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Gamification on Users-Daily Activities

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Mestrado Integrado em Engenharia Informática e Computação

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Abstract

Mobile applications increasingly play an essential role on people's lives, they help us to perform tasks more efficiently that make part of our day-to-day. The ease of access for developing such applications has led to our disposal a wide range of applications that envolve areas such as healthcare, leisure, education , etc.

Gamification is the use of mechanical game design concepts applied in non-game contexts in order to make an activity more interesting. This technique has been adopted in recent years by a lot of services in order to increase the user involvement with the platform itself. This concept is applied in many non-game contexts and physical activity is no exception. Actually, this concept has obtained a lot of sucess in this area since users improve their health while challenging themselves or other users within the network.

This dissertation aims to prove how Gamification can be used in order to encourage the practice of physical activity. With this intention, a platform was developed which is constituted by a Web application that allows the creation of gamified elements that subsequently are sent to a mobile application which challenge and promotes their users to improve their levels of physical activity. Machine learning algorithms were integrated in the platform in order to adapt the application to different type of users.

Resumo

As aplicações móveis desempenham cada vez mais um papel essencial na vida das pessoas, estas ajudam-nos a desempenhar de uma forma mais eficiente tarefas que fazem parte do nosso dia-a-dia. A grande facilidade de acesso para desenvolver este tipo de aplicações levou a que tenhamos à nossa disposição uma grande variedade de aplicações que se inserem em áreas como a saúde, lazer, educação, etc.

Gamification consiste na utilização de mecânicas de design de jogos aplicadas em contextos não relacionados com jogos de maneira a tornar mais interessante a realização de uma determinada actividade. Esta técnica tem vindo a ser bastante adoptada nos últimos anos por vários tipos de serviços de maneira a aumentar o envolvimentos dos utilizadores com a plataforma em questão. Este conceito é aplicado em várias áreas não-jogáveis e a actividade física não é excepção. Aliás, este conceito tem obtido bastante sucesso nesta área pois os utilizadores ao mesmo tempo que se desafiam a si próprios ou competem com outras pessoas melhoraram a sua saúde.

O trabalho apresentado visa demonstrar como a *Gamification* pode ser utilizada de forma a incentivar a prática de actividade física. De maneira a demonstrar isto, foi desenvolvida uma plataforma constituída por uma aplicação Web que permite a criação de elementos da *Gamification* que são enviados posteriormente para uma aplicação móvel que desafia e incentiva os seus utilizadores a melhorarem a sua actividade física. A plataforma encontra-se também integrada com algoritmos de *machine learning* que permitem a adaptação da utilização da aplicação a cada tipo de utilizador.

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In addition, I wish to expresse my sincere thanks to my parents and friends that kept me motivated and encouraged me in the last months.

José Carlos Portela Pereira

"A wise man can learn more from a foolish question than a fool can learn from a wise answer."

Bruce Lee

Contents

List of Figures

List of Tables

Abbreviations

ADL	Activities of Daily Living
AICOS	Assistive Information and Communication Solutions
API	Application Programming Interface
CRUD	Create, Read, Update, Delete
GPS	Global Positioning System
GUI	Graphical User Interface
HR	Human Resources
IT	Information Technology
JSON	JavaScript Object Notation
MDP	Markov decision process
OS	Operating System
REST	Representational State Transfer
RL	Reinforcement Learning
ROI	Return on Investment
RPG	Role-playing game

Chapter 1

Introduction

1.1 Context and Framing

Mobile applications more and more play an essential role in people's life, they enable us to perform day-by-day tasks more efficiently. The ease of access for developing such applications brought to our disposal a wide range of applications that improve fields such healthcare, leisure, education, transportation, etc.

Poor physical activity and adopting a sedentary lifestyle are factors that are quite harmful to our life. As a person ages due to lack of time, stress, lack of will, etc., the time devoted to carry on physical activities is not enough, endangering both mental and physical health. In the elderly it worsens further due to motor difficulties that occur at this age, which makes it even more difficult to carry on physical activities. It's crucial the transmission of motivation to this people so they do not put their health in risk.

Gamification is the utilization of game design mechanics applied in non-based games contexts in order to make more interesting the conduction of a given activity or task. In the last years this technique has been adopted by a lot of businesses in order to increase user involvement with a specific platform. Thus through the successful application of this technique we are able to increase motivation and user involvement regarding a specific platform developed to increase physical activity.

The work presented in this report involves areas like software development oriented for medical applications for mobile devices and the use of machine learning algorithms to learn more about the users habits by using a specific mobile application and a web application.

1.2 Motivation

One of the main problems of people especially when they reach an adult age is continue to perform physical activity and having an active life. Instead they adopt unhealthy habits that in a long term may be harmful to their lives.

This current situation motivates by a scientific perspective the need to analyze the effect of Gamification techniques in people behavior in order to motivate them to improve their physical activity. Looking from a technological point of view, would be interesting to see how people adapt to mobile applications oriented to physical activity.

When performing more physical activity these people will be adopting a healthier life style improving their health and making them feel better. At the same time, it will encourage the contact with other persons, whereas loneliness is a major problem that arises by aging.

1.3 Project and Goals

The project discussed in this report consists in the development of a mobile application that aims to evaluate the effect of Gamification techniques in users lifestyles. Evaluating the usefulness of this concept by checking if is appropriate for use as motivation tool in this type of population. As more specific objectives the project includes:

- Development of an Android application which should motivate their users to increase their daily physical activity (like walking, running, sitting, lying, cycling) through Gamification techniques;
- Development of an Web application which will work like a framework used by users who want to add new content to the system;
- Implementation of a machine learning algorithm which adapts the use of the application to each level of user physical activity;

1.4 Report structure

Besides this introduction this report is composed by six more chapters. In Chapter 2 is carried out a background of concepts that serve as basis for the development of the project , this chapter is divided into a few sections which addresses concepts such Gamification, children, adults and elderly people health and physical activity, machine learning algorithms and some conclusions. Chapter 3 describes the state of the art of the project, some other research projects are mentioned and how these may relate to this project. In addition, are addressed the same concepts of Chapter 2 and how they can contribute to the current research. Chapter 4 and Chapter 5 contains the specification of the solution implemented and how its implementation was carried. Chapter 6 shows how the evaluation should be done and finally, in Chapter 7, some conclusions are drawn and some possible future work regarding the project is described.

Chapter 2

Literature Review: Background

This chapter contains definitions and concepts that are needed as basis for the current research. Section 2.1 contains an overview of the Gamification concept where it is used, its influence, its history, social impact, risks, limitations, etc. In Section 2.2 are described three groups of people and what are they habits regarding health and physical activity. Section 2.3 describes some machine learning concepts that will be useful in the current research. In the Section 2.4, a global overview and conclusions are presented about the subjects in this chapter.

2.1 Gamification

Gamification applies elements associated with video games (game mechanics and game dynamics) in non-game applications. It aims to increase people's engagement and to promote certain behaviors. Although the concept has been explored primarily in the marketing area, the potential of its application has been extended to other areas such as Health, Environment, Government or Education [SoRV13]. It's used primarily as a tool for marketers, often making use of social media to engage existing and potential customers to increase public profile, market a new product or engage potential customers/stakeholders.

Gamification involves adding a game layer into applications or businesses allowing users to collect points, compare stats in leaderboards, compete in specific tasks, etc. Applying game dynamics to an application has one critical advantage, the ability to attach users, keeping consumers coming back for more [Ban12]. The use of Gamification in applications and processes in order to improve return on investiment, data quality, timeline and learning is phenomenal[Sha14].

About its history there are not much to say, Gamification as a term originated in the digital media industry. The first documented use dates back to 2008, but the term did not see widespread adoption before the second half of 2010 [DD11]. The current body of literature on gamification is quite scarce, with few published peer-reviewed articles. Most of these articles either focus on defining Gamification or present case studies of individual gamified systems [Ek].

According to [Sin12] not only social media sites but any firm can benefit from introducing this concept in it's organization. Any process or problem which needs to motivate a worker or a student for example, is a candidate for Gamification. HR can use Gamification for its recruitment, training or welfare activities. Marketing can use it from creating awareness of a product or a service to obtain costumers, feedback from market, marketing research or simply making sales. Product design, research and innovation can benefit immensely by Gamification.

If gamification has to be identified as an academic term, it is necessary to demarcate this phenomenon from previous research as well as embed it into existing fields. Therefore and in order to better understand Gamification, we first need to clearly define the related terms of this definition [ABP+12]:

- **Game:** Firstly, "Gamification" relates to games, not play (or playfulness), where "play" can be conceived of as the broader, looser category, containing but different from "games" [DD11]. Nevertheless, in practice gamified applications can also encourage playful behaviors and mindsets. Additionally, gamification should not be limited to digital technologies. Whereas the majority of gamified applications is digital, this constraint is not required [ABP+12]. As a game, a gamified application should have the following characteristics:
  - **Fun:** the activity is chosen for its light-hearted character.
  - **Separate:** it is circumscribed in time and place.
  - **Uncertain:** the outcome of the activity is unpredictable, i.e., the player must not be able to predict what is going to happen.
  - **Non-productive:** participation does not accomplish anything useful.
  - **Governed by rules:** the activity has rules that are different from everyday life.
  - **Fictitious:** it is accompanied by the awareness of a different reality [Ere12].
- **Element:** Selfrepresentation with avatars; three-dimensional environments; narrative context; feedback; reputations, ranks, and levels; marketplaces and economies; competition under rules that are explicit and enforced; teams; parallel communication systems that can be easily configured; time pressure[DD11], many of these elements can be found in "gamified" systems. See figure 2.1 for some examples or read section 2.1.1.
- **Design:** Using the previous game-based elements there are many ways to interact with the user. Basically the design is the way that these elements will be used in a non-game context to involve the user efficiently.
- **Non-game contexts:** Similar to serious games, Gamification uses elements of games for purposes other than their normal expected use as part of an entertainment game. The only thing that non-gaming contexts explicitly intend to exclude is the use of game design elements as part of designing a game, since that would simply be game design, not Gamification [DD11].

Figure 2.1: Examples of Gamification elements [PB13]

But Gamification is not only applying some game elements to non-game applications since many companies are being lazy, failing to add meaningful game dynamics and as a result ending up with unsuccessful campaigns. There are too few examples of companies integrating game dynamics on a deep level, and too many examples of companies simply adding a basic point-scoring system to a platform [Ban12].

In order to achieve a successful Gamification application in a specific context is required to know all the resources at our disposal and how this affects the users. The correct definition of our goals and metrics are fundamental to develop a game design model capable of engage all type of users. Furthermore, the analysis of the information and feedback gathered from the users is essential to improve the user experience.

2.1.1 Gamification Elements

Game mechanics are composed by design elements which involves rewards at different levels, challenges, points, leaderboards, virtualspace & goods, virtual gifts etc. These game elements are used to motivate users to complete specific tasks rewarding their efforts. They also provide suitable feedback at appropriate time during engagement. Incentives or rewards whether intrinsic and extrinsic, for the players, are critical elements of any gamified design [Sin12].

- **Badges:** a badge is a kind of honorific that can be used to recognize someone within gamification programs or more broadly through a company's social network, newsletters, and other communication channels [Kor12]. These elements can be compared to medals which arouse a need on the users of collect them. Usually, badges are earn throught the completion of one or various achievements. An achievement is the representation of having accomplished something and may have many difficulties or purposes. Badges are often considered "locked" until the player or user completes a set of tasks that are required to unlock the badge.

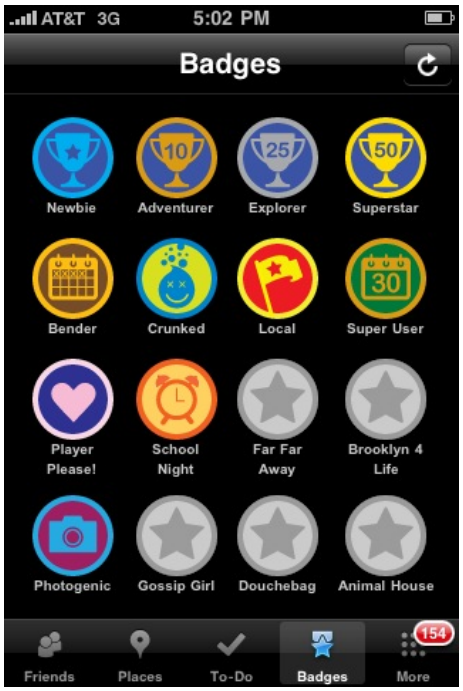

Figure 2.2: List of badges from Foursquare

- **Points:** users are given points whenever they accomplish something the system is trying to encourage them to do. Points keep score, provide immediate feedback, create a sense of progression and provide valuable data for the game designers [Ek].

- **Leaderboards:** the existence of a system of points can lead users to participate in activities or make specific actions. By creating lists of users ordered by the number of points/score, users will be motivated to do specific activities that will give them points in order to achieve top places or become the leader of the list, earning recognition by the rest of the community. But they can also demotivate, causing users who are very behind from the top to stop using the system.

- **Levels:** are a system, by which players or users are rewarded an increasing value by the cumulation of experience. Experience is earned the more an user uses the application or completes specific actions. Often features or abilities are unlocked as players progress to higher levels.

  Experience points (XP) merely identify the rank and performance of a player, and do not have any redeemable value. Users performing desirable actions would gain XP, and XP would never go down, and there is usually no limit.

- **Challenges or quests:** consists in a player doing some sort of specific task or achieve some objective. Challenges require effort to complete them and generally are focused on motivating users to complete even more difficult tasks.

- **Virtual currencies:** points can be used in place of real money to reward users in order to create psychological distance between actions and their rewards. Increasing the number of points it takes to gain a particular reward is easier for users to adjust to than a decrease in the size of the reward [Kor12]. Usually this system works by the gain of digital money throught the using of some platform. After some "money" accumulated users are able to unlock or buy stuff, they may be stuck on a level precluding they for unlock content and this works as a alternative system.

- **Content unlocking or rewards:** are prizes that players unlock as they earn points or level up, they can have many formats like images, videos or even music.

- **Teams:** these allow users to work together and collaborate to complete certain tasks.

According to [HS13] these elements can be classified as self-elements or social-elements:

- **Self-elements:** can be points, achievement or badges, levels, or simply time restrictions. These elements get users to focus on competing with themselves and recognizing self-achievement.

- **Social-elements:** on the other hand, these are interactive competition or cooperation, like for example leaderboards. These elements put the players in a community with other players, and their progress and achievements are made public.

Self-Elements	**Social Elements**
Points	Leaderboards
Levels	Virtual Goods
Badges	Interactive Cooperation
Virtual Goods	Storyline
Storyline	
Time Restrictions	
Aesthetics	

Table 2.1: Some examples of self and social game elements [HS13].

It is important to choose which of these game elements are more appropriate to each case. For example, if a player to complete a level must acquire certain abilities and skills (due to the level difficult), using a self-element may be more suitable as the player may be intimidated by the task at hand. Also if he is put into a community environment right away, they may become discouraged as he is constantly being compared to others.

In the other hand, in order to continue to the next level, it is important to ensure that the player is motivated to move to the next stage. Keeping other factors constant, social elements can motivate users in a community setting. Leaderboards that refreshes on a regular basis encourages new players to participate, and does not make them feel like they cannot catch up and lead.

2.1.2 Behavior Influence and Psychology

In today's digital generation Gamification has become a popular tactic to encourage specific behaviours, and increase motivation and engagement. According to [RAKG13] Gamification is an important instrument towards behaviour persuasion, it stimulates consumer loyalty by incentivising users with points, badges and special offers for performing positive actions.

These factors are key for the completion of a task or encouragement of a specific behaviour. For example in education, the reasons for drop-outs or low performance include boredom or lack of engagement, a pattern of escalating absenteeism where each absence makes the person less willing to re-turn to school. Gamification affecting engagement and motivation leads to acquiring more knowledge and skills [HS13].

People have various needs and desires, getting rewards, collect badges, complete achievements or being recognized by others are some of them. Gamification uses these motivational factors based on needs & desires to get tasks completed. These tasks with game like engagement and actions can make people excited about work and boost productivity [Wu11]. The satisfaction level of these motivational factors keeps changing, therefore the challenge lies in understanding the users as groups and accordingly incorporate the motivational factors as a set or category of rewards for different groups of users [Sin12].

According to Gabe Zichermann, CEO of Gamification.co, there aren't any long-term studies that support the kind of current, broad, context-based solutions involving Gamification due to be nearly a new topic. But gamification is about more than just badges and scoreboards. Those are just the start of the process of applying game techniques to work in order to make it more fun and engaging. Zichermann suggests that companies start with small projects, see how employees actually use them, and build from there. Video games, after all, have been evolving for decades [Kor12].

According to Michael Wu, Chief Scientist at Lithium Technologies, many companies make the mistake of trying to gamify an outcome rather than behaviour. For example in education, a teacher cannot gamify good grades but instead, can gamify the process for students to get good grades. If the instructor hopes for the student to hand in assignments faster, a points ladder according to when the students hand in their work could be added as a game mechanic. This in turn can incentivize them to develop a behaviour of doing their assignments ahead of time and thus, lead to achieving the original objective [HS13].

When a person is occupied on one task and is completely absorbed its called being on the "flow", this state is often found between anxiety and boredom. If a task is too easy, then the user will be bored and not occupied by it. If a task is too difficult, then the user will become anxious and demotivated. Therefore, game designers, educators, and any other person designing a system to motivate its users must consider the user's skill and challenge level, and slowly increase the challenge level as the user gains experience in order to maintain the state of flow [Ek]. See figure 2.3.

Gamification is widely used in learning and development. Well-designed educational games

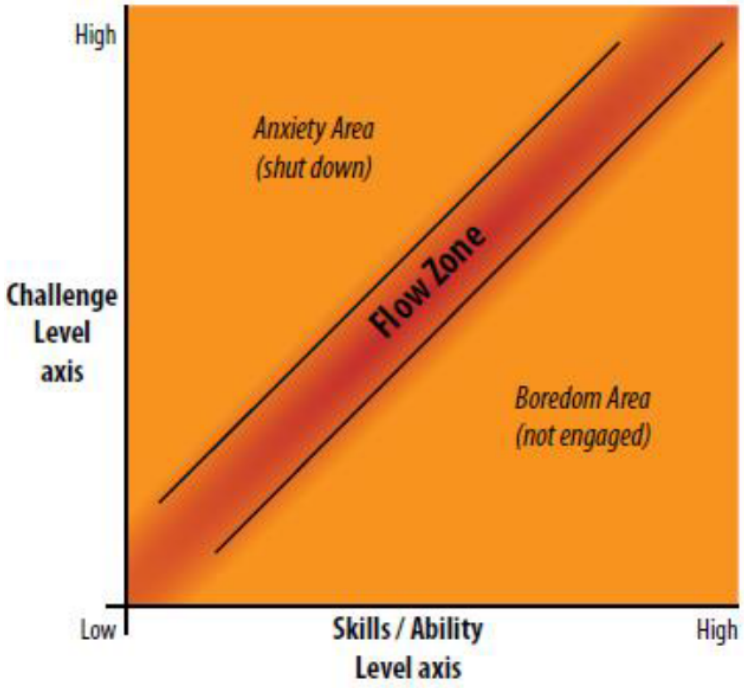

Figure 2.3: The Flow Zone [Ek]

make learning fun, challenging and rewarding [Sha14]. These cover cognitive, emotional, and social needs of students. In games failure is expected, when success follows eventually, student's previous feeling of negativity get eclipsed by satisfaction of having accomplished some objective. Thus gamification help convert the negativity to positivity [Sin12].

Depending on the gamification project, badges, leaderboards and other rewards might not be needed at all. It was the case of Slalom Consulting which had 2,000 employees around the United States. In order to improve communications between them, the company created a mobile application intended to help employees learn the names and faces of their colleagues. To encourage participation, the application included a "leaderboard" showing who had the highest scores.

Against what was expected the application was a flop, only 5% of the employees truly cared about being at the top of the leaderboard, the gift cards rewarded weren't enough, either. But when the company implemented "teams" in the application there was a dramatic shift in the engagement of the game because people didn't want to let their team down, even if the team as randomly assigned. Participation grew from 5% to 90% and recognition scores went up from around 45% accuracy to 89%.

Any Gamification project needs to provide value to participants, and not just meaningless badges. There needs to be something else there that's meaningful. There needs to be some core intrinsic value to the service. Empty points and meaningless badges are not sustainable [Kor12].

2.1.3 Criticisms and Risks

The term "Gamification" is a contested term, many people think it is just a synchronism for a hype within the society, some think it has a negative influence and some think it's an useful tool to solve business problems [Ere12].

