of the currently performed movements, and also by giving feedback on the fly. It is important to consider that its usage improved the learning of movements when compared to only providing a video demonstration of the movement.

In another context, [15] evaluated the usage of MS Kinect in the context of analyzing elderly users through performing a series of movements, and its results show that it is a potential low-cost hardware alternative which can be used in real time health applications.

Similar to the ballet dancing context, physiotherapy has some common aspects: both require repetitive training and it requires the assistance of a professional so that negative results are not achieved. [5] provides an Augmented Reality (AR) system to guide physiotherapy patients through the rehabilitation process, by focusing on biomechanical movements. Similarly, [3] also provides gamification features and feedback, so that the process of rehabilitation becomes engaging and motivating.

B. Ballet Dancing Analysis and Guidance

In parallel to that, many works have been using motion capture data to create systems that not only evaluate the performance of the ballet training/learning process, but also provide interactive visual feedback to the user. Therefore, the process of practicing positions and movements becomes more fluid and productive. One of the most important interactive visual feedback is self-body awareness, which enhances long-term motor skill retention and improves learning and memorization [16].

In the context of recognizing and evaluating movements, [1] provides a Support Vector Machine (SVM) algorithm for analyzing ballet positions. From an RGB video, it performs gray scaling and histogram equalization, followed by feature extraction, to achieve an accuracy of 59.6%. However, the computational cost of its whole pipeline is not mentioned, which does not clarify the possibility of its usage in real time applications.

[17] proposes an algorithm to recognize the 17 fundamental ballet poses from a single image. In order to do that, it performs skin color segmentation, followed by a Skeletonization algorithm, obtaining geometric representations of human poses and achieving an accuracy of 88.9%. However, this method is limited by the content of the image (i.e. the dress the user is wearing), and also depends on the relative position of the dancer to the camera. Similar to [17], [18] proposes a method for recognizing 20 basic ballet postures, which also performs skin color segmentation followed by Skeletonization, and adds a Radon transform to achieve an overall accuracy of 91.35%. However, [18] may not be used in interactive applications, since its execution lasts approximately 2.6s per image.

Not only algorithms for ballet position classification are explored; there are several applications which aim to guide ballet dancers through the training process interactively. In [19], it was proposed the Super Mirror: a VR ballet system whose focus is to provide real-time instructional feedback; it proposes visual skeleton feedback, where the user can visualize the pose to be achieved and how well is the current performance. As it uses the Kinect for human pose estimation, this method only uses body angle data to evaluate the current position.

[8] proposes a system for assessing the learning of ballet movements in a VR environment. Focusing on immersion, it instructs and evaluates the performance of the dancer by using 3D visualizations and gives feedback by using a Cave Automatic Virtual Environment (CAVE). It also uses the MS Kinect in order to abstract the acquisition of human pose data in real-time.

III. Development

A. Application

The BalletVR mainly consists of a system whose main purpose is to guide ballet dancers through learning basic ballet positions. The option to conceive it as a VR approach is that, since self corporal awareness has a key role in this process, we can provide the user with direct visual feedback in an immersive way. In order to do that, we use a human avatar as a representation of the user, who follows the movements of the user, in a mirrored fashion (Figure 2, center). Also, in the bottom right of the game window, users can also have a glance of their body configuration with a chroma key-like information.

In the ballet context, the sequence of positions to be performed is essential, since it gives fluidity and connection between different positions. In parallel to that, gamification features are encouraged to be applied in training systems, since they leverage the motivation and engagement of the user when using the system [9]. In order to do that, we developed a level-based system, where each basic position is a level, and the user progresses levels when positions are performed correctly. As there are five basic positions (and the third and fourth positions have left and right configurations), the BalletVR contains a total of 7 levels. The information of the current level is shown at the top right of the screen (Figure 2, top-right); each circle represents a level, and their colors represent when a level is not already accomplished (white) or already completed (green).

When it comes to feedback context, there are three main features, whose main purposes are two: guide users when they are confused (or not achieving the desired goal) and indicate users when they are doing the assigned task correctly. The first feedback feature is the text feedback: on the top left of the screen, there is a text indicating the user which ballet position is to be performed at that moment. This feedback is shown all the time (Figure 2, top-left).

Fig. 2. The scenario that is shown to the user. **Top-left**: text feedback of the position to be performed. **Center**: human avatar that represents the user. **Top-right**: information about the current and next levels. **Bottom-right**: chroma key-like body feedback.

