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An adaptive framework for the creation of exergames for intangible cultural heritage (ICH) education

A. Grammatikopoulou[1] · S. Laraba[2] · O. Sahbenderoglu[3] · K. Dimitropoulos[1] · S. Douka[4] · N. Grammalidis[1]

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Abstract As of the early twentieth century, a significant body of research has been published that shows how effective game-based learning and gamification techniques can be, compared to other methods. These technologies are also very important for the learning and transmission of intangible cultural heritage (ICH) creations, which include, among others, dance, theater, and other skills where body motion has a primary role. However, creating games can be time consuming and usually demands a significant effort. Therefore, this paper focuses on the design and development of a novel framework for the rapid design of body-motion-based customizable game-like applications. This framework consists of two components: (i) an interface that allows the user to design the game and capture the motion data, and (ii) a customizable game for learning and training using off-the-shelf motion-

✉ N. Grammalidis
ngramm@iti.gr

A. Grammatikopoulou
agramm@iti.gr

S. Laraba
sohaib.laraba@umons.ac.be

O. Sahbenderoglu
ozansahbenderoglu@gmail.com

K. Dimitropoulos
dimitrop@iti.gr

S. Douka
sdouka@phed.auth.gr

1 Information Technologies Institute, CERTH, Thessaloniki, Greece

2 FPMs/TCTS Lab, University of Mons/Numediart Institute, Mons, Belgium

3 Turkish Telecom, Istanbul, Turkey

4 Aristotle University of Thessaloniki, Thessaloniki, Greece

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capture sensors like the Microsoft Kinect. The game is automatically configured based on the output of the game design interface. In order to evaluate the proposed system, three pilot-use cases have been selected: (i) the Latin dance Salsa, (ii) the Greek traditional dance Tsamiko, and (iii) the Walloon (Belgian) traditional dance. Moreover, small-scaled experiments concerning the three different use cases were conducted, where both beginners and experts evaluated the game-like application for dance learning. Furthermore, a group of dance experts were asked to design and generate their own game and evaluate their experience. Results showed that the use of such a game-like application could be efficient, as positive feedback was obtained. In summary, participants found that the generated game-like application meets its objectives; it is generally efficient and satisfactory and offers a novel tool for ICH transmission and education. Last but not the least, the dance experts expressed their interest in developing more such games in the future, since they characterized the game design module as easy and intuitive to use.

Keywords Adaptive framework · Serious games · Exergames · Sensorimotor learning · Intangible cultural heritage education

Introduction

The interest in the use of game-based learning as learning resources for education and training has increased significantly in recent years. Serious gaming or applied gaming refers to games designed for a primary purpose other than pure entertainment (Djaouti et al. 2011). By combining gaming and learning, serious games, which exploit the latest simulation and visualization technologies and target populations, ranging from children to adults (Charlier et al. 2012), are gaining an ever-increasing interest in various domains, such as education, defense, healthcare, aviation, etc. Such games can achieve many types of educational outcomes supporting aspects that modern theories of education consider as central for effective learning. Specifically, studies have shown that modern digital games can promote extrinsic and intrinsic motivation (Garris et al. 2002), engage learners in order to invest effort and commitment in learning tasks (Susi et al. 2007) and support constructive, experiential, situated (Hainey et al. 2011), procedural (Graafland et al. 2012; Martínez-Durá et al. 2001), and self-regulated learning (Zap and Code 2009). Furthermore, it is also argued that serious games can achieve many types of educational outcomes, since, besides teaching effectively mere educational content, games provide the possibility of a variety of additional types of learning, such as: strategic thinking, a variety of cognitive skills, and kinesthetic learning (Boyan and Sherry 2011).

A special category of digital games employed in education are motion-gaming systems or motion-controlled gaming systems that allow players to interact with the game through body movements. Studies have shown that body-motion-based games can have a variety of benefits for the players and are increasingly applied in physical therapy, motor skills teaching, rehabilitation, and prevention for older adults (Boyan and Sherry 2011). During the last decade, the availability of affordable motion-capture sensors (Kinect, Wii, leap motion, etc.) have contributed to the growing interest in designing and developing such games for different disciplines. Gerling et al. (2012) conducted two studies aimed at developing game design guidelines for full-body motion controls for older adults experiencing age-related changes and impairments. Their research outcomes showed how full-body-motion-controlled games can support a variety of users' abilities and have a positive effect on mood and emotional well-being of older adults. In addition, Gao and Mandryk (2012) proved through two studies that motion-based games can improve both the physical and cognitive health of their players. Furthermore, Kourakli et al. (2017) used Kinect motion-based games to achieve positive impact on children's academic performance and improvement of their cognitive, motor and academic skills. In addition, Jenny et al. (2017) presented results proving that motion-based games enable students to perform physical activity and develop their cognitive knowledge, being most beneficial for beginners who are experiencing a sport for the first time as basic sport concepts and skills can be introduced through video gaming.

Taking into consideration all the above studies, it is understandable that serious games can effectively support sensorimotor learning. However, while the process of designing and developing serious educational games can be a creative and positive experience, creating games can also be a time consuming, skill demanding and frustrating experience. Specifically, Kanode and Haddad (2009) present a number of challenges that a game development team is more likely to confront, such as: a poorly established project scope (estimation of the time and resources needed to bring the project to a successful conclusion), the growing need of diverse assets and resources, the overarching phases of game development (preproduction, production, and testing) and issues to deal with when selecting third party technologies.

Therefore, in order to facilitate the game design and creation process of sensorimotor learning games, we propose in this paper the development of a novel framework, which is based on Unity 3D engine[1] and provides an easy and rapid way to design and develop simple serious body motion-based game-like applications (Exergames). Specifically, the Unity 3D platform offers many advantages: it has a free version, it's easy to learn and use and it has a supporting support community. In addition, a Kinect plugin for Unity is offered that allows game developers to add motion controls to their games or simulations with great ease.

The proposed framework was designed and developed within the framework of the project, i-Treasures (Alivizatou-Barakou et al. 2017; Dimitropoulos et al. 2014, 2018), whose main goal was to develop an open and extendable platform to provide access to intangible cultural heritage (ICH) resources, enable knowledge exchange between researchers and contribute to the transmission of rare know-how from Living Human Treasures to apprentices. To this end, the design and implementation of an adaptive game development framework aimed to provide a tool for ICH experts, which would facilitate the production of ICH body motion-based games and support safeguarding and transmission of ICH through a novel ICT-based methodology for ICH capture and analysis in domains where human motion is extremely important, such as performing arts. However, our proposed

[1] https://unity3d.com/.

framework could have application in other domains too besides ICH, such as creating games to teach any kind of action that includes body movements (such as martial arts, medical rehabilitation, kinesiotherapy, etc.), offering users many choices to create easily learning content and adapt the generated games to their needs.

To evaluate our proposed approach, we conducted a two-part study based on questionnaire results, which demonstrates the learning effectiveness of our framework. The first part regards the efficacy of the generated game-like applications in dance education, evaluated by both amateur and experienced dancers. In the following part, experimental results are presented concerning the usability and effectiveness of the game design module. Specifically, a group of dance experts with only basic ICT skills was asked to design and generate their own game and afterward evaluate their experience.

The structure of the paper is organized as follows: "Related work" section presents the background of this work covering the prior research and the existing learning skills modules; "System architecture" section analyzes the system architecture comprising design module and customizable game-like applications modeling of our proposed framework; "Evaluation methodology and experimental results" section presents the details on methodology adopted for evaluating the efficacy and usability followed by analysis of the results concerning the design module presented; and finally, "Conclusions and future work" section summarizes the findings of the study and presents our conclusions and suggestions and implications for future works, based on the findings obtained.

Related work

This work is influenced by prior work in (a) games and applications for sensorimotor learning, (b) authoring tools for customizable game development, and (c) serious games for ICH education, which are briefly discussed below.

Games and applications for sensorimotor learning

Deng et al. (2011) implemented an interactive dancing game based on Kinect's tracking technology. They proposed a novel approach to handle real-time recognition of the user's dance motion based on human body partition indexing. Experiments showed that their proposed method had good performance on both isolated and continuous motion recognition and positive feedback from the subjects was obtained from the user study. Similarly, Chan et al. (2011) implemented a dance training system that enables learners to learn to dance by themselves. Using their system, a student can imitate the motion demonstrated by a virtual teacher projected on the wall screen, while the student's motion is recorded and analyzed by the system, in order to provide them feedback about their performance.

Furthermore, Henderson and Feiner (2009) developed an HMD-based augmented reality system providing real-time guidance for assembly tasks. Sodhi et al. (2012) proposed the LightGuide system using on-body projections to guide a user's hand through 3D space. With this approach, feedback is only available for a single hand, and only when this hand is visible. ModelMA allows a performer to record a repeated movement using the Kinect, which an observer can then practice with; however, learning is not addressed and is left as future work (Velloso et al. 2013). Chye and Nakajima (2012) proposed a game-based learning system, enabling users to learn martial arts using motion-based games. Since martial arts emphasize bodily movements, this system can obtain motion data through Kinect sensors. Subsequently, the user evaluation system achieved a 100% user detection rate and high accuracy, but low precision, proving that Kinect is suitable to replace wearable sensors.

