SmartLife – Exergames and Smart Textiles to Promote Energy-Related Behaviours Among Adolescents

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Abstract. SmartLife aims to promote healthy living habits and avoid sedentary lifestyles in adolescents by creating a mobile game that requires lower body movement, and uses tailored feedback, based on physical activity indices measured by a smart shirt. To date, no serious games exist that tailor game play by real-time feedback on achievement of the target behaviour. This approach can improve current exergames by reaching higher levels of intensity in physical activity, which is needed to impact on health. The tailored approach also supports competence and feasibility and hence reduces drop-out and injury risks.

SmartLife combines exergame and smart textiles. Gaming experience is tailored according to feedbacks and the physical activity indices measured by the smart shirt providing the user with better game experience.

Consequently, SmartLife holds the potential to contribute to better health by exergaming. A mobile exergame has been developed in co-creation with the target group and improved in an iterative testing process.

Keywords: Smart textile · Exergame · Adolescents · Data analytics Lifestyle · Game · Gaming · Sensor

1 Introduction

Energy-related behaviours (physical activity, sedentary behaviour) are main modifiable determinants of several non-communicable health conditions, e.g. diabetes type 2, overweight and obesity, and track into adulthood [1]. Promoting these behaviours among youngsters can have great health and societal gains. Meeting these recommendations shows a strong decline in adolescence and is especially low among adolescent girls and those of lower socio-economic status. These unhealthy lifestyles are known to hinder several areas of physical [2] and psychosocial development for youngsters, and to be associated with a lower academic achievement [3]. An

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intervention to promote energy-related behaviours among adolescents is thus indicated and may also address social inclusion. Exergames, which require movement to be played, have great yet underused potential to promote these behaviours. To fully utilise this potential, exergames need to promote moderate-to-vigorous physical activity; need to be tailored to the individual user; and need to be more engaging. SmartLife project aims to create such an exergame. This project is co-funded by the Horizon 2020 Programme of the European Commission under Grant Agreement No. 732348.

2 Introduction

SmartLife exergame is a mobile game, which requires lower body movements. The game combines with a textile with smart wearables which can be a valid method for measuring physical activity [4], and for example provide immediate feedback (e.g. heartrate, respiration, movement…) and ensures exercises are performed at a moderate-to-vigorous intensity level. The sensors send the information to the user's Smartphone and the game adapts to the physical conditions of the player in order to promote healthy living habits and avoid sedentary behaviours in adolescents in such a way as to reduce the risk of suffering cardiovascular diseases at early ages.

The game is tailored to individual user's needs, using the smart textile data, and based on available evidence and big data analysis. Furthermore, SmartLife try being highly engaging, e.g. by adding a narrative and context information, and using user input throughout the design ('participatory development'). At the end of the project will have two main outputs, the exergame for mobile phones and the development of an intelligent garment in which wearable movement sensors such as accelerometers, gyroscopes and magnetographs is integrated. These objectives are realized within the following SmartLife features.

2.1 Wearable Sensor System

A wearable sensor system has been developed and integrated into textile, for example: t-shirts, wrist bands, bands, etc.; which monitors adolescents' physical activity and sedentary behaviour by obtaining data such as movement of the user while playing the SmartLife game. These sensors integrated into textile are able to send physical activity and sedentary behaviour parameters of the player to the game and the game adapts the activities to the physical condition of the player.

The electronics include physical movement sensors, but also additional functions such as processed activity data obtained from the sensor data, this allows sending relevant information to the game already processed ir real time. This could be controlling different aspects of the game like speed, difficulty, etc. according to the physical activity.

2.2 SmartLife Exergame and Narrative

The game consists of a mobile game requiring lower body movement where the player has to move to meet the game challenges. Specific game features have been tested together with the target group. Thanks to this game, SmartLife promotes active and healthy habits among adolescents, making them run, move or jump for example. The game is synchronized with the wearable sensor system and connected to a community of players where players could share their results with other players encouraging them to improve and obtain better results (Fig. 1).

Fig. 1. First draft of the game shelter

Exciting game mechanics have been developed to engage the users that leads the player in an entertaining narrative experience. The story takes place in a post-apocalyptic world and can be played indoors and outside with a focus on mini challenges that require physical activities that are tracked by a smart textile the player must wear. In the game the user slips into the role of a human survivor in a post-apocalyptic steam punk scenario. This character lives alone in a shelter surrounded by a contaminated abandoned environment. He only can survive by maintaining the shelter's power supply and by exploring the surroundings to gain new resources from time to time. Should the character desire to explore the environment, he or she must wear a protective suit that unfortunately has a limited power, therefore forcing to return to the shelter in time. With the help of the radio set, the player gets in contact with other survivors and finds out that there is a clean decontaminated island next to the coast where other survivors are building up a new livelihood. With this good news in mind, the player must lead the survivor to the coast step by step, increasing the range of the suit durability, improving the shelter together with the help of some robots.

