Blexer-med: A medical web platform for administrating full play therapeutic Exergames

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Abstract. The work presented here is part of the currently ongoing project "Blexer" (Blender Exergames), which aims at creating a complex exergaming environment for people with physical impairments. The games are thought for daily fitness exercises or rehabilitation and are based on movements captured with the Xbox 360 Kinect® sensor. Via a middleware, the games, currently implemented in the Blender Game Engine, communicate with a web platform called "Blexer-med", which is the working tool for the health professionals to manage the sessions of their patients. With help of the platform, clinicians can assign different games to their patients, personalize exercises by adjusting their difficulty, and obtain their performance results in real time. The advantage is that the exercises can be adapted by the therapist according to the results without the need to meet the patients, who do the exercise at their homes. This paper presents the architecture and functionalities of the web platform and its belonging database, as well as an example use case. The platform is currently tested by some volunteers suffering from muscular dystrophies, with a newly created adventure game. Although our work focuses on people with disabilities, the platform is generic and could be connected to any kind of exergames aimed at other purposes.

Keywords: Exergames, web platform, disability, rehabilitation, Kinect, Blender.

1 Introduction

Physical Therapy and Fitness is important and necessary for everybody, as it provides opportunities for strength development, physical conditioning and functional training. Unfortunately, for people with physical impairments, the possibilities to do sports are very limited, and even less if they are wheelchair dependent, therefore they usually are not able to do more than attending some days a week to physiotherapist sessions. To overcome this problem, exergaming, i.e. using active console video games that track player movements to control the game (e.g., Xbox-Kinect, Wii), may provide a form of exercise, if the games were configurable to the possibilities and needs of the disabled. Bonnechère et al. showed that video games, not especially designed for clinical purposes, are as efficient as conventional therapies or lead to even better therapeutic outcomes. They also have numerous advantages, such as preventing monotony and boredom, increasing motivation, providing direct feedback, and allowing double-task training [1].

There are many proposals in literature that present especially designed exergames for the rehabilitation of frequent diseases like Stroke or Parkinson's, which mainly affect elderly. To the best of our knowledge (we published an extensive state of the art section in [2]), there is no proposal for a general solution useful for a broad range of people with different disabilities, which, furthermore, goes beyond the possibilities of a mini-game, i.e. incorporates some kind of a history or purpose other than the exercise, to engage the player.

Regarding the remote configuration and management of the therapeutic games, which has the advantage that people can use them at their homes under supervision by the therapists, the solution is a web platform that can be connected with the gaming software. Some commercially available solutions have been found, e.g. MIRA Rehab Limited [3] and VirtualRehab [4]. Similar to the here presented work, the games register movements with help of the Microsoft Kinect camera and the clinician receives this data via the platform to evaluate the progress of the patient and gets the chance to reconfigure the adjustments. Both systems are applicable to different types of users like patients with Down syndrome, muscular diseases or cerebral palsy.

Furthermore, two similar systems have been developed in the same research group of Valladolid University: TELEKIN [5] and "La Isla EPIKa" [6]. The TELEKIN environment consists of four modules: an administrator web, a therapist web, a family web and the game module. The games work with either a Kinect sensor or a Leap Motion sensor to capture only the hand movements. "La Isla EPIKa" aims at the rehabilitation of stroke patients. Again, via a web platform, the therapist can adjust a number of difficulty parameters; the web offers also a guided mode for patients with severe paralysis.

Apart from those works, the European project REWIRE [7] (Rehabilitative Layout in Responsive Home Environment), funded by the seventh framework program, has to be mentioned. The consortium developed a rehabilitation platform for stroke patients based on virtual reality that allows the patients to do their exercises at home under remote monitoring by the hospital. The platform is composed of three parts: the patient station, the hospital station and the networking station. The patient station offers different simple exercise games, which are working with different sensors, as there is the Microsoft Kinect camera, a Balance Board and a haptic device. The clinician at the hospital who also receives the session output results, via the web, can configure them.