IT research and advisory firm, Gartner, expects that up to 25% of all business processes will take advantage of Gamification techniques by 2015. In other hand, 80% of gamified applications will fail by 2014, primarily due to bad design. Ian Bogost, video game designer, believes that business executives see Gamification as an easy solution to fix problems. They take away what makes games powerful, such as its interactions and behavioural complexities, and reduce them to meaningless points, levels and badges.

Another criticism that is raised by critics is whether Gamification can be used to exploit people. For instance, Disneyland faced this situation when it installed electronic leaderboards that showed how quickly employees completed their tasks. The competition created by this system produced an hostile work environment. In one hand, these leaderboards improved work efficiency, which benefited Disneyland, but in other hand, showed that the application of some game elements in a wrong way can lead to users exploitation [Ek].

Choosing the wrong rewards for a Gamification project is one way to lead a project to failure. Video game companies know that they need to release updates, expansion packs and brand-new games to keep their players interested. Gamification platforms also need to change and evolve. Companies should also be careful not to try to use virtual rewards in place of reasonable compensation. While companies can save money by awarding badges and reputation points instead of cash bonuses, employees will see right through it if a company tries to use gamification as a substitute for being paid [Kor12].

In order to counter the critics is essential know how to design an appropriate gamified system and not be confined only to apply points, badges or leaderboards to a platform.

2.1.4 Social Impact

Gamification can be applied including a social component that encourages competition among users that belong to a community, leading them to try to always be better than others.

Competitions allow users to compete with one another, with a clear winner and loser. At the most basic level, the presence of leaderboards create a form of competition. However, on a broader level, competitions between users and groups determine who can accomplish certain tasks quicker, better, etc [Ek].

According to [Koi13] social leverage or influence is then likely to reflect the user's perceptions of how other users perceive the use of a service. The more strongly a person believes that others expect and support certain behaviour, the better it feels to conform to those expectations. Furthermore, when the relevant behaviour is supported and socially accepted, such social influence has a positive effect on the attitude toward the service.

Another aspect related to social behaviour that people seek inside a community is recognition by other users. Receiving recognition creates willingness to recognise others reciprocally within a service or a application, which further promotes social interaction. So, a service is conceived of more positively when it produces a sense of recognition from others, thus positively affecting the user's attitude to using the service.

Inside a social community users can contibute and, in turn, receive benefit from other users, i.e., reciprocal benefit which can be viewed as another form of social usefulness of the service. The reciprocity, receiving and contributing in a manner considered beneficial by the community, is likely to be of fundamental importance in encouraging users to carry out activities encouraged by the gamification system.

Finally, another factor that can captivate new users and already users to use a system more often is the quantity of friends in the system community. When we see that our friends are using and competing in a specific application, curiosity and the desire to compete can lead us to use that system.

2.1.5 Gamification and Physical Activity

As mentioned earlier, Gamification can be applied in many non-game fields, physical activity is no exception. Actually, this concept has been very successful in this area because users improve their health challenging themselves or competing with others.

According to [MS11] exercise is often seen by some users as not very appealing because physical activities require intense physical effort from the user. Using a Gamification approach to physical exercise might be a viable approach to making these activities more attractive to users, facilitating participation, and as a result, support the associated health benefits.

Traditional approaches to turning exercise into a game generally involve the creation of a competition aspect around the activity. One requirement to enable such a competition is to allow participants to compare athletic performance. In order to compare athletic performance, the activity needs to be measurable and hence quantifiable.

Thanks to recent technology this process is facilited since allows measuring and comparing athletic performance over distance, supporting distributed participants, and over time, meaning that the measurement is persistent and can be compared against future performances. Technology allows sensing new bodily information that was so far difficult to acquire and possibly also difficult to understand, but can now be readily utilized in gaming contexts.

2.1.6 Gamification and its Future

According to Gartner analyst Elise Olding, 25% of all redesigned processes will include some form of Gamification by 2015. And the size of the Gamification market - estimated at around 100 million last fall - will grow to more than 2.8 billion by 2016, according to M2 Research. The company also predicts that the enterprise segment will account for a quarter of that total, the single largest market segment [Kor12]. Towers Watson and the national Business Group (2012), reports

that 60% of employers planned to introduce online games as a part of their health initiatives for employees in the end of 2013.

Some enterprises that used a Gamification platform among their users obtained results like reduce in cost, increase revenue or accekeration of internal processes with higher data quality. The use of data from gamified websites, applications and process have shown huge improvements in areas like user engagements, ROI, data quality, customer retention and learning, etc. [Sin12].

2.2 Physical Activity in People's Lives

Regular physical activity is essential to prevent and reduce risks of many diseases and improve physical and mental health. Even knowing this, a large percentage of the population live adopting sedentary lives. This occurs mostly on elderly people, who have dificulties to exercise their bodies, or children that faces problems of obesity.

2.2.1 Childhood Obesity

A 2007 estimate that 20% of school-age children in Europe are carrying excess body fat, with a quarter of these being obese (see figure 2.4), which poses an increasing risk to them of developing chronic diseases like cardiovascular diseases or type 2 diabetes during early adulthood [Mat08].

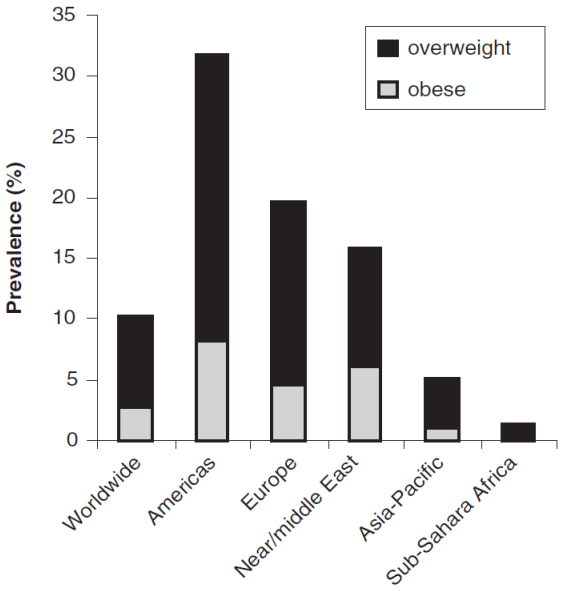

Figure 2.4: Overweight and obesity among children(aged 5–17 years) in global regions defined by IOTF criteria.

The prevalence of overweight is dramatically higher in economically developed regions, but is rising significantly in most parts of the world. In industrially developed countries, children in lowerincome families are particularly vulnerable because of poor diet and limited opportunities for physical activity. In developing nations child obesity is most prevalent in wealthier sections

of the population. However, child obesity is also rising among the urban poor in these countries, possibly due to their exposure to "fast-food" alimentation coinciding with a history of undernutrition [LBUO04].

Multivariate studies have found that television viewing and playing video games for longer periods of time, or not participating in sports outside of school, promotes obesity. Several studies have specifically examined the links between television viewing and children's risk of overweight. Reducing the time engaged in sedentary activities (such as watching television or playing computer and video games) has been shown to facilitate better treatment outcome. Exercise programmes alone without dietary modification are unlikely to be effective, because increased energy expenditure is likely to be matched by increased energy intake. Also, according to [AM98] boys are more active than girls, the amount of physical activity declines with increasing age and also this rate of decline is greater in girls than in boys.

A whole-family approach also appears vital, with several studies showing that outcomes are improved if the parents are engaged in the process, or even are the key instigators of the process. Genetic studies suggest that most children are at risk of weight gain, and that strategies to prevent obesity in a child population – such as encouraging healthful diets and plentiful physical activity – will benefit the health of all children, whether at risk of obesity or not. In the UK, children appear to become less active as they get older, and show decreases in activity levels during adolescence, starting earlier in girls than in boys [LBUO04].

Although reviews have identified many benefits of physical activity in youths, including reduced blood pressure levels, improved lipid profile, increased bone mass and density, improved self-esteem, reduction of anxiety, and reduced symptoms of depression, this report focuses on overweight and obesity prevention. Physical activity among youths is challenging to measure because the capacity to understand and to recall the concepts of time, duration, and intensity of past activity is associated inversely with age and because the nature, context, and practice of physical activity vary with age [DGCH+07].

According to [LBUO04] regimens for physical activity need to take account of the capacity of the patient to endure the exercise, and this in turn depends on the severity of the obesity. Competitive sports may not be appropriate for the obese child, and may increase psychological and social problems if they are required to participate, and equally lead to stigmatization if they are noticeably excluded. Swimming may be considered, but the social aspects of children's use of changing rooms and feelings of exposure in an undressed state should be allowed for. Alternative arrangements need to be considered, and non-competitive forms of exercise developed, such as dancing.

Because physical activity has important health benefits in youth and many young people are not meeting established guidelines, improving the physical activity levels of youth is an important public health challenge [SPT].

2.2.2 Active and Healthy people

Physical activity is essential helping prevent cardiovascular disease and chronic diseases, like diabetes mellitus, cancer, obesity, hypertension, etc. [WNB06]. Furthermore, it brings psychological benefits in young people by improving their control over symptoms of anxiety and depression. Also, participation in physical activity can assist in the social development of young people by providing opportunities for self-expression, building self-confidence, social interaction and integration. In addition, people physically more active adopt healthy behaviours like avoidance of tobacco, alcohol or drug use, and demonstrate better academic performance at school. According to [FIL+99] study, non-smoking and regular physical activity are powerful predictors of a long and healthy life. Previous studies have found that older people who walk or are involved in other forms of regular exercise and those who do not smoke have a lower risk of losing mobility and developing disability. Health promotion programs should target people of all ages, since the risk of chronic disease starts in childhood and increases with age [ho].

2.2.3 Elderly People's Physical Activity difficulties

Aging makes more difficult the execution of tasks or functions that are required everyday, also keeping physically active becomes one of the biggest troubles that elderly people faces.

The rising number of persons living in full-care nursing homes challenges common practices of elderly care which needs to encourage frail elderly to remain cognitively, physically and thus socially active [GM11]. According to [GSM10] from a psycho-physiological perspective, aging affects the quality of life on various levels:

- Cognitive impairments (e.g. decrements in episodic memory, variances in working memory performance) affect problem solving skills and information processing. Elderly persons often suffer from a reduced attention span when working on complex tasks.
- A decline of existing motor skills includes decrements in fine motor skills and changes in posture and balance. Motor learning of new skills is also negatively affected by age. Physical impairments include decrements in sensory processes which affect the interaction with the environment.
- Chronic illnesses ranging from arthritis to severe heart conditions have an impact on the physical abilities and mobility of senior citizens.

In addition, low physical activity has been identified as a risk factor for falling among older adults, and trials of exercise interventions have shown that exercise is beneficial, potentially because physical activity helps to maintain mobility, physical functioning, muscle strength, and balance, all of which may be protective against falls, on the other hand, physical activity may increase the likelihood of falling [GE00].

According to [NRB+07], an older adult with a medical condition for which activity is therapeutic should perform physical activity in a manner that treats the condition. Furthermore, an

older adult with medical conditions should engage in physical activity in the manner that reduces risk of developing chronic diseases. Physical activity should be one of the highest priorities for preventing and treating disease and disablement in older adults. Effective interventions to promote physical activity in older adults deserve wide implementation.

All these problems can be retracted or at least prevent its escalation through engaging games improving elderly people health and their happiness. Motivating users to participate in physical or cognitive therapy by providing game-like experiences which resemble leisure activities and foster the user's engagement and long-term motivation. Also, the data provided by these applications may be used by medical or nursing staff in order to monitor and analyze the user's performance [GM11].

Throught gamified techniques is possible to motivate senior people but a set of challenges has to be considered when designing a model, for instance a lack of gaming experience as well as cognitive decrements caused by age-related processes [GM11]. Besides cognitive and physical challenges, a large part of today's elderly has limited experiences using digital games, which is associated with a generally lower level of computer literacy and the late adoption of new technologies. This results in poor domain knowledge and a higher access barrier when approaching gaming systems [GSM10].

When developing an service to this target group take in account a simple user interface, big-sized fonts, instructions by sound, appealing colors, etc is critical to the application sucess. Additionally, the implementation of social activities and the creation of meaningful play through learning objectives based on research results which suggest that elderly players have a preference for simplistic puzzle and quiz games according to [GSM10].

The presentation of playful activities and the integration of game elements such as game metrics offer the possibility of fostering social interaction between senior citizens living in nursing homes. First focus group results suggest that offering common ground for discussion, e.g. by providing highscores for mini-game challenges, is a great way of playfully getting into touch and transferring positive experiences from the virtual to the real world [GM11].

According to [GM11] the lack of digital gaming experience among today's senior citizens has to be accounted for. While younger users are familiar with gaming systems and game elements can be integrated into regular applications based on common domain knowledge, this is not possible when designing for elderly users. Another challenge is created by necessity of appropriately augmenting routine tasks, which need to be meaningful and entertaining in order to engage elderly players in the long run: The inclusion of game elements in everyday life has to provide an additional benefit to the user instead of being a mere add-on. Thereby, it is possible to avoid the extension of a tiresome task without engaging the user.

2.3 Machine Learning

2.3.1 Overview

Machine learning, a branch of artificial intelligence, concerns the construction and study of systems that can learn from data. It is used in Web search, spam filters, recommender systems, ad placement, credit scoring, fraud detection, stock trading, drug design, and many other applications [Dom12]. For example, a machine learning system could be trained to learn user preferences while using an application, and based on that information could recommend suitable content to the user.

According to [Ayo94] Machine Learning can be defined as a process of building computer systems that automatically improve with experience, and implement a learning process. Machine Learning can still be defined as learning the theory automatically from the data, through a process of inference, model fitting, or learning from examples:

- Automated extraction of useful information from a body of data by building good probabilistic models.
- Ideally suited for areas with lots of data in the absence of a general theory

A major focus of machine learning research is to automatically produce models and a model is a pattern, plan, representation, or description designed to show the main working of a system, or concept, such as rules determinate rule for performing a mathematical operation and obtaining a certain result, a function from sets of formulae to formulae, and patterns.

Learning processes include the acquisition of new declarative knowledge, the development of motor and cognitive skills through instruction or practice, the organization of new knowledge into general, effective representations, and the discovery of new facts and theories through observation and experimentation. The study and computer modelling of learning processes in their multiple manifestations constitutes the subject matter of machine learning.

The field of Machine Learning can be organized around three primary research areas:

- **Task-Oriented Studies:** The development and analysis of learning systems oriented toward solving a predetermined set, of tasks (also known as the “engineering approach”).
- **Cognitive Simulation:** The investigation and computer simulation of human learning processes (also known as the “cognitive modelling approach”)
- **Theoretical Analysis:** the theoretical exploration of the space of possible learning methods and algorithms independent application domain.

There are many Machine Learning algorithms but according to [Dom12] they can be divided in just three components:

- **Representation:** a classifier must be represented in some formal language that the computer can handle. Conversely, choosing a representation for a learner is tantamount to choosing

the set of classifiers that it can possibly learn. This set is called the hypothesis space of the learner. If a classifier is not in the hypothesis space, it cannot be learned. A related question, which we will address in a later section, is how to represent the input, i.e., what features to use.

- **Evaluation:** an evaluation function (also called objective function or scoring function) is needed to distinguish good classifiers from bad ones. The evaluation function used internally by the algorithm may differ from the external one that we want the classifier to optimize, for ease of optimization (see below) and due to the issues discussed in the next section.
- **Optimization:** we need a method to search among the classifiers in the language for the highest-scoring one. The choice of optimization technique is key to the efficiency of the learner, and also helps determine the classifier produced if the evaluation function has more than one optimum. It is common for new learners to start out using off-the-shelf optimizers, which are later replaced by custom-designed ones.

  A list of this algorithms can be found in the table 2.2.

Representation	Evaluation	Optimization
Instances		
K-nearest neighbor		**Combinatorial optimization**
Support vector machines		Greedy search
Hyperplanes	Accuracy/Error rate	Beam search
Naive Bayes	Precision and recall	Branch-and-bound
Logistic regression	Squared error	**Continuous optimization**
Decision trees	Likelihood	*Unconstrained*
Sets of rules	Posterior probability	Gradient descent
Propositional rules	Information gain	Conjugate gradient
Logic programs	K-L divergence	Quasi-Newton methods
Neural networks	Cost/Utility	*Constrained*
Graphical models	Margin	Linear programming
Bayesian networks		Quadratic programming
Conditional random fields		

Table 2.2: The three components of learning algorithms [Dom12]

2.3.2 Reinforcement Learning

Reinforcement learning (RL) is learning what to do mapping situations to actions, so as to maximize a numerical reward signal. The learner is not told which actions to take, as in most forms of machine learning, but instead must discover which actions yield the most reward by trying them. In the most interesting and challenging cases, actions may affect not only the immediate reward, but also the next situation and, through that, all subsequent rewards. These two characteristics, trial and error search and delayed reward, are the two most important distinguishing features of reinforcement learning [SB98].

A reinforcement learning agent learns by interacting with its environment, using a scalar reward signal as performance feedback [SB98]. RL uses discrete state-spaces with low dimensional input-spaces, because current RL algorithms require extensive repeated searches of the state-space in order to propagate information about the rewards available, and so smaller state-spaces can be examined more easily [RN94]. The environment is typically formulated as a Markov decision process (MDP), and many RL algorithms for this context are highly related to dynamic programming techniques. The main difference between the classical techniques and RL algorithms is that the latter do not need knowledge about the MDP and they target large MDPs where exact methods become infeasible.

A MDP is a tuple $\langle X, U, f, \rho \rangle$ where: X is the discrete set of environment states, U is the discrete set of agent actions, $f : X \times U \times X \to [0,1]$ is the state transition probability distribution, and $\rho : X \times U \times X \to R$ is the reward function. As a result of action u_k, the environment changes state from x_k, ending up in x_{k+1} with probability $f(x_k, u_k, x_{k+1})$. The agent receives feedback on its performance via the scalar reward signal $r_{k+1} \in R$, according to $\rho : r_{k+1} = \rho(x_k; u_k; x_{k+1})$. For deterministic models, the transition distributions is replaced by a function, $f : X \times U \to X$. The reward is then completely determined by the current state and action, $\rho : X \times U \to R$. The agent chooses actions according to its policy that may be either stochastic, $h : X \times U \to [0;1]$, or deterministic, $h : X \to U$. A policy is called stationary if it does not change over time. The agent's goal is to maximize, at each time step k, the discounted return: $R_k = \sum_{j=0}^{\infty} \gamma^j r_{k+j+1}$, where $\gamma \in (0,1)$ is the discount factor. The *action-value funcion* (Q-function),$Q^h : X \times U \to R$ is the expected return of a state-action pair under a given policy: $Q^h(x,u) = E\{R_k | x_k = x, u_k = u, h\}$. The agent can maximize its return by first computing the *optimal* Q-function, defined as $Q*(x,u) = max_h Q^h(x,u)$, and then choosing actions by the greedy policy $h*(x) = argmax_u Q*(x,u)$, which is optimal [BBS06].

2.3.2.1 Q-Learning Algorithm

Q-learning is a model-free RL technique because is able to compare the expected utility of the available actions without requiring a model of the environment. This technique can be used to find an optimal action-selection policy for any given MDP. It provides agents with the capability of learning to act optimally in Markovian domains by experiencing the consequences of actions, without requiring them to build maps of the domains. The agent tries an action at a particular state, and evaluates its consequences in terms of the immediate reward or penalty it receives and its estimate of the value of the state to which it is taken. By trying all actions in all states repeatedly, it learns which are the best policy to follow, judged by long-term discounted reward [WD92]. Also, it has been proven that for any finite MDP, Q-learning eventually finds an optimal policy.

In Q-learning, the goal is to reach the state with the highest reward, so that if the agent arrives at the goal, it will remain there forever. Each time the agent selects an action, and observes a reward and a new state that both may depend on both the previous state and the selected action. The core of the algorithm is a simple value iteration update which formula can be seen below.

$$\text{Q(state,action)} = \text{Q(oldState,oldAction)} + \alpha$$
$$+ (\text{ R(state,action)} + \gamma * Max[Q(nextState, allActions) - Q(oldState, oldAction)]) \quad (2.1)$$

According to this formula, a value assigned to a specific element of matrix Q, is equal to the sum of the corresponding value in matrix R and the learning parameter γ, multiplied by the maximum value of Q for all possible actions in the next state.

