

# SmartRabbit: A Mobile Exergame Using Geolocation

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## Abstract

This paper presents SmartRabbit and how the location-based games concepts were used in the development of this game. SmartRabbit is a mobile running game where players compete using a smartphone with GPS. This game was developed to show how a player's location can be used to create exergames and encourage people to practice exercises.

**Keywords:** Physical Activities, Exergames, Location-Based Games, Mobile Games

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## 1. Introduction

Being physically active is a very important factor for a healthy life [WHO 2011]. Active living and physical activity may contribute to population health and disease prevention [Zakus et al. 2007]. Indeed, a great deal of research literature indicates a positive association between physical activity and improved health [Zakus et al. 2007]. Some people exercise regularly through the practice of sports such as soccer, basketball, swimming or running. This practice can be both training for competitions, where people practice sports as their profession, or just for fun. However, a lot of people do not engage in fitness activities on a regular basis, although their benefits are known [Boschman 2010].

Physical inactivity is now identified as the fourth leading risk factor for global mortality [WHO 2011]. The adoption of better physical exercise habits assists in reducing problems such as obesity, high blood pressure, diabetes, depression, and others [Payton et al. 2011]. Moreover, physical activity also encourages social interaction and fosters friendships [Mueller et al. 2007]. Therefore, researches about how to stimulate people to practice physical activities become beneficial to society, improving well-being and quality of life.

One way to encourage physical activity is to make it a requirement, either directly or indirectly, for popular activities [Sinclair et al. 2007]. Using games

for exercise is a good way to motivate people to have this habit, because video games have great potential to reach a wide audience [Payton et al. 2011]. Games that incorporate exercise, or exergames [Sinclair et al. 2007], can make physical activity more attractive and rewarding for players, and these games are able to address a wide range of health issues [Payton et al. 2011].

Exergames offer a variety of fitness activities and often support social exchange, factors that can increase the commitment of players [Boschman 2010]. With them, players have an opportunity to undertake lifestyle changes that may include exercise, healthier eating habits and food choices, and strategies to control stressors [Boschman 2010]. Nowadays, consoles like Nintendo Wii [Nintendo 2011] and Xbox 360 [Microsoft 2011b], with Kinect [Microsoft 2011a], provide resources for designing exergames. Games like Wii Fit, for Nintendo Wii, can counter perceived barriers to fitness because they may be played in short bursts at the convenience of the user [Boschman 2010]. Besides that, smartphones with integrated GPS hardware have been proved to be a great platform for creating location-based games. As we show in this article, this platform can be used to implement mobile exergames.

Mobile exergames have the additional benefit of allowing people to incorporate physical activity into their everyday lifestyles. A person's awareness of their fitness has also been shown to be a significant factor in behavioral change [Payton et al. 2011], and exergames can be designed to provide self-tracking of game related physical activity to players [Payton et al. 2011].

The idea of designing location-based games has been studied years ago, like in "Can you see me now" [Benford et al. 2003]. Nowadays, with smartphones like iPhone [Apple Inc. 2011] and Android [Google Inc. 2010b] devices, it is possible to offer an even better user experience. Furthermore, developing for these platforms has become easier, thanks to extensive and affordable documentation, powerful APIs and low cost of development.

This paper presents the location-based games concepts and how they can be used to design games that help or foster practicing physical activities. To

illustrate these concepts, we designed and developed a mobile running game for Android, called SmartRabbit, in which players really need to run using a smartphone with GPS.

In the next section, some examples of exergames and location-based service applications are presented. In the third section, the concept of location-based games is detailed and some issues while developing these games are shown. Section four covers the presentation of the game developed in this work, introducing its game modes and the frameworks used to add a fun factor in the game. In the fifth section some technical aspects of the game are shown, like the architecture and the resolution of the player's current location during the race. The conclusion of this work comes in the section six.

