Mobile phone applications for motivating physical activity

Ilina Kareva

Faculty of Electrical Engineering and Information Technologies, Ruger Boskovic bb, Skopje, Republic of Macedonia
ikareva@gmail.com

Jovan Kostovski

Faculty of Electrical Engineering and Information Technologies, Ruger Boskovic bb, Skopje, Republic of Macedonia
jovan.kostovski@gmail.com

Andrea Kulakov

Faculty of Computer Science and Engineering, Rugjer Boshkovikj 16, Skopje Macedonia
andrea.kulakov@finku.ukim.mk

Abstract. The goal of the research described in this article was to determine the possibilities of using the widely spread every day used smartphones to motivate physical activity among the youngest users. Another aim was to find out to which degree these devices and applications can replace the expensive exergaming equipment offered on the market. Three prototype applications were developed and tested with the target group. The applications can be used indoor and outdoor, they offer mental training and the possibility of user generated content which makes them highly customizable to the user's needs and ages. The applications are entertaining, educational and at the same time motivate physical activity.

Applications were tested in a kinder-garden with a group of 30 children at the age of 5 and 75 primary school students at the age of 10-11 and they were well accepted by both groups. Teachers and parents present during the testing found the applications very helpful for educational purposes as well as for motivating physical activities and activities that can be used in the free-time.

The principal conclusion was that the smart phones with these applications are decent replacement for the expensive equipment offered for edutainment and exergaming. On the other hand, the possibility to create new levels boosts the involved parties' (both parents and children) creativity.

Keywords: mobile development, physical activity, exergaming, edutainment

adfa, p. 1, 2011.

S. Markovski, M. Gusev (Editors): ICT Innovations 2012, Web Proceedings, ISSN 1857-7288

1 Introduction

In the recent past the computers left the research labs and moved into the everyday life of people. Recently they are in our pockets in the form of so-called "smart phones". This migration certainly influenced the lifestyle, behavior of people and the whole society. Although in many areas they justify their existence, their usage has serious draw-backs in children's world. The advancement of computer hardware became foundation for development of better video games. Game consoles equipped with powerful processors enabling games with excellent 3D graphics and features to be played immediately became widely accepted in homes. These are another reason for children's inactivity.

The percentage of overweight children is growing at an alarming rate with each 1 in 3 children are considered obese [1]. Many children spend less time exercising and more time in front of the gaming devices. Once this problem was spotted some companies offered products on the market with a purpose of solving it. The game consoles got wireless controllers with embedded sensors that can reflect the human's position at every point in time and thus determining the movements [2,3]. So seating was suddenly replaced by a physical activity. That is defined as exergaming. The aim of this paper is to bring exergaming to a device that is part of the everyday life of many people nowadays - smartphones.

2 Related Work

2.1 Existing solutions for mobile devices that motivate physical activity

With the decreasing prices of sensors like small size multi-pixel cameras, accelerometers, GPS devices and Bluetooth devices they became widely used for research in laboratories. Usually the goal is to turn the phone as a game controller or create applications that measure the amount of physical activity and spent calories. When it comes to motivating children's activity the situation is different. Children would never keep logs of their activities, measure how many kilometers they have run or how long they have been exercising, instead they should be engaged to exercise by the fun the game offers. We will mention some good examples where this has been achieved. MarioFit[4] is system for playing the Nintendo game SuperMarioBros using a handheld computer and natural human movements as a mechanism for entering data. In this implementation MultiSensorBoard is used for collecting data from the accelerometer and compass. Then based on these data six different movements are used as input for the game: jumping, low walking, turning, walking, running and throwing. This project was developed in 2005 when smart phones were still not widespread, and are very expensive so it never gained any significant popularity. Another project in which augmented reality comes to the streets of Singapore is physically interactive version of the famous arcade game - Pacman. Human Pacman [5] is a real mobile entertainment system built on the concepts of ubiquitous computing, human-computer interaction and networks entertainment from a wide range. Players interact with each

other and with digital 3D PacWorld placed in their range of view using a portable computer, headset and goggles. One player has the role of Pacman and others are ghosts and their playground are the streets from the real world augmented through the goggles. GPS is used for locating and WLAN for communication. These projects are example that mobile and portable devices can be used to create a new genre in computer games that has the potential to help solving obesity problem.