However, although most of the studies presented above have shown positive educational outcomes, they are also characterized by some significant limitations. Most cases do not include any adaptive features and can only support a limited number of movements. In addition, in some cases, the feedback provided to the users is quite limited, while others use high cost motion-capture systems that limit their wide use. On the other hand, there are also few recent works that allow users to both record and learn physical movement sequences. Most notably, Anderson et al. (2013) proposed YouMove, a novel Kinect-based system that enables users to record and playback body-movement sequences allowing them to create and share training content. The corresponding training system that uses a large-scale AR mirror trains the user through a series of phases that gradually reduce the user's reliance on guidance and feedback. The authors also presented a user study showing that YouMove improved the learning effect compared to a traditional video demonstration. However, although users can record and share training exercises, the proposed system does not provide any choices to the users to adapt the training system to their needs.

Authoring tools for customizable game development

User-friendly authoring tools seem to be irreplaceable for educational videogames development, as they do not demand specialized technical knowledge and reduce considerably the necessary cost and time for production of new games. In order to be successful, these authoring tools should exhibit great accessibility, customization, and content integration features.

An approach developed by the authors in this field is the authoring system StoryTec (Göbel et al. 2008), which integrates the concept of narrative game-based learning objects (Garris et al. 2002) in the course of the EU-funded project 80Days for configuring a game which can be adapted based on a user's input at runtime along the axes of storytelling, gaming (using player modeling), and learning. The structure of a game is determined in the authoring tool using the Story Editor, in which the authors create the entire (story, game) structure by splitting up the game into scenes which are connected by (adaptable) transitions. In the context of games for health such as those presented in this paper, the authoring tool can be repurposed for the configuration of such games. Scenes in the Story Editor correspond to stages in a session of playing the game. Such stages could be identified as stages similar to regular training stages, including warm-up, actual 1664 exercising, and cool-down.

Adaptation during gameplay could either be provided, based directly on user input (by querying the user, for example, whether he/she wants a low or high intensity workout); or automatically by adapting the game at runtime. As an example, based on values determined during the warm-up, the system could automatically choose between a low-intensity version of the core exercise and a high-intensity version. An input parameter might be the user's heart rate combined with the intensity of the warm-up (e.g., the power setting of the ergometer).

DigiArt project developed a robust and user-friendly storytelling engine, which is a web-based tool that allows users without ICT knowledge (e.g., museum curators or general public) to upload 3D assets, assign behaviors into them, and wrap everything in a Unity3D game. This software allows a virtual museum visitor to view the museum artifacts—and learn about them—in a 3D first-person view game. For the development of this engine, the project used a novel method to transpile entities from WordPress into Unity3D YAML format that provides a basis for new future potential enhancements. The Mesch (Material EncounterS with digital Cultural Heritage) project (Petrelli et al. 2014) has also produced tools for creating exhibitions that incorporated new forms of interactive storytelling.

Some commercial platforms for creating games (e.g., an adventure game), which require limited coding knowledge, exist: GameMaker,[2] which allows almost anyone to create games using drag-and-drop options and other easy features; and Adventure Game Studio,[3] which allows developers with more experience to create adventure games.

However, a study of the existing game authoring tools reveals that none of them can support the production of motion-based games by users of moderate ICT skills.

Serious games for intangible cultural heritage education

Regarding the use of serious games for cultural heritage (CH) area, two interesting reviews exist: Mortara et al.'s (2014) study focuses on educational objectives of games in this domain and analyzes the complex relations between genres, contexts of use, technological solutions, and learning effectiveness. Furthermore, Anderson et al.'s (2009) study sketches a panorama of the actual use of serious games in cultural heritage.

In the field of Intangible Cultural Heritage transmission, only a few serious games exist; however, some of them are considered very promising (Mortara et al. 2014):

- 'Remembering 7th Street'[4] is aimed at showing West Oakland in the time period post World-War-II.
- 'Real Lives'[5] simulates a different life in any country of the world (e.g., a peasant farmer in Bangladesh, or a computer operator in Poland).

[2] https://www.yoyogames.com/gamemaker/.

[3] http://www.adventuregamestudio.co.uk/.

[4] http://7thstreet.org/.

[5] https://reallivesworld.com/.

- ‘Papakwaqa’ (Huang and Huang 2013) is a serious game about the Atayal minority in Taiwan, particularly focused on intangible cultural assets like tribal beliefs, customs, and ceremonies.
- ‘Icura’ (Froschauer et al. 2010) presents a 3D realistic environment in which the player can learn about Japanese culture and etiquette. This can be useful to raise cultural interest and support a real pretrip planning.

There are also some existing limited research works, using sensorimotor learning for ICH education For example, Chang et al. (2017) developed a motion-sensing-based system for learning Chinese cultural festivals by using Kinect and integrating situated learning to design objectives for users to engage in situational interactive learning using motion sensing and virtual objects. Through virtual animated stories integrated into real-life settings, the proposed system can enable students to interact with virtual characters as if learning in an authentic story setting, thereby assisting them with attaining learning objectives. According to the experiment, the system increased students’ interest and sense of novelty toward learning, thereby improving their learning motivations and outcomes compared with those of students who were taught using traditional methods. Moreover, Tisserand et al. (2017) created a game application for teaching a Traditional Sports and Games (TSG) skill in a fun interactive environment, where the user’s performance can be compared in real-time to the same skill as performed by a local/national hero, providing positive reinforcement in an engaging manner. An image-based 3D scanner was used including 80 compact cameras synchronized and controlled from a single computer for the 3D reconstruction of 3D realistic humanoid avatars. In addition, Vicon, a high-accuracy motion capture was used to capture sports skills with a high level of precision. For the play-and-learn module of the system, different hardware configurations can be used. The simplest one consists of only one Microsoft Kinect sensor, while the most complex one uses a set of Kinects placed around the capture space and WIMU sensors placed on the user’s body and the instrument related to the selected TSG.

Last but not least, within the i-Treasures project, several non customizable game-like applications for sensorimotor learning of specific dance types and other activities involving full-body gestures were designed and developed to support the learning and transmission of a number of ICH expressions. Specifically, a serious game application for transmitting ICH knowledge concerning the Greek traditional dance “Tsamiko” was designed and implemented (Kitsikidis et al. 2015). The game is structured as a set of activities, each consisting of several exercises, aiming to teach different variations of the dance. One of the most important elements of the proposed game-like application is the evaluation of the performance of the learner (Kitsikidis et al. 2014b), in order to provide meaningful feedback. To this end, the learner’s movements are captured using a markerless motion-capture approach (Kinect v1 or v2 sensor), which aims to fuse skeletal data from multiple sensors into a single, more robust skeletal representation. Subsequently, the motion similarity between the learner’s movements and an expert recording is performed through a set of appropriate performance metrics and a DTW/FIS-based approach (Kitsikidis et al.2014a, b). Preliminary small-scale user studies in Thessaloniki, Greece, have shown the positive educational potential of the proposed game. Based the obtained positive results, our proposed framework was influenced in a great degree by the aforementioned Tsamiko game design. In fact, it was used as a guide and basis for the design of the game-generated-game-like application module.

Respectively, more such educational game-like applications were developed for other types of traditional dances (Walloon, Callus, etc.) as well as other types of ICH such as singing and wheel-throw pottery (Yilmaz et al. 2015). Dagnino et al. (2015) studies the adoption of serious games (SGs) in the specific area of ICH, highlighting the educational dimension of i-Treasures project.

System architecture

In this work, we developed a generic framework, which provides an easy way to design and develop simple serious game-like applications for dance learning or other kind of activities involving full-body gestures (e.g., martial arts or kinesiotherapy). This framework consists of two components: (i) a game design module that allows the user to capture or load the required motion-capture data and to select the desired game parameters (environment, evaluation algorithm, etc.) and (ii) a customizable game-like application for motor skills learning, which is automatically configured based on the output of the game design module (Fig. 1). The target users of the game design module are mainly experts who would like to teach a sequence of movements to their students and need to have moderate ICT skills. Accordingly, the target users of the game-like application are learners with limited ICT skills who are interested in practicing or learning new movement sequences.

