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Gamification and the Improvement of Urban Sustainability

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Abstract. An information centric society needs means to improve itself by taking advantage of the communication channels and knowledge it possesses. Smart-cities provide some of the response for this problem, but the aims remain open and generic. Taking the case study of urban transports and urban driving, there are already projects that generate and analyse data, but the information is often only disclosed to the user. Exposing some sort of this information to a community may lead to a faster behavioural modification. The fundamental objective of this work is to use the information acquired to improve awareness and behaviours in these societies. From this perspective, information tools such as gamification, user and community awareness are discussed in relationship to urban transports applications. The aim is to generate improved habits in a society using non-intrusive methods as mandated by smart-city design.

Keywords. Gamification, Urban Transportation, Intelligent Systems.

1. Introduction

Awareness can be interpreted as a tool to add focus to some topic of discussion. In the case of urban transportation, there are problems identified by people in the society which, due to lack of knowledge or interpretation remain unsolved. Specifically to the area which this article is inserted, driving analysis can be analysed by processing driving data, however, contextual information that derives from such behaviour is often not present or difficult to grasp. In this sense, creating awareness for the problematic driving pattern can make people improve their behaviour by simply showing them processed information of their normal behaviour.

Exploiting sociological and psychological dimensions, group awareness and open information make people more responsible. In fact, the use of sensors and other methods for the acquisition of data and relevant information is common for most projects. Moreover, the need to present such data and information to the user is motivated by studies that state that user awareness influences the way a user interacts with a system. Therefore, using data obtained from sensors it is possible to gather data and to develop intelligent systems that have impact on user behaviour [3], [4].

One example is the subject of smart cities which have been implemented with the purpose of offering services that reduce unnecessary expenses and improve management

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of resources [10]. For instance, the project executed in the city of Santander [15], Spain, allows people to access the data that are being captured, such as the location of public transports, traffic control, illumination and water control. In these projects, people can interact with these systems either by being presented with useful information gathered or challenged based on motivational strategies to engage user into certain behaviours or actions. While data received from sensors can be informative to a machine, it is often not suited to inform people. The metrics representing features should therefore have a justification that is not opaque to the user. Gamification is a common case in these scenarios as through user competition, behaviours and actions that benefit the system are promoted. The objectives, challenges and points are often rewarded by a monitoring platform designed for that effect.

Taking the example of driving inside cities, the developments in this article aim to use an existent platform to demonstrate the use of gamification to manage urban driving sustainability in a smart-city design. After the exploration of gamification methods and mechanics, this article details the developed prototype to launch services related to sustainable driving. It leans on the PHESS platform [17] [18] for service composition and to implement user awareness and motivational strategies towards the management of traffic and PHESS Driving, dedicated to the case of urban sustainability [16]. This extension also includes a gamification engine that manages the motivation between users and aims to reduce risky behaviours and discomfort.

2. Backgrounds

The development of these studies relies on development on smart-city design and gamification to produce its results. The topics introduced in this section introduce these concepts and developments on these areas.

2.1. Smart-Cities

The Smart City is a concept that is defined differently throughout the literature. There are competing trends in how it is defined. A focus on a single urban aspect such as technology or ecology and definitions relating to the integration of the various urban aspects. Other approach can be described as a concept that refers to a technology based integration of both social and economic aspects of a city so as to maintain a sustainable and resilient development [12].

In Spain there are interesting Smart City projects occurring, an initiative headed by an electrical company showcases one of the two trends in Smart Cities. Enel has several Smart City projects with the goal of energy savings, this is a case of a one dimensional approach to Smart Cities, in Spain there are two testbed cities namely Málaga and Barcelona. Málaga was able to reach its targets of 20% energy savings, and a reduction of CO2 emissions of 6,000-tonne per year [7].

In the European cities Santander and Genova along with the Japanese cities Mitaka and Fujisawa, the ClouT (Cloud of Things for empowering the citizen clout in smart cities)[8], [19] project is an example of a citizen-centric multi aspect approach to a Smart City. It attempts to classify use cases of Smart city resource management, safety and emergency management and citizen health [21].