Today smartphones are equipped with powerful processors, large memory and different types of sensors - camera, GPS, compass, light sensor, temperature sensors and they offer good basis for development of various applications.

3 Applications' Overview

For purposes of this research three applications were developed: RunGame, ColorGame and MapGame. For playing RunGame a smartphone and a personal computer or laptop with a monitor or projector is required and the phone is used as a controller. ColorGame is a game designed to replace interactive walls[6]. MapGame is an application designed for playing outdoors. In this application GPS location of the user is read and he needs to reach certain points given on a map which hold a different tasks. Augmented reality view is used to guide the user to the next point of interest.

Important aspects in the development of the games were:

- Easy installation
- Easy connection
- Possibility to work without an internet connection
- Possibility to create new challenges – levels
- The phone as sufficient device for playung without additional hardware or server for data processing

4 Applications' Implementation

4.1 RunGame

The purpose of this application is to transform the phone into game controller like the ones used with consoles. The application sends accelerometer readings while their processing and determination of the player's movement is executed by the desktop application. The desktop application is a game from the book by David Brackeen - Developing game in Java[7]. This game is chosen for this research because it has a part for editing levels. Additionally a module for communication and movement classifier were added to the implementation.

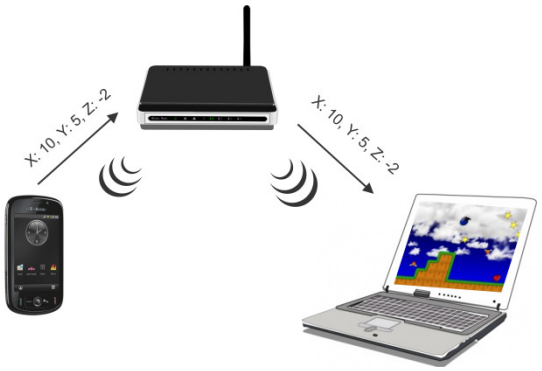
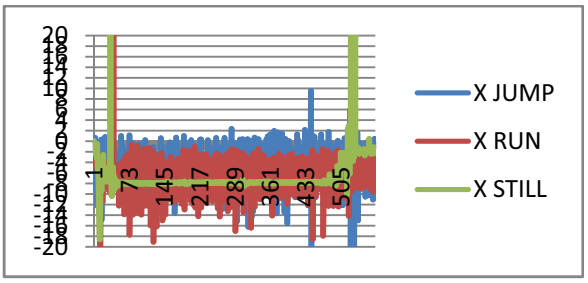


Fig. 1. Setting connection

The built-in accelerometer detects movement in X- Y- and Z-axes. The most challenging task was the determination of the user's activity in real-time: running, standing still or jumping. For the purpose of this application an accelerometer logger application was developed. With the help of this application few testing data files were created with different activities: standing in place, running and jumping. From their plots one can come to several conclusions. Since the application needs to use only three types of motion the classification can be done only by using the values of two axes. When the phone is placed in the pocket the Z-axis always gives the same values because it is parallel to the ground. Depending on whether the phone is set with X- or Y- axis pointing toward the earth the data from one of these two is relevant for making conclusions.



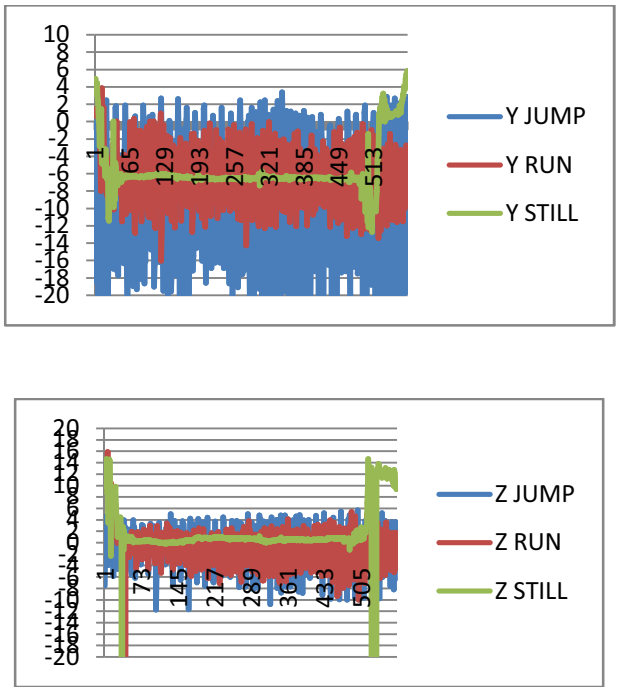


Fig. 2. X-, Y- and Z- axes logged values from different activities

The algorithm that was used in the preparation of the classifier determines the difference between maximum and minimum value of the sensor readings on the axes in a window of 30 readings.