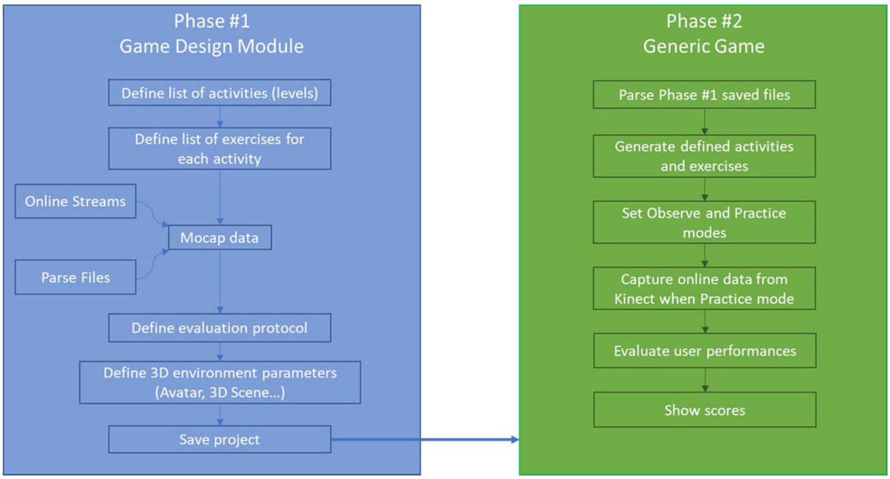

Fig. 1 The architecture of the proposed framework

Game design module

In order to design and develop the serious game-like applications for activities involving full-body motion, the ITGD (i-Treasures Game Design) module has been developed. ITGD provides the user with a simple interface to: (a) record or parse, and annotate, motion-capture data (3D skeleton movement data and video), and (b) customize various game parameters. It is written in C++, based on the open-source MotionMachine framework (Tilmanne and d'Alessandro 2015), and can support different motion-capture data formats or records in real-time data from the Kinect sensor.[6]

Specifically, after launching the ITGD tool, the users can specify the name and the description of the project and also the number of activities (levels) and exercises in each activity. Each exercise represents a body movement sequence to be learned. The interface allows adding new exercises or editing existing exercises. In both cases, a new window appears (Fig. 2) that allows (a) editing the name and the description of the exercise and (b) recording or loading mocap data and annotation of these data. The interface also allows users to adapt the game according to their needs. Specifically, they can select: (a) the evaluation algorithm to be used in the game out of a list of provided choices: DTW (Dynamic Time Wrapping) (Berndt and Clifford 1994) and HMM (Hidden Markov Model) (Eddy 1996), which are described in more detail at "Evaluation using probabilistic modeling" and "Evaluation using time-series alignment and fuzzy reference," and (b) the group of joints to be evaluated (upper body, lower body or all joints) for each exercise. The motion editing and annotation interface (Fig. 3) allows authors to crop the recorded data to eliminate any unwanted parts.

In addition, the users can further customize their game by uploading audio files and synchronizing them with the exercises, selecting the avatar models and the 3D environment of the game (Fig. 4), and adjusting the difficulty level of each exercise by setting the minimum score threshold needed to pass to the next level (exercise).

Evaluation using probabilistic modeling

Hidden Markov models are a general statistical technique for modeling sequences or time series and have been widely used in speech-recognition applications for last decades. HMMs have been used before for modeling body-motion time series (Bevilacqua et al. 2009; Bettio et al. 2013; Ravet et al. 2014; Laraba and Tilmanne 2016), while researchers in (Dimitropoulos et al. 2016) have used linear dynamic systems for the modeling of time-evolving data, such as human motion. In this work, we use HMMs to recognize gestures of students who imitate expert moves in the game using statistical models and provide a final score of their performance.

First step consists of feature extraction. Two sets of features are extracted. The first set is named relational features. It is a subset of features proposed by Meinard Müller (2007). Relational features represent geometric relations between different body joints (examples in Fig. 5a, b). The second set of features is named Relative

[6] Kinect V2.0. https://www.microsoft.com/en-us/download/details.aspx?id=44561.

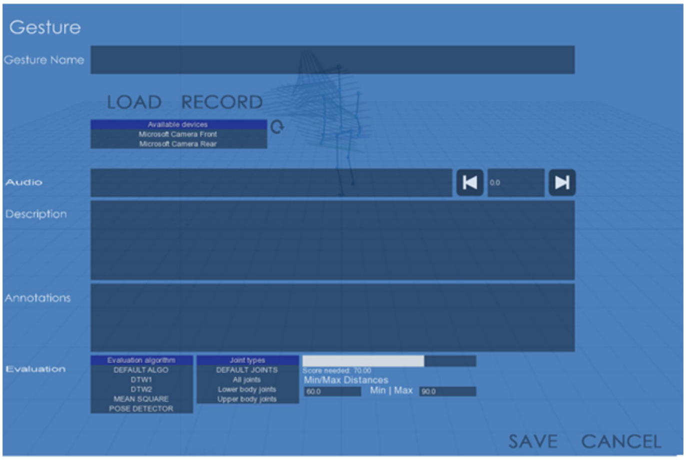

Fig. 2 Screenshot of the gesture creation/edition within the ITGD module

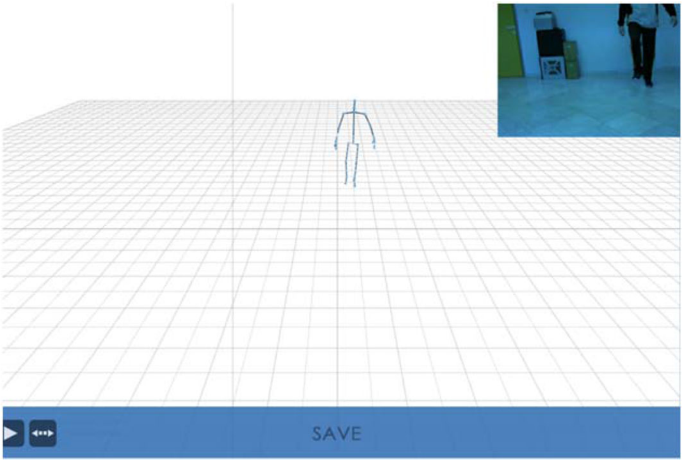

Fig. 3 Motion editing and annotation interface

Motion (RM) between joints (Pazhoumand-Dar et al. 2015). These features are calculated as the distance between two joints (Fig. 5c).

The extracted features are used then for the training of one HMM for each gesture class using the Hidden Markov Model Toolkit (HTK).[7] In our case, we consider the situation of having a large database from a high-precision Mocap system (Qualisys) and a small Kinect II motion dataset. For training and recognition purposes, only Kinect II motion data is available. The approach we follow is based on training sensor-dependent HMMs thanks to an adaptation procedure (Müller 2007). This approach is inspired by speech recognition where a speaker-independent system is adapted to improve the modeling of a new speaker by updating the HMM

[7] http://htk.eng.cam.ac.uk/.

Fig. 4 Selection of avatar and game environment

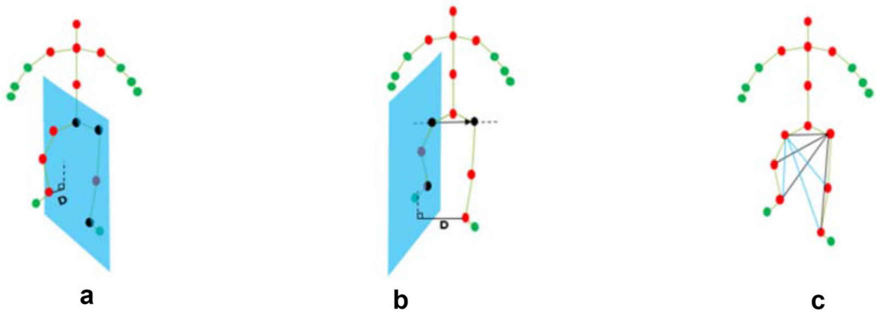

Fig. 5 **a** *D* distance between right ankle and the plane defined by (pelvis, left hip, left ankle). **b** *D* distance between left ankle and the plane fixed in right ankle and normal to vector right hip → left hip. **c** Example of relative motion

parameters using Maximum Likelihood Linear Regression (MLLR) algorithm. MLLR estimates a set of linear transformations W for the means component of an HMM so that these transformations shift the means component in the initial system in a way that each state in the HMM system is more likely to generate the adaptation data. More details about MLLR approach can be found in (Ganitkevitch 2005; Leggetter and Woodland 1995).

We tested recognition of gestures recorded by a Kinect II sensor using both models, before and after adaptation. Models of four basic gestures of the Walloon dance were trained. The topologies of the Hidden Markov Models we have selected are 11-states left–right HMMs and emission probabilities were modeled with a single Gaussian distribution (Fig. 6).

Figure 7 shows first that recognition using trained models from Qualisys data before adaptation has an average accuracy of 75.86% and is even better than using Kinect data alone for training (72.41%). Second, when we adapt Qualisys data

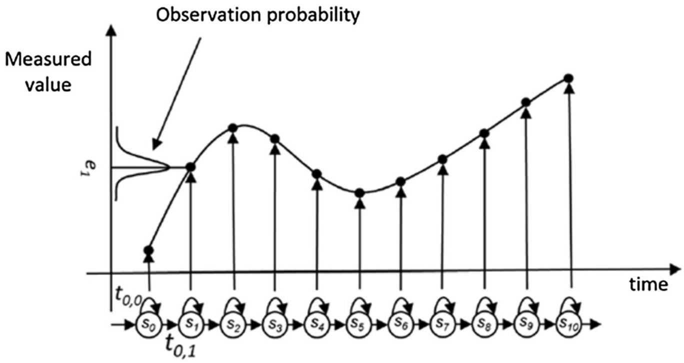

Fig. 6 11-States left-to-right hidden Markov model for learning procedure

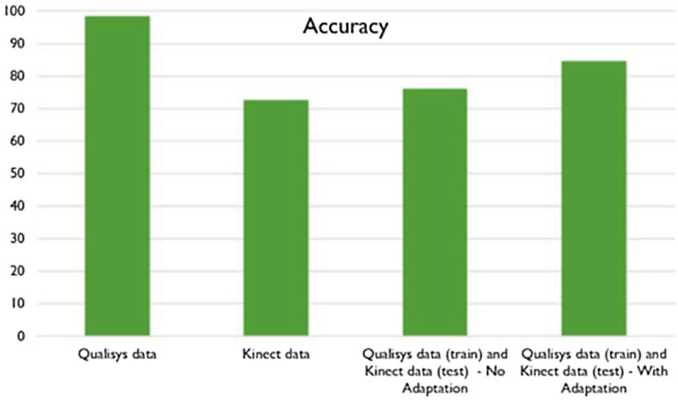

Fig. 7 Comparison of recognition accuracy before and after adaptation

models combining with a small set of Kinect data, the average accuracy has improved to 84.48%.