It is recommended that the practitioner holds the position for a certain period of time. For that, the second main feedback is the clock feedback: when the user is performing the assigned position, a clock appears on the screen, which performs a countdown, inducing the user to hold the position until the countdown is over. Not only the amount of remaining seconds to end the countdown is shown inside the clock, but also a green pie-like progress bar is completed around the clock until it performs a complete lap (Figure 3). In BalletVR, the clock is set to count for ten seconds.

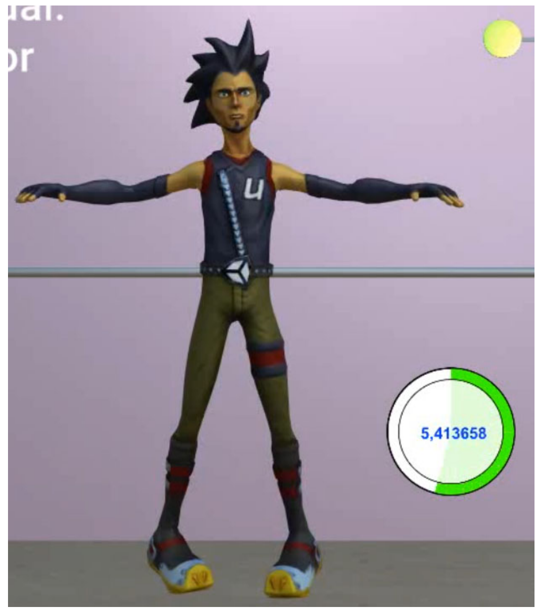

Fig. 3. Clock feedback that is shown to the user when the current position is correct.

The third feedback refers to the importance of ballet dancers to memorize which are the ballet positions. However, in some cases, the dancer may not remember the position and get stuck. In order to solve that, a "ghost avatar" feedback is given to the user: a transparent avatar overlaps the user's avatar, and its position is set to the desired position to be performed. With that, the user is induced to remember what is the position's body configuration. In our system, this feedback is shown only when the user does not remember the position for twenty seconds (Figure 4).

In order to fit all feedbacks together with a ballet position level, a flow was conceived (Figure 5), containing 3 states:

- **State 1**: the initial state, where the user has just started to attempt performing the current position. If the user does not perform the correct position within twenty seconds, the user is directed to State 2. However, if the user "hits" the correct assigned position, the user is directed to State 3;
- **State 2**: this state starts when the user could not perform the correct position. In this case, the "ghost avatar" feedback is triggered. If, at any moment, the correct position is "hit", the user is also directed to State 3;

Fig. 4. Ghost avatar feedback that is shown to the user (transparent).

- **State 3**: this state starts when the user is currently performing the correct position, and the clock feedback is shown. If within the ten seconds countdown, a position misperformance occurs, the clock is reset, the user is directed to State 1 and directed to perform the position again. However, if the position is performed correctly for ten seconds, the system identifies that the user performed the position, and is directed to the next position level.

B. Position Analysis

In order to analyze if the pose that is performed by the user is correct, we developed a frame-wise pose manager that compares the user's pose with the ground-truth. Using the MS Kinect Software Development Kit (SDK), we obtain the user's skeleton normalized accordingly to the body's proportions.

The user's pose is used by the application by applying a technique called rigging, which is responsible for connecting each body part that is tracked by the MS Kinect to its relative in the application. For each body part from the user that is tracked, its position and rotation are applied to the equivalent body part from the avatar. The result of this process is the avatar moving accordingly to the user.

Having the avatar rigged to the user's body parts, we can then use the avatar's position to calculate the position that is being performed by the user and compare it with the ghost avatar, which now also serves as a ground-truth for pose comparison. For this, we used an approach based on collisions since this approach is not consuming in terms of computational power. Given two objects with mass, a collision happens when they begin contact with each other, and a physics engine calculates the physical response to this action. In our application, we placed collision areas that serve to calculate contact. Since there is no mass in these areas, this contact is called a trigger instead of a collision.

Leveraging the ghost avatar that is already placed on the scene, we place colliders in each of the body parts that we want to use in the position comparison, and the ghost avatar