## 2. Related Work

In exercise context, many commercial games have been developed for home video game consoles. Games like "Wii Sports" [Nintendo 2011] and "Kinect Sports" [Microsoft 2010] allow people to have fun doing physical exercises. These games were developed for Nintendo Wii [Nintendo 2011] and Xbox 360 [Microsoft 2011b], respectively, and have some types of sports that can be played with friends. In the Wii case, a distinguishing feature is its wireless controller, the Wii Remote, which can be used as a handheld pointing device and detects movement in three dimensions [Nintendo 2011]. On the other hand, Kinect uses a motion sensor for Xbox 360 that tracks player's entire body enabling users to control and interact with the console without the need to touch a game controller. Playstation 3 [Sony 2011] also provides a motion-sensing game controller, the Playstation Move. Using these features, some games have been developed exploring players movements. Games like "The Biggest Loser: Ultimate Workout" [THQ 2011], "Your Shape: Fitness Evolved" [Ubisoft Entertainment 2010] and "Wii Fit" [Nintendo 2011], allow users to play while doing gym exercises.

The use of location to build digital games within real physical space can exemplified by "Can you see me now" [Benford et al. 2006], a game of catch played online and on the streets, where online players are chased through a virtual model of a city by runners. These runners are the street players, they have to traverse the actual city streets in order to capture the online players. Using a GPS device, the runners have to capture the online players to win the game. On the other hand, the online players, which can see the positions of the other players in the virtual world, have to avoid the runners. If a runner gets within five virtual meters of an online player, the player is seen and out of the game.

In mobile platforms context, there are many examples of applications using user's location being

developed, like Foursquare [foursquare 2011], Tourality [creative workline 2011], Geocaching [Groundspeak, Inc. 2011] and GPS Athlon [Jay's Outdoor Games 2010]. Foursquare is a location-based mobile platform that allows users to share their location with their friends. The fun factor comes from the fact that it is possible to accumulate points and virtual badges relating to specific places, through check-in via a smartphone app or SMS a certain number of times in these places [foursquare 2011]. Geocaching is a real-world outdoor treasure hunting game. Players try to locate hidden containers, called geocaches, using GPS-enabled devices and then share their experiences online [Groundspeak, Inc. 2011]. Tourality is a location-based game where player's location and movements are identified via GPS-signal emitted from your cell or smartphone. The target of the game is to reach certain predefined spots in the game set by moving towards them with your mobile device [creative workline 2011]. In GPS Athlon, players have to run to get fruits, simulating reality version of Pac-Man [NAMCO BANDAI Games Inc. 2010] game. The game motivates you to run to break through all levels. Each level asks you to get certain numbers of fruits and veggies by shaking your iPhone [Jay's Outdoor Games 2010]. In this example, we see location-based game running in a mobile device which has exercises as a key of the game.

The works presented above use the concepts of exercise games and location-based games. Our work combines these two concepts in order to create a game that encourages physical exercise. It is important to show that there are commercial games for this purpose being developed for the current generation of video games, which shows that the idea of mixing games and exercises can succeed.

## 3. Using Mobile Devices and Geolocation to Build Games

In this section, concepts of Location-Based Game (LBG) will be presented and how to deal with some restrictions while developing this kind of game for mobile devices. Besides that, some technical details of developing LBG will be shown.

### 3.1 Location-Based Games

Location Based Service (LBS) provides information services based on the current or a known location [Kumar et al. 2009]. To provide these services, LBSs use Global Navigation Satellite System (GNSS), Geographic Information System (GIS) and Wireless Communication (WC) technologies [Sadoun and Al-Bayari 2007].

Global Positioning System (GPS) is a GNSS system in operation [Sadoun and Al-Bayari 2007]. With an increasing number of mobile devices featuring

built-in GPS technology, LBS has experienced rapid growth in the past years [Kumar et al. 2009].

LBS can provide customized contents according to the user's current location such as the nearest restaurants, hotels or clinics [Kumar et al. 2009]. Moreover, LBSs provide a way to share your current position with other people. There are plenty of applications that use this feature, like Foursquare [foursquare 2011] and Gowalla [Gowalla Incorporated 2011].