For the use of this gesture-recognition module for learner evaluation, a score based on the cumulative log-likelihood (L) provided by the recognizer is computed. In order to obtain this score, we map the resulting normalized log-likelihood (L) on the following function:

$$\text{Score} = \begin{cases} 0 & \text{if } L < a \\ 1 & \text{if } L > b \\ \dfrac{L-a}{b-a} & \text{otherwise} \end{cases}$$

a and b are determined empirically by outputting the values of the log-likelihood when decoding reference gestures. The function is illustrated in Fig. 8 and allows computing a score that evaluates the performance of the user.

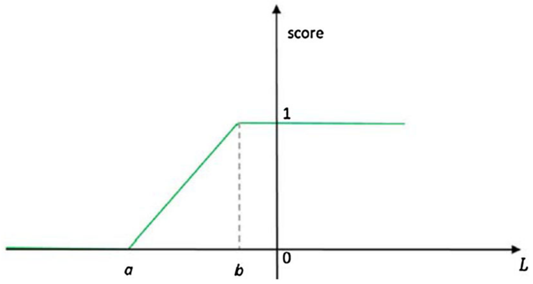

Fig. 8 Score function used for mapping the normalized log-likelihood

Evaluation using time-series alignment and fuzzy reference

Dynamic time wrapping (DTW) is a widely accepted technique for measuring similarity between two temporal sequences varying in time or/and speed (Kitsikidis et al. 2014a). In order to perform a comparison between the performance of the learner (Kinect motion data received during practice of exercises) and the expert (prerecorded data of exercises), specific features (set of joints selected at ITGD) are extracted from the learner and expert motion, consisting of the two time series, which are afterward compared by DTW. Specifically, DTW computes the distance between each possible pair of points/features of the two time series, constructing a cumulative distance matrix. The least-expensive path through this matrix is found, which represents the ideal wrap, i.e., the alignment of the two time series, which minimizes the feature distance between their points (ten Holt et al. 2007). This is considered as a distance between the time series under comparison and provides a metric of their similarity. In our case, a multidimensional variant of DTW is used, where three-dimensional time series are formed by the 3D position of each joint relative to the waist. However, these distances both depend on the height of the dancers; thus, to ensure invariance to dancer's height, a normalization process is applied: normalized distances are calculated by dividing each distance by the distance of a "body path" connecting specific joints.

For each feature set, DTW calculates a distance measure between the time series of the learner and the expert. These distances, one per feature set, are subsequently fed to a Fuzzy Inference System (FIS), which computes the final evaluation score. The proposed FIS system is based on Mamdani method (Mamdani and Assilian 1975), which is widely accepted for capturing expert's knowledge and allows the description of the domain knowledge in a more intuitive, human-like manner. The evaluation function produces a normalized output value between 0 and 1, which is then transformed in the range of 0–100 and displayed by the virtual tutor.

Game-like application

Once the game design procedure has been completed, the selected configuration parameters are saved in an XML file, along with all associated data (mocap data, annotations, and video). By simply copying these data files to the game folder, the game-like application is ready to be used for learning the recorded activities/exercises.

In the remainder of this section, we will evaluate the efficacy of learning using this game-like application in a specific pilot case, i.e., learning the basic steps of Salsa dance. Toward this end, four learning activities were designed and implemented, in close cooperation with dance experts, each consisting of a number of specific exercises of increasing difficulty. The learner has to perform all of the exercises successfully to achieve the activity objective. Each exercise consists of several dance steps, which are presented to the learner one by one. In order to proceed to the next exercise, the learner must perform the current exercise correctly. In each exercise, a 3D animation of the virtual avatar of the expert performing the specific moves is shown to the learner who is expected to imitate the same moves synchronously. If the evaluation score achieved is larger than the threshold set during the design phase, the game progresses to the next exercise. Otherwise, the learner is expected to repeat the same exercise until his/her performance is sufficiently improved.

The game allows users to learn Salsa by either observing expert's movements in the Observe mode or by starting practicing the dance routines shown, respectively, in the Practice mode (Figs. 9, 10, 11). There is also a tutorial aiming at explaining to the learner the basics of how to play the game. In order to teach how to use each user interface element, a 2D virtual tutor presents both the sensors and the GUI to the learner. More specifically, the virtual tutor explains (a) the sensing technology used in this game, (b) the Observe screen components, and (c) the Practice screen components. When the tutorial is completed, the learner is expected to continue with the observe phase of the first activity, followed by the practice phase.

The practice starts with an introduction from the virtual tutor. After providing some basic instructions, the virtual tutor asks the learner to get ready and a counter starts counting down. Then, the learner is expected to imitate the moves of the expert avatar displayed on the screen. A video of an expert performing the target move is also shown on the left of the game screen to show the learner the real-life Salsa dancer. The learner's motion gestures are captured by the Kinect sensor and then transferred to the game and used to animate the learner's avatar. Then, they are further analyzed by the game-evaluation system selected in order that the similarity

Fig. 9 Menu interface of the Salsa game-like application

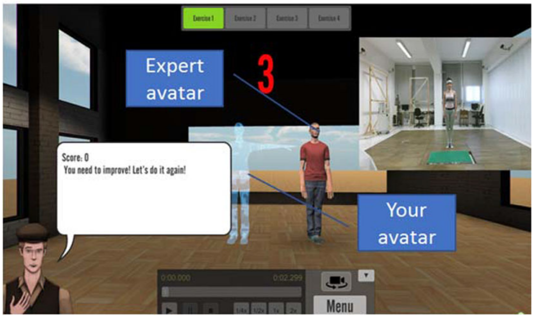

Fig. 10 Front view of the game's practice mode

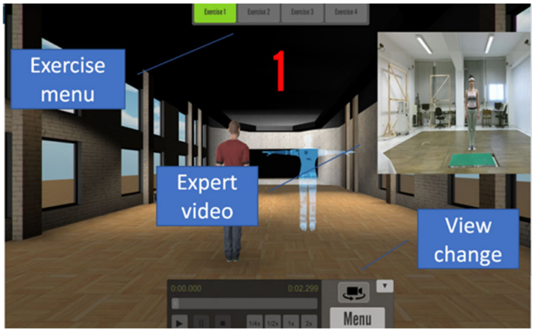

Fig. 11 Back view of the game's practice mode

between the learner's and the expert's movements to be estimated. Taking into account that in Salsa dance both the leg and hand movements constitute key elements of the choreography, it was decided to use all joint positions (head, shoulders, elbows, knees, ankles, etc.).

After the user performance is completed, evaluation is performed, and the virtual tutor presents the evaluation score along with an appropriate message, e.g., "Outstanding performance! You are ready for the next exercise/activity!." If the learner goes beyond a predefined success threshold, the virtual tutor asks him/her to get ready for the next exercise. If the performance was not as good as expected, the learner is asked to repeat the same exercise. This tutor has different mood expressions (happy, explanatory, unsatisfied, confused, etc.), so as to provide the learner with the proper feedback depending on their performance. Although the exercises progress sequentially, in some cases, the learner has to repeat not only the previous exercise but also some of the previous ones.

Within i-Treasures project (Dimitropoulos et al. 2018), this generic game-like application was used within a broader framework for safeguarding and transmission of intangible heritage. Specifically, the expert could capture a dance performance and extract medium-level features (e.g., dance steps) and high-level concepts (e.g., dance style) to the database of the system. In addition, he/she could design additional educational courses, using a dedicated pedagogical planner software, for the learning of each recorded dance, thus conveying more domain knowledge to the user. Out of the seven dimensions of ICH knowledge identified in Pozzi et al. (2014), General info, physical, emotional, social, knowledge and meta-knowledge, Context/environment, Teaching and Value, many can be conveyed, up to a certain extent (e.g., only the Social and Emotional dimensions cannot be well conveyed via the game application).

Evaluation methodology and experimental results

The evaluation methodology consists of two parts. The first part, described in "Evaluation of the efficacy of the generated game-like applications," deals with the efficacy of the generated game-like applications in dance education, evaluated by both amateur and experienced dancers. Following, at "Evaluation of the usability and effectiveness of the game design module ITGD," we focus on evaluating the usability and effectiveness of the game design module. Therefore, we asked a group of dance experts with limited ICT skills to design and generate their own game and evaluate their experience.