Agent will learn through experience, without a teacher (unsupervised learning). The agent will explore from state to state until it reaches the goal. Each state exploration can be called episode, which consists on the agent moving from the initial state to the goal state. Each time the agent arrives at the goal state, the program goes to the next episode.

The Q-Learning algorithm goes as follows:

1. Set the gamma parameter, and environment rewards in matrix R
2. Initialize matrix Q to zero
3. For each episode:
    - Select a random initial state
    - Do While the goal state hasn't been reached:
        - Select one among all possible actions for the current state
        - Using this possible action, consider going to the next state
        - Get maximum Q value for this next state based on all possible actions
        - Compute the mentioned above Q(state, action) formula
        - Set the next state as the current state

The algorithm above is used by the agent to learn from experience. In each episode, the agent explores the environment, receives the reward (if any) until it reaches the goal state.

The *Gamma* parameter has a range of 0 to 1 ($0 <= \gamma > 1$). If *Gamma* is closer to zero, the agent will tend to consider only immediate rewards. If is closer to one, the agent will consider future rewards with greater weight, willing to delay the reward [McC].

2.4 Summary

The topics covered in this chapter represent a board of knowledge required to understand the problem that motivates the project described in section 1.3.

Gamification can be used as a strategic tool, influencing the behavior of its application users, enhancing performance and productivity, giving recognition by others, powerful feedback mechanism, etc.

The adoption in non-game contexts of the Gamification concept can be seen, more and more, as an option to be applied in many services from different fields. Throught it engagement and customer loyalty regarding a specific service can be easier because the user is challenged by the service or by other users that belong to the community. However, to achieve a successful gamified service is central the definition of our goals and the resources available and thus may build a model suitable to solve the problem.

The existence of a social component in a gamified service or application is one of the most important aspects to consider when developing this type of systems. Since, games encourage to competition among people, in a gamified service community users are always trying to surpass others. Another aspect that users seek is receiving recognition from the application community, for example, when we achieve a top score in a ranking, we enjoy a privileged position compared to others and this makes us feel better.

Gamification has also been shown to create positive results. In some situations where it is applied, it seems to increase adoption of a system and increase enjoyment of its users. However, the long-term results of gamification have not been fully studied. It could be found that after a while, these game mechanics lose their novelty, become expected and lose their ability to motivate.

Physical activity is another field that its practice can be encouraged throughout gamified applications adoption. Lack of will to do efforts and sloth can be factors that hinder the realization of this type of activities. But throughout Gamification techniques incorporated with a social component it becomes much easier to give motivation to users and with new technology the data measurement and adaptation of the platform for different users is possible too.

Obese children or elderly people are vulnerable to a lot of diseases or cognitive and physical problems. Motivating the practice of physical activity among this people may avoid some of these problems improving their health and wellness. With the help of gamified systems is possible to motivate such persons to practice physical activity, because these people have lack of knowledge of how to use these technologies, it is necessary to develop intuitive applications or services with good communication channels between the user and the device. Furthermore, through the use of these gamified systems, contact with other persons from the community can be increased.

The application of machine learning algorithms offers generalizations, classifications and pattern identification in order to adapt the application or service to the customer needs and behaviour. With a large amount of data, these algorithms can be better applied because it becomes much easier the definition of models that can adapt the service to different type of users.

Chapter 3

Literature Review: Related Works

This chapter essentially describes what has been done with the Gamification concept and how that can contribute to my current project. Section 3.1 describes what has been done recently in this field and how can be useful to my project. Section 3.2 presents some Gamification applications examples that obtained success in the market. Finally, Section 3.3 mentions some conclusions about the existing work.

3.1 What has been done using Gamification?

During my research I noticed that Gamification is a very recent term, it only began to spread around the second half of 2010. So, it's normal that the amount of information and projects related to this subject are not very abundant. However, with the information that I was able to collect I concluded that there has been developed many application using the same game elements but focused in different type of activities with a wide variety of type of users. Through some examples of success in the existing market I saw how these elements were applied in order to learn how to adapt them to my problem.

3.2 Examples

There are many examples of services or applications that effectively employ gamified techniques. To understand how the Gamification concept works, i.e., how game elements are applied in non-game contexts that make part of everyday life I described some popular examples that cover different tasks: Foursquare, Nike+ Running,"Zombies, Run!", "The Fun Theory", Siemens's Plantville and LinkedIn.

3.2.1 Foursquare

Foursquare is a location-based game-like service where players check-in to locations for virtual points and rewards. It is probably the most recognized forerunner of applying game mechanics to location-based networking application and made badges rewarding a common practice in most of catch-up gamified applications. Foursqure proved that simple game mechanics can affect behavior that can engage 10 million customers and being a successful business model. By employing gamification elements such as points, badges, levels and leaderboards, it engages users to revisit a location such as restaurant or pub and become a loyal customer and finally the "major" of the place. Some virtual rewards such as the "mayors" of Starbucks or certain badges could be converted into real products, e.g. a free coffee [Xu11].

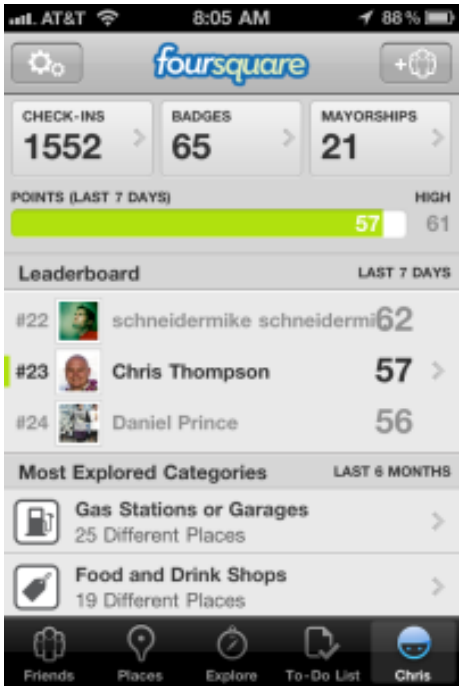

Figure 3.1: Foursquare mobile application overview [Tho11a]

Foursquare is a friend-finder, a social city guide and a game that challenges users to experience new things, and rewards them for doing so. Foursquare lets users 'check in' to a place when they're there, tell friends where they are and track the history of where they've been and who they've been there with". When doing a check-in, foursquare examines the user's current location and shows a list of nearby places [LCW+11]. When users discover places which are not listed in the application they can register that new place and connect with social networks like Facebook or Twitter in order to have their check-ins published on the theses communities. Also, if someone has a local business that person can see who made check-ins on its place of business.

The game aspect of Foursquare offers virtual and tangible rewards for check-ins. Virtual rewards come in the forms of points, badges, and mayorships visible in one's public profile. Badges are awarded for a variety of reasons, e.g. for starting to use the service, checking-in on a boat,

checkingin with 50 people at the same time, or checking-in at a special event. Foursquare also enables social recommendations through tips, a small snippet of text associated with a place. Tips are intended to suggest possible activities for that place [LCW+11].

Foursquare has several features, which are responsible for increase user engagement and encourage exploration, from which I highlight:

- **Mayorship:** if a user has checked into a venue on more days than anyone else in the past 60 days, and the check-ins are valid under foursquare's time and distance protocols, they will be crowned mayor. The user must have a profile picture in order to be crowned "Mayor" of that venue. Someone else may earn the title by checking in more times than the previous mayor. It is harder to be crowned mayor in spaces that are swarming. Even after someone has been crowned "Mayor", they must continuously check in to maintain their position as mayor [Cen].

Figure 3.2: User being crowned "Mayor" of some place [Ste12]

- **Scoring system:** Every time you check into a location, you receive points. If you are checking into a place for the first time, you earn more points. If you check in with a friend, you earn even more points. The points don't actually amount to anything except a friendly competition among your friends and the bragging rights of being on top. According to [Tho11a] there are more than 100 reasons Foursquare awards points. Some of the most commonly awarded ones are below:

  - Checking in to a new place: 3 points
  - Becoming the Mayor of a venue: 5 points
  - Checking in when already the Mayor: 3 points
  - Being the first of the user's friends to check into a new location: 3 points
  - Checking in to a place the user has been before: 1 point

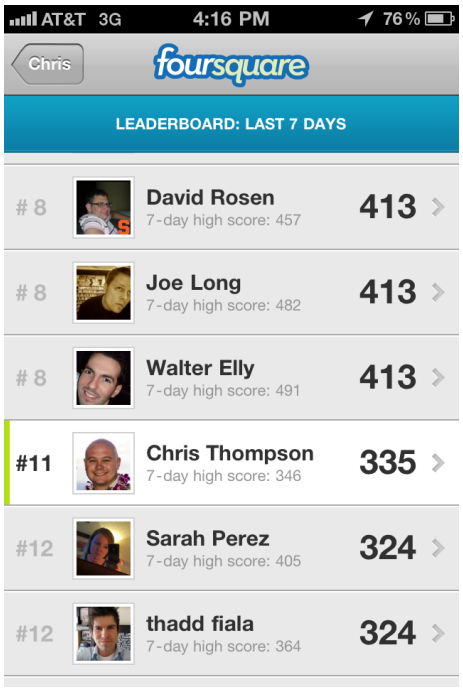

Figure 3.3: Foursquare's leaderboard [Tho11b]

  - Checking in to a new category for the first time: 4 points

- **Tips:** A popular function of each location is the opportunity to leave a tip. For example, if you checked-in to the Kimmel World Marketplace, you might leave a tip to go to the pasta line and say hello to Robert. You can turn anyone's tip into a "to-do" item and the next time you are wondering what to get at Kimmel, you will have a reminder in your Foursquare account.

- **Badges:** Badges are earned by checking into various venues. Some badges can only be earned in a specific city. Foursquare has, however, changed the way they handle badges, and now when a user gains a badge, he or she has the same badges across all cities. Once a badge is earned by a user, it will remain on that user's profile indefinitely. There are a handful of introductory badges that are earned as milestones in usage. Some badges are tied to venue "tags" and the badge earned depends on the tags applied to the venue. Other badges may be specific to a city, venue, event, or date. Some badges use identical icons, but are earned differently [Low]. For some badges examples see figure 3.4.

3.2.2 Nike+

People like to share and compare activities they are doing. This is the basis of many social platforms, such Facebook or Twitter. Nike+ combines Gamification elements with "share and compare" [DMRK12] yielding a social running game-like service that employs game mechanics to

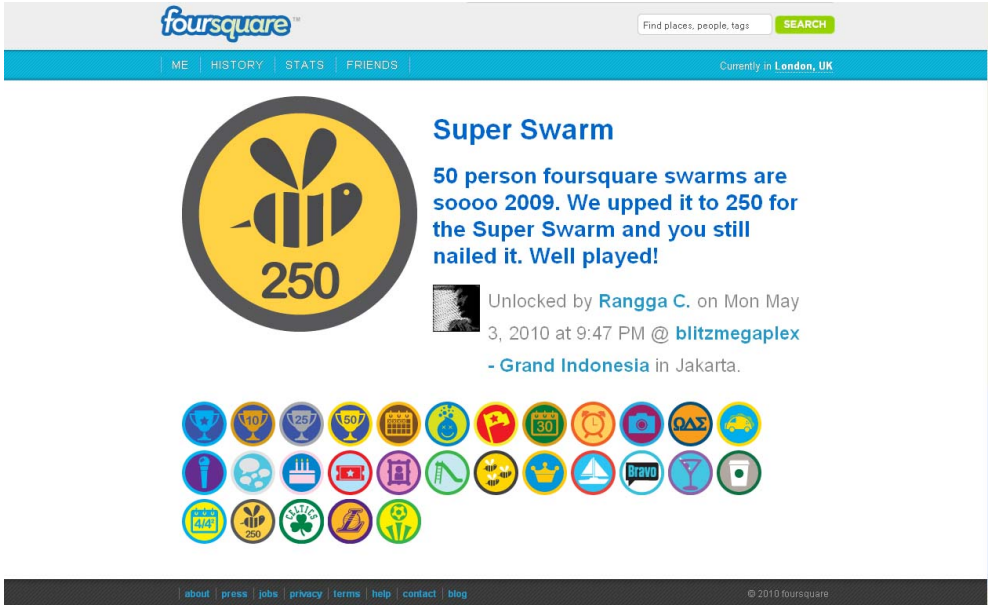

Figure 3.4: List of badges on foursquare's Web Application

encourage runners - both casual and hardcore - to compete and improve their fitness, with the goal to solve the main problem of fitness program: motivation.

Nike+ makes it easy for runners to upload their run data to the website and start challenging themselves and their friends, they can also get supports from their friends [Xu11]. Furthermore, users have the ability to track, share and challenge with friends and other runners across the world. Game elements, such as challenges, badges, achievements and rewards create an engaging experience that enriches the real world activity [DMRK12]. With the data sent to the website, users can view their history, their evolution throught time, receive advices from personal trainers, view maps, create contests and challenges with other runners and many other features. The service is divided in a Mobile and Web application (see Figure 3.5).

In order to track all user running activity the Android application uses the GPS and the accelerometer of the smartphone. The main page of the Nike+ Running app has the upper part of the user interface divided into two sections: Home and Run. On tapping the Home button, it instantly shows a dropbox featuring options such as Activity, Challenge Me and Shop Nike (Nike's store). While the Home section let us take on newer running challenges- it actually asked us to surpass our previous/ best running activity – and track activities to see our progress, the Run section instantly put us on the running track [Khe12].

The app goes the social way, allowing in-ear cheering from friends and you can also tag friends you ran with and share a map of your route. Furthermore, through social networks like Facebook, Twitter or Flickr you can interact with other users and being informed about events, new products and news [Plu].

Many people find music relaxing as well as motivating while running, and so the Nike+ Running comes with the option to add music called Powermusic. You can add your own playlist too. The Run summary offers all the information about the route taken, the type of trail and also the

Figure 3.5: Nike+ Web Application

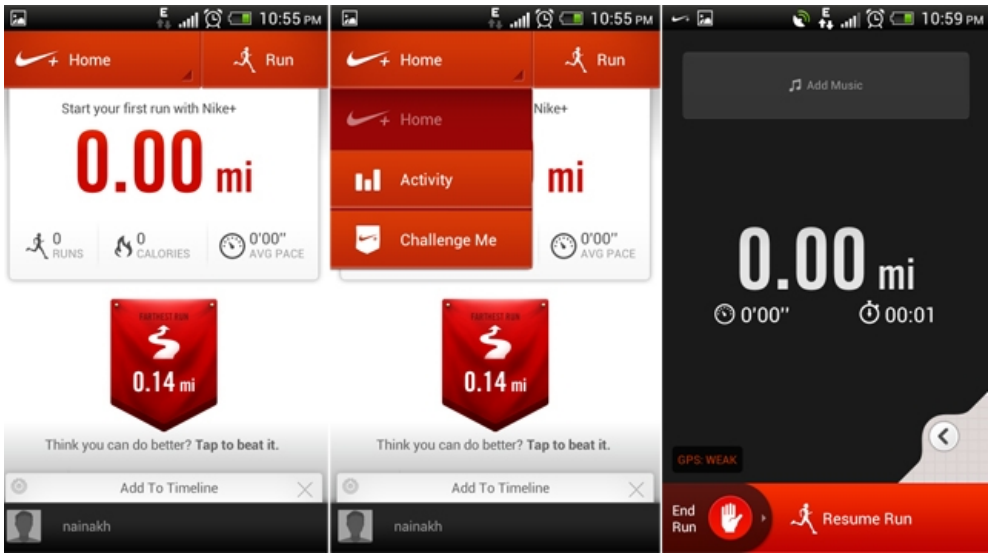

Figure 3.6: Nike+ Running mobile application main page [Khe12].

weather conditions.

All the data is synced with Nike's website , allowing you to view it from your web browser anytime, anywhere. The summary of your progress is neatly broken down and shown in the form of graphs too. So you can clearly track your progress each day and review each run. The Challenge Me section pushes you to beat your own good scores and elevate your fitness level. The Home dropbox also includes a Nike Shop tab that takes you to the Nike webpage for some shopping [Khe12].

3.2.3 Zombies, Run!

"Zombies, Run!" is an immersive running game experience that places the player as a runner through a mobile application in a post-apocalyptic zombie environment [Cob]. First, "Zombies, Run!" is not based on badges and points. Rather it functions more as a RPG since the runner is given a character that exists inside the game. The recognition of different game mechanics is incredibly helpful when deciding which gaming systems would work best [Jou11].

Players are able to listen to a predefined story using their headphones. They will receive orders and voice recordings while running [Ere12]. What makes this application most unique is that at any time during a run the player can be attacked by zombies and will have to increase your speed by 20% during the attack to survive.

Figure 3.7: "Zombies, Run!" mobile application screens [War12].

Zombie attacks are simulated with a warning message and then the groaning sounds of Zombies getting closer and closer until the player either evades them or is consumed. Fortunately for players, being caught by zombies isn't the end of the world, but will result in a loss of potentially valuable supplies [Sou]. After completing a run, they can build and grow their "base" with the

items they have collected. The task is to save people from zombies. In order to do so they automatically collect items like medicine, batteries, and ammunition while running. These items can be assembled freely on the "Zombies, Run!" platform. For educational purposes "Zombies, Run!" records the distance, time, pace through GPS and accelerometer information.

Although the application was just deployed it will be interesting to evaluate if the usage of the application has an motivational influence on the running behavior of a person [Ere12]. And appears that has because currently "Zombies, Run!" has more than 300 000 players worldwide, a surprisingly substantial following since the application is a little expensive comparing to others [Sou].

3.2.4 The Fun Theory

The Fun Theory was a contest held by German automotive company, Volkswagen, to find the most innovative ideas that could prove their theory: "Fun is the easiest way to change people's behavior for the better" [Coa]. Which believes that by making things fun, people's behaviour can change for the better, and it has created multiple experiments to showcase this [Ek].

Whether it is encouraging drivers to buckle their seat belts or citizens to recycle and lower the rates of littering, Volkswagen puts a twist on these mundane tasks to make it fun. One of their initiatives that went viral, was the Piano Staircase (Figure 3.8) at the Odenplan sub-way in Stockholm, Sweden. Each step of a staircase in the subway was setup to play a musical note when it was stepped on. At the end of the campaign, the results showed that 66% more people used the musical stairs over the escalator [HS13]. Another example was reshape the task of throw away garbage by transforming bins into the "World's Deepest Bin" something that gave people a bit of joy doing the task. As a result, people deposited 230% more trash in the custom bin than in a common one [Ste].

Figure 3.8: The Piano Staircase one of "The Fun Theory" experiments [Pel].

According to [Zic] The Fun Theory is, in essence, the same concept behind Gamification: by making things fun, people are more likely to become engaged. This solves one of the core concepts that is missing from even the best business and strategy books: "without employee and customer engagement, the best laid strategies and tactics are doomed to fail".

The Fun Theory is a prime example of Gamification, and is a common tactic that companies are using in their marketing strategies [HS13].

3.2.5 Siemens' Plantville

Plantville is an online gaming platform that simulates the experience of being a plant manager. Players are faced with the challenge of maintaining the operation of their plant while trying to solve several real world and real time plant problems by improve the productivity, product quality, customer service, efficiency, sustainability and overall health of their facility.

Siemens viewed Plantville as an innovative, educational and fun way to engage customers, employees, prospects, students and the general public while driving awareness of their brand. The game enables players to improve the health of their plants by learning about and applying industrial and infrastructure products and solutions from Siemens [Ban12]. Players who sign up will have access to three areas: the PlantVille game, an online simulator allowing users to manage a bottling, vitamin, or manufacturing plant(Figure 3.9); the PlantVille Café, where Siemens can engages with players to discuss game solutions; and the PlantVille Puzzler, where users can test their knowledge with brain teasers [Car11].

Figure 3.9: Plantville online simulator user interface [Car11].

While engagement with potential customers was not the main goal, Plantville was developed to help make manufacturing "cool" again and drive awareness of Siemens technologies and solutions among customers and potential customers. Additionally, Plantville was targeted to students and university graduates to aid the company in recruitment. The company targeted particular universities to recruit from, all of which are now users.

Regarding results, the response to the game has been impressive. It has 20,000 users in 150 countries and has inspired other companies to develop similar games. In terms of Siemens' recruitment objective for Plantville, 85% of students perceived that engineering and industry could be "fun" after playing Plantville. The same survey revealed that 92% of teachers saw the game as having possible educational benefits, and 85% would use it in a classroom environment as a teaching tool. Additionally, over 600 universities are among the users of the game [Ban12].