Like the applications mentioned above, a Location-Based Game is a game that uses the player's physical location, usually via a GPS sensor module [Jacob and Coelho 2011].

Even before the mobile devices using LBS, some research works were made on LBGs using GPS receivers, as "Can you see me now" [Benford et al. 2006]. Nowadays, smartphones are emerging as a personal computational platform of significant popularity. The latest generation of handsets (iPhone 4, Android 2 devices, etc.) are equipped with a sophisticated combination of excellent media capabilities (screen, GPU, audio) and considerable processing power and memory. Features such as GPS and compass make smartphones attractive for location-based mobile games [Naliuka et al. 2010].

A mobile game is simply a game that runs on a mobile device. Some mobile games use environmental space as playing ground. Location-based mobile games introduce an element missing in interactive console games: the physical effort of sports. In this kind of game, the players' positions, and sometimes locomotion, constitute key game elements [Schlieder et al. 2006].

### 3.2 Dealing with LBG Development Restrictions

In the process of designing games, it is important to care about experience that users will have with it [Jacob and Coelho 2011]. An excellent idea of a game can become frustrating if it has performance issues. LBGs can give users a whole new experience, but some issues require attention to offer a good one.

Location-Based Games are often unpredictable, as they often use the player's real location as a means of input, and so, they frequently provide very discrepant gaming experiences. When the position is hardly determinable by the GPS module, the game can become unplayable [Jacob and Coelho 2011].

Jacob and Coelho [2011] present some LBG's issues, as hardware limitations and game-design issues.

In LBGs, hardware limitations have to be considered, as they will make the difference between a playable game and an unplayable one. Since most Location-Based Games rely on GPS signal in order to

determine the player's current position, this means that most LBGs become unplayable in areas or situations where this signal is unavailable. Furthermore, it is important to consider other hardware limitations as low amount of available RAM, video memory, slow CPUs and device's battery charge [Jacob and Coelho 2011].

Regarding game design issues, it is important to observe that Location-Based Games involve player exposure to physical interaction with the real world. In a racing Location-Based Game, the player can use a motorized vehicle and puts his safe in risk. Limiting the maximum speed of the player is a way to avoid this problem. Additionally, and in order to ensure that the game is played on foot, using the devices sensors such as the accelerometer to work as a pedometer may help [Jacob and Coelho 2011].

Jacob and Coelho [2011] also present problems related to player's data protection. As the game knows the user's location, the people's data privacy is an important issue. Even if opting to store information locally, the user should enter a username and password to see it. The information stored varies from game to game. These games should guarantee the safety of the player's geoinformation or at least alert the player about the risks.

Even with the problems mentioned, it is possible to find ways to minimize them and provide a good playing experience. For Xin [2009], the use of LBS applied in mobile games can bring benefits such as catching people's attention, bringing new experiences in game, providing new development opportunities and encouraging new ideas in game development.

### 3.3 Developing a LBG

One way to implement a LBG is developing for Android. Android is a software stack for mobile phones and other devices that includes an operation system, middleware and key applications. The Android SDK provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language [Google Inc. 2010a].

By providing an open development platform, Android offers developers the ability to build extremely rich and innovative applications [Google Inc. 2010a]. The continuous increase of mobile devices popularity, such as smartphones and tablets, the Android's powerful APIs, excellent documentation, thriving developer community and no development or distribution costs, together, provide an exciting scenario for developers to create innovative mobile phone applications [Kumar et al. 2009].

Android has some features [Google Inc. 2010a], like:

- Application framework, that enables reuse and replacement of components;

- Optimized graphics powered by a custom 2D graphics library; 3D graphics based on the OpenGL ES 1.0 specification (hardware acceleration optional);
- Rich development environment including a device emulator, tools for debugging, memory and performance profiling, and a plugin for the Eclipse IDE;
- SQLite for structured data storage;
- Additional Hardware Support. Android is fully capable of making use of video cameras, touch screen, GPS, accelerometers, and accelerated 3D graphics.