Evaluation of the efficacy of the generated game-like applications

In order to evaluate the perceived quality of the game-like applications, generated by the adaptive framework for the creation of body-motion-based games, three different pilot games were created:

(A) *A Salsa game* After its creation, described in detail in "System architecture**"**, an evaluation was conducted by a group of Latin dancers in order to assess their attitude toward the use of such a game-like application for Salsa learning. The evaluation was performed by 11 persons aged between 25 and 43 years old (5 females–6 males). Eight of them were Latin dance students (4 females–4 males), who are novice in the Salsa dancing (assigned to Group N1) and three of them were dance teachers (one male Greek folk dance teacher, one female classical ballet teacher and one male Salsa dance teacher) and they can be considered experienced dancers (assigned to Group E1).

(B) *A Walloon game* A game-like application was created for teaching the basic steps of Walloon traditional dance, originated from the eighteenth, nineteenth and early twentieth centuries and practiced in the Walloon region of Belgium. Toward this end, four learning activities were designed and implemented, in close cooperation with dance experts, each consisting of a number of specific exercises of increasing difficulty. Experts' video was not captured by the ITGD tool, so the "Observe" and "Practice" screens did not display the experts' video. The game was evaluated by a group of ten people aged between 22 and 65 years old (5 females–5 males). Three of them were beginner dancers (3 males), who are novice in the Walloon dancing (assigned to Group N2) and seven of them were experienced dancers (two males, five females) and were assigned to Group E2.

(C) *A Tsamiko game* The third game-like application was created for teaching the basic steps of Greek traditional dance, Tsamiko. Toward this end, five learning activities were designed and recorded using the ITGD tool, in close cooperation with dance teachers, each consisting of a number of specific exercises of increasing difficulty. The game was evaluated by a group of 30 people aged between 18 and 25 years old (15 females–15 males). Twenty five of them were beginner dancers (13 males–12 females), who are novice in Greek Traditional dancing (assigned to Group N3) and five of them were experienced dancers (two males, three females) and were assigned to Group E3.

In all three experiments in order to capture and record the performers' body motions, we used a motion-capture system using one Kinect II depth sensor. Specifically, since there are some limitations that should be taken into account: the sensor is designed to track the front side of the user and as a result the front and back side of the user cannot be distinguished, and that the movement area is limited (approximately 0.7–6 m), the participants were asked to face the sensor as they were practicing the exercises and to stand approximately 2 m away from it. In order to evaluate the efficacy of the three games, all subjects practiced the games for approximately half an hour and all the experts along with the majority of the amateur dancers (approximately 80%) completed all the activities successfully. Subsequently, a questionnaire was used for evaluating cognitive, emotional and behavioral elements of the students' attitudes toward the use of the Salsa game-like application for learning the Latin dance Salsa. The subjects were asked to answer seven groups of questions that concerned the game scenario, the visualization elements of the game, the accuracy of the user performance evaluation, the sensor set-up, the usability, the learning experience and the perceived performance of the game. The subjects used the following scale (from 1 to 5) to rate each question: (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree and (5) strongly agree. The results for each group of questions for both Groups N and E are presented below.

Game scenario

This section presents the key outcomes derived from the analysis of the questionnaires regarding the game scenario of the game-like application. This group consisted of six questions, depicted in Table 1 and average ratings regarding the satisfaction of the users from the game scenarios are shown in Figs. 12 and 13. Therefore, it is clear that both types of groups, experts (avg. 4.01) and beginners (avg. 4.25) made a positive assessment and stated that the game scenario was satisfactory, the objectives of the game were clear, the instructions offered were helpful and the order of the offered activities helped them learn dancing in a progressive way.

Table 1 Questions regarding the game scenario

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	I have clearly understood the objectives of the game	4.47 (0.28)	4.4 (0.57)
Q2	I found the game scenario clear and satisfactory	4.46 (0.29)	4.16 (0.33)
Q3	I have easily understood what I have to do in each activity of the game	4.21 (0.32)	4.1 (0.52)
Q4	I think that the sequence of offered activities helped me to learn how to dance Salsa in a progressive and smooth way	3.83 (0.41)	3.82 (0.44)
Q5	The “getting started” section was informative	4.25 (0.12)	3.71 (0.57)
Q6	I found helpful the instructions offered by the virtual tutor	4.3 (0.28)	3.89 (0.64)
	Average (SD)	4.25 (0.21)	4.01 (0.23)

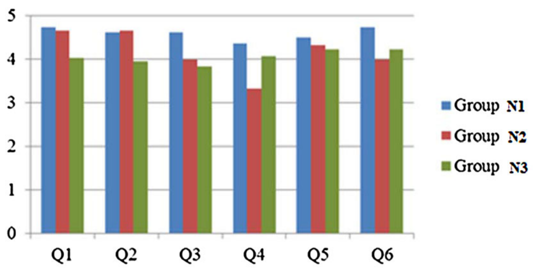

Fig. 12 Average ratings of the three groups (N1, N2, N3) of novice dancers regarding the game scenario

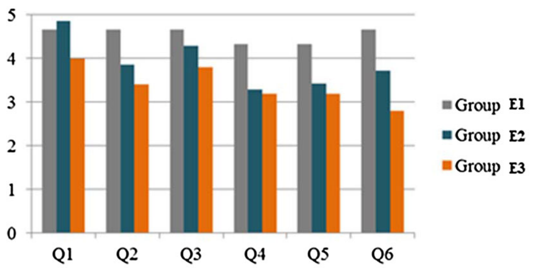

Fig. 13 Average ratings of the three groups (E1, E2, E3) of experienced dancers regarding the game scenario

Visualization

The second set of questions consisted of six questions presented in Table 2 regarding the evaluation of the visual elements and graphics of the game-like

Table 2 Questions concerning the visualization of elements of the game

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	I found the 3D game environment pleasant in terms of design and aesthetics	4.55 (0.22)	3.89 (0.68)
Q2	I found the appearance of the expert and learner dancer avatars satisfactory	4.11 (0.46)	4.0 (0.52)
Q3	I found the visualization of the dance movements by the avatars accurate	4.14 (0.35)	3.99 (0.4)
Q4	I found the animations performed by the virtual avatar of the expert helpful in order to learn the basic movements of Salsa	4.21 (0.09)	4.09 (0.44)
Q5	I found the video of the expert helpful in order to learn the basic movements of Salsa.	4.3 (0.46)	3.93 (0.73)
Q6	I found the practice of the dance movements and the watching of the virtual avatar at the same time comfortable	3.92 (0.21)	3.91 (0.6)
	Average (SD)	4.2 (0.19)	3.96 (0.07)

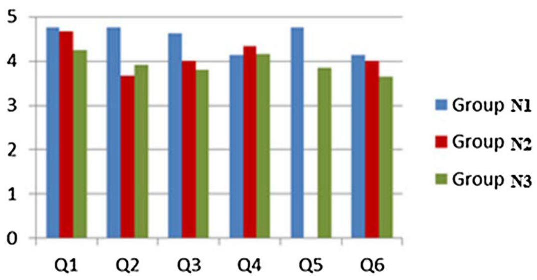

Fig. 14 Average ratings f of the three groups (N1, N2, N3) of novice dancers regarding the visualization elements

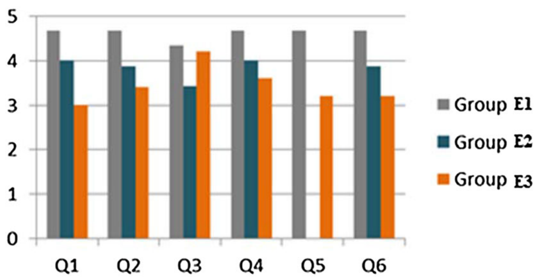

Fig. 15 Average ratings of the three groups (E1, E2, E3) of experienced dancers regarding the visualization elements

application. The average ratings obtained are displayed in Figs. 14 and 15. Regarding question 5, groups N2 and E2 did not provide an answer since the videos of the expert's performance were not recorded for the Walloon game. However, the

Table 3 Questions concerning the user performance evaluation

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	The evaluation score displayed in the screen at the end of each exercise helped me to understand when my movements were not correct and, thus, I improved/corrected my dancing performance	4.00 (0.39)	3.69 (0.49)
Q2	I found the evaluation algorithm used by the game accurate	3.66 (0.52)	3.38 (0.44)
Q3	I didn't have to perform some exercise many times because I could not understand what to do	2.71 (0.45)	3.07 (0.3)
Q4	I didn't have to perform some activity many times because the evaluation of my performance was not accurate	3.08 (0.54)	3.42 (0.22)
	Average (SD)	3.37 (0.5)	3.39 (0.22)

results show that both types of groups found the animation system of the game accurate and the visual elements of the game satisfactory, pleasant and helpful.

User performance evaluation

This set of questions (Table 3) included four questions about the evaluation of the user performance and to what extend the subjects thought that the score they received after completing an exercise was accurate. The average ratings are displayed in Figs. 16 and 17 for both novices' and experts' groups. The average values were 3.37 (SD 0.5) for Groups N and 3.39 (SD 0.22) for Groups E, which reveals a mixed attitude regarding the accuracy of the evaluation system of the game. Both Groups stated that sometimes they had to perform an exercise many times because they hadn't understood what they had to do (Q3), a remark that reveals that the feedback and guidelines provided to users before and during each exercise could be improved. Regarding the questions concerning the evaluation system of the games (Q1 and Q2), both types of groups agreed that the evaluation system was relatively accurate and the feedback they were receiving during the practice mode helped them improve (Q1 and Q2).