The company views Plantville as a success, and their survey data supports this. According to [Onl] there currently are 23,000 registered users in 150 countries, and the average playing time is 14 minutes per session. Moreover, 87% of Plantville players said they would recommend the game to colleagues, and 62% said their impression of Siemens has improved since playing the game.

The company aims to keep using game dynamics as a tool for recruitment, mainly among graduates. Through the creation of Plantville they have created a realistic, tangible and interactive game that has increased engagement with their stakeholders to the benefit of the company.

3.2.6 LinkedIn

To make the professional network LinkedIn valuable for all members, information about each member is needed. The more a user enters, the more valuable for the overall network. When new members sign up, they tend to fill out the most basic information only, hesitating how much information shall be shared [Her13].

LinkedIn uses also a number of Gamification design elements. Believe it or not, the profile completeness bar (Figure 3.10) on LinkedIn can be seen as an example of game mechanics. By seeing how much more complete the profile needs to be, many people will be driven to take steps to 100% completion with the promise of being able to take advantage of LinkedIn's more advanced features [Hem12]. The enhancing service increases the perceived value of filling all details by invoking progress-related psychological biases [HH12].

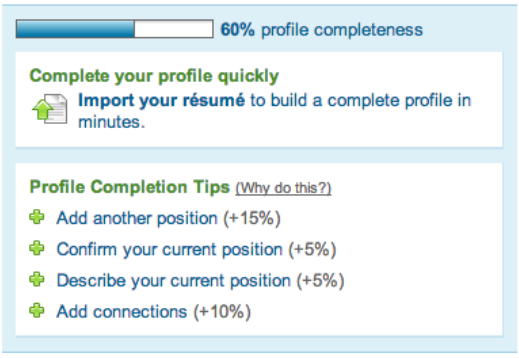

Figure 3.10: LinkedIn progress bar.

LinkedIn was replaced the completeness bar and introduced a new form of such a display, called profile strength(Figure 3.11). Depending on how much the circle is filled levels are assigned to it.

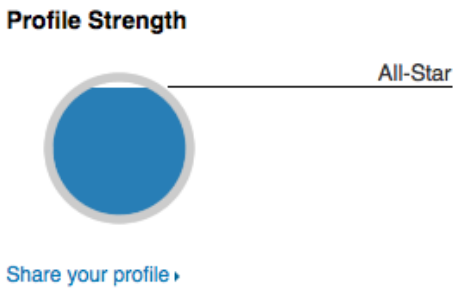

Figure 3.11: LinkedIn profile strength [Her13].

The reason for this visualization has to do with a disadvantage that the original form of a progress bar for the profile completeness brings. Once the bar reaches 100%, there is no need to add more information to the profile, which would make updates such as job changes, new titles, or certifications less relevant [Her13].

3.3 Summary

After analyzing these examples of Gamification implementations, due to the great success obtained by these services we can see the influence or the power of gamified elements on people's behavior.

Foursquare service leads millions of people to use the application because they see it as if they were playing a game. While exploring a city that person is having fun and at the same time is competing with their friends. The same applies to Nike+, but instead of being a service focused on exploration of places, it aims to motivate the user to run. "Zombies, Run!" showed that Gamification is not only apply points, badges or leaderboards in some context, study the specific case and the type of players is essential in order to create innovative ideas or ways of create a game experience. Volkswagen's "The Fun Theory" proved that our daily routine petty tasks can be transformed into something that engages and is promoves fun to people. Siemens's Plantville took some "boring" job (plant manager) and using a game interface turned this into an engaging experience allowing users to have an idea about what a plant manager tasks are. LinkedIn showed that even the simplest concepts or tasks can be gamified.

In short, all the methods applied are from games but applied in different contexts using goals, challenges, badges, competition among friends, etc. that are available to us. Thus, these elements can be applied to this project, it is only necessary to perform a correct definition about what is pretended to reach, what kind of users we are dealing of and the utilization of appropriate metrics to measure and study user behavior.

Chapter 4

MoverGami: Project Specification

This chapter describes the project specification conducted in order to specify what the system required and how it was designed. Section 4.1 describes how the system developed works. Next, in Section 4.2 the non-functional and functional requirements are listed, as well the use cases. The system architecture is explained in Section 4.3, and the class model is described in Section 4.4. Finally, Section 4.5 explains the Gamification model adopted.

4.1 System Overview

The proposed solution to solve the problem identified in Chapter 1 is a mobile application for Android named *MoverGami* complemented with a web application *MoverGamiWeb* which will operate as a framework to manage new contents of the platform.

This application uses data obtained from *Mover*, a mobile application previously developed at Fraunhofer's(see Section 5.2), which while running on background on a smartphone tracks and monitors all the user physical activity identifying if he is walking, running, sitting, etc. and the quantity of meters traveled, calories burned, time performing some activity, etc.

The accumulation of the retrieved data builds up the user personal stats, and with these statistics the player or application user is able to unlock or complete objectives proposed by the platform. These objectives are proposed in form of game elements which are created using the web framework. On the web application, *MoverGamiWeb*, admin users are able to manage the game elements from the "game"(see Section 2.1.1), in other words, create, edit or delete badges, rewards, challenges or facts.

These elements after being created are requested by the mobile application whenever the user starts it. As soon as there are game elements to "play" the user can start to unlock badges completing achievements, unlock rewards by leveling up, complete challenges doing *quests* or receive facts. By unlocking badges users have the possibility of share with his Facebook friends what they have obtained.

Furthermore, the application also features a machine learning algorithm, more properly, the Q-Learning technique, running on *MoverGami's* in order to generate new challenges suitable for each user. For example, if the algorithm finds that the user has performed few physical activity in the past hours, the application will defy the user with a challenge to encourage him to perform more activity.

Finally, on the web side, admin users can also view user statistics which are sent hourly by the mobile application. These statistics are represented graphically in graphs and pie or bar charts, and show the user data organized in different ways, as by timeframe, activity, etc.

4.2 Specification Requirements

The following section describes the intended behavior and architecture of the developed system. This is accomplished by listing both non-functional and functional requirements and a view of the system's class and architecture model.

4.2.1 Non-functional Requirements

Non-functional requirements detail constraints, targets or control mechanisms for a system. They describe how, how well or to what standard a function should be provided, i.e., requirements that specify how a system should operate, rather than specific its behavior or features [Com14]. The system developed must fulfill the non-functional requirements described below:

- **Scalability:** is the ability of a system, network, or process to handle a growing amount of work in a capable manner or its ability to be enlarged to accommodate that growth. For example, it can refer to the capability of a system to increase its total output under an increased load when resources are added [Bon00]. The system should allow the creation of dynamic content using a web application that will be sent to the mobile application in order to challenge the user.

- **Extensibility:** is the ability of a system to be extended with new functionality or through modification of existing functionality with minimal or no effects on its internal structure and data flow. Basically, it is a systemic measure of the ability to extend a system and the level of effort required to implement the extension [LÖ9]. The system should be developed in such a way that eases the insertion of new game elements, different types of activities or other features.

- **Interoperability:** describes the extent to which systems and devices can exchange data, and interpret that shared data. For two systems to be interoperable, they must be able to exchange data and subsequently present that data such that it can be understood by a user [HIM14]. The system allows a total integration between the web framework and the mobile application. All the game elements created on the client web side will be available to unlock or complete in the mobile application.

- **Usability:** assesses how easy user interfaces are to use. The system should possess simple and appealing web and mobile user interfaces with menus that allow the user to reach all the wanted information just with a few "clicks". Also, the web application with a intuitive interface should encourage users or admins for insertion of new content.

4.2.2 Functional Requirements

Functional requirements capture the intended behavior of the system. This behavior may be expressed as services, tasks or functions that system is required to perform [MB01]. In order to understand the main features of the system, the functional requirements listed below were gathered:

- Graphical view of physical activity statistics organized by different timeframes;
- List of badges to unlock and challenges to complete;
- Mobile application integrated with social network Facebook, with share and scores functionalities implemented in order to allow unlocked content sharing and leaderboards competition;
- Level system, leveling up with gain of experience and rewarding each new unlocked level;
- Reception of facts relating some achievement to some cultural curiosity;
- Web application enabling the insertion of new challenges, achievements, rewards, etc.

4.2.3 Use Cases

The use case model provides detailed information about the behaviors of the system or application being developed. Usually, it contains use case diagrams and activity diagrams that describe how users interact with the system.

The use case model identifies the requirements of the system in terms of functionalities that must exist to achieve the goals set out by the user or to solve a problem identified by the user. Use cases describe the major behaviors identified in the requirements and describe the value that the results give the users, still they do not describe how the system operates internally [IBM].

4.2.3.1 Actors

Actors are the users of the system and represent the different roles that people and other systems play when they interact with the system. The system possess two main actors (Figure 4.1): the common user that uses the mobile application and the admin user who uses the web application [IBM].

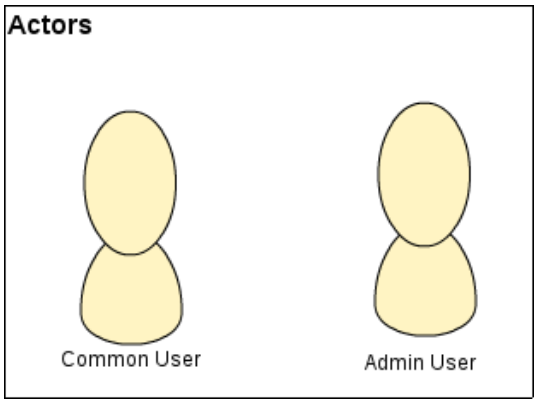

Figure 4.1: MoverGami system actors

4.2.3.2 Admin User

The admin user, as mentioned earlier, uses a web application that works like a framework to create, edit, update or delete(CRUD) game content like badges, challenges, rewards, etc. which after their creation are sent to the mobile application, also this application allows to consult user graphic statistics. In Figure 4.2 are presented the admin user's use cases.

4.2.3.3 Common User

Regarding the common user, he uses the mobile side in order to "play" with the game content created by the admin in the web application. He also can consult his personal statistics and what he has unlocked or completed. In figure 4.3 are presented the common user's use cases.

4.3 Architecture Model

An architecture model helps ensuring that a software system or application meets users needs, the creation of this model makes part of the description of the overall structure and behavior of the system or application. These models can also describe design patterns used and help understand the existing architecture, discuss changes, and communicate your intentions clearly. The purpose of this model is to reduce the ambiguities that occur in natural language descriptions, help in the visualization of the design and to discuss alternative designs.

The architecture of a system can be divided into:

- **High-level Design:** which describes the major components and how they interact with one another to fulfill each requirement. If the system is large, each component might have its own high-level design that shows how it is composed of smaller components.
- **Design Patterns:** a pattern describes a particular approach to achieving a programming goal. By using the same patterns throughout a design, your team can reduce the cost of making changes and developing new software [Mic].

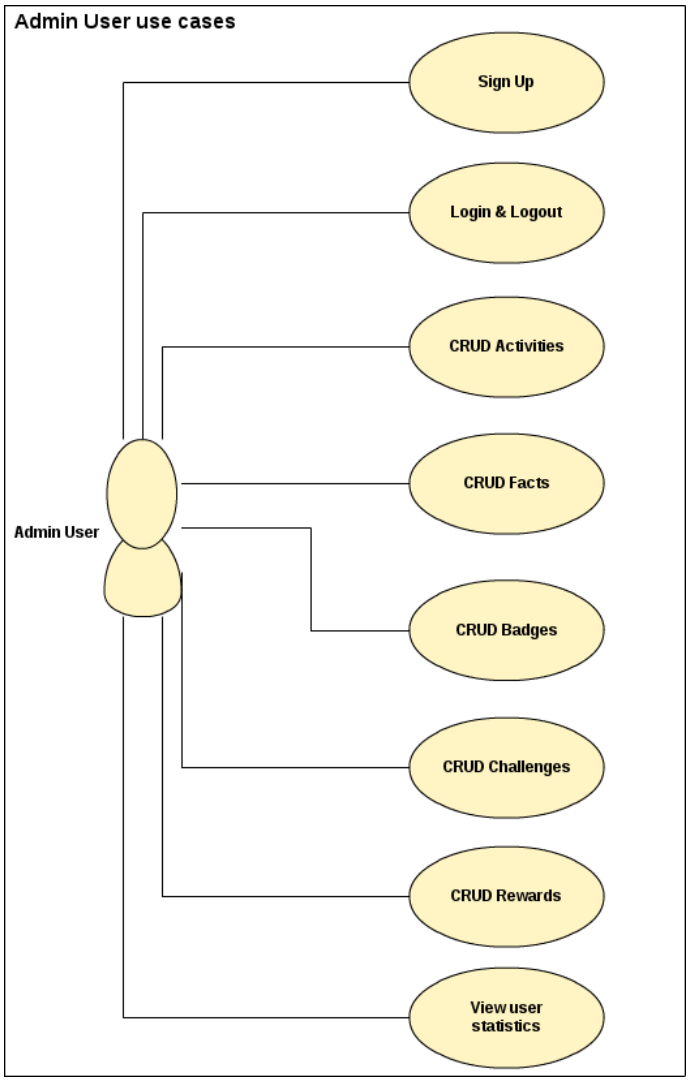

Figure 4.2: Admin User use cases

In order to specify the architecture of the current project an abstract architecture of the system was designed which can found in Figure 4.4. In the Figure, "objects" represent system components and the yellow shapes represent mechanisms that manage the data which flows on the platform. Note that weren't chosen design patterns due to the simplicity of the high-level system.

The system architecture is quite simple to understand. Firstly, through the accelerometer from the device, *Mover* application collects and tracks user data about physical states and quantity of physical activity. Although there are other ways to determine user's location and consequently track his activity like GPS, due to its high degree of imprecision, it was decided that *Mover* should only use the accelerometer [FCR10].

Then, *MoverGami* application requests that data using suitable methods from *Mover's* library, each chunk of data is received each 5 seconds by a service or listener running on background. After receiving the information, the new information about the user activity is stored or updated in a SQLite local database. Using the data stored on the device local database, there are machine

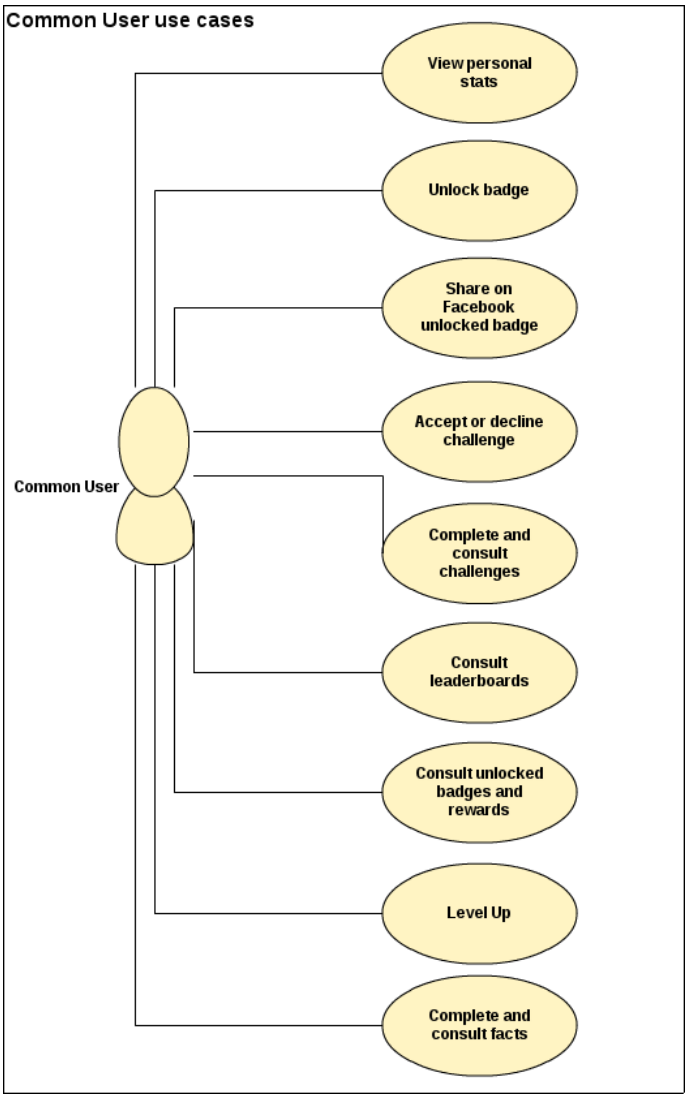

Figure 4.3: Common User use cases

learning algorithms analyzing the history of information and creating new contents, ahead this will be explained in more detail.

Next with the information stored on the local database, takes place a constant data exchange between the server and *MoverGami* using the REST protocol and JSON format. The mobile client sends information about levels of activity from the user and generic data regarding content unlocked or completed. Eventually, this information is stored on the server and used to display user stats on the web application.

Finally, occurs a data flow from the web client to the server and subsequently to *MoverGami*. Through this flow is transported new game content created by the admin user on the web application.

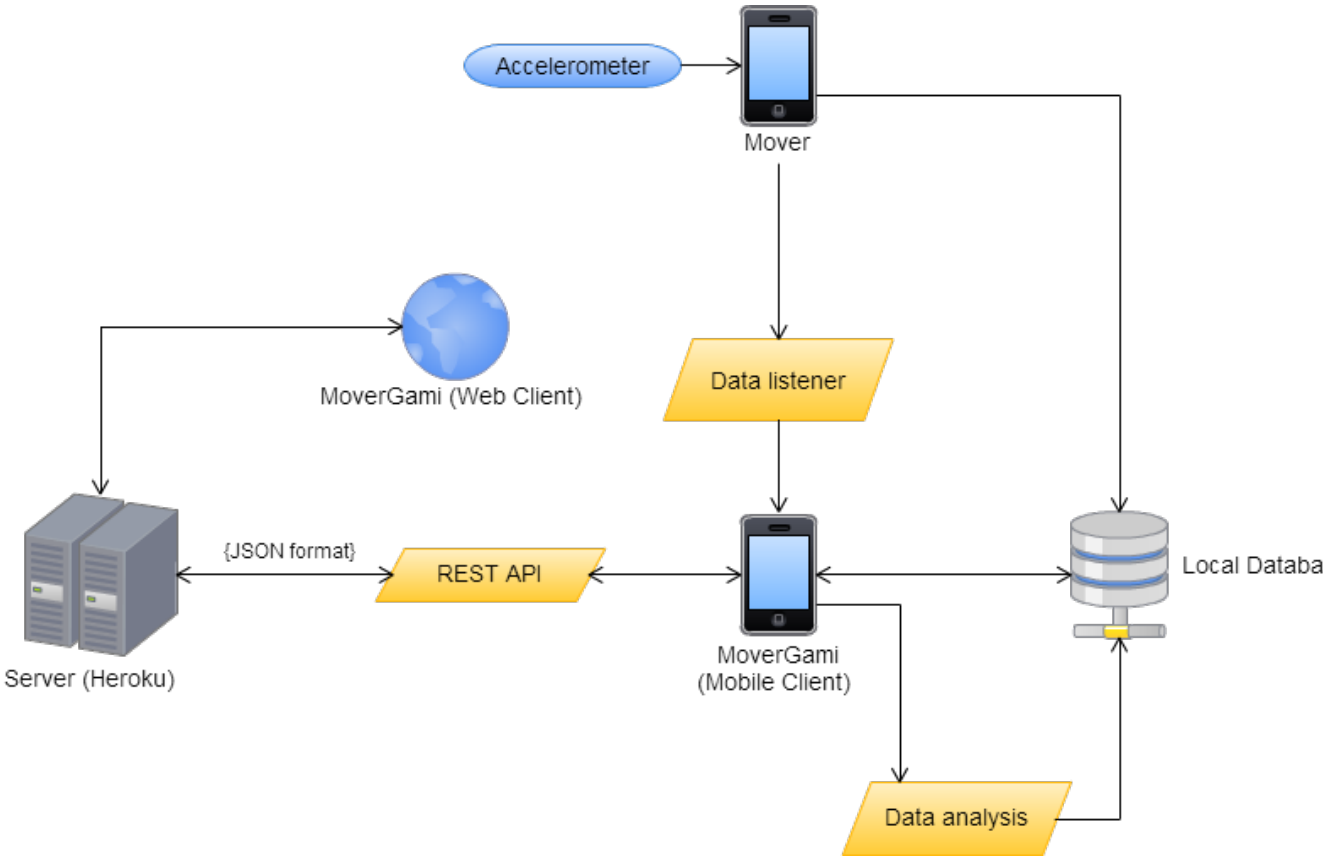

Figure 4.4: Platform abstract architecture

4.4 Class Model

The class model shows class objects in a system and the relationships between them. Two particularly important relationships are generalization or inheritance and aggregation. Each class object on the diagram often shows the class name, its attributes and operations. Details like data types for attributes and arguments for operations can also be shown on the diagram [Sof]. On the diagram below (Figure 4.5) is shown the relationships between the different classes from the system.