Android offers objects to create LBS systems and provides a location framework that can be used to determine the device's location and bearing and register for updates through the classes in the android.location package [Google Inc. 2010a]. Android provides components like Location Manager, Location Provider, Geocoding and Google Map that facilitate the implementation of LBS [Kumar et al. 2009]. This facility makes Android a good platform to develop LBGs.

LocationManager system service is the central component of the location framework, which provides APIs to determine location and bearing of the underlying device [Google Inc. 2010a].

LocationProvider represents the technology to determine the physical location, i.e., to handle GIS. LocationProvider component of Android application facilitate the determination of available provider and selection of suitable one [Kumar et al. 2009]. Each provider has a set of criteria under which it may be used; for example, some providers require GPS hardware and visibility to a number of satellites; others require the use of the cellular radio, or access to a specific carrier's network, or to the internet [Google Inc. 2010a].

Geocoder provides a way to convert geographical coordinates (longitude, latitude) into street address and a mean to get geographical coordinates from street address [Kumar et al. 2009]. These coordinates are converted in an Address class, which has information such as street address, zip code, city, state and country [Google Inc. 2010a].

Google provides a Maps external library to make it easier to add powerful mapping capabilities to an application [Google Inc. 2010a]. Android furnishes a number of objects to handle maps in LBS system like MapView which displays the map. To handle it, a MapActivity class is there. To annotate map it provides the overlays class. Even it provides canvas by which one can easily create and display multiple layers over the map. Moreover, there are sufficient provisions to zoom the map and localize it by means of MapController [Kumar et al. 2009].

For all these characteristics, Android was chosen as the development platform for SmartRabbit.

## 4. SmartRabbit

To illustrate the concepts discussed in this work, we developed a Location-Based Game, called SmartRabbit, for Android.

SmartRabbit is an exergame where players need to run to win several challenges. Players can compete with friends, choosing a certain route to run, as they can compete with someone in the world just setting the distance of the track. With SmartRabbit, players can compete without necessarily being present on the same day and location. Nowadays, playing with people from anywhere in the world has become possible with online games. People can meet friends at home or play over the Internet. This allows matches with different players, as well as new social relations.

So, the idea of SmartRabbit is basically to use mobile devices with GPS, as almost all of the smartphones nowadays, to promote running disputes between different users anywhere in the world. The game is divided into different modes, each one with their own goals, but the basic element is simple: run a certain distance in the shortest time possible. With this mechanics, the game aims to encourage people to practice an important and simple physical activity, which is inexpensive and can be practiced almost anywhere, interacting with several players from anywhere in the world in a fun and competitive way.

In the following sections all game modes of SmartRabbit will be detailed and also the treatments performed to evaluate the fun factor in the game.

### 4.1 Game Modes

The game is divided into three modes, called Training Mode, Duel Mode and Circuit Mode.



Figure 1: Game Modes

### 4.1.1 The Training Mode

The Training Mode is recommended for novice users, especially those who do not usually practice running or even any physical activity. In this mode, the user plays without interact with others players just in order to know his limits. The user is free to run wherever he wants, as long as he likes and through any distance. At the end of training, the player can save his performance, maintaining a history to assess his own performance over time.

Although no interaction with other users, this mode is very important, because is where the user will know how to evaluate his limits. Besides that, the training mode has some goals, which, when reached, release other game modes. This makes the training mode fun for more experienced players too, which will easily reach the first goals and will have some challenges with the most advanced targets. The idea of these targets, which will be awarded with medals, is to provide incremental targets, which act as a guide for training. Thus, novice users will have lighter training objectives which will gradually evolve difficulty, helping players to improve their performances over time.

The medals are acquired when these goals are met, ranging from being able to run a distance of 2 km for the first time, or run a distance of 5 km for 4 weeks in sequence, for example. In other words, these goals are based on run a distance for the first time or the frequency that a distance is traveled. These goals are acting as a kind of personal trainer for beginners, to prepare players for the Duel and Circuit modes. In addition, the medals have the target to include playfulness in the game because these achievements can be shared for other users to see. Thus, encourages the competition between users to see who wins the most medals and an instinct of collection, which is important to make SmartRabbit a fun game [Dillon 2010].