Sensor setup

The next set of questions concerned the attitude of the subjects toward the setup and use of the Kinect. This group consisted of four questions, shown in Table 4. The average ratings are displayed in Figs. 18 and 19, and average values are 4.20 (SD 0.34) for Groups of amateur dancers and 3.68 (SD 0.1) for Groups of experienced dancers. Therefore, it can be assumed that both Group N and E have a positive

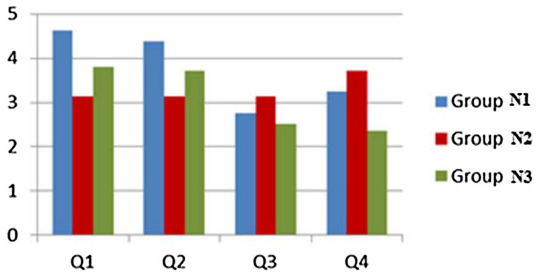

Fig. 16 Average ratings of the three groups (N1, N2, N3) of novice dancers for questions regarding the evaluation system

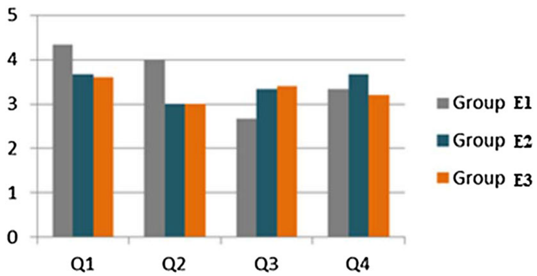

Fig. 17 Average ratings of the three groups (E1, E2, E3) of experienced dancers for questions regarding the evaluation system

Table 4 Questions concerning sensor setup

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	I easily understood where I should stand (in which area) when practicing the dance movements	4.417929 (0.53)	3.688889 (0.71)
Q2	It was comfortable to dance within a specific area so as to be captured by the sensors	4.47601 (0.51)	3.688889 (0.71)
Q3	The placement of sensors did not cause any disturbance to me and did not affect my performance	3.627525 (0.98)	3.822222 (0.90)
Q4	It will be easy for me to handle the sensor(s) by my own	4.292929 (0.7)	3.53 (0.41)
	Average (SD)	4.20 (0.34)	3.68 (0.10)

attitude toward the use and set-up of the sensor and believe that it would not be a challenge for them to use it on their own in the future (Q4). However, especially Groups N1 and N2 of the beginners and Group E3 of the experts admitted that the presence of the Kinect sensor caused a degree of annoyance to them (Q3).

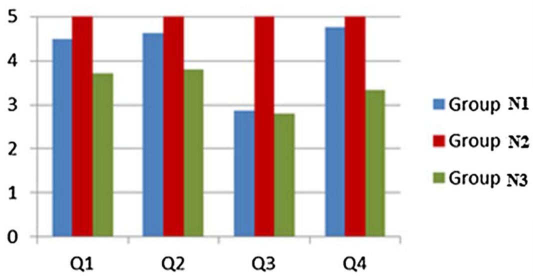

Fig. 18 Average ratings of the three groups (N1, N2, N3) of novice dancers regarding the system setup

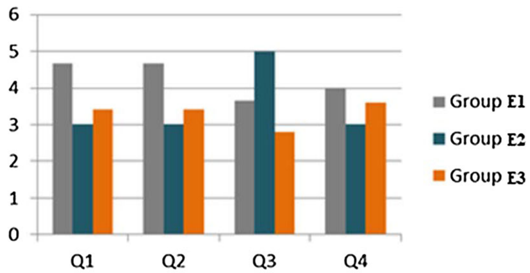

Fig. 19 Average ratings of the three groups (E1, E2, E3) of experienced dancers regarding the system setup

Table 5 Questions concerning the usability of the game

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	It was easy to learn how to play the game	4.35 (0.23)	4.24 (0.66)
Q2	I would be able to learn how to play the game alone (without any external guidance)	4.44 (0.56)	3.51 (0.59)
Q3	It was easy to perform the different activities	4.08 (0.42)	3.76 (0.69)
Q4	It was easy to follow the avatars' movements and practice them myself	3.75 (0.59)	3.51 (1.06)
Q5	I found the existence of several windows in the screen not to be confusing and annoying	2.24 (0.17)	3.38 (0.49)
Q6	I found the general feedback provided by the game satisfactory	3.91 (0.26)	3.53 (0.41)
	Average (SD)	3.79 (0.73)	3.66 (0.29)

Usability

The next set of questions (Table 5) included six questions regarding the usability of the game. The average ratings are displayed in Figs. 20 and 21. The average values

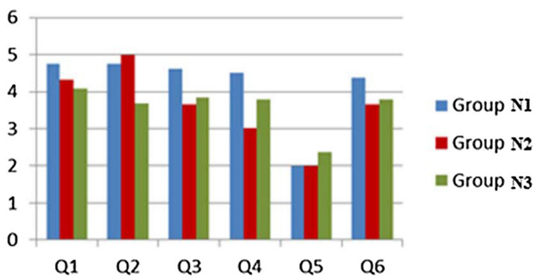

Fig. 20 Average ratings of the three groups (N1, N2, N3) of novice dancers regarding usability

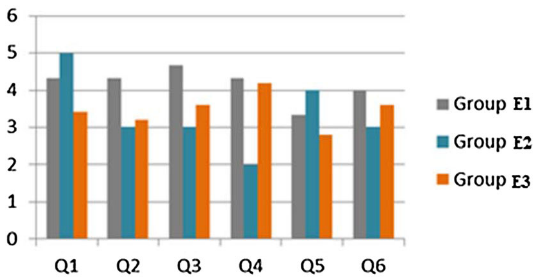

Fig. 21 Average ratings of the three groups (E1, E2, E3) of experienced dancers regarding usability

were 3.79 (SD 0.73) for groups N and 3.66 (SD 0.29) for groups E. Although results show that both groups found it easy to learn to play the game and use the visual elements of the UI, the beginners stated that the existence of several windows in the screen sometimes caused them confusion (Q5).

The learning experience

The next set of questions concerned the educational effectiveness of the game-like application. This group consisted of fourteen questions, presented in Table 6. The average ratings are displayed in Figs. 22 and 23. The average values are 3.96 (SD 0.97) for beginners and 3.66 (SD 0.56) for experienced dancers. Taking into account the key outcomes, it can be assumed that both Group N and E evaluated in a positive way the educational character of the game. However, although the beginners found the game more enjoyable and easier compared to traditional methods of dance teaching and they stated that their short use of the game helped them learn the basic steps of salsa (Q5). On the contrary, the groups of experienced dancers, although they characterized the games as fun (Q7), they did not find that the such applications can be better than traditional techniques (Q2 and Q3) and as they stated "such games cannot be used as an alternative to the traditional techniques, but can be a tool to be used in parallel to learn dancing. Moreover, both types of groups expressed appositive attitude toward the idea of using similar games to learn dancing (Q4). In addition, they supported that it would be useful for the learners to be able to contest against each other and to be able to view the instant score of their performance during the practice of the exercises. Such additional features would be considered as positive improvements for the game.

Table 6 Questions concerning the users' learning experience

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	I found the activities satisfactory	4.03 (0.43)	3.78 (0.49)
Q2	I think that this game makes the dance learning experience easier compared to traditional techniques (e.g., observing a teacher live)	3.40 (0.05)	3.18 (0.12)
Q3	I think that this game makes the dance learning experience more enjoyable compared to traditional techniques (e.g., observing a teacher live)	3.57 (0.30)	2.78 (0.49)
Q4	I would use a similar game to learn how to perform some other dance by myself	3.71 (0.41)	3.57 (0.48)
Q5	The game helped me to learn how to dance each dance	3.78 (0.25)	3.35 (0.94)
Q6	I did not find the game stressful in any way	2.73 (1.14)	3.93 (0.78)
Q7	I had fun playing the game	4.35 (0.23)	3.96 (0.52)
Q8	I think that the game respects the tradition of dances	4.013 (0.14)	3 (0.70)
Q9	I would like to see such a game or similar technologies included in the educational process of my school/organization	4.13 (0.18)	3.188 (0.82)
Q10	I would find it interesting to be able to contest against other individuals for the best dance performance using this game (i.e., support of multiplayer scenario)	4.03 (0.39)	3.27 (0.45)
Q11	It would be helpful to be able to watch a video focusing on the virtual avatar's legs in order to learn the basic movements of Salsa	4.45 (only group N1)	4.67 (only group E1)
Q12	The addition of the overlay of the virtual avatar and the user ghost image helped me would help me to improve/correct my own dancing performance	4.55 (only group N1)	3.67 (only group E1)
Q13	It was useful to be able to navigate through the 3D virtual environments and change the position of the virtual camera (zoom in/out, rotate virtual avatar)	4.27 (only group *N*1)	4.67 (only group *E*1)
Q14	It would be helpful to be able to watch the evaluation score displayed on the screen during the activities	4.55 (only group *N*1)	4 (only group *E*1)
	Average (SD)	3.96 (0.97)	3.66 (0.56)