The SmartLife game consists of several goals that can be seen as the main drivers of the game and supporting activities to ensure longevity of the gameplay as well as a long-term engagement. The overall goals of the SmartLife Game are:

- Survive in the present!
- Get in touch and meet up with other survivors!
- Find a way to reach the coast in order to travel to the save island!

As part of interactive storytelling scenarios, a number of narration types are differentiated. These can be narrated to the level the player is currently playing on or to the activities they are performing.

Narration Related to Level - The story tells with the use of events that appear in form of pop-ups with text, illustrations and sometimes voice over dialogs. These events are triggered by the player's progress in the game that is expressed in their current level.

Narration Related to Activities - Some of the activities the player has to execute (outside, inside, daily jobs, other players) are introduced with a story snippet that is related to different situations, NPCs and places. During each activity, the player is accompanied by the navigator bot via radio set that gives status updates to the player via headset or smartphone internal speaker. Some of these updates also contain story relevant texts.

Some of the story events allow the player to influence the story by making decisions via multiple choice answers. These selections influence the progress of the story in different ways therefore ensuring non-linearity of the gameplay and increases perceived autonomy and sense of control. During the performance of the physical activities, the story experience is also related to and influenced by the intensity level of the user that is tracked by the smart textile (T-Shirt).

2.3 Game Data Analytics

Data collection, cleaning and fusion services, can use the collected data to classify physical activity. The users' physical activity can be classified in two separate ways, activity type or activity intensity. Regarding activity intensity, the main objective is to identify when the user is doing moderate to vigorous physical activity (MVPA). Since the project aims to promote physical activity and reduce sedentary behaviour, it's very important to be able to detect when the user is doing the so called MVPA. This identification is made in real-time and is directly connected with the game itself. Classifying physical activity type is the other classification method that was developed. The activity type was considered, in order to add an extra layer of activity identification and to allow a better personalized gaming experience to each user, by label them depending on the type of exercise they usually perform. This type of classification is done in an offline mode and using two different types of input, activity index (AI) and raw accelerometer data, both collected from the wearable sensor. In short, a creative model has been used in the Data Collection Module to measure the intensity and magnitude of the activities, but for detecting the activity type, a more complex data analytics model had to be developed.

A common approach to data analysis, usually requires applying machine learning algorithms to data. Among various tasks of data mining, supervised classification is suitable for activity recognition task. Classification is used to categorize data into predefined classes. In this sense, by defining a set of activities, a classification model can reveal the activity performed at the time of data collection. The data collected from the sensor is used in Data Analytics module to train a classifier for detecting six different activities: Still, Walking, Brisk Walking, Running, Up Stairs, Down Stairs. Supervised learning models, sometimes also referred as predictive models, use a set of known data samples (training data) to build a model for predicting the value of unknown occurrences. The training data is used to find relations between values in the same class and later can be applied to unknown data (testing data) to find the most similar class for it. Hence, like any other classification application, activity classification requires to train a classification model based on labelled activity data and then use the model to predict the label of unlabeled activities.

The collected data from the sensor is captured by the smartphone and used by the Data Collection Module in real-time to calculate users' MVPA. While this data is being used in real-time, it is also saved locally on the device in a SQLite database to lately serve as an input to the offline data analytics module. When measuring physical activity, the data usually includes noise in the start and in the end of the activities data that can reduce the accuracy of the model. The noise on the collected data can occur for several reasons such as the time difference between starting the data collection in the app and start doing the exercise. Another type of noise can come from the sensor itself, since if the data collection process starts mid-exercise, the first values are always off the normal expected values. Thus, before providing the activity data as training data into the model, it is necessary to **clean it**. Machine learning and statistics techniques can also be used for automatic outlier detection and removal. The objective in outlier removal is to eliminate the observations that are very different from the others and considered as polluted. These deviant observations can be detected using standard deviation.

The accelerometer sensor provides data in two modes, AI and 3-axis acceleration. While 3-axis data can provide more details about the situation of the player for detecting the physical activity, AI mode consumes less energy and can be used for longer playing sessions. Two different **training models** have been developed for recognising the activities of the players in each mode of the sensor. The first model uses machine methods such as Decision Tree to do the activity classification using AI data and the second uses deep learning methods for implementing a Neural Network to predict the activity using 3-axial data of the sensor.

After the training process, the model is ready to be used to identify the activity type that the user is performing. The activity type model is able to predict which type of exercise the user is doing, based on the similarity between the data being collected and the occurrences that had been used in the training phase. The output of the model is the activity label usually including a prediction certainty value.

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