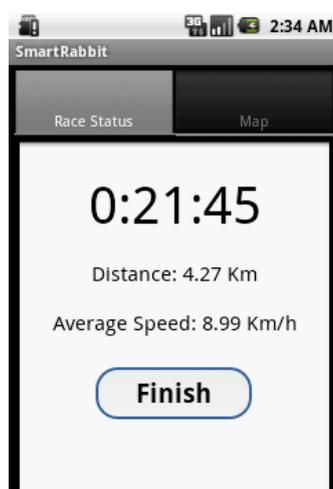


Figure 2: Race Status

### 4.1.2 The Duel Mode

In Duel Mode, the player can challenge another player for a duel. Normally, when two people want to dispute which one is the fastest by running a certain course; they mark a time and place for the race. The Duel Mode is intended to make this race more likely to happen. Thus, the two contestants can run in different days and locations.

This mode is not initially enabled. To enable this game mode, players must acquire sufficient training mode medals. Challenges for up to 5 km, players must have the medal of 5km and for up to 10km challenges, players must have the 10 km medal. This idea is to prevent injury of players who normally do not usually practice physical activities. They can get injury by challenging others players without the necessary training.

A player can challenge any other player of the game, which will have a time limit specified by the challenger to answer whether or not to accept the challenge posed. When the challenge is accepted, both users will have a space of five days to run the route chosen and the player with the lowest time wins the duel. The winner collect points and probably gain positions in Duel's ranking.

By challenging an opponent, the player has three possibilities. The player can choose just the distance of the route so the opponent can compete anywhere else in the world. Another possibility is to determine the location, by choosing a country, state or city. The third possibility is to determine that the initial and final locations of the race will be the same for the players, as well as the distance traveled. The game is responsible for assessing if the duel was fought properly, checking the initial and final locations and distance traveled.

To allow competition and encourage duels, there is a ranking listing the players who have the highest score. This ranking can be filtered by age, distance traveled, gender and location (country, state and city). The scoring system for ranking the Duel Mode is built based on the ranking used in chess, called the Elo rating system [Vovk 2011].

With the adoption of this scoring system, more experienced players are required to challenge users of the same level, because they will win a few points by winning players with lower rating. On the other hand, players with low ratings will have more willingness to challenge players of high rating, because if you can overcome them, will gain many points and will rise faster in the ranking.

In this mode, the playful aspect is completely in the competition between the players, the greed to become leaders in the ranking, is the overall rankings or ranking in their age group or city, for example.

### 4.1.3 The Circuit Mode

In this game mode of SmartRabbit, a circuit is defined by a distance and a city. For example, a 5 km circuit in Rio de Janeiro is any path with this distance that can be used to race in Rio de Janeiro. By competing for this circuit, players choose any space in the city and run a distance of 5 km. A competitor who has the best time for that distance, in Rio de Janeiro, is the owner of this circuit. Moreover, this time will be used for the 5 km circuit of the corresponding state and country. The best player for a 5 km course in his area may also be the best runner of 5 km in his country. The game features a ranking by state, city and country. In addition, the game features a general ranking, showing the best players in the world.

A player may compete for circuits 1, 2, 5 or 10 km. However, to compete for these circuits; the player should get the medals corresponding to these distances playing in Training Mode. The player must indicate which distance he is competing. The game stores the time so the runner reaches the goal. The city is recognized by the game itself and therefore the rankings are updated.

The game allows each player to run in place of his choice and still can play the Circuit Mode. In addition, this game mode encourages the player to run in different places in the world, to conquer other circuits of different cities. When a player has the best time in a circuit, he becomes the owner. Just as the Training Mode, the Circuit Mode also has medals that can be won by the player, such as: 'owning a city', 'owning a country', 'owning more than one city' and 'owning more than two cities of different countries'. The owner of a city changes as other players can do better times, but the medals for achievements are always from a player, according to the achievements he has won.