Perceived performance

The last set of questions (Table 7) consisted of four questions regarding the general perceived performance of the game by the subjects, i.e., to what extent users found

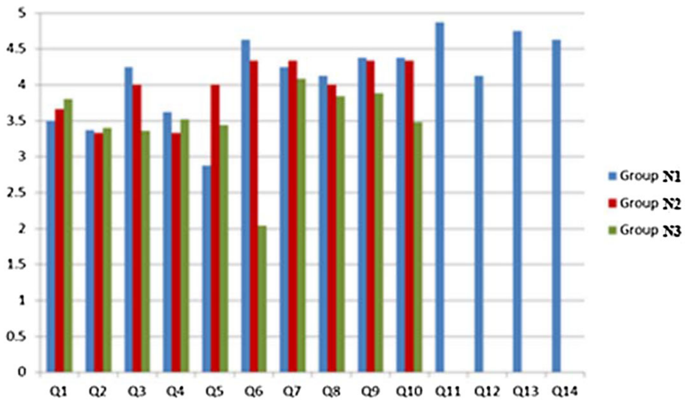

Fig. 22 Average ratings of the three groups (N1, N2, N3) of novice dancers on questions concerning the learning experience

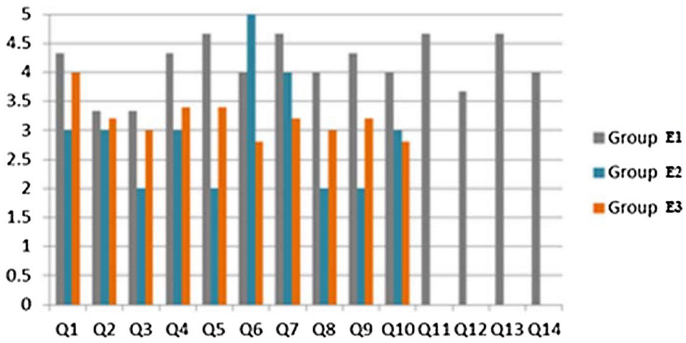

Fig. 23 Average ratings of the three groups (E1, E2, E3) of experienced dancers on questions concerning the learning experience

Table 7 Questions concerning the perceived performance of the game

Q#	Questions	Avg of groups of novice dancers (N1, N2, N3)	Avg of groups of experienced dancers (E1, E2, E3)
Q1	The game is effective (if the game meets its objectives)	3.93 (0.77)	4.25 (0.35)
Q2	The game is efficient (if the game responses satisfactorily and in a short time)	3.92 (0.60)	3.84 (0.48)
Q3	The game provides satisfaction (if the game provides satisfaction to the user)	4.14 (0.53)	3.88 (0.68)
Q4	The game is innovative (if the game offers novel tools/techniques in ICH transmission)	3.93 (0.19)	4.10 (0.51)
	Average (SD)	3.98 (0.09)	4.02 (0.16)

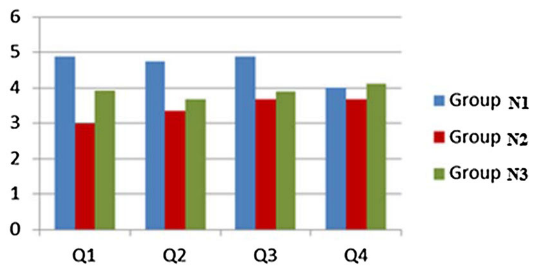

Fig. 24 Average ratings of the three groups (N1, N2, N3) of novice dancers for the seventh set of questions concerning the perceived performance

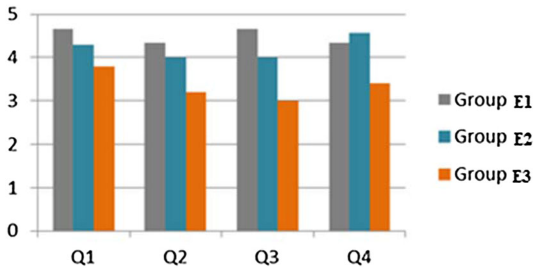

Fig. 25 Average ratings of the three groups (E1, E2, E3) of experienced dancers for the seventh set of questions concerning the perceived performance

the game to be effective, efficient, satisfactory and innovative. The average ratings are shown in Figs. 24 and 25 for Groups N and E respectively. The average outcome of the questions was 4.63 (SD 0.36) for Group N and 4.5 (SD 0.17) for Group E, showing that both groups shaped a very positive attitude toward the game in general.

Evaluation of the usability and effectiveness of the game design module ITGD

The aim of this evaluation was to assess the usability and effectiveness of the game design module of our dance game development framework. A group of dance experts was asked to choose a particular Greek traditional dance and then plan and record their own educational material for teaching this dance along with a game-like application for teaching this dance. In this way, game-like applications for 10 Greek folk dances were created (Table 8). The group consisted of ten postgraduate dance students (six female and four male), 21–25 years old, who are highly experienced dancers, since they are already teaching traditional dances in local dance associations or schools. Almost all of them will continue teaching traditional dances in public schools, dance schools, or local communities after they graduate. They are the future teachers/experts of this kind of ICH, which adds to the importance of their assessment, since they can be the ones that will establish the use of new ICT technologies for ICH learning and transmission.

Table 8 List of Greek folk dances for which game-like applications were created

Names of folk dances recorded
Sybethera (mother in law)—an Ikarian folk dance
Baintouskino—a Macedonian folk dance
Kori Eleni (daughter Helen)—a Macedonian folk dance
Leventikos—a Macedonian folk dance
Olympia—a Macedonian folk dance
Pentozali—a Cretan folk dance
Tsourapia—a Macedonian folk dance
Zamantas—a folk dance performed in the town of Serres
Syrtos—a popular and well know Greek folk dance
Syre–Syre—a Macedonian folk dance

ITGD was used to capture the performances of the students as they danced the various dances (or parts of each dance) several times. Next, the students used the ITGD tool to design the game scenario, i.e., define the activities and exercises for learning the steps of a specific dance, provide small descriptions for each activity/exercise, and edit the recorded videos so as to create the corresponding video segments (and motion data files) for each envisaged activity/exercise. They also provided audio files of the music accompanying each dance. The output of this step was the creation of one XML file per game, accompanied with the appropriate video and skeletal data files, which was then used for the generation of the corresponding game-like application. Once the design of the games using the ITGD interface was completed, the XML files and motion data were fed to the generic framework and thus ten game-like applications, one for each dance, were created. Figure 26 depicts screenshots from some of the developed games. Once created and tested, the games

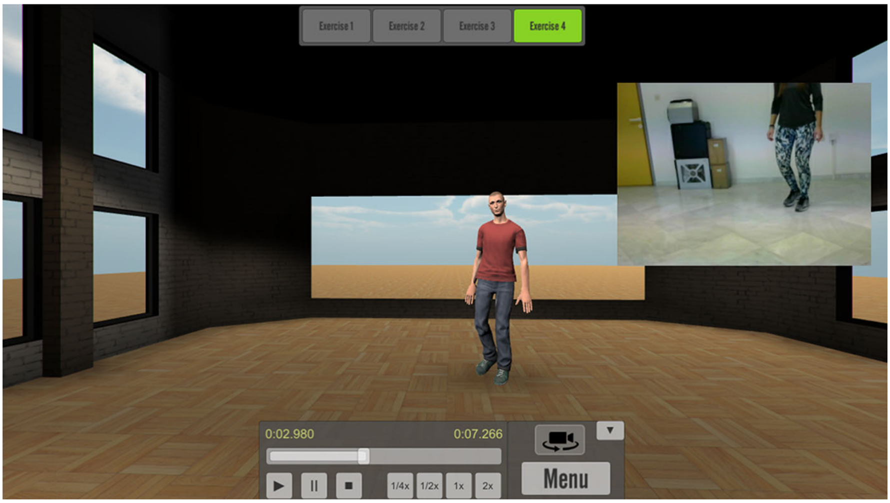

Fig. 26 Screenshots from six Leventikos game-like application's observe mode

were shown to the students so as to examine them and test them by themselves. Changes and improvements were made based on the students' requests and the updated versions of the games were released afterward.

At the end of this demonstration activity, we collected 5 e-questionnaires from the participants, which evaluate the generic game development framework and provide valuable information about how teachers/experts assess our technologies potential for designing and developing new ICH education material and games.

Usability of ITGD module

The set of questions concerned the attitude of the subjects toward the usability of the ITGD module. This group consisted of six questions, shown in Table 9 along with the average values of experts' answers. Specifically, the response of the users was positive (avg. 4.06). They thought that it provided them a very simple and quick way to design and create an attractive and easy to create a game-like application for practicing any kind of dance. They thought that the game design and data capturing process was simple and believed that they could probably do it by themselves after receiving some training on how to use the tool. In addition, they stated that they are willing in the future to use such a tool to create more game-like applications for teaching different kind of dances.