All mentioned systems have one thing in common: they manage a number of minigames, i.e. games without interrelation as each represents a different exercise in a different environment and with an own purpose. The patients have to use those corresponding to their needs repeatedly to improve their physical state, but the exercise itself is not very different to doing it in a clinical centre together with a therapist. The difference of our work is to overcome this pure translation of exercises from the gym to a virtual environment. Instead, the exercises are integrated into a meaningful gaming environment, where the user is not aware of doing exercises but engaged to have the gaming experience and to win. This avoids that the patient gets bored and demotivated through too much repetitiveness and too evident exercises. Here, the application of gamification rules is very useful, as they help to create a gameplay that captures the players, such that they continue without being forced. As stated by Yu-kai Chou in his book "Actionable Gamification" [8], there are eight core drives that engage a person to do an activity, not only referring to games. A very important one is "Epic Meaning & Calling", which refers to the identification of the player with the main game character of a game and their feeling to be part of its history. As a consequence, the creation of full games with a complex history and meaning, seems to us a very promising way to really engage patients in doing their exercises, above all in long-time exercises, which are needed in case of chronical diseases.

Therefore, this work does not present yet another web platform. The main contribution of the here presented "Blexer-med" platform, which is part of the project "Blexer" (Blender Exergames), is to provide direct access to a personalized configuration of the gameplay of immersive large full play games. As opposed to mini-games, they rest upon multiple scenes and different levels, which camouflage the exercises as tasks to be performed by the game character. The patients, while playing, are not aware of doing rehabilitation, but are forced to do the exercises due to the gameplay, i.e. they are motivated to win and therefore have to do what the therapist adjusted for them via the web. In our future work, the interaction between the games and the web will be enhanced with intelligent algorithms to augment its utility for the therapist. The aim is to adapt the game flow according to the user's performance, mood and necessities in real time, keeping motivation always at a maximum level. Furthermore, it is planned that the game could act as an assistant for the therapist, by indicating possible reconfigurations of the game according to the user's performance.

In the following, the system architecture is outlined and a use case is presented to show the versatility of the platform.

2 "Blexer-med": Proposed System Architecture

Requirements.

First, the "Blexer-med" web environment is a tool for clinicians that helps to configure and supervise the exercises of their patients like a remote control. It is not intended for the patients like in some of the formerly mentioned approaches, because the patients should only concentrate in playing and should not be aware of doing exercises.

For organizational reasons, three user roles have been defined in a hierarchical manner:

1. **Super-Administrator** (super-user with several functions):

   – Create new game structures including: name, description, exercises, configurable parameters, etc. Furthermore, he/she is in close contact to the game developer for

carrying out new configurations in the web environment based on the new game characteristics.
– Create Centers: For new patients and professionals to access to “Blexer-med”.
– Register and unregister Center-Administrators, Clinicians and Patients.

2. Center-Administrator

– Register and unregister Clinicians and Patients.

3. Clinician (therapist or doctor)

– Register and unregister their patients.
– Configure the gaming parameters of their patients.
– Observe and comment the data of other patients of the same center.

Currently, there is one game in alpha phase connected to the web. It is an adventure game with a young amphibian called “Phiby” as the main character, who is exploring an unknown world and has to find the way out of a valley. Therefore, it has to overcome certain obstacles like lakes, rivers and steep slopes by diving, rowing a boat or climbing up a tree next to a slope. There are also sites to chop wood, which is gained and enables to build bridges over the rivers, or little huts to rest. When a hut is built, the game status can be stored like a level to continue there a next time. In-between the obstacles, some apples are placed to recover energy. Whenever one of the obstacles is passed, a new part of the map is discovered, so step by step the player gets aware of the surroundings and is motivated to keep on exploring the world and to bring “Phiby” to its destiny. A more detailed description of the game can be found in [9].

The movements necessary to do the tasks involved in the scenes have been formerly tested in form of independent mini-games by a group of volunteers with different disabilities who were mostly wheelchair dependent [2]. Results have proven that the movements are functional and safe, so they have been transformed to the here mentioned exercises.

The requirement for the web environment is to allow personalized configurations of the individual exercises of any game similar to the formerly described one. Therefore, a hierarchical structure is needed, consisting in a root, the depending exercises and a generic number of adjustable parameters:

Game A:

– *Exercise 1 (parameters 1 to 4)*
– …
– *Exercise n (parameters 1 to 4)*

Here, each exercise would be a task to perform in the game, e.g. climbing. The parameters can be adjusted according to the difficulty level of the exercise, e.g. in case of climbing, the height of the tree and/or the time to perform it.