The fun factor in this way is also by competition between players to be the best ranking and greed to own the largest number of circuits. It also awakens feelings of collection of the circuits and medals, beyond vengeance, when the player loses possession of a circuit.

## 4.2 Evaluating the Fun Factor

Fun is an important factor in an exergame design. To achieve success in an exergaming system, the game have to be fun and captivating. If the system is only used for a limited period, because the game is not fun, then ongoing health benefits will not be realized [Sinclair et al. 2007].

The instinct for improving ourselves, our results, and doing better than our friends, featuring a competition, give the right motivation to come back to the game after playing it [Dillon 2010]. Dillon presents what makes a compelling game through emotions and instincts. According to him [Dillon 2010], an instinct is

something that arises in response to a given situation and that we hardly can control, so we can use games to create situations that manipulate these instincts (and consequently the emotions), making them attractive enough to get the player back to play it after the first experience.

The studies done by Dillon [2010] suggest that exists six principal emotions and eleven basic instincts which can be stimulated by a game (the 6-11 framework). Each game usually stimulates some specific instincts that lead to specific emotions. The six emotions are fear, anger, pride, sadness, joy and excitement, and the eleven instincts are survival, identification, collecting, greed, aggressiveness, competition, revenge, protection, color appreciation, curiosity and communication.

During the design of the SmartRabbit, the 6-11 framework was used to map the instincts and emotions of the game. In addition, we combined the 6-11 framework with the MDA framework [Robin et al. 2004], as proposed by Dillon [2010]. This way we can create a map of a game in which instincts are linked to emotions and also the dynamics of the game, which is linked with the mechanics of the game.

The MDA Framework [Robin et al. 2004] is a model to assist game developers in their creative processes. This model was built based on the concepts of "Mechanics", "Dynamics" and "Aesthetics". The Mechanic is responsible for the rules of the game while dynamics is responsible for the way the game is played. Finally, the aesthetic is responsible by emotions that the game developers want to manipulate through the dynamics of the game [Dillon 2010].

SmartRabbit handles basically six instincts (Self-Identification, Curiosity, Collecting, Greed, Competition and Revenge), and these lead to four distinct emotions (Excitement, Pride, Joy and Anger). These instincts are induced by the dynamics of the game (exploring, winning, challenging) and are made possible by the game mechanics (walking, running).

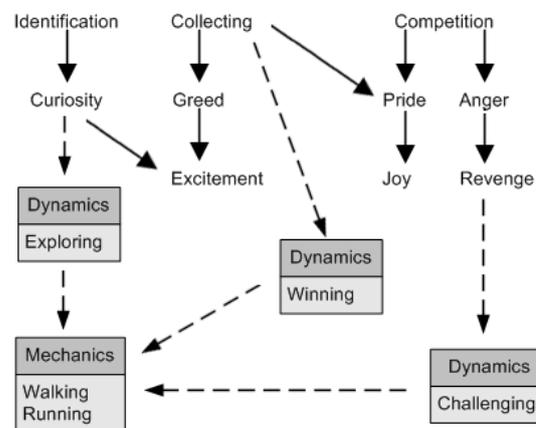


Figure 3: Analysis of SmartRabbit using concepts of the 6-11 framework

The model is pretty simple, we begin with three instincts: Identification, Collecting and Competition. Identification is present because the character of the game is actually the player; Collecting is present in the form of medals and points; Competition is present in the form of ranking. These three instincts will lead to another instincts or emotions. In this case, Identification leads to Curiosity, which makes the player think if he is good enough, for example. Collection leads to Greed, making the player wanting more points and medals to become the best in the game. And Competition leads to Pride by finishing a race with a quick time and to Anger, because nobody likes to lose. Curiosity and Greed lead to Excitement, Pride leads to Joy and Anger leads to Revenge.

These instincts are induced by the dynamics of the game, such as exploring, challenging and winning, which are possible by the game mechanics: walking and running. We notice particularly that the player is holding to a competition to be the best in the ranking and an ability to collect medals. These facts stimulate the instincts which in turn generate emotions, which leads the player to repeat the process, i.e., keep playing.