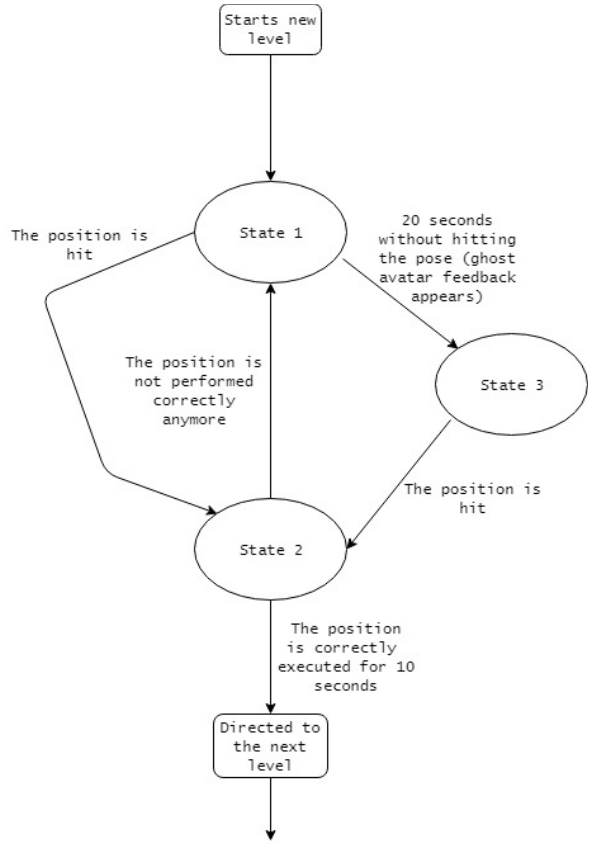

Fig. 5. The flow of a level (ballet position) in BalletVR.

serves as a ground-truth for position verification. The same process is made on the avatar that is rigged accordingly to the user's position.

The best parameters for the colliders were chosen upon testing during the development stage. The area for each collider needs to be chosen carefully since small values mean that the two positions need to be more precise, which can prejudice the experience due to the MS Kinect's noise. In Figure 6, we show the colliders that were placed on the user's avatar and the ghost avatar.

Due to MS Kinect's inconsistency in tracking the lower body parts, we check for position correctitude using only the arms' positions. For each frame, the position manager calculates if there are any collisions triggered by the contact zones. The system considers the pose to be correct when all of these contact zones have triggered collisions. This means that the avatar's pose is overlapping the ground-truth, so the pose is similar to the ground-truth.

IV. EVALUATION

In order to evaluate the quality of our system, a usability test was conducted. A total of 22 people took part in the evaluation, in which 12 were male and 10 were female. Also, 11 reported to have no ballet experience and 11 people have some ballet

Fig. 6. The colliders on the user's avatar and the ghost avatar.

experience. In this test group, the average age was about 24 years old.

The usability test was divided into two steps; first, the user was invited to freely use the system, until all five positions were performed. For that, we set up an environment, which can be seen in Figure 7. After that, the participant is asked to answer two sets of questions:

- A set of 6 subjective questions elaborated by the team;
- A set of 10 general objective usability questions.

Fig. 7. Setup of our evaluation environment. **(A)** The MS Kinect, pointed to the user; **(B)** The current evaluated user; **(C)** The monitor where the user can see the application; **(D)** A notebook where BalletVR is being executed, which also gives visual feedback to the evaluation conductor; **(E)** The evaluation conductor.

The first set of questions contemplates the experience the user had by using the system, and the participant was freely to speak about the positive and negative experienced aspects. The questions are listed as follows:

1) Was the ballet position to be executed clear?
2) Was the scenery pleasant?
3) When you perform a correct position, a countdown clock appears. Was this feedback interesting? Did you feel like you were progressing?
4) When you had difficulties in performing a position, a ghost avatar is shown. Did this avatar give you clarity about what is supposed to be done?
5) Did you learn how to perform the positions? If not, why?
6) Do you have any additional suggestions to the system?

In addition, the participant was asked to answer the System Usability Scale (SUS) [22], a well-known questionnaire which aims to evaluate the usability of systems in general (products, services, applications, websites) by contemplating three general aspects:

- Effectiveness, the success of users on reaching their goals;
- Efficiency, how much effort and resources were necessary;
- User satisfaction when using the system.

All SUS questions are answered with a 1 (Strongly Disagree) to 5 (Strongly Agree), and the final score for each participant varies from 0 to 100. The questionnaire is divided into 5 positive assertions and 5 negative assertions, presented in an alternating fashion. The list of questions is as follows:

1) I think that I would like to use this system frequently;
2) I found the system unnecessarily complex;
3) I thought the system was easy to use;
4) I think that I would need the support of a technical person to be able to use this system;
5) I found the various functions in this system were well integrated;
6) I thought there was too much inconsistency in this system;
7) I would imagine that most people would learn to use this system very quickly;
8) I found the system very cumbersome to use;
9) I felt very confident using the system;
10) I needed to learn a lot of things before I could get going with this system.

V. Discussion

In order to analyze our results on the SUS questionnaire, we calculated the final score for each participant by considering the existence of people with (and without) ballet experience. So, three SUS scores were calculated, and can be seen in Table I:

- SUS results considering all participants;
- SUS results considering only participants with no previous ballet experience;
- SUS results considering only participants with previous ballet experience.