Effectiveness of generated games

Table 10 presents a set of seven questions regarding the attitude of the experts concerning the effectiveness of the generated game-like applications. The group of experts stated that in the future they would be interested to use such games in parallel with traditional teaching methods to help beginners learn the basic steps of a dance. What they found very intriguing was how fast the design process was and how user-friendly and functional the produced game-like application was shown to be. Another attractive feature was the fact that the provided sensorimotor feedback, which they characterized as accurate (Q5) about the learner's performance. A feature, which is considered necessary for meaningful practice without the presence of the teacher. Moreover, they all agreed that the proposed tools allowed them to

Table 9 Set of questions concerning the usability of the game design module and average results

Q#	Questions	Avg
Q1	The motion recording process was easy and easily understood	4
Q2	The motion recording process was enjoyable	4.5
Q3	The use of ITGD module for the motion recording process was easy	4.25
Q4	In the future it will be easy for me to use the ITGD tool by myself	3.75
Q5	In the future I would like to use the ITGD tool to create more dance games applications	4
Q6	It was comfortable to dance within a specific area so as to be captured by the sensors	4.5
Q7	In the future it will be easy for me to place and use the motion sensors by myself	3.75
	Average (SD)	4.06 (0.3)

Table 10 Set of questions concerning the effectiveness of the generated game-like applications and average results

Q#	Questions	Avg
Q1	Do you believe that such game-like applications could help you teach beginners a dance sequence?	3.25
Q2	Would you desire such applications and technologies to be included in the learning processes of your school/institution?	3.75
Q3	In the future would you like to use such game-like applications to teach dancing?	4
Q4	Do you believe that students are able to learn how to use such game-like applications by themselves?	2.75
Q5	The evaluation algorithm used by the game is accurate.	4.33
Q6	Is the game-like application innovative?	4.33
Q7	Is the game-like application efficient?	4
Q8	Do you believe that the i-Treasures game framework can generate learning content and game-like applications that can help the transmission and preservation of ICH?	4
	Average (SD)	3.8 (0.51)

design educational interventions that allow teaching the basics of a dance tradition in a meaningful and innovative way.

In addition, the experts agreed that the generated game-like applications can contribute positively to the transmission and preservation of ICH (Q8) and thought that the use of such game-like applications could be suitable and useful for other domains too, such as training, rehabilitation purposes, etc. (Table 11).

Conclusions and future work

This paper presented a novel adaptive framework for the easy and rapid design and creation of serious game-like applications (exergames) for learning full-body gestures (e.g., dance steps) by imitating the prerecorded performance of an expert. We proposed a novel game design system which supports motion-capture data

Table 11 Set of questions concerning other potential applications of such game-like applications and average results

Q#	Besides dance learning what other applications do you think could have such a game-like application?	Avg
Q1	Creation of training exercises	3.75
Q2	Creation of games to teach athletic skills in sports (e.g., tennis, basketball, golf, etc.)	3.5
Q3	Creation of games for martial arts teaching	3.5
Q4	Creating rehabilitation exercises	4
Q5	Creation of games for children dance music-therapy	4.33

based on an inexpensive Kinect sensor and we briefly presented the architecture and main features of an educational body-motion-based interactive game.

The evaluation methodology included two phases. The first phase focused on the evaluation the efficacy of the generated game-like applications in dance education, evaluated by both amateur and experienced dancers. Experiments concerning three different use cases were conducted, where both beginners and experts evaluated a game-like application for dance learning. The subjects were asked to answer seven groups of questions that concerned its game scenario, its visualization elements, its accuracy of the user performance evaluation, the sensor set-up, its usability, the learning experience provided, and the perceived performance of the game. Following the "Evaluation of the usability and effectiveness of the game design module ITGD," we focus on evaluating the usability and effectiveness of the game design module. Results showed that the use of such a game-like application could be very efficient, as positive feedback was obtained. Specifically, both groups considered the game scenario satisfactory, the visual elements pleasant and helpful, the evaluation system accurate, the provided feedback useful, and the sensor set-up easy to do it on their own. Furthermore, both experts and beginners evaluated positively its educational character stating that such a game could help them learn the basic steps of a dance in a progressive and fun way. However, the group of the experts estimated that the game cannot be considered more adequate for learning than traditional techniques, and after discussion with experts, they explained that the game itself cannot be an alternative to the traditional techniques, but can be a tool to be used in parallel to learn the basics of a dance.; In general, they perceived the game-like application as efficient, satisfactory, and as an adequate and novel tool for ICH transmission and education, which can be particularly appealing to younger people. The second evaluation phase focused on the evaluation of the game design module by dance experts, when they were asked to choose a dance and design/create their own game. The evaluation outcomes showed that the experts were surprised by the user friendliness of the tool and the short time required to actually create a simple, but meaningful game. In addition, they expressed their interest in developing more such games in the future, since they characterized the ITGD module as very easy and intuitive to use, which does not require any background in ICT.

In future work, we will consider providing more meaningful feedback to the users in the practice mode, such as an instant score, which will readily indicate to the users how well they are performing during the different phases of an exercise. Preliminary tests with such an "instant score" feature, computed via the DTW algorithm and visualized using a color-coded scale (red to green), were conducted in i-Treasures project and were successful, despite causing some minor slowdown.

Moreover, we will work toward adding more adaptation mechanisms, so that the games become more personalized according to the specific needs of the users and each use case. In addition, taking into consideration the positive outcome of the evaluation and the opinion of the expert dancers, we consider that it will hold research value for the study of other potential applications of the framework.

In addition, various motion-capture technologies will be tested, since new inexpensive motion sensors need to be supported, as well as VR/AR/MR displays that can immerse the user into new VR environments. Last but not the least, we may also examine the addition of more game scenarios (i.e., multiplayer games), which could significantly improve the users' engagement.

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A. Grammatikopoulou had graduated from the Informatics Department of the Aristotle University of Thessaloniki in 2010 and completed his Master's Program in Computer Science in the same department in 2012. Her research interests include human–computer interaction (HCI), user experience design (UX), computer games design, and sensorimotor learning. She works as a research assistant at the Information Technologies Institute of the Centre for Research and Technology Hellas since July 2016.

S. Laraba holds an Electronics Engineering degree from the National Polytechnic School of Algiers (ENP) and a Master degree in Signal, Image, Speech and Telecom from the National Polytechnic Institute of Grenoble (INPG | Phelma) in France. Currently, he is a PhD student at the TCTS lab of the University of Mons (UMONS) and his research includes the use of machine learning and deep learning techniques for recognition and evaluation of body gestures, captured mainly using low cost sensors.

O. Sahbenderoglu has a Bachelor's degree in both Software Engineering and Computer Engineering and now works as a game developer in Turkish Telekom.

K. Dimitropoulos is a research fellow at Information Technologies Institute - Centre for Research and Technology Hellas (ITI-CERTH) and an academic faculty member of AIMove (Artificial Intelligence and Movement in Industries and Creation) Post-Master Programme at MINES ParisTech University. He holds a diploma in Electrical and Computer Engineering and a Ph.D. degree in Applied Informatics. His main research interests lie in the fields of multi-dimensional data modelling and analysis, human computer interaction, virtual reality and serious games. His involvement with these research areas has led to the co-authoring of more than 110 publications in refereed journals and international conference proceedings. He has participated in several European and national research projects and has served as a regular reviewer for a number of international journals and conferences. He is a member of IEEE and the Technical Chamber of Greece.

S. Douka is an associate professor at the Department of Physical Education and Sport Science at the Aristotle University of Thessaloniki (Greece). Her research interests are Physical education, Dance, Sociology of Sport and Leisure, Technology in Sport, Event Management and Use of Information and Communication Technology(ICT) to support physical education. She is responsible coordinator ECTS for her department and member of the curriculum development committee. She has published more than 130 papers in Journals and in well-known refereed conferences and she is co-author in 3 books. She has been a PC member and referee in various international journals and conferences. She is also involved in numerous sport and cultural event organizing committees. She is also member of the Laboratory of Sport, Tourism and Recreation Management. The mission of the lab is the promote excellence in research, training and education in areas related to sport management, physical activity promotion through recreational activities (included but not limited to fitness, outdoor sports and traditional / modern dancing), technology in sport and sport tourism development.

N. Grammalidis is a Senior Researcher (Grade B') at CERTH-ITI. He received his Diploma in Electrical and Computer Engineering and Ph.D. degree in Electrical and Computer Engineering, both from the Aristotelio Panepistimio Thessalonikis, Greece in 1992 and 2000, respectively. His main research interests include Image, Video and Multidimensional signal Processing, Computer vision, Machine learning, Intelligent Systems and Applications, ICT in Cultural Heritage, Analysis, Modeling, and Visualization of body movement and facial expressions,. His involvement with those research areas has led to the co-authoring of more than 130 articles in refereed international journals and conferences. He has received the IET Premium Award 2012 and the Euromed 2012 Best Full Paper Award, as a co-author in scientific papers. Since 1992, he has been involved in more than 15 projects funded by the EC and 13 by the Greek General Secretariat of Research and Technology. He has been the coordinator of several European and National research projects, including the FP7 i-Treasures and FP7 FIRESENSE projects.