To allow the configuration of any type of game to any type of user, this structure has to be totally generic and extensible, such that it does not depend on the type or number of parameters handled in each exercise. In this way, the same game could be configured differently for any player.

Layered Architecture.
Figure 1 shows the architecture of the currently implemented system environment. The patient's PC contains the Exergame, created in Blender [10] and a Middleware named "Chiro" [11] that is in charge to transmit the data obtained from different sensors which is used as input to control the games.

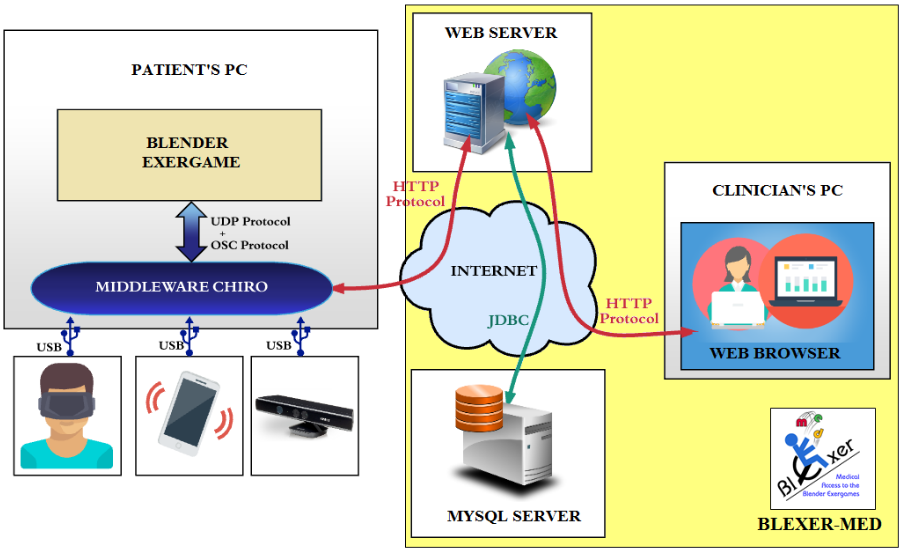

Fig. 1. "Blexer" system environment. On the left, the patients' PC represent the users at their homes; on the right, the "Blexer-med" system consists of a web server with the MYSQL database. The clinician's PC represent doctors and therapists at different medical centers.

With the aim of avoiding from the beginning the possible coupling between the different parts that compose the "Blexer-med" web environment, the web platform is structured into three layers:

a) **A data layer** using MySQL server as an open source database manager. This layer stores all data belonging to the clinicians, administrators, center, patients, and game settings, etc. This layer provides information to the business layer in case of requests.
b) **A business layer** implemented in Java using a RESTful web service (Representational State Transfer). The web service is accessed with help of the API JAX-RS (Java API for RESTful Web Services). This layer processes the user requests and accesses to the database.
c) **A presentation layer** which is the heart of the distributed system that manages three types of interactions based on the client/server model. The aim of this layer is to maintain the system independent and easily adaptable to different platforms. The presentation layer shows the information to the user (clinician) and captures the events triggered by them.

As Figure 1 shows these are the Protocols used in the different interactions:

1. **User ←→ Web** interaction with HTTP (Hypertext Transfer Protocol) to access the platform
2. **Middleware ←→ Web** interaction with HTTP to download game configuration and upload user results
3. **Database ←→ Web** interaction with JDBC (Java Database Connectivity) to obtain the data to transmit to middleware or user.

Database.

The database is a relational database and contains identification tables for administrators, centers, clinicians and patients on one hand, and game dependent tables for comments, game description, game setting, exercises, and session results. Two types of dependencies are used:

- **Identifying** (the "son's" existence depends on the "father's" existence), e.g. if a Center is deleted, also the administrator, clinicians and patients are deleted
- **Not identifying and independent** (a "son" would not be deleted in case the "father" was), e.g. Session Results are not deleted if a Game is deleted. This relation is needed to save performance data of the patients as long as they are registered on the platform, as it could be still of interest for the therapist.

Web representation.

Regarding the presentation layer, Fig. 2 shows one example form, which is accessible by the Super-Administrator to define the exercises of the formerly mentioned adventure game. Some views of the clinician can be seen in Fig. 4 and Fig. 5 and are explained in section 4.

