

# Exergaming Simulator for Gym Training, Fitness Testing and Rehabilitation

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**Abstract**—Exergaming products are gradually becoming more common in gyms. Evidence of the benefits the exergaming products can provide for people of different ages has been widely published. During the last 1.5 years we have developed a new exergaming simulator for gym training, fitness testing and rehabilitation. As a next generation exergaming device, it combines various gym and rehabilitation equipment (treadmill, exercise bike, etc.) with virtual environments, games, sports applications, immersive gaming view and advanced motion controllers.

**Keywords:** Exergaming, simulator, gym training, virtual environments, games, CAVE environment

## I. INTRODUCTION

Exergaming solutions have been mostly targeted to home markets where dance pads and Wii boards merge exercising and gaming together. Recently exergaming solutions for gyms, rehabilitation centers, and amusement and activity parks have started to become more common. There is only a limited amount of high quality exergaming products on the market at the moment, but it is easy to anticipate that this market will expand in increasing pace in the fight against obesity and inactivity. Another growing field is exergaming training spaces in which all activities and devices are exergames. One of the pioneers in this field is the company called Exergame Fitness USA which provides a large variety of different products and training space solutions.

Exergaming has also become a part of the traditional exercising equipment. Modern gym devices, such as treadmills and exercise bikes, are often equipped with a screen and an integrated computer. The user can choose to play games or use virtual and/or video landscapes during the training. These devices with additional integrated applications, such as social media and web browser, may motivate and bring fun for some users. Nevertheless, the lack of immersion due to the small screen and the limitations in the control of the game (most often it is only the speed that can be controlled) may restrict their usability and leave space for innovations, in which these features are developed to a new level. There are also some products in which an exercise device is connected to a computer and a screen (e.g., TacX, Spivi Indoor Cycling Training system) or the exercise device can be connected to a mobile application (e.g., Kickr, BitGym).

Extensive research has been carried out concerning the possible physical and psychological benefits of exergames for different ages (e.g., children, seniors) [1, 2, 3] and for different target groups (e.g. inactive children, rehabilitation groups) [4]. Also the use of virtual environments in exercising has been studied [5]. These results indicate generally that exergames have positive psychological and physical impact to the studied groups. The studies have shown, e.g., increase of exercise motivation [6], physical activity [4] and energy expenditure while playing exergames [3, 7], and improvement of the balance [2], mood and attention after playing exergames [8]. However, some studies exist with no clear evidence of the benefits [9], but no harmful effects concerning the use of the exergames have been reported.

Several research groups and laboratories have concentrated on the scientific study, development, and/or testing of exergaming products in order to get better understanding and evidence of the possible benefits of the use of exergame devices. Such groups are, e.g., Exergame lab in Coastal Carolina University, University of South Florida Research Labs, the Canadian Exergaming Research Centre, and ExerGame Lab in in SUNY Cortland's Kinesiology Department.

During the last 1.5 years, we have been working in Kajaani University of Applied Sciences with a new kind of exergaming simulator for gym training, fitness testing and rehabilitation. Our aim has been to develop a simulator which integrates different exercising and rehabilitation devices, immersive virtual environments, games and advanced motion controllers, in order to bring these devices to a new level.

Our core team worked previously in the University of Oulu, where our focus was to develop different kinds of driving simulator solutions [10], and carry out psychological research in the field of simulator sickness [11] and driving skills [12, 13]. During the research and development of driving simulators we learned, for example, how to create high quality virtual environments, how to build and use a multi-screen CAVE environment and how to control and fine tune different motion platforms. In 2012 we continued our work at Kajaani University of Applied Sciences, where we built a high-end driving simulator with a cockpit of a real car, a real wheel, gauges, a gearshift and pedals as well as with a 6DOF motion platform. During the development of the high-end driving simulator we started to plan how to apply our knowledge and expertise of simulators to the area of sports,

games, well-being, health and tourism, which are strengths of the Kajaani University of Applied Sciences, and in which game education is internationally well-known.

In the beginning of the year 2013 the development of the new exergaming solution started. The project received funding from Cemis Development Programme (EU funding), and expanded six months later with a parallel game intensive project, supported by the Finnish Funding Agency for Technology and Innovation and 17 project partners. Game companies, such as Supercell and Remedy, joined the project together with partners from the areas of tourism, sports, healthcare, education and technology, and provided resources and expertise for the project.

## II. DEVELOPMENT OF THE EXERGAMING SIMULATOR

In the beginning we did not know exactly which group will be mainly targeted in our project. We designed a three step roadmap in order to find out the potential customers for the product, and to recognize the product's prospects in the exergaming market.