As shown in Table I, most of the users felt that the system is not complex at all (second question), however the first SUS question points that some users would not use this system with frequency. This highlights the existence of non-ballet

TABLE I
BALLETVR RESULTS ON SUS, SEPARATED BY QUESTION.

SUS Question	BalletVR (all users)	BalletVR (non-experienced users)	BalletVR (experienced users)
Q1	72.72	63.63	81.81
Q2	96.59	95.45	97.72
Q3	84.09	81.81	86.36
Q4	77.27	77.27	77.27
Q5	84.09	77.27	90.90
Q6	93.18	88.63	97.72
Q7	90.90	86.36	95.45
Q8	85.22	86.36	84.09
Q9	77.27	68.18	86.36
Q10	82.95	72.72	93.18
SUS Result	**84.43**	**79.77**	**89.09**

participants on the test who do not have an interest in performing ballet. On the other side, experienced ballet dancers point that most users would learn how to use the system with ease (third question) and that incoming ballet students would quickly engage with the system (seventh question). Although results were similar, non-experienced users that the system was less cumbersome to use, when compared to experienced users (eighth question). The final BalletVR SUS score for non-experienced users was 79.77, which is considered good (grade ”B”), while the SUS score for experienced users was 89.09, which is considered excellent (grade ”A”). The average score of the systems evaluated with SUS is 68.

We also compare our results with the Super Mirror [19]; a study [20] proposed the evaluation of this system, and its SUS results presented a score of 57 for students and 42.5 for evaluated teachers. As it can be seen in Table II, the BalletVR outperforms Super Mirror on SUS.

TABLE II
SUS QUESTIONNAIRE RESULTS FOR BALLETVR SYSTEM. OUR SYSTEM SURPASSES SUPER MIRROR USABILITY TEST ON SUS.

System	SUS Score
Super Mirror (teachers) [20]	42.5
Super Mirror (students) [20]	57
BalletVR (all users)	84.43
BalletVR (non-experienced users)	79.77
BalletVR (experienced users)	89.09

In respect to the interview containing the open questions, most of the participants understood which ballet position was intended to be performed. In some cases, users without previous ballet experience only were successful in performing positions when the ghost avatar feedback was shown. For some experienced ballet dancers, the name of the position to be performed (shown in the interface) was confusing; arm positions were shown as ”superior positions”, which is not the correct nomenclature. In respect to the user avatar, some of the users felt confused about its mirroring.

When asked about the scenery contents, most of the users were neutral and did not feel bothered about it. However, some of the participants reported that the scene looked slightly dark, and the user avatar did not agree with the environment. On the other side, some said that the scenario was pleasing and delicate.

When it comes to the clock feedback, most of the people felt that they were doing the asserted tasks correctly. Not only that, users reported that they were gradually converging to performing the correct positions. In the other side, some reported that the chronometer inside had too many decimal places, and should contain fewer numbers.

In respect to the efficiency of the ghost avatar feedback, most reported that it had a very important role in remembering which position was to be executed. In some cases, participants felt confused when the ghost avatar feedback was overlapping the user avatar, and the upper limbs depth were unclear.

When asked about the success of learning the ballet positions, all non-experienced ballet users reported that they could learn the proposed ballet positions by using BalletVR with more frequency. Not only that, a ballet teacher (one of the ballet experts participants) said that, by using the system and having awareness of what ballet position is to be performed, potential ballet students would certainly learn how to perform those positions.

Finally, when users were asked to give general suggestions to the system, most of them pointed out that a background classical music would fit with the scenario. Not only that, the ballet teacher participant pointed out that, when the ballet dancers are listening to classical music, their postural configuration improves.

Other general feedback is related to the user avatar; users point that there should be a male/female selection. In respect to the ghost avatar feedback, users reported that it should be positioned beside the user avatar, in order to avoid the overlapping between the avatars. Also, an experienced ballet dancer reported that there should be a position visual briefing before the practicing so that the user is aware of what position is to be performed without having to wait for feedback from the system.

VI. CONCLUSION

We have presented BalletVR, a system for guiding ballet dancers through learning basic ballet positions. As a VR system, our work provides the user the corporal self-awareness while practicing the positions, at all times. BalletVR also provides real-time feedback when the user is performing correctly and aims to guide the user when he/she is not executing the positions as desired. We applied game-like features to our system, in order to make the learning/practice experience more pleasant, engaging and motivating. At last, we performed an evaluation of the system with its potential users, which include people with and without ballet experience, so that we could obtain feedback and use it for improving our system. As a limitation, we focused only on guiding arm positions, once the MS Kinect tracking was not satisfactory for tracking basic leg ballet positions.