$$\Delta x = \max(x) - \min(x) \mid x = x_k .. x_{K+30} \quad (1)$$

$$\Delta y = \max(y) - \min(y) \mid y = y_k .. y_{K+30} \quad (2)$$

In other approaches[8,9,10,11,12,13] windows with width three times greater than the frequency of the accelerometer readings is used. In our approach a window with a size one third from the accelerometer readings is used because it gave best results when changing from one activity to other. This was determined after several tests with windows of varying width. This simple approach is sufficient for the application to feel like real-time. According to test this approach has proven well in cases when the user holds the device in his hand. Another important feature is that users can create their own levels with different length and weight, with more running or jumping. The game elements are displayed on the next images.

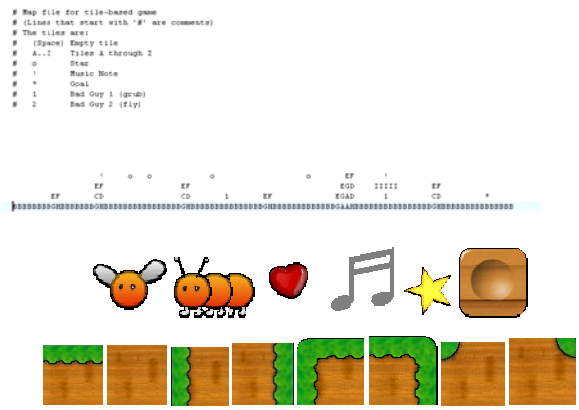


Fig. 3. Game levels design and game tiles

4.2 ColorGame

The purpose of the second application is transformation of any wall with papers in different shapes and colors into interactive [6]. The player must point the figure with a shape and color that is displayed on the screen. This is a good exercise for younger children who have just learned the shapes and colors. It can also be played in "Memory" mode that offers mental training. When making this application it was necessary to take certain approaches from computer vision[23]. Image processing in mobile phones is new and exciting field with many challenges because of limited hardware. The Hue component from the HSV color space is used for determining the color of the pointed figure. For optimization purposes only the central pixels were processed. Next challenge was the determination of the geometric shape that is being pointed by the player. First a threshold is applied to get a binary image and then the geometric properties of the region are analyzed. For determining the shape of the region we use the surface of the region - counting the pixels that compose it. The number of pixels in the area defines the shape. In the case of a square that would be from 85-100% of total area, circle - 65-85% and triangle less than 65%. One can have the same results when comparing the formulas for the area of geometric shapes within the same region.

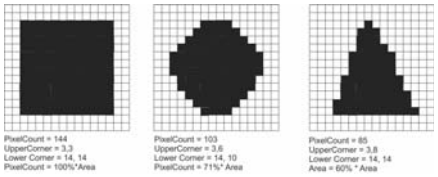


Fig. 4. Figures areas

$$P_{square} = a^2 \quad P_{circle} = a^2 * \pi / 4 \quad P_{triangle} = a^2 \sqrt{3}/4 \quad (3)$$

This method for determining the shape proved most convenient and with real-time response. For this implementation we also tested several well-known libraries like OpenCV [14], silhouette [15] and jjil [16] (John's image processing library) which didn't satisfy the real-time demands.

4.3 MapGame

This application is a combination of several new and modern technologies and approaches in developing applications for mobile phones. It consists of two parts:

- Web interface - a map where users can create games by adding points of interest and questions.
- Mobile application - application that displays games created in an Augmented reality view and guide the player.

This application is primarily designed for playing outdoors, such as amusement parks, zoos and other green areas. Web application is developed using Openstreet-Map[17] . The OpenLayers[18] JavaSctipt library was used for maps manipulation and display and the web interface of the application is made using jQuery[19] library.