These project are inserted in the design of smart-cities. Urban transport, like these applications aims to demonstrate use cases with the same strategy, which is, demonstrating sample use of case scenarios that demonstrate the application and added value to the society and smart-city design.

2.2. Gamification

The concept of Gamification has already been applied since several years back but it only appears documented for the first time, under this denomination, in the year of 2004, with Nick Pelling using the term Gamification as a part of his business consultancy [14]. Although, at the time, it carried a different meaning from the current one, and the term only began to be widely adopted in the on 2010 when Jesse Schell gave a presentation where he stated that game elements will invade part of our daily life and will gain more prominence over time [20].

Even though it is a recent concept, it has been applied with several purposes and there is much debate regarding its exact definition. The notion that the design of user interfaces can be build by other design practices has a great tradition in HCI (Human-Computer Interaction); during the first peak in the development of computer games. With the solidification of videogames and a wider adoption of these by people, the game design suffered a thorough research and their interest grew.

Following this tendency, researchers explored the concept of playfulness as an attractive user experience and the best way to outline it, however, no consensual solution was achieved. Many attempts were made, from Gaven that tried to describe it as activities motivated by curiosity, exploration and reflection rather than externally-defined tasks [9] by calling them ludic activities. Korhonen, Montola and Arrasvuori combined the pleasure experience framework of Costello and Edmonds [5] with an advanced study on user experiences with video games and created the Playful Experience Framework that was able to classify 22 playful experiences [13], probably an complex analysis that prevented it from reaching a consensus.

Likewise, none of the alternative terms were widely accepted. In the 2000s, researchers in the field of HCI became very interested on the investigation of the design and experiences of video games so, through the development of methods to measure metrics like user experience, playability heuristics and game experience, they achieved ways to quantify and classify a video game concerning the experiences it provided [2] [11].

The games developed with a main objective other than entertainment, usually training or educating users and named as ”serious games”[1], date back a few millennia in the military sector and has reached the education and business in the second half of the 20th century.

The classification of gamification patterns can be found in table 1 where according to Deterding [6] such explanation is made.

The system implemented for this works relies on these classification to find gamification elements and mechanics to manage a gamification initiative.

3. Urban Gamification

In order to improve the general sense of awareness for urban transport, a gamification modules was implemented over the existing PHESS Driving platform. This platform al-

Table 1. Levels of Game Design Elements, according to Deterding [6]

Level	Description	Example
Game interface design patterns	Common and successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badges, leaderboards, levels
Game design patterns and mechanics	Commonly recurring parts of the design of a game that concerns gameplay	Time constrains, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyse a given design solution	Enduring plays, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	Challenges and Mechanics, Dynamics, Aesthetics
Game design methods	Game design-specific practices and processes	Playtesting, playcentric design

ready registers and processes driving data from a community of user providing feedback on their driving performance and suggestion based on community knowledge of how to improve it.

A desired aspect of the gamification element is to drive people to improve themselves by competing with other people in the same platform. The objective is to pit user against user and drive a healthy competition environment that rewards society with the improvement of driving habits.

The use of these game mechanics increases the competitiveness factor between users of the system, because users may have access to a summary performance of other users, motivating and encouraging users to engage in competition and as a consequence, improve bad driving habits.

To this respect, a set of gamification elements were used in a general platform from point and level attribution to achievement and user feedback. Each of these components has the objective to improve awareness towards driving behaviour and motivate people to comply with safety standards. The game elements used on this work were:

- Points - Rewarding users for their performance;
- Levels - Separate user with different experience on the platform;
- Achievements - Special tasks issued by the gamification platform that allow the gain of additional points. It can be used to correct abnormal behaviour detected on the platform;

The strategy behind the use of these game elements is to promote good driving behaviours and urban sustainability. To this end, some approaches were studied in the platform to identify good approaches to both engage and motivate users. An overview of the system implemented can be interpreted in figure 1 where it is displayed where a user profile for a sample user is in display.