3 Data exchange for game configuration and observation of results

The configuration data set up by the clinician in the web environment, as well as the results obtained from the play, are stored in text files formatted in JSON (Java Script Object Notation) format to facilitate the exchange. As illustrated in Fig. 3, the middleware "Chiro" sends a HTTP GET request to the web service to download the configuration file, at the moment the user logs in.

If the user authentication was successful, the web service creates a JSON file containing the parameters marked by the therapist as "in use" (see also example in Fig. 4). The file contains a map for each game and inside a map for each exercise. A map is formed by a set of items, each consisting in the structure "key-value". The key is an array of three strings: `[id_exercise, code, title]`; the value is obtained from the object created for the exercise. The file is then downloaded by "Chiro" and saved to the user's hard disc. Finally, the game itself de-serializes the JSON code and applies the values established for the different parameters in each exercise to the game flow.

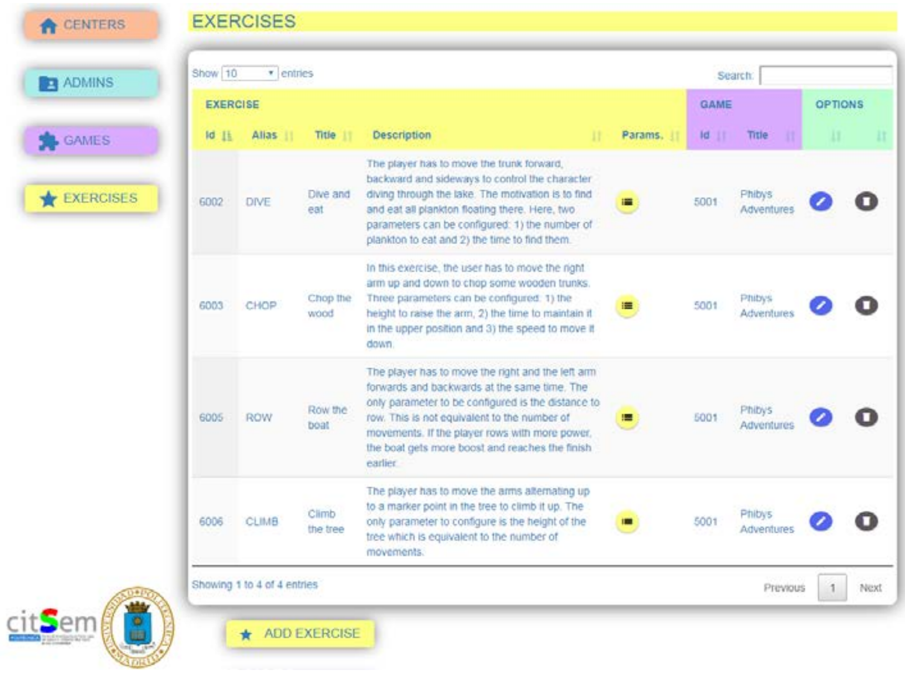

Fig. 2. Super-Administrator view of the exercises defined for a game. Example for the game Phiby's Adventures which contains four exercises (Dive, Chop, Row and Climb). On the left, the tabs "Centers" and "Admin" give access to administrate health centers and their staff. "Games" gives access to administrate different games.

For the interchange of the results obtained during the game play (scores, times etc.), the game creates a text file, also in JSON format, containing those values in form of an array. When the patient quits the game and closes "Chiro", "Chiro" sends one result at each timer to the web platform, awaiting the confirmation of a correct de-serialization. In case of success, the result is deleted from the file and the next one will be sent. In this way, no results are lost due to bad internet connections. When a connection fails, the failed data will be re-sent the next time the user starts "Chiro".

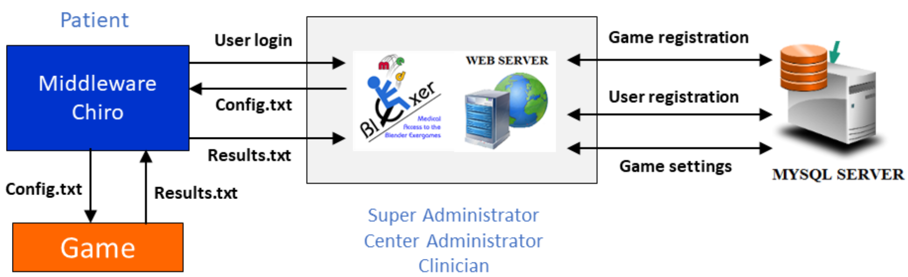

Fig. 3. Exchange of configuration information and results between the game and the web