The mobile application is an augmented reality browser where the user has two views:

- Forward - Augmented reality browser and markers display
- Down - map display with markers

Fig. 5. Mobile and web application

The built-in GPS and compass were used for determining the position of the user. On the market there are several augmented reality browser like Wikitude [20], Layar [21], Junaio [22], but they were not used because it was not possible to customize them for our needs. Creating the game through the web interface is simple and intuitive. First the user must choose the region in which they would like to create a game. Points are added by clicking on the map. Then through a dialogue the user sets the questions and possible answers. At the end the game should be downloaded and played on the mobile device.

Following is a table where the three games are compared according the criteria set at the beginning.

	RunGame	ColorGame	MapGame
Installation	Easy	Easy	Easy
Connecting	Wireless router needed (Android devices can't create ad-hoc connection)	No connections needed	No additional connections needed
Internet connection in play-time	Not needed	Not needed	Not needed (except when creating new games)
Possibility to create new levels	Yes	No	Yes
Intended for	Parents, teachers and instructors that would like to create new challenges. Could be played indoor on a big screen.	Indoor and outdoor on a white wall with geometrical figures.	Outdoor play in amusement parks, zoos, open areas
Types of activities that this applications motivates	Running and jumping	Aerobic activities and stretching, mental activities	Movement and coordination in space, mental activity

Fig. 6. Applications comparison table

5 Testing and discussion

In order to test the effectiveness of the developed games testing was carried out in the kindergarten "25 Maj" and elementary school "Blaze Konevski". Totaly: 30 children at the age of 5 were present during testing and 75 children at the age of 10-11 tested RunGame and ColorGame.

The game evaluation was done by the principles of the Structured Expert Evaluation Method[24]. A short list of questions was created in order to test if the game goals would be understood and can be achieved by making certain actions and whether the goal would be fun. As evaluation criteria was analyzed the opinion of children compared to the list of questions. Children said that they were able to understand the goal of each game, the actions that they were supposed to perform and they had fun playing the games. They even set their own rules like: being better than the previous player, opening a new level, discovering a new trick in the level, forgetting about the fact that they are actually exercising. This was is accordance to our assumptions about how a fun game should engage the children into exercising without them being aware of it.

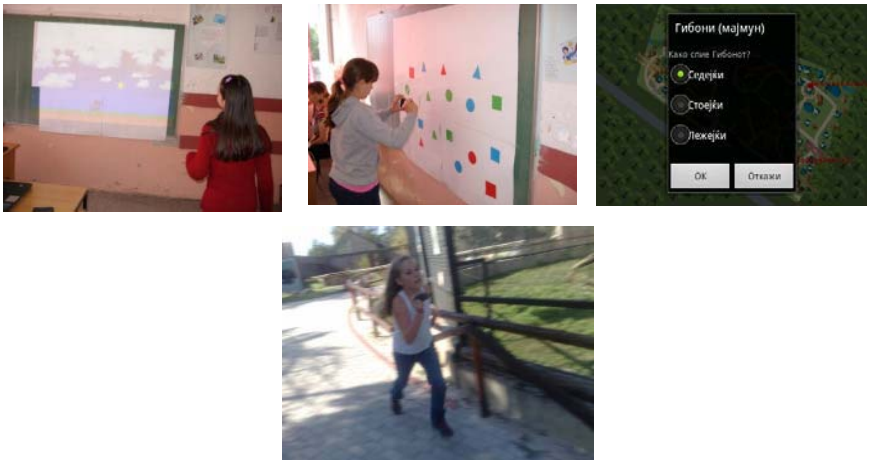


Fig. 7. Children testing the applications

Additionally a challenge for the Zoo - Zoogame was set for the Mapgame. Different locations from the zoo were chosen close to the animal cages and different questions regarding the animals were set. The challenge was tested one day at the Zoo by a group of 10 children. Even though the tests were made with an early prototype user-unfriendly version of the mobile application the children quickly understood how to use it. They were able to find the answers from the panels near the animal cages and to finish the challenges successfully. This test gave us an overview of the current state of the game regarding the gameplay and the players' reactions and adoption. The children showed great interest to play the game again and learned many new facts about the animals while exercising. ZooGame won the 2nd place on a competition for an Android application organized by the Agency for Electronic communication of Macedonia where the jury was impressed by the fact that it was intended for the youngest audience.