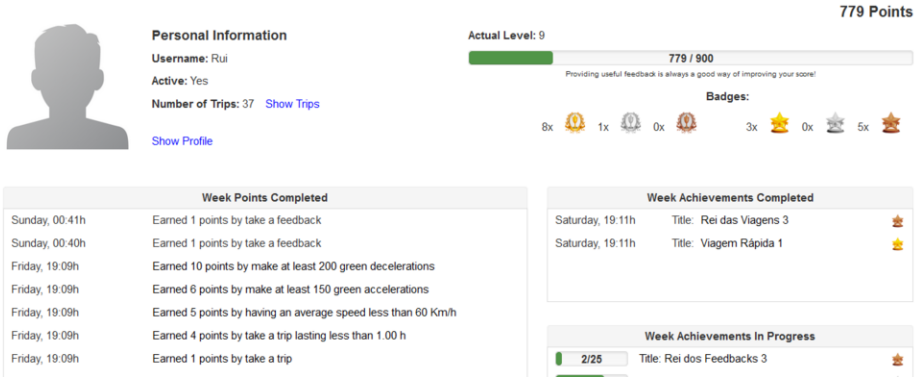

Figure 1. Gamification implementation

3.1. Point and Levels Attribution Strategy

In order to reward user and concentrate their awareness towards the objectives set by the platform, a set of point rules was defined. In table 2, there are a sample of the rules used in the platform. A platform administrator has the possibility to create these rules according to its criteria, and to manage the flow of the gamification process. In this perspective only positive points are considered. With this implementation it becomes possible to compare user over time in a timeline. Such strategy is used so that user may be able to compare their performance with other users.

Table 2. Point attributions

Action	Condition	Points
green accelerations =>	200	10
green accelerations =>	150	6
green accelerations =>	100	3
green decelerations =>	200	10
green decelerations =>	150	6
green decelerations =>	100	3
average velocity <=	$60\,\mathrm{km\,h^{-1}}$	5
average velocity <=	$90\,\mathrm{km\,h^{-1}}$	3
average velocity <=	$120\,\mathrm{km\,h^{-1}}$	1
total distance <=	1 km	4
total distance <=	2 km	2
total duration <=	1 h	4
total duration <=	2 h	2
user trip		1
user feedback		1

In figure 2 we can see the comparison between three platform users. These user are in the same social network, and the points over time suggests the two players in competition between each-other while the another is continuously increasing its lead in burst of intensive point-generating activity.

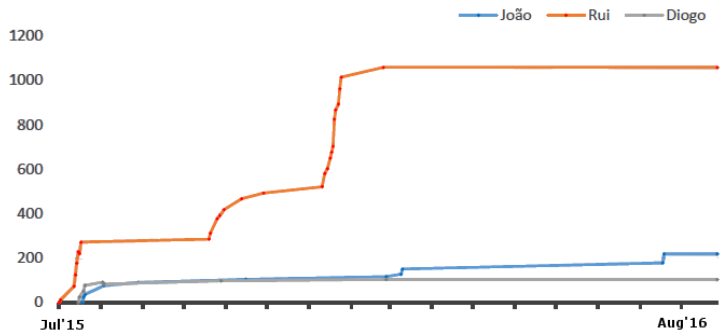

Figure 2. Points per user in the gamification platform

A potential problem that can be identified, resides in the fact that, people with greater number of trips in system are in advantage, as there more opportunities for them to score points, even if their majority driving behaviour is considered poor. With respect to this observation, a set of negative point attributions was envisioned to balance this criteria. In table 3, a negative points are awarded for dangerous behaviours while driving. A comparison between these two approaches shows that while the first favour frequent users of the application the latter favour the correct driving behaviour, by decreasing acquired point sum when risky driving habits are employed.