Firstly, an user as an set of personal statistics like his experience or actual level. The data received from *Mover* provides statistics regarding physical activity like distance traveled, number of steps given, quantity of calories burned, average speed and total time using the application.

Furthermore, users are related to game elements, each user can have many badges, rewards, facts or challenges. Users have also access to leaderboards formed by system users which are ordered by experience, number of unlocked badges or by level. Apart from rewards, each game element has its own restriction. All restrictions have thresholds that establish the value to be achieved in order to unlock or complete some goal regarding the game element. Also, each restriction is linked to some activity and feature, and may also have one timeframe to restrict the available time to achieve some game element.

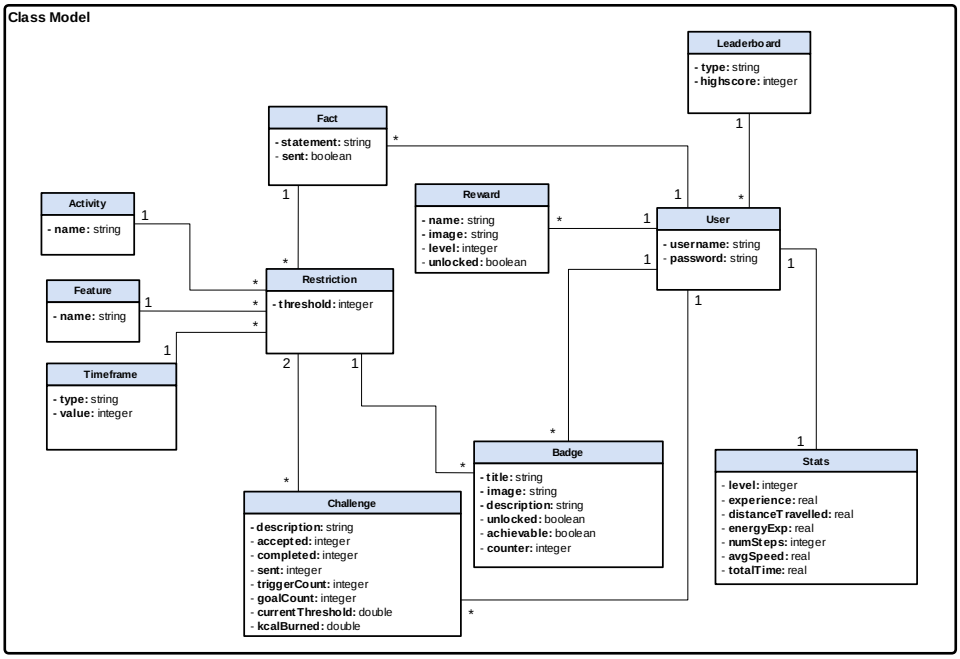

Figure 4.5: Class model diagram

This is an overview of the system relationships, on the next Chapter 5 functions of each class referred in the diagram will be explained in detail.

4.5 Gamification Model

The design of a Gamification model to be applied in order to evolve users and thus change their levels of physical activity, is one of the main features of the project alongside with the user statistics and generation of new challenges by machine learning algorithms.

After the revision of the existing literature and analysis of related works, several design decisions and ideas were taken in order to develop a model to solve the problem that motivated the project.

In order to develop a gamified system capable of effectively engage users, the utilization of a *Gamification* framework was necessary. Kevin Werbach's six-step Gamification design framework [Wer] known as *D6* was chosen for this purpose. According to this process, to gamify something the game designer should answer the following questions:

1. **Define business objectives.** *Why are you gamifying? How do you hope to benefit your business, or achieve some other goal such as motivating people to change their behavior?*

   The need of this gamified system relies on people which in their daily activities perform poor physical activity which can be harmful for their health. What we pretend to benefit

from this application is understanding people's behavior through serious Games and foster their engagement and motivation through Gamification. Furthermore, we aim to improve users health and influence them to adopt better lifestyles. Essentially, we want to study the effect of Gamification techniques on users daily routines.

2. **Delineate target behaviors.** *What do you want your players to do? And what are the metrics that will allow you to measure them?*

   We want users to increase their daily physical activities and adopt better lifestyles through time using Gamification techniques. Using gamified elements like progression through levels, leaderboards, badges, rewards, etc., users will be able to receive indirect feedback from the application which will tell to them their evolution through time. Regarding system's metrics, to do a proper analysis of the system results, we focus on statistics gathered by the application. User personal statistics will be represented in graphics of different types showing the user volume of activity.

3. **Describe your players.** *Who are the people who will be participating in your gamified activity? What is their relationship to you? For example, are they prospective customers, employees at your organization, or some other community? And what are they like?*

   Whom will be captivated by the application experience will be essentially people that are concerned about their health and enjoy doing physical activity. These people are from both sexes, lying on middle or elderly ages and are from upper-middle classes.

   According to Bartle's player types framework [Kya13] users using the application may be: "killers" if they only want to be on the top of the leaderboards; "achievers" who only want to collect rewards, badges, etc; and "socializers" if they only use the application to be on touch with other people and being part of the community.

4. **Devise your activity loops.** *Explore in greater detail how you will motivate your players using engagement and progression loops. First, describe the kinds of feedback your system will offer the players to encourage further action, and explain how this feedback will work to motivate the players. Second, how if at all will players progress in your system? This includes how the system will get new players engaged, and how it will remain interesting for more experienced players.*

   In order to give constant feedback the application will monitor users physical activity during all day notifying them when they accomplish some challenge or objective. Users also will be able to see their progress in graphic representations and see their progress through levels in a progress bar. Also, there will be possible to share unlocked content which will encourage competition among users. Finally, users will unlock entertaining content (rewards) when they achieve some level. Regarding progression loops the application will have various types of achievements relating to a certain period of time (daily, weekly, monthly and custom) in order to make a progressive unlocking or completion of content. In the users stats there will

be a progress bar which will mark the user progress and how much lacks to the next level or reward.

5. **Don't forget the fun.** *Although more abstract than some of the other elements, ensuring that your gamified system is fun remains as important as the other aspects. In order to fully explore this aspect of the design process, consider how your game would function without any extrinsic rewards. Would you say it was fun? Identify which aspects of the game could continue to motivate players to participate even without rewards.*

   - UI design cheerful and intuitive
   - Social competition
   - Progression bar
   - Funny and cultural facts

6. **Deploy the appropriate tools.** *By this point, you've probably identified several of the game elements and other specifics of your gamified system. If you haven't already, you should explain in detail what your system would look like. What are some of the game elements involved and what will the experience be like for the players? What specific choices would you make in deploying your system? For example, you might discuss whether the gamified system is to be experienced primarily on personal computers, mobile devices, or some other platform. You might also describe what feedback, rewards, and other reinforcements the players could receive. Finally, think about whether you've tied your decisions back to the other five steps in the process, especially the business objectives.*

Game Element	Description	MoverGami Usage
Badge	A Badge is a representation of some achievement. They are graphical and text representations that show that the user has reached a certain level or accomplished some objective. Usually they can be found on profile pages where they can be viewed by other players telling to everyone what the user has done or accomplished. Badges are very flexible since they can represent anything in it, whether to be an objective, random events, etc. They increase motivation among users and can have many graphical styles.	MoverGami's badges are unlocked whenever a player achieves some specific value in one of these features: distance traveled; energy expended (calories burned) and number of steps, which can be related with the user's stance (sit, stand, lay down ,etc) and physical activity (walk, run, tilt, etc).

Leaderboard	A Leaderboard represents a ranking, telling exactly the player's position relative to other players in a list. They give feedback about competition, how well some player is doing relative to others and who play the game.	MoverGami has three types of leaderboards ordered by points/experience, number of badges/achievements or by level. Personalized leaderboards (focused on the player position telling who is above and below the player) were implemented in order to not demotivate users. Players will have the possibility of share with their friends whenever they reach a better position on the list.
Points	Points keep users score, which tells how well someone is doing in a game (real-time feedback). Points are connected to levels through progress which can be connected up to rewards. They also provide data to the game designers who can evaluate players evolution and behavior through this. Finally, Points can be used for all sort of things within a game, they can represent anything we need.	MoverGami's points or experience (XP) will be earned through number of calories burned. The more calories burned more points the player will possess.
Level	Levels are user states normally represented numerically which tell the user progression through the game. New levels can be reached earning points and each level has a lower limit and an upper limit which represents an arrival to a new level and proceeding to another, respectively.	As mentioned earlier, users evolve through levels earning points. Whenever a player reach some new level this will unlock a new reward. There will be a progression bar in order to users follow their progress.
Fact	A Fact is some curiosity connected to subjects like culture, sports, history, etc.	MoverGami will measure and analyze user features data (distance traveled, calories burned, number of steps, etc.) and players will receive statements through dialogs "Did you know?" relating the data from the features to facts linked to culture. For instance, "The Great Wall of China's length is equal to your traveled distance".

Content unlocking	Content unlocking means that users need to accomplish something in order to get access to certain new content in the game.	The content to be unlocked on MoverGami will be rewards. These rewards will be cultural, motivational or funny images.
Quest/Challenge	Quests are similar to achievements. The difference is that the player has to do something within a certain range of time with a defined lower and upper time limit.	Challenges will be proposed within a certain range of time and users must achieve something in order to earn points. These achievements defy users to reach some value in some specific feature (distance traveled, number of steps, walking time, etc.).
Social Graph	Social Graph is the possibility of seeing friends who are also in the game. And allowing the player to interact with them, to play with and against them. Making the game an extension of social networking experience.	Whenever a user unlocks a new reward and badge or reach a better position on a leaderboard this fulfillment may be shared on Facebook.

Table 4.1: MoverGami game elements.

4.6 Summary

This Chapter described the requirements of the system developed as well the use cases of the application for each actor: common and admin users. Regarding the non-functional requirements it was verified that the platform must be implemented in order to support huge amounts of data and to ease the addition of new game elements. Towards the functional requirements it was described the main functionalities that must be available on the system.

In Sections 4.3 and 4.4 are explained the system architecture and the class model, respectively. Figure 4.4 shows an overall view of all the platform components which can help to understand how the system works. The class model, essentially, displays all the objects composing the system and the relationships between them.

Finally, Section 4.5 described the Gamification model adopted to implement all the platform game components. A framework developed by Kevin Werbach was used in order to develop an appropriate model to engage users. Note that the design of a Gamification model is an iterative process that takes many changes and testing through time in order to develop an ideal and effective gamified system.

Chapter 5

MoverGami: Implementation

This Chapter contains the description of the solution implemented with its design and technological decisions taken. Firstly, Section 5.1 explains which are the system requirements needed to use the platform. Section 5.2 describes the smartphone application that monitors the user daily activity. On Section 5.3 is given a description about the mobile and web applications from MoverGami, as well, the machine learning algorithm implemented.

5.1 System Requirements

In this Section are described the requirements to run the implemented solution.

The mobile application was developed and tested on devices running Android versions 4.4.2 or newer. Nevertheless the application might run on older versions, however, it is not recommended since it hasn't tested.

The mobile device Wi-Fi should be enabled in order to the mobile application be able to request and send data to the server. Even though the mobile application monitors the number of steps or the distance traveled by the user there is no need to enable GPS since *Mover* uses the accelerometer to track all the user activity.

To acess the web application users just have to access *http://movergami.herokuapp.com/* and *SignUp* or *LogIn* to access all the framework functionalities.

Regarding the language both applications are suitable for English users.

5.2 Mover

In order to develop the MoverGami it was necessary data gathering regarding the quantity of physical activity from the user. For this end, it was used a mobile application developed by Fraunhofer named *Mover*.

Physical activity includes a broad range of bodily movements performed in various contexts, for example recreational activities, active transportation or ambulation. Therefore, it is difficult for most people to keep track on their physical activity and reach the desirable levels. The main approaches used for activity monitoring are based on user-external sensors or wearable sensors. More recently, the sensors embedded in the smartphones have been used for developing activity monitoring applications. Using smartphones avoids the need to acquire other wearable sensors and since users are perceiving them as personal and less obtrusive items, smartphones are becoming the ideal ubiquitous monitoring devices.

Regarding concerns about efficient use of the device battery charge, *Mover* only uses the accelerometer of the smartphone to gather motion signals while performing different daily activities. Signal processing techniques were implemented to extract features from the signals that were then fed to a classification algorithm. The energy expended in each of the classified activities was computed. For ambulation activities energy expenditure calculus considers an estimation of the velocity during the activity period [ASR+14].

The application identifies the following user activities: sit, stand, walk, run and tilt (stir the device), and estimates the distance traveled, number of steps and energy expended for each activity. The application collects data in segments of 5 seconds duration (time windows), which are the atomic time interval used for the activity classification task. Then, all the information is classified in daily, weekly or monthly timeframes.

Basically, this platform using the phone's accelerometer tracks all the user activity and sums it throughout the day. All the information gathered by *Mover* is stored in memory, i.e., data stored since the user starts the application until its closing, or on the device local database. On the local database information is stored hourly and data is held by time period: daily, weekly or monthly. *Mover's* data is sent in two possible formats: ADLs(activities of daily living) or JSON. The first one are objects that store the data gathered by *Mover*, with its own methods and data fields. The second one correspond to all ADL's data converted in the famous JSON format, an example of the information sent in this format can be seen in the Appendix A. Knowing the user levels of physical activity, through a library that uses *Mover* methods, it was possible to develop a gamified approach which is described in the next Section.

5.3 MoverGami

In this Section is described the implemented functionalities for MoverGami's web and mobile application. Each application feature will be presented and explained, moreover, the most important functionalities will be clarified in detail.

5.3.1 Mobile Application

Throughout the data obtained from *Mover* the mobile "side" from MoverGami was developed. This application tries to solve the problem that motivated this project, improving users daily activities using *Gamification* mechanics.

This mobile "side" is aimed for common users with a simple and intuitive GUI. With the intention to adapt the application for elderly people the application is composed by large buttons and icons to facilitate the touching, the statements or instructions are short and with big letters in order to facilitate its reading.

This interface is basically the gamified component of the platform, where users can access their informations, view statistics, interact with other users, obtain new challenges and collect badges, for instance. All the application functionalities are described in the next subsections.

5.3.1.1 Start Menu

When the user starts the application if the application doesn't have access to the Internet a dialog appears in order to user enable it in the settings menu. The user will only be able to enter the application with access to the Internet for the purpose of keeping the application game data updated. Figure 5.1 shows an example of this situation.

With Internet access granted, when the application starts, another dialog appears showing that the application is retrieving information from the server. An *AsyncTask* runs on background requesting to the server all the badges, challenges, facts and rewards, besides their respective restrictions, activities, timeframes or features. All the data about these components is stored on the device local database, if an instance of a specific component already exists on the database the application only updates it, otherwise, a new entry is created. This behavior can be seen in Figure 5.2.

After the application requested successfully information from the server, users only have the option to enter or exit the application through the start menu buttons.

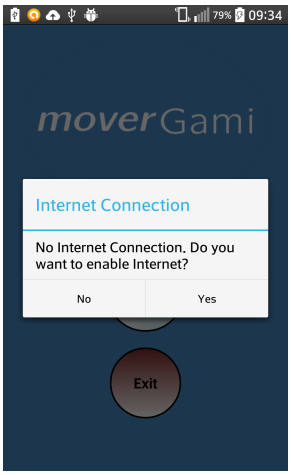

Figure 5.1: Wifi warning

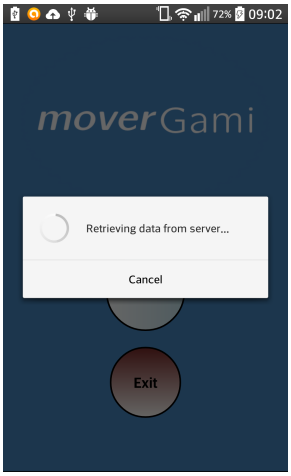

Figure 5.2: Start Menu screen

5.3.1.2 Main Menu

After the start menu, users face the application main menu. Here, users have access to their personal statistics and to consult the state of all gamified elements. Should be noted that this appli-

cation's purpose is to users consult the state about all game elements, the real "game" experience runs on the background according to the level of physical activity, and only when users achieve or complete something they are reported.

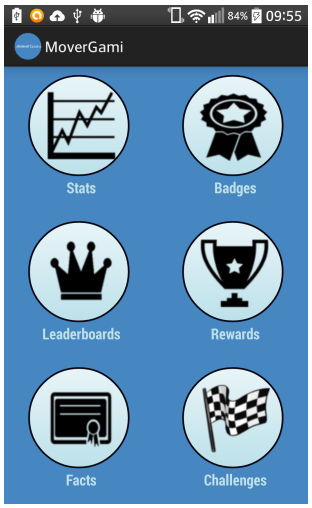

Figure 5.3: MoverGami's Main Menu

5.3.1.3 Stats

Choosing the Stats option on the main menu, users obtain access to their personal stats. In this screen (Figure 5.4), every 5 seconds is updated the information coming from *Mover* about user activity. Through the data obtained from *Mover*, organized on ADLs (data kept in the device memory), MoverGami accumulates the information values regarding distance traveled, number of steps given, calories burned and total time and stores it on the local database. So, in this screen the information displayed corresponds to the all time user activity, i.e., information stored since the user started to use the application.

Therefore, users can consult their walking or running velocity at the moment, either their current activity and stance, and also their current level and progress in experience points. Users earn *XP* (experience points) by burning calories ($\cong 1kcal$ to gain 1 *XP*), when they reach the upper limit of a level the user is notified through a dialog leveling up and unlocking a new reward. The formula to define the upper limit of each level was:

$$XP\_to\_next\_level = level * 100 + level^4$$

Through this formula users will be able to level up easily in the first levels which motivates the player. However, as they reach high levels leveling up it will be a major challenge, leading players to increase their physical activity to reach new levels more quickly.

5.3.1.4 Badges

Badges are Gamification game elements that can can be earned through the completion of achievements. An achievement is the representation of having accomplished something and can have

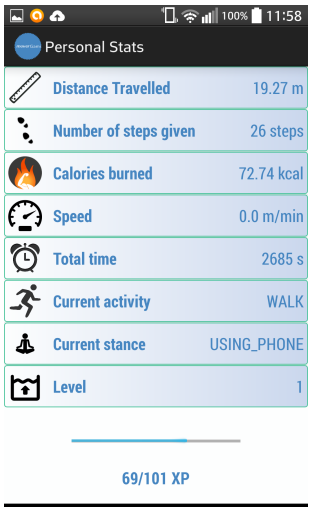

Figure 5.4: MoverGami's user personal stats

many difficulties or purposes. These elements can be compared to medals which arouse a need on the users to collecting them. Badges are often considered *locked* until the player or user completes a task or set of tasks that are required to unlock the badge.

One of MoverGami's mobile application features is the possibility of unlocking sets of these game elements through the player's physical activity. Using the proper main menu button, users are able to access the screen that is shown in Figure 5.5. On this screen is displayed the list of unlocked badges and those who still remain locked. MoverGami's badges are grouped in four different timeframes: *daily*, *weekly* or *monthly*, badges to complete within one day, one week or one month, respectively, and there also *custom* badges, which should be complete within a specific period defined by the administrator. Administrators will be able to insert these game elements in the platform through the web application, but this will be explained in detail on sub-section 5.3.2.

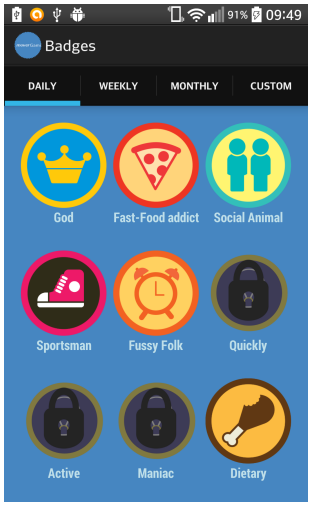

Figure 5.5: List of MoverGami's Daily Badges

In Figure 5.6 is displayed the appearance of a badge still locked. On the bottom of the locked

badge image is the description of what the user or player should accomplish to unlock that badge. In this example, the user should travel 2 meters, walking, during one day to be able to complete this achievement. So, looking to this example, the application will track the daily user activity and if that user accomplishes a value above the specified distance traveled doing the activity "walking" it will unlock the badge. After complete the achievement, users are able to see the same badge unlocked with its image and pos-description, like it is shown in Figure 5.7.