As further improvements, we shall analyze and apply the suggested features and corrections received from the evaluated users, as well as continue to investigate the feasibility of performing ballet leg positions analysis. At last, we aim to invest efforts on integrating our SVM-based position analysis algorithm, in order to improve the position analysis algorithm of our application.

ACKNOWLEDGMENT

The authors would like to thank Arlindo Gomes for helping with the design and Maria Euzebio for the support related to the equipment used in the project. The authors also would like to acknowledge the availability of all people who took part in the evaluation and provided important feedback for the system.

REFERENCES

[1] M. Fourie, and D. van der Haar. "Ballet Pose Recognition: A Bag-of-Words Support Vector Machine Model for the Dance Training Environment." International Conference on Information Science and Applications. Springer, Singapore, 2018: 317-325.

[2] K. C. Ng, et al. "3d augmented mirror: a multimodal interface for string instrument learning and teaching with gesture support." Proceedings of the 9th international conference on Multimodal interfaces. ACM, 2007.

[3] R. R. Barioni, et al. "ARkanoidAR: An Augmented Reality System to Guide Biomechanical Movements at Sagittal Plane." 2017 19th Symposium on Virtual and Augmented Reality (SVR). IEEE, 2017.

[4] A. Da Gama, et al. "Ikapp-A rehabilitation support system using Kinect." Proceedings of the 14th Symposium on Virtual and Augmented Reality. 2012.

[5] A. Da Gama, et al. "MirrARbilitation: A clinically-related gesture recognition interactive tool for an AR rehabilitation system." Computer methods and programs in biomedicine 135 (2016): 105-114.

[6] A. Da Gama, et al. "Guidance and movement correction based on therapeutics movements for motor rehabilitation support systems." 2012 14th Symposium on Virtual and Augmented Reality. IEEE, 2012.

[7] Y. Chang, S. Chen, and J. Huang. "A Kinect-based system for physical rehabilitation: A pilot study for young adults with motor disabilities." Research in developmental disabilities 32.6 (2011): 2566-2570.

[8] M. Kyan, et al. "An approach to ballet dance training through ms kinect and visualization in a cave virtual reality environment." ACM Transactions on Intelligent Systems and Technology (TIST) 6.2 (2015): 23.

[9] F. Anderson, et al. "YouMove: enhancing movement training with an augmented reality mirror." Proceedings of the 26th annual ACM symposium on User interface software and technology. ACM, 2013.

[10] Z. Cao, et al. "Realtime multi-person 2d pose estimation using part affinity fields." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2017.

[11] A. Newell, K. Yang, and J. Deng. "Stacked hourglass networks for human pose estimation." European conference on computer vision. Springer, Cham, 2016.

[12] S. Wei, et al. "Convolutional pose machines." Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition. 2016.

[13] H. Thiruvengada, et al. "System for controlling home automation system using body movements." U.S. Patent Application No. 13/367,015.

[14] N. Villaroman, D. Rowe, and B. Swan. "Teaching natural user interaction using OpenNI and the Microsoft Kinect sensor." Proceedings of the 2011 conference on Information technology education. ACM, 2011.

[15] S. Obdržálek, et al. "Accuracy and robustness of Kinect pose estimation in the context of coaching of elderly population." 2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE, 2012.

[16] K. Dearborn, and R. Ross. "Dance learning and the mirror: comparison study of dance phrase learning with and without mirrors." Journal of Dance Education 6.4 (2006): 109-115.

[17] A. Banerjee, et al. "A novel approach to posture recognition of ballet dance." 2014 IEEE international conference on electronics, computing and communication technologies (CONECCT). IEEE, 2014.

[18] S. Saha, and A. Konar. "Topomorphological approach to automatic posture recognition in ballet dance." IET Image Processing 9.11 (2015): 1002-1011.

[19] Z. Marquardt, et al. "Super Mirror: a kinect interface for ballet dancers." CHI'12 Extended Abstracts on Human Factors in Computing Systems. ACM, 2012.

[20] M. Trajkova, and M. Ferati. "Usability evaluation of kinect-based system for ballet movements." International Conference of Design, User Experience, and Usability. Springer, Cham, 2015.

[21] R. Tang, et al. "Physio@ Home: Exploring visual guidance and feedback techniques for physiotherapy exercises." Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. ACM, 2015.

[22] J. Brooke. "SUS-A quick and dirty usability scale." Usability evaluation in industry 189.194 (1996): 4-7.