## 5. SmartRabbit's Technical Aspects

SmartRabbit has a web interface and a mobile interface. The mobile interface is used at the time of the race, it is responsible for analyzing the performance of the player and works directly with geolocation. Since the web interface works mainly with data visualization, such as profile data, rankings and statistics.

The game's architecture is presented and explained in 5.1, while the technical details of the implementation of geolocation are explained in 5.2.

### 5.1 Architecture

To provide a communication between the two interfaces used, SmartRabbit uses the following architecture:

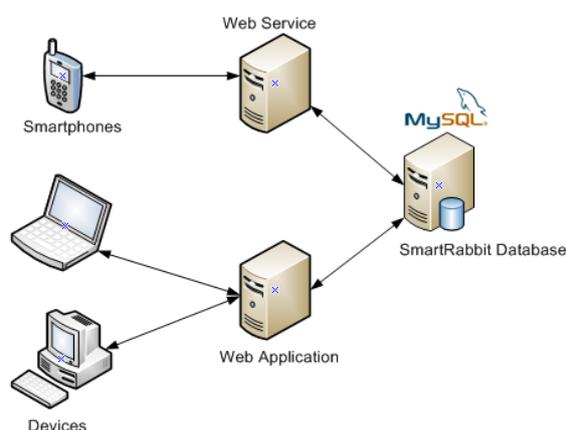


Figure 4: SmartRabbit's architecture

The mobile application, used in smartphones, was created using Android [Google Inc. 2010b] API version 2.2 or later. The Web Service and Web Application was created using Rails Framework version 3.0.8 [Hansson 2011] and both communicates with the same MySQL database [Oracle Corporation 2010].

The information about each player are presented in the Web Application, including for example: medals won, each run with the respective time, date and distance, how many points the user current have and so on. This is how the user can access the information about their performances summary and see if he is improving, addition to seeing the performances of other players. Moreover, the web application is responsible for the registration of players and the challenge for the duels. Thus, data stored by the web application in the database are read by the mobile application through a web service.

When the player is running, the game calculates his time, distance and average speed. When finished, the game saves that data in the database on his smartphone. After that, data is synchronized with the database of the game. For this, the mobile application create an Extensible Markup Language (XML) [W3C 2011] structure containing the run info and send that over Hypertext Transfer Protocol (HTTP) to the Web Service which then parses the information and save the parsed data on the SmartRabbit database.

Each request to the Web Service has to be authenticated using Basic Http Authentication before the Web Service parses the run data, if that's not the case a response will be sent with a XML structure indicating that the operation must be authenticated.

To avoid spending on data exchange whenever the game is accessed, the game keeps statistical data stored in smartphone's database of the player. Thus, the player can see his medals and his performances through his mobile phone. These data are linked directly to the user's identifier, to avoid data conflicts if another player uses the same smartphone to play.

### 5.2 Dealing with Player's Location

Android provides features to work with LBS, as seen in 3.3 and, therefore, every implementation of geolocation was made in the mobile application. The player can run with his smartphone, which will store the coordinates covered by him that will be used to calculate the distance traveled and average speed.

Before each race, the game will search the player's current position. Only with this particular position the player can start his race, pressing the start button. At this point, the game starts the stopwatch timing and position of the player, showing the path traveled, average speed and map the current location. This interface is used in all game modes.

The map's display is possible thanks to Google Maps' library and a MapView class. The handling of this view is made through the MapController, which allows choosing some characteristics of the map appear, as initial zoom and display buttons for zooming.

To determine the player's current location was used the LocationManager class. This class requires a provider, through which will locate the player's position. In SmartRabbit's case, GPS was the chosen provider. In addition, you must have a listener that checks when the game has to get a new position. In SmartRabbit was used 100 meters and 10 seconds as distance and time, i.e., every 100 meters or 10 seconds the current position of the runner is updated, as well as his total distance traveled and average speed. The update frequency is important and needs to be balanced properly. A higher frequency allows greater accuracy in calculations, but results in higher consumption of data and battery. The player's current position is represented by a geographic point which has its latitude and longitude. With each update, the geographic point obtained is inserted in a list and a new point is drawn on the map through the overlay class, updating the path.