4 Example use case

In the following, we present a use case[1] to illustrate the particularities and advantages of our approach:

"Pepe Sanz" suffers a progressive muscular dystrophy and is using a wheelchair since 5 years. As a small boy, he could walk and play outside with his friends, now he is mostly alone and sitting in front of his computer. Unfortunately, the seated position is provoking a quicker degeneration of his muscle strength and a bad posture. His physiotherapist is visiting him twice a week and recommends daily arm and trunk movements to keep fit, but he is not motivated to do them, as they are very arduous and tiring. As he is a passionate gamer, he tried out the Xbox with Kinect and some sports and adventure games. But soon he got frustrated, as it was impossible for him to reach the same scores like his friends. One day, Maria, his therapist, came up with "Phiby's Adventures", connected it to his Kinect and calibrated the embedded movement amplifier to Pepe's motion range. Through the web, she adjusted the parameters of the exercises as visualized in Fig. 4 for the exercise "Dive and eat" as an example. Fig. 5 represents the view of the results for the same exercise.

In this exercise, "Phiby" has to be moved through the water with trunk movements to find a number of planktons to eat in a limit of time. Fig. 6 shows a screen shot of the exercise.

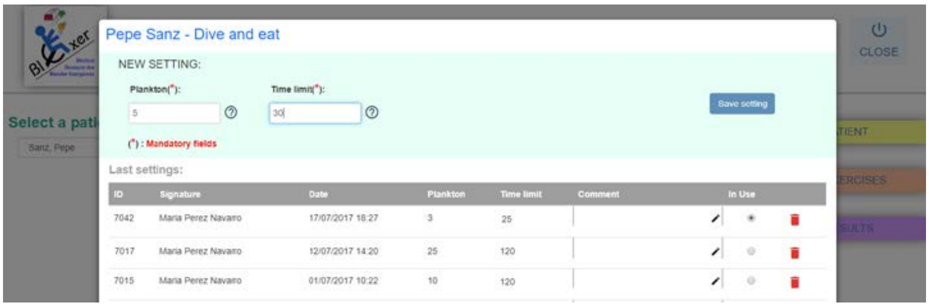

Fig. 4. Example for different configurations made over time for one exercise

It can be seen, that the initial setting of 10 pieces of plankton was too much, Pepe only got 5 and gave up after 20 minutes as it was the first time he played. Nevertheless, Maria augmented to 25 pieces and Pepe got 20, needing the maximum amount of time. As this was evidently too much effort, Maria set up only 3 pieces to get in 25 minutes. The first time, Pepe got them in 13 minutes, the next time, on the same day, he needed 25 minutes, because he got tired from the former play, where he also realized other exercises of the game. In short time he got engaged, because his therapist found quickly the right values for all exercises, and he played more each day and progressed such that his back muscles augmented in strength. This story is not real, and the values have been

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[1] All names and personal data is invented and any possible relation to a real case is neither intended nor known. The performance data is also not real.

obtained while testing the environment, but we believe that they are useful to show how the tool could be used.

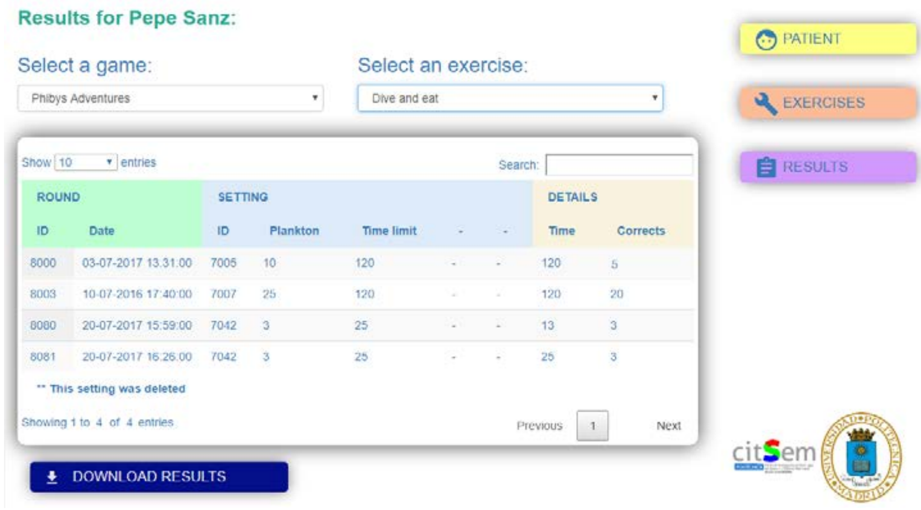

Fig. 5. Example for results obtained in different sessions performing the "Dive and eat" exercise. "Time limit" and "Time" in minutes.