6 Conclusion

We have developed a prototypes of a games which are entertaining, educational and motivate physical activity. Since smartphones nowadays are necessity many mobile operators have packages that offer free devices which is a precondition for the acceptance and spread of these applications by many users. People do not carry game consoles wherever they go and in case one has a smartphone, it can easily turn any wall into an interactive or any park into fun. There is no need for special game rooms or additional expenses, but the games can be played at home or outside. Children love things related to technology and this is a way to unobtrusively encourage physical activity. This system is recommended for parents or teachers that would like to spare some time for developing applications for their children's wellness.
We hope that in this era in which people get attached by modern technologies like internet, gaming, social networking and spend huge amount of time sitting in front of the screens with our gaming system we can make them use the same technologies in a way that it would make them more physically active and healthy.

7 References

1. http://www.letsmove.gov/learn-facts/epidemic-childhood-obesity
2. http://www.xbox.com
3. http://www.nintendo.com/wii
4. MarioFit: Exercise Through Mobile Entertainment - Chandrika Jayant and T. Scott Saponas, December, 2005
5. Human Pacman: a mobile, wide-area entertainment system based on physical, social, and ubiquitous computing - Adrian David Cheok,Journal: Personal and Ubiquitous Computing, Volume 8 Issue 2, May 2004, Pages 71 - 81,Springer-Verlag London, UK
6. http://en.wikipedia.org/wiki/Interactive_whiteboard
7. Developing game in Java-David Brackeen, Publication Date: August 31, 2003 | ISBN-10: 1592730051 | ISBN-13: 978-1592730056 | Edition: 1
8. Activity Recognition Using Optical Sensors on Mobile Phones - Michael Wittke, Uwe Janen, Aret Duraslan, Emre Cakar, Monika Steinberg, and Jurgen Brehm, Leibniz Universitat Hannover, Institut fur Systems Engineering, 2009
9. Single-Accelerometer-Based Daily Physical Activity Classification - Xi Long, Student Member, IEEE, Bin Yin, and Ronald M. Aarts, Fellow, IEEE 31st Annual International Conference of the IEEE EMBS Minneapolis, Minnesota, USA, September 2-6, 2009
10. Activity Recognition from Accelerometer Data - Nishkam Ravi and Nikhil Dandekar and Preetham Mysore and Michael L. Littman, Department of Computer Science, Rutgers University Piscataway, NJ 08854, 2005, American Association for Artificial Intelligence
11. Real time human activity recognition using tri-axial accelerometers - Narayanan C. Krishnan,Dirk Colbry,Colin Juillard,Sethuraman Panchanathan, Center for Cognitive and Ubiquitous Computing, Dept of Computer Science and Engineering, School of Computing and Informatics, Arizona State University, Tempe, AZ. 85281, 2006
12. Classification of basic daily movements using a triaxial accelerometer - M. J. Mathie, B.G. Celler, N.H. Lovell, A.C.F. Coster, Centre for Health Informatics, University of New South Wales, Sydney, Australia, Med Biol Eng Comput. 2004 Sep;42(5):679-87.
13. Activity Recognition using Cell Phone Accelerometers - Jennifer R. Kwapisz, Gary M. Weiss, Samuel A. Moore, Department of Computer and Information Science, Fordham University, 441 East Fordham Road, Bronx, NY 10458, ACM SIGKDD Explorations Newsletter, Volume 12 Issue 2, December 2010, Pages 74-82
14. OpenCV - www.openCV.org
15. Silhouette - http://mark.koli.ch/silhouette-project.html
16. Jon's Java Imaging Library, for mobile image processing - http://code.google.com/p/jjil/
17. http://www.openstreetmap.org/
18. http://openlayers.org/
19. www.jquery.com
20. http://www.wikitude.com/
21. http://www.layar.com/
22. http://www.junaio.com/
23. Digital Image Processing - An Algorithmic Introduction using Java, Mark J. Burge, ISBN: 978-1-84628-379-6, Textbook with 560 pages, 271 figures and 17 tables © Springer 2008
24. A Structured Expert Evaluation Method for the Evaluation of Children's Computer Games, Ester Baauw, Mathilde M. Bekker and Wolmet Barendregt, Lecture Notes in Computer Science, 2005, Volume 3585, Human-Computer Interaction - INTERACT 2005, Pages 457-469