Figure 5.6: Example of a locked Badge

Figure 5.7: Example of a Badge decription

When an user completes some achievement a dialog is displayed to inform the user that he unlocked a badge (see Figure 5.8). In this dialog users have the possibility to share on Facebook what they have achieved.

Figure 5.8: Dialog displayed when a player unlocks a Badge

After hitting the proper button a Facebook interface appears to request the user *login* on the social network, also the user must fill the publishing form which will appear in a publication on the user Facebook's timeline as shown in Figure 5.9.

Facebook users by clicking on the shared-badge publication will be redirected to MoverGami's Web application when they will be able to see information about the achievement or even become new users of the platform.

Figure 5.9: Facebook publication after sharing a badge

5.3.1.5 Leaderboards

The existence of a system of "points" can lead users to participate in activities or make specific tasks. By creating lists of users ordered by the number of points/score, users will be motivated to perform specific activities that will give them points in order to achieve top places or become the leader of the list, earning recognition by the rest of the community.

MoverGami's Leaderboards alongside with the possibility of sharing badges on Facebook, will be responsible for creating a social experience in the platform. For the simple reason that when users consult the list or *ranking* they will see other users' scores leading to competition between them, demanding the need to earn points through the realization of physical activity. There are three types of rankings on MoverGami's Mobile application: sorted by experience, current level and number of badges unlocked.

Figure 5.10: MoverGami's Leaderboard sorted by user experience

According to Prof. Kevin Werbach [WH12] Leaderboards can lead players to demotivate. If, for example, some user has 100XP and another one have 100.000.000XP this will cause demotivation on the subject with less points which might lead the player to not use the application. To avoid this *personalized* Leaderboards tell exactly where the player stands relative to others who play the game. They provide direct feedback regarding competition between users. Consequently, MoverGami features personalized Leaderboards which focus on the position where the user stands, enabling to see who is immediately above or below.

The integration of MoverGami's users with their Facebook friends in order to build social network leaderboards is another feature that would be interesting to be implemented, Section 7.2 describes this in more detail.

5.3.1.6 Challenges

By using continuously MoverGami's Mobile application users will be challenged to make changes in their behavior in order to earn points or experience. With this intention, the platform supports a system of challenges which defies players to complete them by performing physical activity.

Each challenge has one "trigger", if a player during a specific timeframe does not fulfill a previous defined restriction the challenge is enabled. As soon as the challenge is launched users can accept or decline it, see Figure 5.11. If the user declines the challenge, this one is ignored and another will be launched eventually, otherwise, if he accepts it that one becomes the current challenge and by fulfilling it the user earns *10XP*.

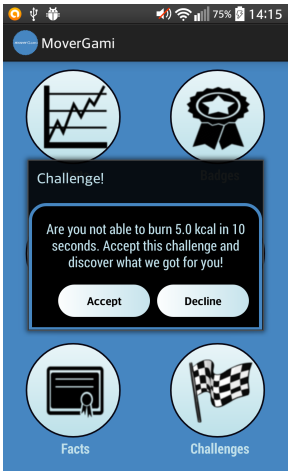

Figure 5.11: MoverGami challenging a player

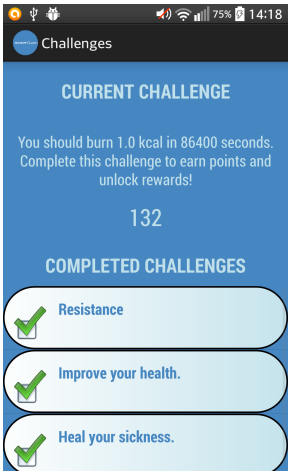

Figure 5.12: Current and completed Challenges

On the challenges screen (Figure 5.12), is described what the player must do to complete the current challenge, as well the remaining time to complete it. Whenever the Challenge's time counter reaches 0, it starts over again, until the user completes it. Also, below the counter users can check their completed challenges.

Challenges are also generated automatically through the use of a reinforcement learning algorithm, this is explained in Section 5.4.

5.3.1.7 Facts

Facts are another game element that players will be able to unlock or collect on MoverGami's Mobile application. These elements appear from the player perspective as *Did you know?* dialogs and, usually, offer some cultural fact or curiosity in form of text.

These elements are "secret", the user doesn't know which Facts exist on the system, as users perform physical activities they unlock them. Users unawareness regarding when they will unlock a new fact, captivates players to continue using the application. The feeling of wanting to discover or complete for curiosity all the facts, it's what keeps users engaged with the task of complete these elements.

MoverGami's Facts are unlocked by comparing the quantity of user's physical activity to some value from something that the fact-creator wants to compare. For example, if the user traveled a 42km distance, the fact could be " *You have traveled a distance equal to a marathon length*".

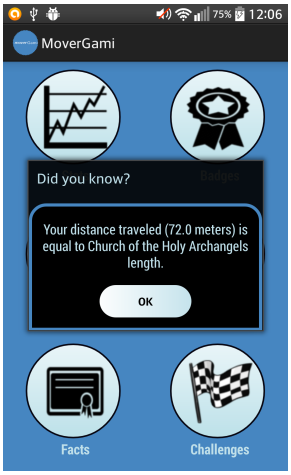

Figure 5.13: Player unlocking a new Fact

Figure 5.14: List of completed Facts

Figures 5.13 and 5.14 help to understand better how these elements appear in MoverGami's Mobile application.

5.3.1.8 Rewards

As MoverGami's players earn experience and level up by burning calories or completing challenges they unlock new rewards per each new level reached. Rewards are prizes which in the case of MoverGami are a collection of images that users can unlock. The aim is that these images with its content be able to captivate users' curiosity. However, users administrators of the Web application can choose whatever they like to put how the reward's image.

Figure 5.15 shows the grid of rewards per level, in this example, as can be seen the player only reached level 5 the remain rewards still locked. Users can also see the description of a specific reward like in Figure 5.16.

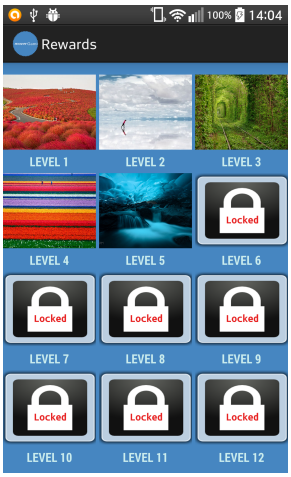

Figure 5.15: List of Rewards per level

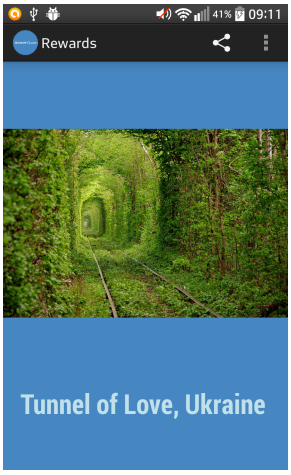

Figure 5.16: Example of a Reward description

5.3.2 Web Framework

Apart from MoverGami's Mobile platform a Web application was implemented which functions like a framework for administrators allowing the insertion of new data on the system. This MoverGami's "side" GUI is very simple in view of this application's aim is only provide CRUD operations on the system data and see its impact on the Mobile application users.

In order to make this application, Ruby on Rails, an open source Web application framework, was used to develop a server for storing data and a WebClient to admins access and perform operations through the browser. Also, a remote server was needed in order to store data for being retrieved by the mobile application, as a consequence, the application had to be deployed to a *Heroku* domain. Thence, the Web application can be accessed on:

http://movergami.herokuapp.com/

The behavior of MoverGami's game elements was already explained in Section 5.3.1. In the next sub-sections is explained how the management, mostly their creation, of MoverGami's game elements instances is performed within *MoverGamiWeb*.

5.3.2.1 Badges

A detailed description about MoverGami's Badges can be consulted in 5.3.1.4. In order to create instances of these elements the administrator user must provide a name, an image or icon and a description (badges main components). Also, the admin must specify the restriction that the user should met to earn the Badge. Within the restriction, a timeframe (daily, weekly, monthly or custom) is required, as well as the name of the activity which shall be performed (walking, tilting, running, etc.). Therefore, a feature (distance traveled, number of steps or energy expended) must be specified too, along with a threshold, which will be the value to be achieved in order to unlock the badge.

Badges, unlike Facts that consider all-time data, take in account previous data stored by *Mover* on the device's local database divided by timeframes. If a Badge is created with a restriction

already fulfilled by the user within the respective timeframe, the user automatically unlocks the Badge when the mobile application receives it from the server.

In Appendix B some MoverGamiWeb's screens regarding Badges management are displayed.

5.3.2.2 Challenges

MoverGami's Challenges were explained in 5.3.1.6 and are the structures responsible for defying common users. To create these elements admin users must specify a description of the challenge and define two restrictions, each restriction has its own threshold and timeframe and the same feature and activity. The first restriction, works like a "trigger" to enable the challenge, if the user, within the specified timeframe, does not satisfies the threshold the challenge is triggered. Then, a dialog appears on the Mobile application stating which goal the user shall accomplish (second restriction) and player have two options: accept or reject the challenge. Like MoverGami's Badges, Challenges also consider data stored on the local database, besides the data from the device memory.

In Appendix B some MoverGamiWeb's screens regarding Challenges CRUD are displayed.

5.3.2.3 Facts

An explanation of what are these game elements was given in 5.3.1.7. Towards the creation of these elements the admin user must specify a name of an object, a street or a monument, for example, and a feature with a threshold. The feature along the threshold is the restriction that the common user shall accomplish to discover a new Fact.

When comparing the user activity to the restriction, Facts only consider data from all-time user activities (timeframes are not considered). They analyze user's total distance traveled, steps or energy expended and compare the values to the thresholds.

See Appendix B for some MoverGamiWeb's screens regarding Facts management.

5.3.2.4 Rewards

Rewards were already described in 5.3.1.8 and are another game element that can be created in MoverGamiWeb. For the purpose of creating a new Reward the admin user only has to provide a name, an image and an integer corresponding to the level. Once the Mobile application user reaches the level specified it will unlock the Reward.

In Appendix B are also displayed some MoverGamiWeb's screens regarding Rewards management.

5.3.3 User Statistics

On MoverGami's mobile application users can view their all-time personal stats but this might not be enough assuming that they pretend to obtain feedback regarding their progress through time

on daily activities. For this reason, on MoverGamiWeb users or administrators are able to consult players' statistics represented graphically and organized by daily, weekly or monthly time periods.

In order to MoverGamiWeb build graphs or charts with users statistics, physical activity data is sent by the mobile "side" coming from *Mover*. MoverGami's mobile application receives information in JSON format from *Mover*, rearranges the JSON message by adding other relevant information and dividing into daily, weekly, monthly or all-time activities. Finally, MoverGami's sends the JSON message hourly, as long as the application is running, to the *Heroku* server which stores the information on the remote database that will be used to build graphics.

Of course that the Web framework only receives data when the mobile application is running, and if the user doesn't carry the phone with him, it will be not possible to track all the user daily activity.

In Figure 5.17 is displayed an example of a graph belonging to MoverGamiWeb with some user personal statistics. This graph shows the quantity of energy expended per activity during a day. On the left side, on the *y-axis*, is the quantity of energy expended in *kcal*, alternatively, on the*x-axis*, is displayed the hour of the day, from 0 (midnight) until 23 hours. On the right side of the graph are listed activities that the user can perform during the day with a respective color. Also, if the user wants to know the exact value of kcal burned in some specific hour, he just has to pass the mouse over the respective line from the graph.

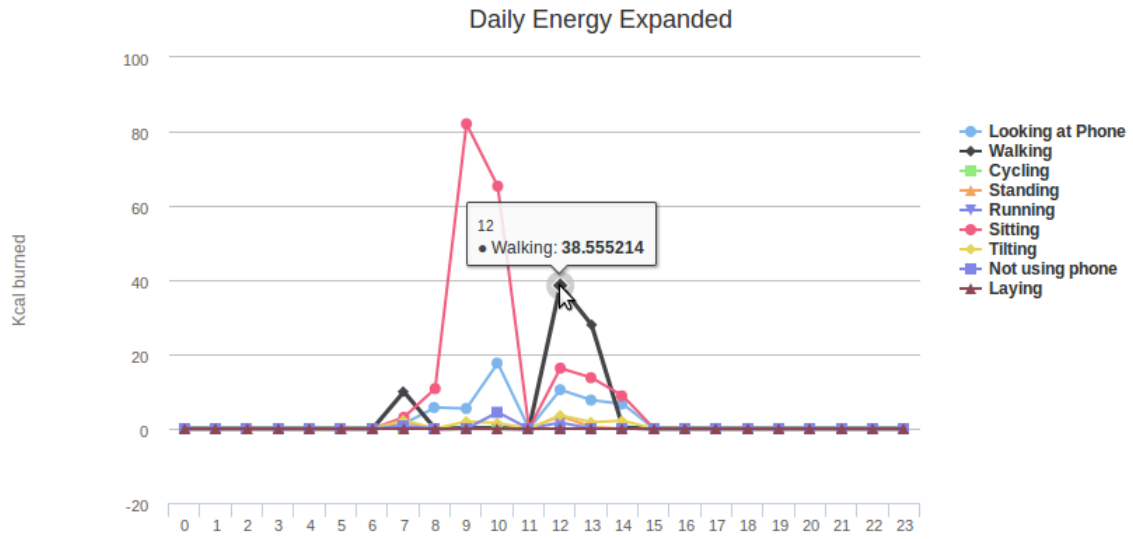

Figure 5.17: Daily energy expended in *kcal* by an user

Figure 5.18 is another example of MoverGamiWeb's graphs, but this one relates to weekly activity. On the left side are refereed the number of steps given, on the opposite side is listed the physical activities and below is each day of the week.

The next MoverGamiWeb's graph example (Figure 5.19) displays user quantity of physical activity regarding distance traveled in a month, so far. On the *y-axis* is refereed the quantity of

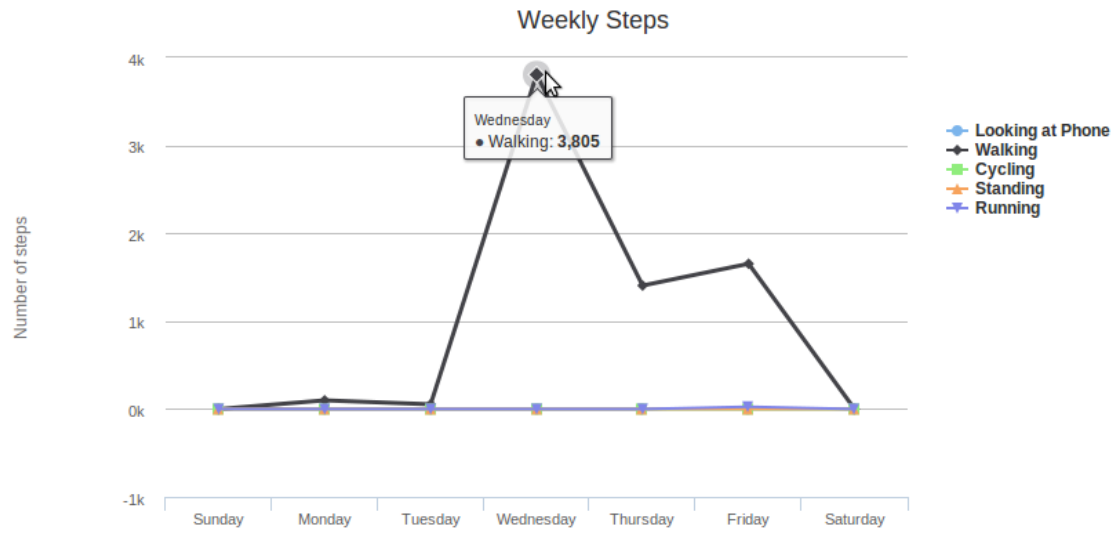

Figure 5.18: Weekly number of steps by an user

meters traveled and in the *x-axis* the respective day of the week. By passing the mouse over a graph line, users or admins can view the exact number of meters traveled by the user.

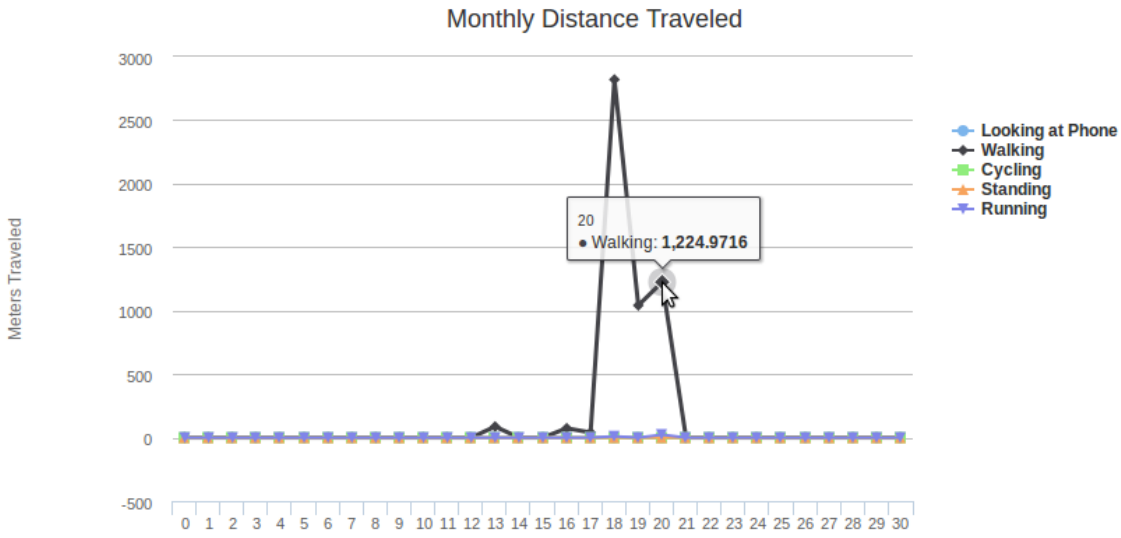

Figure 5.19: Monthly distance traveled in meters by an user

Furthermore activity graphs, MoverGamiWeb also generates pie charts that display the daily total time of some a user performing each physical activity. With this type of representation users or admins have a better insight about the activities that the user spends more time. An example of these representations can be seen in Figure 5.20.

Finally, Figure 5.21 shows the third type of graphical representations of MoverGamiWeb's statistics: the stacked column chart. This example displays the quantity of energy expended in percentage (%) for each day of the week. On the *x-axis* each number represents a day of the week,

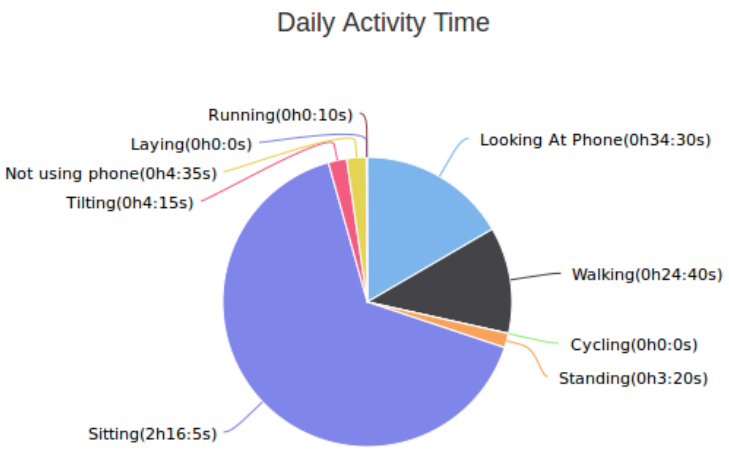

Figure 5.20: Quantity of daily time performing each physical activity

for example, 0 is *Sunday*, 1 is *Monday*, and so on. By passing the mouse over each column, users or admins can view the exact number of *kcal* expended, also, there may be days with no activity performed.