Fig. 6. Screen shot of the "Dive and eat" exercise. The main character "Phiby" has to be moved with trunk movements (seated or standing) to catch the yellow pieces of plankton.

5 Conclusions and Future Work

In this work, we presented the web platform "Blexer-med", which aims at assisting doctors and physiotherapists in the usage of exergames as an additional instrument for their therapies. The platform can be connected to customized games that incorporate different configurable exercises based on movements captured by the Kinect camera. Those games are not simple translations of real exercises to a virtual environment, but incorporate advanced game mechanics that enhance the user's immersive feeling and motivation. Via the web-based platform "Blexer-med", the therapist can adjust the difficulty of the exercises in relation to the patient's needs and preferences, with the aim to maximize the user's motivation to perform the exercises without being aware.

Currently, one full play adventure game that contains four different types of exercises, repeated in the order chosen by the patient, is tested together with the platform on a number of volunteers with disability suffering from rare diseases. Results will be hopefully published at the end of the year.

The next step of the project "Blexer" is the incorporation of an automatic adaptation of the game flow to the user's performance and mood in real time. Therefore, the game will observe the user and adjust the parameters within the thresholds defined by the therapist, with the aim to keep the patient's motivation at a maximum level. More advanced parameters regarding the exercises will be taken into account and decisions will be reported to the therapist via the platform.

Furthermore, a face recognition will be implemented to check if the right person is playing, a quality check of the movements and a more versatile configuration will be added and the processing of additional sensor data will be integrated to enhance the possibilities to check the user's performance. All enhancement will then be tested with different types of user adaptive games.

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References

1. Bonnechère, B., Jansen, B., Omelinab, L., Van Sint Jan, S.: The use of commercial video games in rehabilitation: a systematic review. International Journal of Rehabilitation Research 39(4), 277-290 (2016).
2. Eckert, M., Gómez-Martinho, I., Meneses, J., Martínez, J.F.: New Approaches to Exciting Exergame-Experiences for People with Motor Function Impairments. Sensors 17(2), (2017).
3. MIRA Rehab, http://www.mirarehab.com, last accessed 2017/06/28.
4. VirtualRehab, http://www.virtualrehab.info, last accessed 2017/06/28.
5. TELEKIN, http://gti.tel.uva.es/juegos-serios-para-rehabilitacion-fisica-yo-cognitiva/telekin-sistema-de-telerehabilitacion-para-discapacidades-motoras-y-cognitivas, last accessed 2017/07/02.
6. La Isla Epika, http://gti.tel.uva.es/juegos-serios-para-rehabilitacion-fisica-yo-cognitiva/la-isla-epika-juego-serio-de-realidad-virtual-para-rehabilitacion-de-ictus, last accessed 2017/07/02.
7. REWIRE, FP7-ICT-2011 Call 7 - Personal Health System (PHS), https://sites.google.com/site/projectrewire/, last accessed 2017/06/28.
8. Chou, Y-K: Actionable Gamificación. Beyond Points, Badges, and Leaderboards, Octalysis Media, (2015).
9. Eckert, M., Gómez-Martinho, I., Estéban, C., Peláez, Y., Meneses, J., Salgado, L., Blexer – Full Play Therapeutic Blender Exergames for People with Physical Impairments. In: 3rd EAI International Conference on Smart Objects and Technologies for Social Good, Pisa, Italy, Nov 29–30, (2017).
10. blender.org, https://www.blender.org, last accessed 2017/07/02.
11. Eckert, M., Gómez-Martinho, I., Meneses, J. Martínez, J. F.: A modular middleware approach for exergaming. In: IEEE Int. Conf. on Cons. Elect., pp. 172–176, Berlin, (2016).