*The first step* was to carefully select the project partners from many different areas that could help us 1) in finding the existing solutions, potential needs and markets for exergaming simulators, and 2) in providing information about the business potential in the field they represented. The collaboration has been fruitful especially with sports, gaming, technology and health care sector.

*The second step* consisted of mapping carefully existing products, creating networks, and testing different exergaming solutions, which helped us to get acquainted with the state of the art of the exergaming field. Based on all this information and our analyses we decided to focus primarily in developing the exergaming simulator for gyms and secondarily for fitness testing and rehabilitation.

*The third step* was to build several pilot setups in which the simulators were tested for different purposes with different kinds of test groups.

Our first setup presenting Athene Exergaming was an orienteering simulator, in which a treadmill, Kinect motion controller, high quality virtual environment and an in-house programmed orienteering game were integrated together. This pilot case was chosen because the World Orienteering Championships were held in our region, which provided a unique environment to pilot and seek for validation for our solution. During the Championships, the sportsmen and other visitors were able to try the simulator and the orienteering game (Figure 1). The task in the game was to find as many checkpoints as possible in three minutes by using real map of the city of Kajaani. Using the real map was possible because virtual Kajaani is an exact copy of real city environment. We attached a HALL-sensor in the treadmill and used it to calculate the speed of the treadmill and transferred the speed information into the game in order to get the gameplay follow the speed of the user. We used the Kinect motion sensor device to recognize the user's gestures to define the direction where the player wanted to go. The user was able to choose between using head tilt or hand movement to turn.



Figure 1 Over 300 people tested Athene Exergaming for Orienteering at WOC2013.

After each test run we asked the user to answer a questionnaire and give us feedback by using the iSurvey iPad application. We got over 300 answers from professional and national level athletes, which was very useful for further development of the simulator. An example of the questionnaire's results is presented in Figure 2.

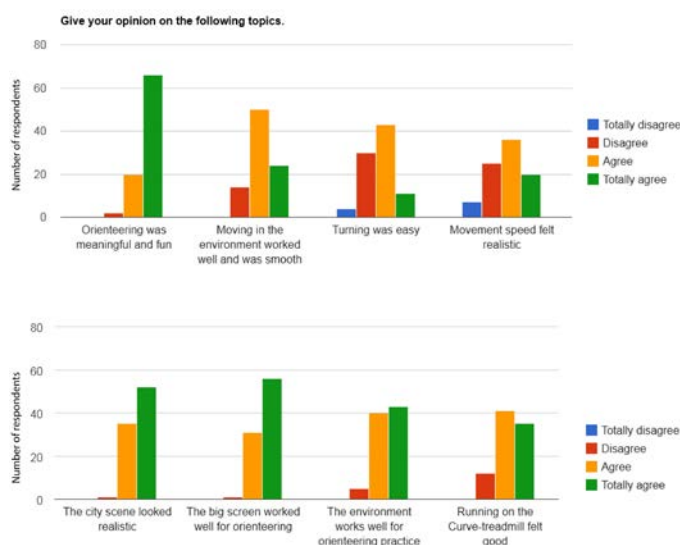


Figure 2 Distribution of user opinions when testing Athene Exergaming during the World Orienteering Championships 2013. Data from 305 users.

The first pilot was followed by a series of different pilot cases (e.g., gym, rehabilitation, fitness testing, and adventure contest pilots) which were defined with specialists of each area. The pilot cases were carefully analyzed afterwards.

*Athene Exergaming Team* consists of specialists from different areas. The project organization is divided to Lead, Software and Technology Teams which are working closely together. During the project special attention has been paid to improve the communication between different teams. It is difficult to develop efficiently a new product together if vocabularies do not match. The team uses an iterative and incremental agile software development framework for managing product development (SCRUM). Each morning the software team has their daily standup in which everyone reports on the progress made since the last meeting, goals for the next one, and if they have confronted any impediments.

The progress is followed in one week periods by weekly sprint reviews in which the team reports their accomplishments to the whole project organization.

Recently an important step in our product development process and QA management was taken when we started to use a new testing tool called the Deeper Game Testing Software (Figure 3) which was developed in our previous *Pelitys* project. This software makes it possible to monitor the test person, the virtual environment view and the physiological signals simultaneously. It is also possible to add comments and mark important findings in the software. The software shows all data and video records synchronized together.



Figure 3 The interface of the Deeper Game Testing Software.

### III. PRODUCT PROTOTYPES

Athene software includes beautiful virtual environments with a free run option (user can explore the area freely) and several routes of different lengths and difficulty levels. Finnish forest (Virtual Vuokatti) and city (Virtual Kajaani) environments, a tropical island, and mountain scenery are the first available scenes.