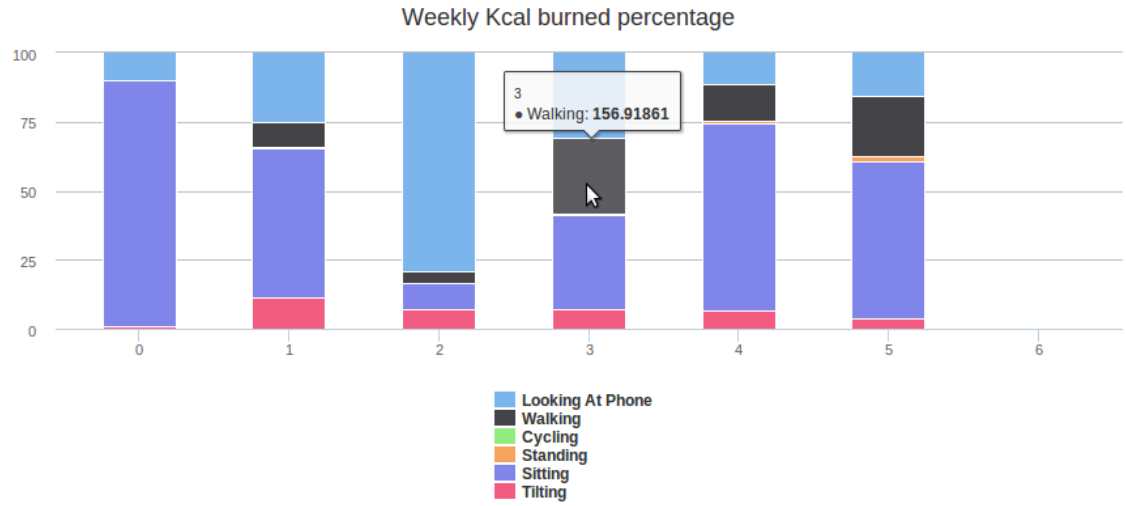

Figure 5.21: Quantity of energy expended in *kcal* during the week

5.4 Machine Learning Implementation: Q-Learning

In order to adapt MoverGami to different levels of users physical activity and to encourage inactive subjects to perform more physical activity a reinforcement learning algorithm was implemented. The main goal of this implementation is the automatic creation of new Challenges according to the quantity of activity conducted by the application user. For instance, if a user during a day has practiced few physical activity, MoverGami using a machine learning algorithm will generate a new challenge to increase the level of activity.

For this purpose, a reinforcement learning algorithm had to be chosen to solve this problem. Among the existing, the Q-Learning algorithm was which seemed more appropriate to this situation.

First of all, the implementation of this algorithm in MoverGami's mobile application was an iterative process due to the progressive data collection and the variation in users' behavior. The continuous use of the application through time led to adjustments on restrictions values, this was crucial in order to obtain a better and accurate algorithm.

From now on is explained how this algorithm was adapted to MoverGami's context.

5.4.1 Initial variables, States, Actions and Rewards

Firstly, it's necessary the definition of the gamma (γ) and the alpha (α) parameters, that have a range of 0 to 1. If the gamma parameter has a value closer to zero, the agent will tend to consider only immediate rewards. Otherwise, if is closer to one, the agent will consider future rewards with greater weight, willing to delay the reward. Regarding the alpha parameter, also known as the learning rate of the algorithm, it determines to what extent the newly acquired information will override the old information. A factor of 0 will make the agent not learn anything, while a factor of 1 would make the agent consider only the most recent information. In MoverGami's case, a fixed of 0.1 was used to define α and 0.9 to the (γ) parameter.

Next, for the implementation of a Q-Learning algorithm, is also necessary the definition of a set of states and actions which reflects the agent behavior within the environment of the problem.

MoverGami's users are the agents in this context, therefore, their level or type of activity performed are the algorithm's states and actions are the change of current physical activity. With this definition of states and actions, transitions between states are translated into changes of user activity. For this reason, MoverGami's Q-Learning algorithm states were defined as a tuple consisting in two variables, one the level of activity and the second the current activity of the user. How this classification was made, is explained in the next Sub-section 5.4.2 and for better understanding about the transitions between states see Appendix C.

Finally, Q-learning's Rewards, the value presented in each state transition which affects the decision making by the algorithm, were also previously defined. A matrix with constant values for each transition was built in order to be used by the algorithm to retrieve reward's values. Briefly speaking, when a user transits from a lower to a higher state the reward is bigger, in contrast, when the user does the opposite the algorithm "receives" a minor value.

5.4.2 Level of Activity Analysis

Towards the algorithm running, an initial state is needed so the agent has a starting point to begin the exploration phase. During this phase, the agent will explore the "environment" starting at an initial state, and going from state to state until it reaches a goal or final state.

It was decided that the initial state should be the level of physical activity along with the current activity performed by the user. For this purpose, the level of activity was classified in:

Activity Level	Energy Expended (kcal)
Very Low	< 100
Low	>= 100 and < 250
Medium	>= 250 and < 400
High	>= 400 and < 600
Very High	>= 600

Table 5.1: Classification of level of activity

In order to assign these classifications to user activity, it was taken in consideration data regarding the 2 previous hours of activity performed by the user. In other words, the number of calories burned in each activity by the user were summed during those 2 hours.

Since a user while sitting burns on average *1.56 kcal* per minute, during those 2 hours he will burn about *187 kcal* (even when we are inactive our body burns calories naturally). The values on Table 5.1 were those who seemed best suited to classify the user activity. Note that, although users burn more than *100 kcal* being inactive, the classification "Very Low" fits on situations where the application was not running or the user was not with the smartphone within on those 2 hours.

This classification of the user activity is done every 5 seconds, MoverGami checks if the level was changed along with his current activity (walking, tilting or inactive), and calls another episode (see next sub-section) from Q-learning algorithm.

5.4.3 Q-Learning Episodes

A Q-learning episode is the process of learning the environment which the algorithm goes from an initial to a final state. Each time the agent arrives at the goal state, the program goes to the next episode. The agent starts out knowing nothing about the environment, the matrix Q, which store the highest reward values, is initialized to zero.

In each episode the agent explores the environment and receives rewards, positive or negative, until it reaches the final state. The purpose of each episode is to enhance the "brain" of the agent, represented by the matrix Q. More episodes results in a more optimized matrix Q. In this case, each algorithm call executes 1000 episodes, if the matrix Q has been enhanced, instead of exploring around, and going back and forth to the same activity states, the agent will find the best route to the goal state (best policy) [McC]. Below, is explained through pseudo-code how the algorithm works.

MoverGami's mobile application only receives data updates from *Mover* about user activity every 5 seconds. So the changes of activity states are only detected within this period, thus the algorithm is called every 5 seconds retrieving the best policy to be followed depending on the current state.

Regarding the automatic creation of new challenges, every 2 hours MoverGami analyzes if the level of activity of the user has not changed. If this happens the application generates automatically a new challenge using the current state and the level of activity to set the values of the parameters using another 2 hours as the time period to complete the challenge. This process operations can be

Algorithm 1 MoverGami Q-Learning algorithm

```
1: procedure EPISODE WHILE LOOP
2:     initialState ← level of activity along with current activity
3:     finalState ← depending on initial state
4:     while(initialState! = finalState)
5:     selectedAction ← Select one among all possible actions for the current state
6:     nextState ← Using selected action, consider to go to the next state
7:     Qmax ← Get maximum Q value of this next state based on all possible actions
8:     state ← nextState
9:     close;
```

better understood in the next Chapter 6, through the view of graphs representing users' physical activity.

5.5 Summary

Firstly, Section 5.1 described all the system requirements needed to run the mobile application with success and how the web application can be accessed. In the next Section, is explained how the mobile application *Mover*, previously developed at Fraunhofer, works and its usefulness for the platform developed.

Then, in the following sections, the platform developed is described. First is explained all the mobile application features: menus, what the user can do using this platform side, which are and how the game elements were implemented, etc. Next, the web framework is described, telling how administrators can manage system data and how they can view and analyze user statistics within this application.

Finally, Section 5.4 explained how the *Q-Learning* algorithm was adapted and implemented in the application, as well, the steps that it follows in order to create challenges automatically.

Chapter 6

Evaluation and Results

Testing the efficiency and impact of Gamification techniques on a system is a laborious and time-consuming task, and an appropriate monitoring and observation of the system users is essential to know how to develop the most suitable Gamification model. Unfortunately, due to the time required for this task, it was not possible to perform tests observing real application users, since this could last months until an effective Gamification model was found. Normally, only for the application to start causing curiosity among users it can take several weeks. Instead, it was studied and designed how the tests with real applications users could be made, in order to be carried out on future work. Next, in Section 6.2 is described the verification of the Gamification model adopted. Also, some MoverGami's results regarding the levels of user activity in order to provide feedback are presented in Section 6.3.

6.1 Test Procedures

In order to evaluate and obtain results about the application developed and to find the most suitable Gamification model to the problem, the development of different *MoverGami* versions would be necessary. A certain number of sedentary or weakly active subjects would be selected in order to be more easy to notice the application influence. This would be an iterative process with the following steps (having surveys to obtain user feedback in each phase):

1. **User Daily Activity data**

   In this *MoverGami* version, the application only would gather the user activity data coming from *Mover* and present it on the mobile and web applications. Neither Badges or the leveling system, for instance, would be present in the application, the user would merely had access to the *Stats* screen from the current *MoverGami* version. Normally, this would be the least engaging system for users, since they only can view their level of activity.

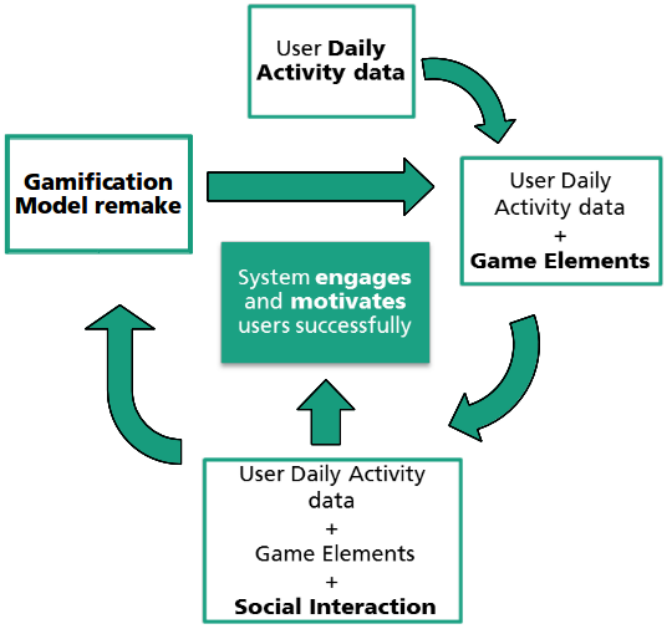

Figure 6.1: Test procedures diagram

2. **User Daily Activity data + Game elements**

   This platform would be composed by the previous version along with the implementation of some game elements. Badges, Challenges, Facts and Rewards (with the level system) would be the elements chosen for this *MoverGami* version. In this phase, users would begin to show some interest in using the application by unlocking some Badges or completing a few Challenges, but only for curiosity, not expecting the user engagement already.

3. **User Daily Activity data + Game elements + Social interaction**

   This *MoverGami's* version would have the previous versions along with a social component. In order to integrate a social component and to create a community within the system, Leaderboards composed by users Facebook friends and the possibility of sharing, also on Facebook, some events like unlocking Badges would be features selected for the purpose. Later, the possibility of unlocking content or complete challenges as a team, it would be another interesting implementation. Due to social interaction which fosters competition among players, would be expected that in this step users begin to become engaged with the application. Also, in this phase would be where the surveys and statistics about application usage for each phase would be analyzed and evaluated in order to discover if the system engages and motivates users successfully. If this happened the process ends, if not the process continues to the next phase.

4. **Gamification Model remake**

   If the application still not engages user efficiently a remake of the Gamification model shall be done. Using surveys and feedback collected, Game elements that aroused less interest

in users would be removed and added new ones, thus forming a new *Movergami's* version. This step would be repeated until the system reached an application capable of changing user behavior regarding daily activities.

6.2 Gamification Model Verification

The development of an efficient Gamification platform is not a simple task as it seems. Confining only to the use of Points, Badges or Leaderboards applied to a system is not enough to develop an successful gamified platform. In order to develop and verify a Gamification model for this platform, as already explained in Section 6.2, Kevin Werbach's six-step Gamification design framework[Wer] was used. According to this process, *MoverGami* fulfills:

1. **Business objectives well defined:** *MoverGami's* main purpose is motivate and engage users with the application in order to increase their level of physical activity and consequently improve their health.

2. **User behavior expected:** it is expected that users or players become engaged by the application enjoying and participating in the "game" that *MoverGami* offers, in other words, use it to see their stats, complete challenges or achievements, unlock rewards, etc.

3. **Target users:** although the application is suitable for the population in general, it was developed mostly focused on people with physical activity difficulties like obese children or elderly people.

4. **Providing motivation:** the application provides indirect and direct feedback, respectively, using game elements and displaying user statistics. This helps users to be constantly aware of their level of physical activity which motivates them to keep a stable level.

5. **Providing "Fun":** although *MoverGami* is supposed to be a game involving the user physical activity it does not mean that the user will be having fun performing more physical activity. However, with the social component users will be interacting with other players and competing among them which is one way of providing fun efficiently.

6. **Game elements chosen:** all the game elements chosen to feature on *MoverGami* have different functions to induce feelings on users. For example, Facts causing curiosity, Challenges defying users to perform some task, Badges stimulating the desire of collect things or even Leaderboards encouraging competition among users.

Although the application was not tested with a specific population, it is expected that with this verified Gamification model the application is able to change users' behavior successfully.

6.3 User Physical Activity Feedback

In this Section it is displayed some graphical statistics providing feedback from some users' physical activity. Furthermore, this data is compared to the automatic creation of new Challenges by the *Q-Learning* algorithm implemented. As already explained in previous sections when a user stays more than 2 hours in the same level of activity, the application creates a new Challenge according to user level of activity. However, if the user is with a "High" or "Very High" activity level the application will conclude that there is no need of generating a new Challenge. When the user reaches lower levels a challenge is triggered with the intention that the user feels challenged and accepts thus the new challenge in order to increase the level of activity. Next, examples of some statistics about users activity in different time periods are shown.

- **Daily Impact**

  Figure 6.2 shows a graph of an example of the daily activity of a user throughout the hours of the day. The graph displays the number of calories burned for each activity. Observing the graph, we can see that the user spent most of the morning sitting (red line), MoverGami found this and generated a new challenge which led the user to start walking at hour 12.00 until hour 13. During the rest of the day, no more data were recovered from MoverGami, maybe because the user does not carry the smartphone or stopped the application.

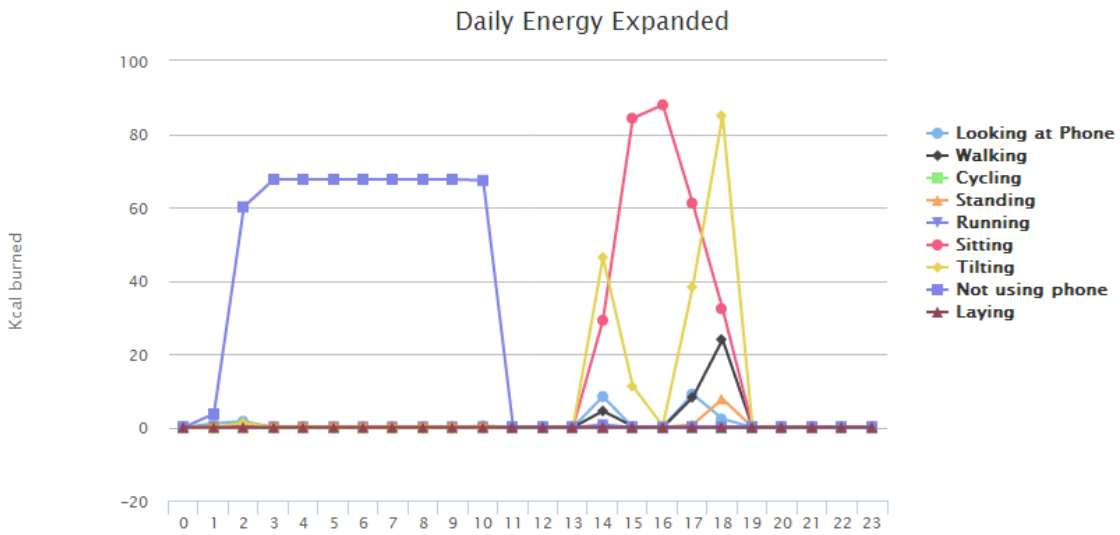

Figure 6.2: Daily energy expended in *kcal* by a user

Figure 6.3 is a different example of a user daily activity, in this case the first difference is shown during the sleeping time period, unlike the previous example the user turned off the application while sleeping from hour 2 until hour 8. Then, during the day, we can see that he was more active than the other example, he stayed less time sitting, and walking was the activity that he expended more calories.

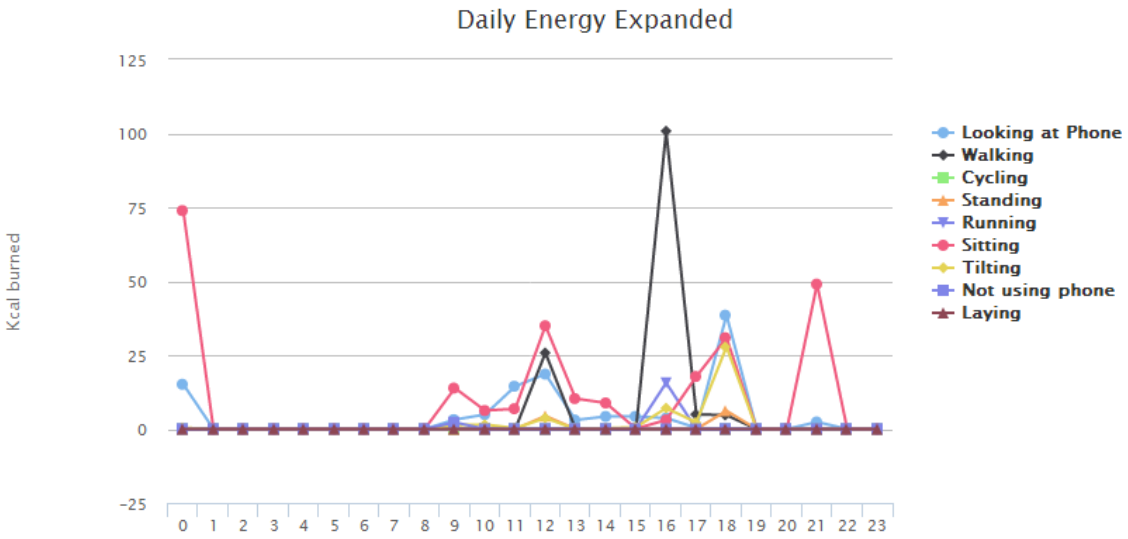

Figure 6.3: Daily energy expended in *kcal* by a user

- **Weekly Progress**

  In Figure 6.4 example, it can be seen that the user started the first days of the week with a very low level of activity. But on Wednesday, maybe due to the high level of challenges received the user changed his inactivity by starting walking some distance during the day. Then, in the last days of the week, the level of activity was declining again.

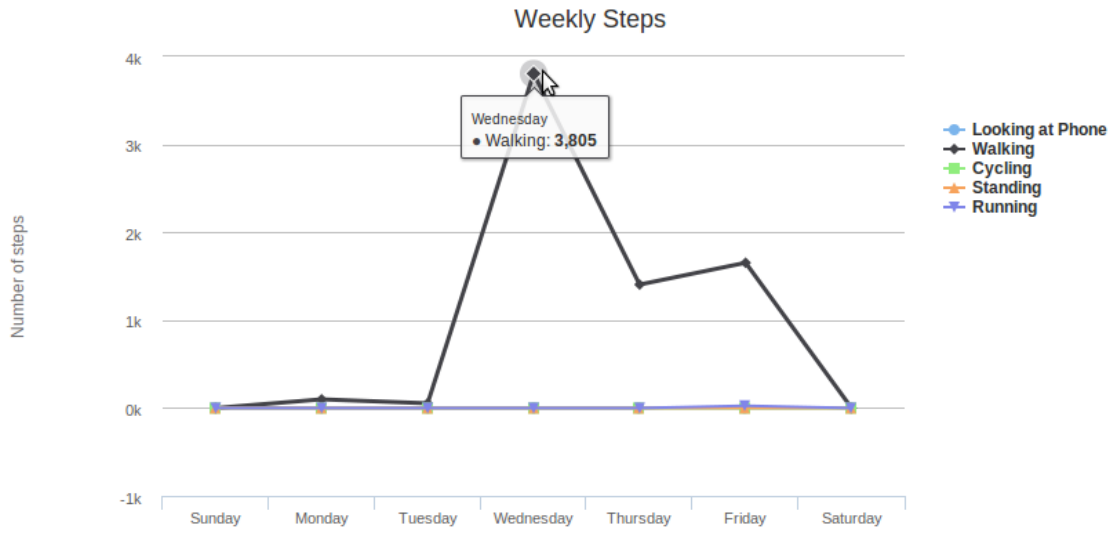

Figure 6.4: Weekly number of steps by a user

In the case of Figure 6.5, which shows the quantity of distance traveled per day of the week, it can be seen that the user increased gradually his level of activity during the week, taking only the weekend to rest.