The list's points are connected by straight lines in the drawing path. With each new geographical point detected, the distance traveled is calculated between this point and the previous one. Thus, the total distance calculation is performed dynamically, i.e., the distance traveled is recalculated for each new coordinate detected and this information is displayed to the player.

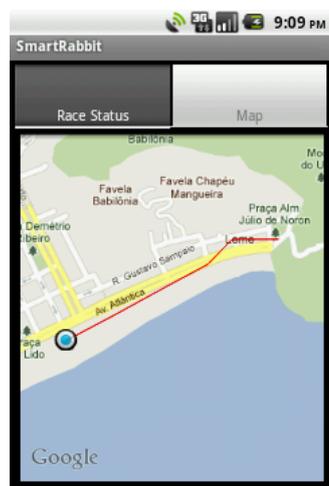


Figure 5: Race Map

This mechanism is valid for all game modes. But Duel Mode and Circuit Mode have some considerations more.

In the event that the duel is set for the same course by the challengers, it is necessary to validate that this has occurred. The first validation is to only allow the duelist starts his race at the same location of his opponent. Besides that, the race of the two competitors

has to finish in the same location and has to have the same distance traveled. But, determine the exactly location of the players is not an easy task, because of the GPS accuracy in certain places. To resolve this problem, the initial and final locations of the players are represented by a circle, not a point. The center of the circle is the location determined by GPS and radius value chosen is 50 meters. So, if these circles have an intersection, means that the players are in same location. Thus, the distance traveled has an error tolerance and these solutions are transparent for the players. In addition to these validations, the path made by the duelist is also displayed to the player can see the exact path to follow.

In the Circuit Mode, the circuits are determined by state, city and country where the player ran. Thus, it is necessary to establish the region through the points covered. This process is done through the Geocoder, which returns the location information from the geographical locations provided. After finishing a race in this mode, the game checks the location of the race to update the Circuit Mode's ranking.

## 6. Conclusion

This work presented SmartRabbit. The game shows how to use LBS on mobile devices in developing exergames. As shown, exercises can provide better living conditions, since they can help prevent several diseases. Thus, exergames like SmartRabbit can be fun and increase the life quality of the players.

As seen in the studies presented in this article, there are some factors that should be considered when constructing an exergame with LBS, seeking a good game experience. In fact, the game needs to prevent problems such as low GPS signal in some areas that can compromise the player's results. In addition, the game should be attractive and provide fun for the player to continue playing, which is necessary for the exercise to become effective.

During the design of the game we were concerned with emotions and instincts that the player would have while playing it. Thus, elements were inserted as duels and rankings, to increase competition, and medals and circuits to activate the instinct of the collection. The 6-11 framework was used with the MDA framework to evaluate the fun factor of the game, making the game not just a new way of doing exercises, but also a fun game that encourages people to do it.

The game was tested using a Motorola Defy [Motorola Mobility, Inc. 2011] cell phone and presented a good GPS signal when used in places more open and a sign of inferior quality when played in closed environments. Thus, a control to allow only the beginning of the race with good GPS was used so that players know they are a suitable place to play. The settings of time and distance to get a new geographical

point resulted in a good design course at the end of the race, with no problems of high cost of battery and consumption of data in the cell phone indicated.

As future work, we see the evaluation of algorithms used in comparing paths. Similarity results provided by different algorithms can be used and tested for evaluation of the algorithms themselves as well as the gaming experience. Besides that, the game can evolve to enable users to create more services to the user, such as help in training and conditioning.

In conclusion, this study aims to present a way to create exergames, using the concepts of LBG. With the popularity of smartphones with GPS, more games of this type can be developed, making people have healthy lifestyles while having fun with a game.

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