The software includes variety of exercising modes, such as jogging, mountain biking, orienteering, and adventure. Gaming plays a major role in all exercising modes. As an example, it is possible to challenge a friend in an adventure game or, in future, participate in competitions in which numerous people are participating via Internet. Also in fitness testing, the users may challenge themselves or their friends by competing against avatar characters based on their previous exercise results. The software includes also support for different add-ons, such as heart rate monitor, stride and cadence sensors, and Oculus Rift.

At the present, there are three prototype products in the Athene Exergaming product family. The Athene Basic is a light version of Athene Exergaming. It has been designed for limited space requirements. It includes the Athene software (based on the Unity3D game engine), PC, television or projector, Kinect motion sensor and an Athene communication device (ACD), a sensor to exercise machine or connection to exercise device's interface. It also includes Athene wall, which provides a safe place for devices and wires, and polishes the product looks. In the Athene Advanced (Figure 4), three televisions are used to create an

immersive exergaming experience. The setup is provided with an Athene triple wall structure.



Figure 4 Prototype of the Athene Advanced with the Kickr device.

In the Athene Premium (Figure 5), the CAVE environment provides an ultimate exergaming experience. Three projectors and the CAVE structure enhance the virtual or video environment to the next level. There is also a more lightweight CAVE solution which can be easily passed from one place to another.



Figure 5 Prototype of Athene Premium with Curve treadmill.

*Athene Communication Device* (ACD) has a size of a match box. It enables communication between the exercise device and the Athene software, and includes also different sensors (for recording of heart rate, cadence, stride, and acceleration). It has support for the most typical protocols, such as ANT+, Bluetooth 2.0 and 4.0, but it is also possible to integrate the device by USB serial port.

ACD is the key for the integration of different exercising devices into Athene Exergaming even wirelessly. Full Integration can be made directly by using device's interface which is usually done in collaboration with the manufacturer.

In this case information can be read from the device (speed, RPM, etc.) and data can be sent to the device (angle of actuators, resistance etc.). Semi-integration means that the data can be read by the device interface, but the data cannot be sent to the device. The third option is to attach, e.g., a HALL sensor to the device and then calibrate the received data from the sensor in order to get the device speed synchronized with the speed of the virtual environment. Currently the integration has been made with Woodway Curve and Tunturi Pure Run 10 treadmills, HUR Monark FCM exercise bike, Kickr bike trainer and a couple of other devices.

#### IV. DISCUSSION

Exergames have good prospects to motivate people from all age groups to be more physically active. They are often perceived as fun to play, but the idea behind exergames also promotes a healthier lifestyle. Sedentary people may find joy in moving through the gameplay. In addition to positive effects in physical activity, it is as important to consider the positive effects on the mental side of the people, as has been presented in several publications mentioned above.

Exergaming, especially with features that allow the users also to travel virtually, can bring fascinating exercising experiences for many people. There are several places in the world that are too dangerous to visit. The climate can be too hot or polluted for exercising outdoors. In urban cities the nature is just too far for many people to reach. Exercising in virtual environments may bring people a unique experience that is realistic, but without great deal of trouble.

The exergaming industry is still small and in its early phase, but many interesting products for different purposes can be found and new products are created with increasing pace. One major player in the exergaming business is Exergame Fitness USA which is the global leader in exergaming products. Also, one recently recognized product takes advantage of arcade game devices. NBA Baller Beats is a prototype of an arcade machine in which Kinect motion sensor is used to turn a basketball computer game into a very promising exergame that aims to get lots of American children and adults to move.

Athene Exergaming takes advantage of existing technologies and equipment. What makes a difference to the other similar products on the market is the innovative way of combining existing exercising and rehabilitation devices with the virtual environment, application of games, advanced motion control and immersive visual systems and wall structures. Also, the Unity 3D game engine provides an ideal platform to apply the software for developing, e.g., more game content for different target groups.

In April 2014 the innovation was awarded as the second best innovation in the world wide Leading Trade Fair of Fitness, Wellness and Health (FIBO). Good feedback from different pilots and success in FIBO Innovation competition has encouraged the developmental work of the whole team for new endeavors. The Athene Exergaming will be launched

in the markets in the fall 2014 by a spin-off company from the University.

#### ACKNOWLEDGMENT

Athene Exergaming has been developed at Kajaani University of Applied Sciences in collaboration with University of Jyväskylä and University of Oulu. Numerous companies have provided their expertise and resources for our R&D. We are grateful of all the support we have received from our partners, as well as encouraging feedback we have got from people all over the world.

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