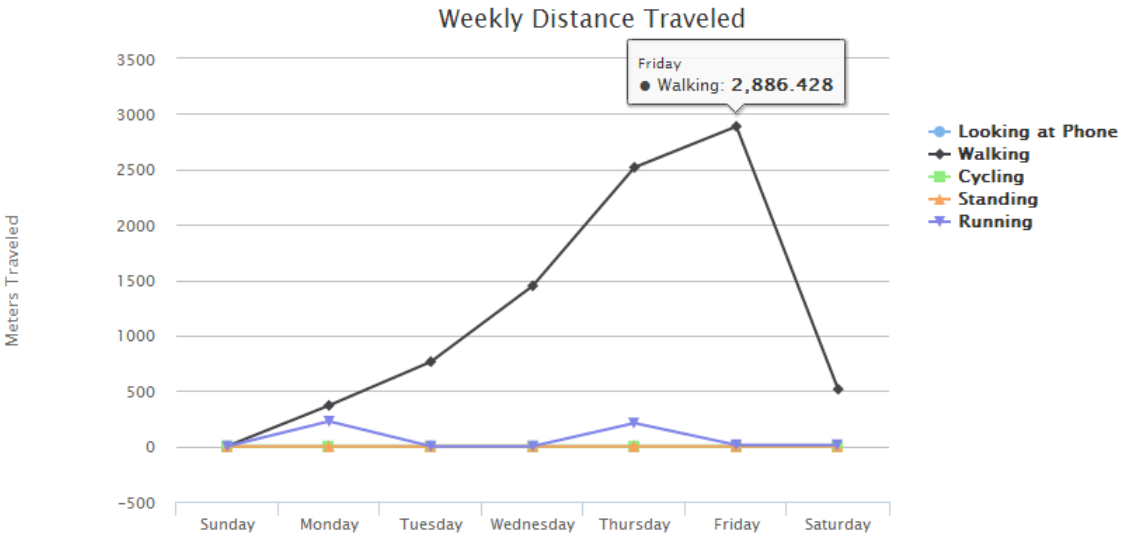

Figure 6.5: Weekly distance traveled by a user

Even so, Figure 6.6 which shows the same week but regarding the quantity of energy expended, allows to conclude that even walking more the user burned more calories doing other activities.

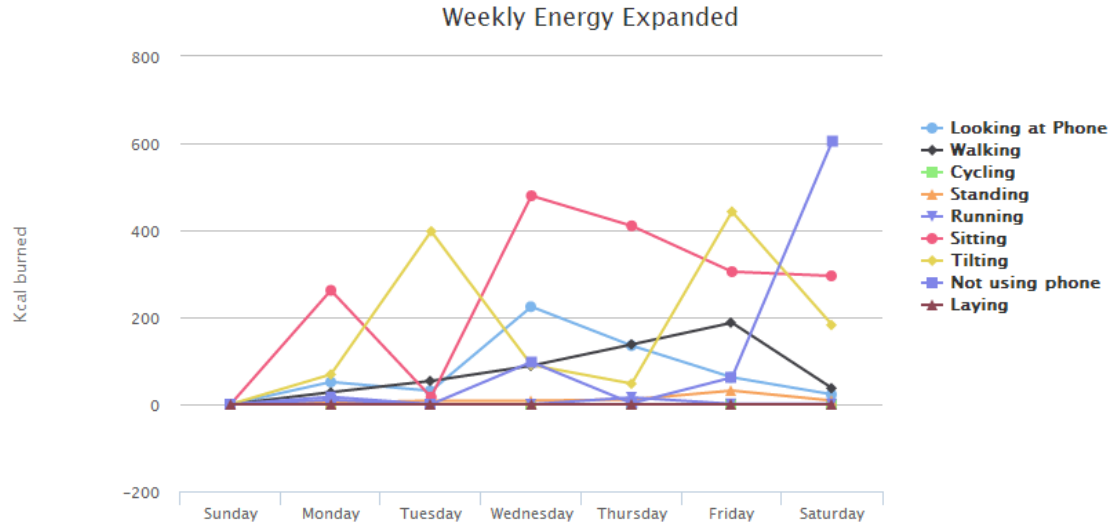

Figure 6.6: Weekly energy expended by a user

In order to *MoverGami* be able to retrieve more accurate feedback from users level of activity is essential that the application be running as long as possible during each day.

6.4 Summary

Although it was not possible to validate the usefulness of the application with a selected population, it was verified that the application meets all the requirements pretended for the system. A Gamification model was carefully designed and adopted in order to be the most suitable for this context. Also, all the data collected by either the web and the mobile application is very promising since provides feedback from all user activity allowing to know and evaluate each subject lifestyle.

Furthermore, the mobile application running it is plus since doesn't force users to "waste" time looking at the application, users "play" the game in accordance with their daily activity. However, if they want to be on top of a leaderboard or unlock all the badges, for example, in that case, they must change their behavior according to the application challenges.

Chapter 7

Conclusions

7.1 Final Remarks

The adoption of sedentary lives increases the percentage of obese children and physical issues, mainly on elderly people, leading to the appearance of a lot of diseases or cognitive problems among these subjects. The encouragement of these people to adopt better lifestyles it's urgent since they can avoid some serious health problems related to physical inactivity. Making daily physical activities more fun and engaging can be a way to motivate people to become more active, by applying Gamification concepts this can be achieved.

The main goal of this project was to study the effect of Gamification techniques on people's daily routine through the use of a mobile application implemented with several game elements. It was central the correct application of the gamified elements in the platform in order to users don't lose interest in it. On one hand, people may have many reasons to use the platform, like a lot of free time, curiosity, contact with other persons and especially indirect health improving. But on the other hand, they may lose interest in the application if they possess problems that hinders the use of the application or the design of the game elements are not fun enough or catchy in order to bring them to use the application continuously.

Gamification concept is a very simple concept for understand, however, applying it to a service is quite complicated in order to obtain user interest and engagement. Building a system that engages users continuously, is a task that implies many observations and changes through time, in order to reach a suitable platform that appeals to players' interest. The biggest challenge when developing a Gamification system is the implementation of gamified elements in order to involve users successfully, since sedentary people is not an easy target group to motivate. Gamification is not only applying points, badges or leaderboards to a service or idea, it is necessary to define well what is pretended with the system, whom are the target group or how is their behavior. All this comprises an iterative process which may require a lot of time to develop a Gamification model capable of produce user addiction.

In order to evaluate the impact of Gamification on users daily activities, *MoverGami's* platform was developed. *MoverGami's* was divided into two components: one destined to being used by smartphone users with possess the gamified content, and a web framework for administrators manage the gamified information. The first one, offers to users their personal statistics on real-time and the possibility of entering in a "game" where the player has to unlock achievements or complete challenges, for instance. Regarding the web framework, admins users are able to insert new game content on the mobile application and to view statistics regarding users daily, weekly and monthly activities.

Regarding the evaluation phase, how was explained in Section 6, it was not possible to obtain concrete results with tests by a selected population using the application. Since, how was already explained, a process for evaluating the efficiency of a gamified system is a task which can take lots of months to obtain perceptible effects.

Although, no relevant results were obtained, *MoverGami* reveals itself as a powerful tool to make people be more aware about their daily activities. By using the mobile application users have real-time information about their activity and on the web application a lot of graphic representations provide direct feedback regarding activity through time.

Nevertheless, all the project goals were fulfilled: a literature review of the Gamification techniques oriented to physical activity was conducted; although the realization of future tests would be needed to know every user need, a system composed by a mobile application and a web framework was developed in order to track and give feedback to users about their daily physical activity; and a simple machine learning algorithm was implemented for the purpose of adapting the application to every user level of activity.

7.2 Future Work

Despite all objectives that have been met, there is still room for some improvements on *MoverGami's* functionalities and in the Gamification model adopted.

Regarding the Gamification model adopted would be necessary to do a controlled assessment over several weeks with a selected group of subjects about the impact of the model on the users daily activities. Then depending on the results obtained, would be necessary insert or delete some gamified elements to see the impact of each one. For instance, instead of users only be able to unlock single badges, the application could support the unlocking of thematic sets of badges, where users should complete a set of related achievements to unlock a new set. Another game element could be the possibility of unlocking or complete achievements as a team, players would be able to create teams with their friends and together try to complete a set of achievements within a certain range of time. A possible process to test and validate the application influence could be the one described in Section *sec:procedures*.

MoverGami's mobile application was integrated with Facebook in order to allow users to share with their friends when they unlocked a new Badge. Another possible functionality would be the possibility of *MoverGami's* leaderboards being composed by the player Facebook's friends. And

when the user reached a new position on the ranking, this fulfillment will be shared on Facebook's timeline.

The reinforcement learning algorithm allows only the creation of new Challenges. Another improvement for *MoverGami* could be the automatic creation of new Badges, Facts or even Rewards. Thus, for the creation of system game content wouldn't be required any handling by admin users. Therefore, the creation of dynamic states and actions for the Q-Learning algorithm would be another interesting functionality.

Finally, since *MoverGami's* Web application receives a lot of data regarding the user activity through days, weeks and months, more graphical representations and type of statistics would be possible in order to provide more feedback to users and admins.

Appendix A

MoverGami Application JSON requests

A.1 *Mover* Request Example

The listing below shows an example of data sent by *Mover* by JSON format corresponding to activities performed for some user in a specific day.

Listing 1 Daily Activity JSON

```
{
     "lookingAtPhone":{
        "time":85000,
        "energy":2.2560415,
        "steps":0,
        "distanceTraveled":0.0
    },"walking":{
        "time":0,
        "energy":0.0,
        "steps":0,
        "distanceTraveled":0.0
    },"sitting":{
        "time":215000,
        "energy":5.267499,
        "steps":0,
        "distanceTraveled":0.0
    },
    "moderateAcitivtyTime":0,
    "totalEnergyWithOffTime":1624.7685268428916,
    "vigorousAcitivtyTime":0
}
```

Appendix B

MoverGami's Web Application Screens

B.1 Badges

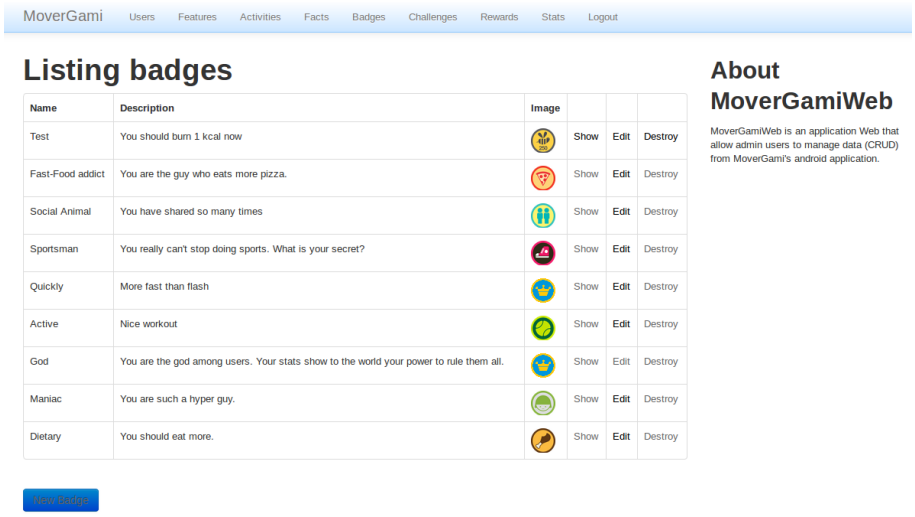

Figure B.1: MoverGamiWeb's list of Badges

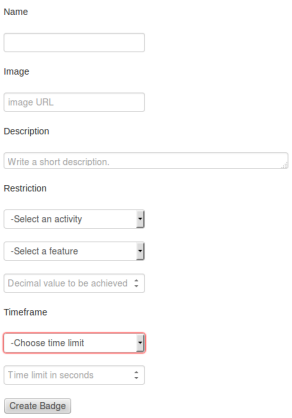

Figure B.2: Form for creation of a new Badge

B.2 Challenges

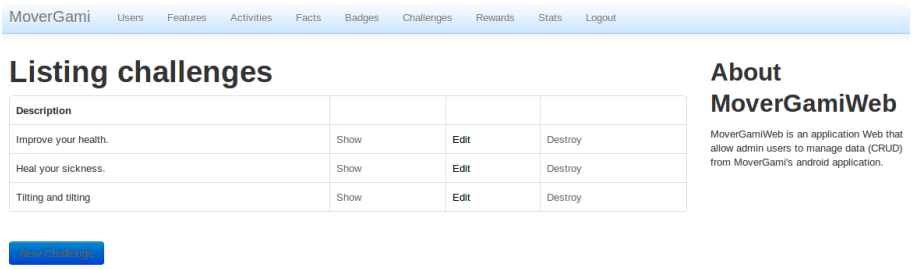

Figure B.3: MoverGamiWeb's list of Facts

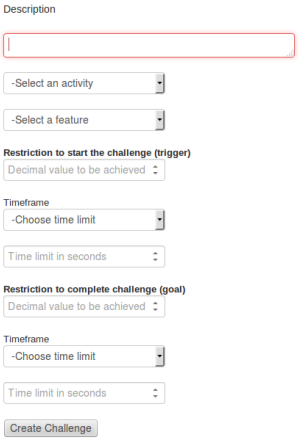

Figure B.4: Form for creation of a new Challenge

B.3 Facts

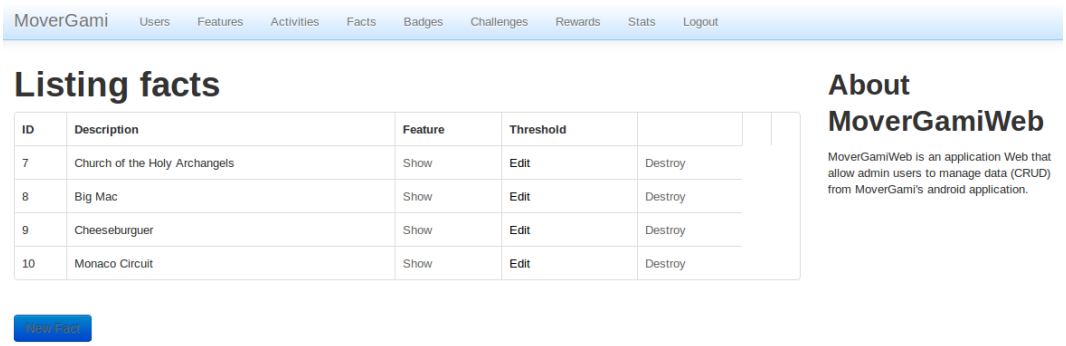

Figure B.5: MoverGamiWeb's list of Facts

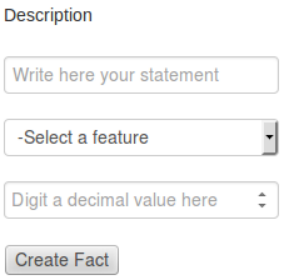

Figure B.6: Form for creation of a new Fact

B.4 Rewards

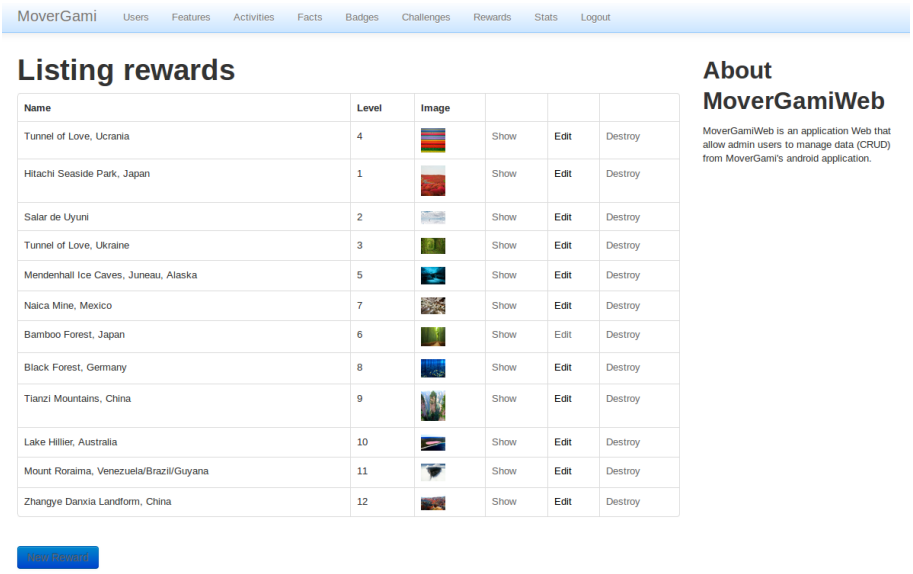

Figure B.7: MoverGamiWeb's list of Rewards

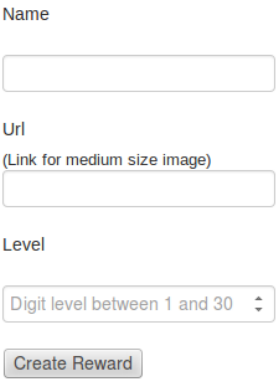

Figure B.8: Form for creation of a new Reward

Appendix C

Q-Learning Algorithm

C.1 States-Transictions Diagram

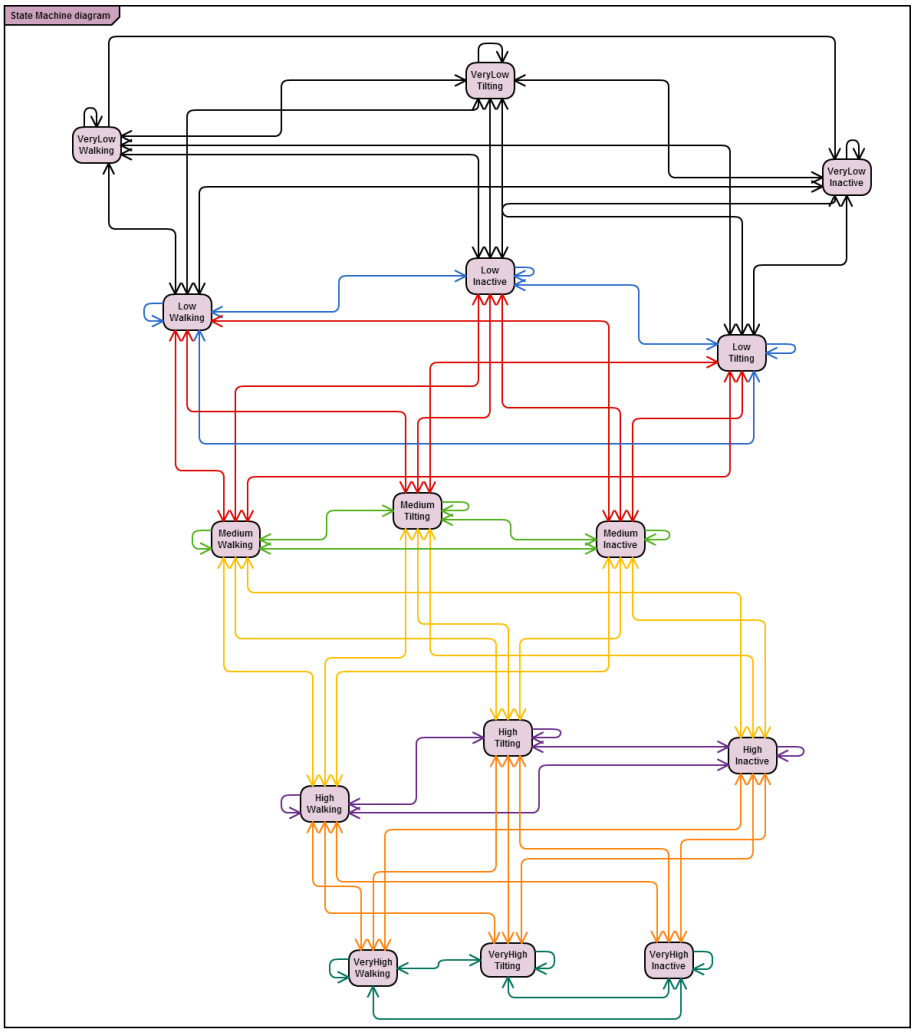

Figure C.1: Q-learning states machine diagram

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