Table 3. Negative point attributions

Action	Condition	Points
red accelerations =>	200	-10
red accelerations =>	150	-6
red accelerations =>	100	-3
red decelerations =>	200	-10
red decelerations =>	150	-6
red decelerations =>	100	-3
average velocity >	$120\,\mathrm{km\,h^{-1}}$	-25
average velocity >	$150\,\mathrm{km\,h^{-1}}$	-50
total distance >	4 km	-4
total distance >	2 km	-2
total duration >	2 h	-2
total duration >	4 h	-4
user trip		1
user feedback		1

The attribution of negative points in this platform has a further implication which is the potential decrease of the level of the user. Corroborating with urban sustainability principles, the greater objective shall be lead people to alter not only their behaviour but also their habits and traditions towards urban sustainability. In order to stay at the top, these habits should be ever present.

3.2. Achievement and Badge Attribution Strategy

Achievements are a special task, which is scheduled upon a user or group of users which implied the satisfaction of a number of conditions in order to receive a reward. The conditions can be generic as specified in the review made in [6], but in this platform, time, score count based on the metric of the PHESS Driving platform where used.

Among the metric are assessments based on the classification of events such turning, accelerating and decelerating, trip time and trip distance. The classification present in this system are assessed in three levels: red, yellow and green meaning less risk behaviour respectively.

The achievements are conditioned by contexts in which they make sense to the user, for instance, long period of inactivity, detection of high frequency of red or yellow classifications, detection of competition between users or platform wide objective enforcing.

Badges on the other hand, are meant to be a recognition of activities made by the user. Implemented in this platform, their structure is not much different from achievements, but their achievement does not imply extra rewards by their completeness only visual recognition for completing the condition required. This recognition acts as a complementary reward system for users which may have trouble in engaging in point based competitions, thus offering an alternative recognition system that does not discriminate users.

3.3. PHESS Driving Information

The PHESS Driving project is focused on the analysis of user mobile sensor data to assess user driving behaviour and profile [16]. From a list of attributes validated by the project and in literature review, the platform is able to track user driving activity and maintain a community of user data updated in its central servers.

Users are constantly monitored unobtrusively by a smartphone application which analyses position, accelerometer, gyroscope as primary sources. Secondary context is analysed with temperature, sound and location information fusion. Aside from individual classification, a community feature of this project allows to classify regions of a map as potentially hazardous based on the aggregation of its user analysis.

Its importance for this study is the classification of driving behaviour and user base. It acts as a datasource of information that can be interpreted in this gamification system. The actual implementation considers only user trip information, however, future implementations can take advantage of the region and community knowledge also generated in this platform in order to produce variable gamication mechanics. Nevertheless, the objective with this study is to demonstrate the usefullness of gamification to gear and influence user behaviour towards better practices in terms of urban sustainability.

Figure 3 depicts the profile imported from this system in the gamification implementation. The combination of the log of user driving activities results in the creation of a gamification profile in figure 1. The translation is made according both static rules and gamification mechanics explained in this section.

3.4. Gamification Management

The management of the gamification platform is made with a central unit that gathers information about users and tracks their performance. The PHESS Driving environment is

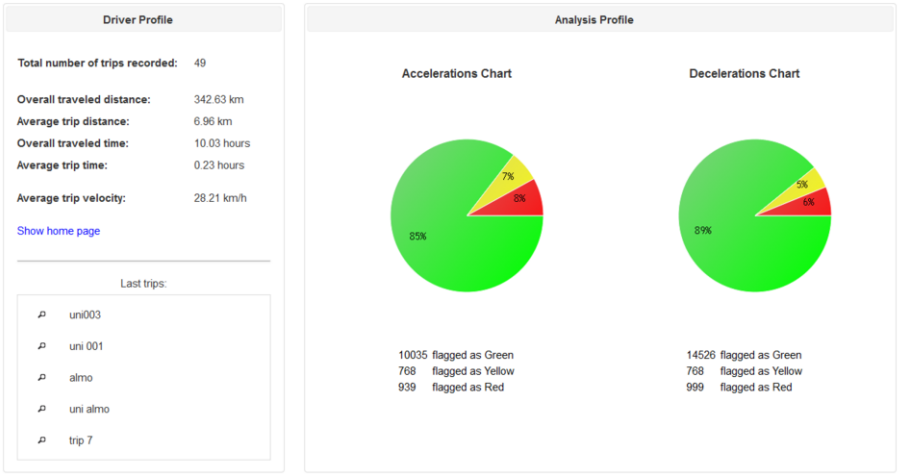

Figure 3. User profile imported from PHESS Driving

responsible for gathering user activity through smartphone sensor analysis and reporting user performance to this platform. This communication channel is based on web services restful communication.

The gamification central unit is responsible for administering points to users based on their activity, classify users by their levels and manage achievement availability to users. As part of the autonomous nature of the platform, there are the selection of users for achievements proposal and enforcement of gamification logic.

There is also an administrative area which requires a physical administrator where it is possible to review point schemes, alter levels definition and launch manual achievements as needed.

4. Result Analysis

In order to test the practicability of a gamification platform in urban driving sustainability, a field experiment was conduced with voluntary participants during a period of July 2014 and September 2015. In the platform a total of 14 active users were analysed during this time period.

The methodology for this experiment was to collect data from the activity and classifications generated by the PHESS Driving platform and observe user behaviours while using the gamification platform. The implementation required positive reinforcement with no penalties. Through record data, the competition was restructured using penalties in order to compare the nature of the competition and their outcomes under these assumptions. This scenario testing was used to try to give answers to problems identified in the initial experience.

The number of points using only a positive reinforcement strategy is on average higher than the average number of points using negative reinforcement. This corroborates the idea that rewarding only positive behaviour may not be enough to drive users toward positive habits. In this approach, user can still achieve high punctuations only by the sheer commitment to the platform and accumulate points with more trips as a compensation.

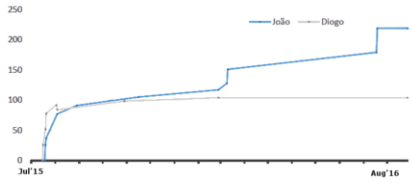

Figure 4. Progress with negative points

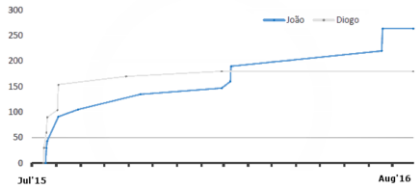

Figure 5. Progress with only positive points

With negative reinforcement these behaviours are modified, and the as the presence of bad behaviour influences the final punctuation the results in average power points per trip. An analysis of the platform corroborates, table 4.

Table 4. Average points per trip

Gamification Mechanics	Average Points
Positive Reinforcement	20,31
Negative Reinforcement	16,85

Comparing two anonymous users on the platform we can recall the effect of negative reinforcement on the gamification implementation. Considering in figure 5 two users engaged in competition we can observe one player being overtaken in points by another. However, observing figure 4 we can see the same two player under a in the same timeline with negative reinforcement enabled, this is, with negative points enabled. The analysis shows that the same user overtaking occur earlier in the timeline.

5. Conclusions

This article studies the implementation of a gamification platform, based on user driving activity to promote urban driving sustainability behaviours. Prior work in the implementation of this gamification platform can be found in the PHESS Driving platform, which captures, analyses and classifies user driving. This information is then managed by the gamification platform with gamification elements such as points, levels, achievements and badges to engage users and consequently good habits.

During the analysis, some concern are evidenced in the mechanics of the gamification process, and adjustments are simulated in an alternative configuration which includes negative reinforcement. This seems to correct anomalies identified in the first attempt and reward users based on their performance rather only positive behaviour.

Future work on the platform resides in the increment of autonomous process for managing gamification implementations. Namely, the existence of variable points attribution requires the tracking of user context and increase the value of actions according to some criteria and decrease when antagonist criteria is found. There is also the opportunity for automatic custom achievement generation based on user profile analysis. Based on generic suggestion algorithms, user-based suggestion can be implemented combining problem areas in the user profile with gamification mechanics in an automatic manner.

The configuration and implementation of the gamification mechanics are also responsible for the experience and results and these initiatives, thus they should be done carefully and avoid abnormal user behaviour to take advantage of the game logics.

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