

ECO-DRIVER: USING AUTOMOTIVE SENSOR DATA TO CONTROL MOBILE DRIVING GAMES

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ABSTRACT

Nowadays, context-aware mobile gaming is mainly focused on GPS location as the sole context information. This paper extends the scope by introducing the idea of using automotive sensor data as an input for games played by the cars' drivers. We present the results of a short online survey on the subject and demonstrate the applicability of the approach with a mobile game prototype called "Eco-Driver". As this serious game is not only a simulation, but augments the driving reality by effectively reducing the fuel consumption on certain routes, it gives strong feedback to the driver. Besides setting the stage for a new genre of games to be played while driving, "Eco-Driver" technically demonstrates a way to extend an existing browser oriented location based gaming framework with additional sensor input.

KEYWORDS

Eco-Driver, In-Car Car Sensors, Play-While-Driving, Location-Based Gaming

1. INTRODUCTION

With the advent of small but powerful smartphones, which can maintain a constant connection to the Internet and identify their current location using GPS services, more and more location based games appear in research and on the commercial market. The creation of new games is simplified by mobile gaming frameworks like MScape [shgr07, chmh09], Create-a-Scape [ldfh08], Hermes [dc08], or AMoGA [shtm09]. While other ways of context input for mobile games have been discussed theoretically [mbsc08], implementations mainly focus on using the users' global position as single context information. This might be due to the lack of other sensors on the typical user's device.

Cars are loaded with digital sensors. An average luxury class car contains about 100 sensors [buß04] and counting. Using the standardized diagnostic interface OBD2 [borg08] it is possible to access these sensors' values and use the driving itself to generate implicit input for a game.

An example of how to design such a game for the driver is our prototype "Eco-Driver". Integrated into the routine of driving (e.g. commuting), it motivates the driver to act in awareness of his car's fuel consumption by comparing its current amount to earlier rides and to other drivers who take the same way.

The remainder of this paper is organized as follows: In the following section, we take a look at existing approaches to use (serious) gaming for raising ecological awareness. After that, we present the findings of an online survey about the acceptance and implications of integrating car sensor data into a game experience. Then, our prototype is introduced, followed by a short architectural overview. At the end of the paper, we discuss further potentials and possible risks of games played while driving and explain our next steps in research.

2. RELATED WORKS

Just a few approaches of integrating mobile games into vehicles are known to us: In "Road Rager" [brun04], a game by the Mobility Studio Interactive Institute in Stockholm, driving situations like passing and overtaking are used as contexts to fight virtual duels using dedicated equipment. Another game from the

same institute, “Hocman” [ejoe04], tries to support social networking for motor-cyclists by exchanging digital “business cards” on the road. “Carcade” [flp08] is a concept for an in-car video game for the passengers, capturing the landscape and using it as an environment for a video game, where the player has to navigate his space ship through a dynamic landscape formed by existing objects like trees and houses. It is common to all these approaches, that while they are using the driving situation as part of their game design, they neither take advantage of using car sensors as game input, nor do they provide an interactive role for the driver himself.

Ecological serious games offer an approach integrating ecological awareness in our daily routine. They integrate learning content and challenges concerning eco-friendly behavior in a digital game. Over the last five years serious games have reached an enormous public and industrial acceptance world-wide and are used in numerous sectors from educational games in schools, health games in health care, corporate games in companies to persuasive games handling social or even ecological problems. The ecological agency of Berlin and Brandenburg (UBB) offers a database with currently 195 links and descriptions of serious games concerning the subject ecology [ubb10]. The games are divided in categories like age class, game character and subject, while the last one is distinguished in “Land, Water, Air”, “Energy, Electricity, Radiation”, “Food”, “Flora & Fauna”, “Climate & Ozone”, “Recycling”, “Planet Earth”, “Fauna” and “Coherences”. In 2009 the Serious Games Award was given to an ecological serious game called Imagine Earth [wi09]. Its aim is expanding cities while holding the balance between growth, sustainability and pollution. All these games are played in a virtual environment so there is little reference to reality. In order to reach the maximum learning effect serious games should not only simulate reality, but also augment it with additional situational information [rww07]. This implies engaging and interpreting reality by using all kinds of sensors and techniques like image and pattern recognition. Some serious games augmenting reality already exist in specific sectors. For example, “Rogue Signals” is a location-aware augmented reality game to teach firefighter teams coordination skills using head-mounted displays, global positioning receivers (GPS), speakers, radio, and a backpack-mounted computer to create an immersive game environment in which players need to coordinate effectively in order to be successful. Another game is “Solar-System and Orbit Learning in Augmented Reality System” [wbla04], which promotes knowledge of volcano eruptions, coherences of the solar system and information about Earth’s surface. However, we could not spot a serious game augmenting reality specifically to raise ecological awareness.

Today’s cars offer about a hundred sensors monitoring electronic components, which constitute the base for assistance systems [buß04]. Sensor information as a whole represents the car’s status and its environment, thus an image of reality. Via an OBD2 interface, which every European automobile manufacturer is bound to build into cars since 2004 [borg08], a lot of sensor information can easily be read with adequate hardware. Still, the extent of accessible sensor data in a car partially depends on its manufacturer. Currently, there exist only a few projects like AUTOSAR [auto10], that aim at developing standardized software architecture focusing on using car sensors, e.g. linking active systems and allowing cars to communicate among each other. This is simplified in most standard and luxury class cars by high-capacity, power-saving computers, so-called In-Car-Entertainment and –Infotainment systems. They are mainly used to control electronic components, multimedia applications and navigation systems. Hence these systems offer a good basis for games and applications on the basis of sensor data.

3. PLAYING WHILE DRIVING?

To evaluate the general acceptance of playing games while driving, we conducted a short form based online survey upfront. The survey was carried out in the first week of February of this year and advertised using personal e-mail contacts and mailing lists known to the authors. While the results are not representative, the relatively high number of 353 participants allow to at least draw conclusions with indicating character.

By selecting only those participants who answered at least 27 of the 34 questions, 276 individual answer sets were evaluated. Despite the fact that the survey was offered in three languages (German, English and French), only 4% of the survey participants chose English and 1% French as query language. About two thirds (65%) of the participants were male, 35% female. The majority of participants (82%) stated being between 17 and 32 years old (“12-25”: 37%, “26-32”: 45%), 17% were aged between 33 and 64 years.

More than half of the participants answered that they were bored from time to time while driving. To combat this, 84% listen to the radio or other music and 74% talk with their co-drivers. Only 8% occasionally play riddles or word games. Regarding the acceptance of interactive electronic equipment, more than 60% do not feel distracted by their navigation system. Asked about which games they could imagine, 51% of the participants sympathized with contextual games which incorporate their current situation inside or outside the car. To interact with the user interface, speech commands were preferred (63%) over buttons at the steering wheel (42%), touch displays (37%), stand-alone touchpads (14%) and turning wheels in the central console (11%).

As most of the participants name their driving style “easy-going” (57%) or “slow” (59%), and almost 75% take pleasure in driving, it looks feasible to integrate mobile games into a positive driving experience. Designing games which improve environmental awareness seems reasonable, since 82% know about the environmental impact of their driving style, but only about 60% apply this knowledge while driving. Only 14% of the participants would not accept a technical system giving live advice for environmentally friendly driving. While 74% of the participants enjoy chatting with their co-driver, only 29% agree to playing games against them. If this is due to the fact that the driver feels disadvantaged, since only the co-driver can completely concentrate on the game, it confirms the idea of only involving the drivers themselves in a multiplayer game.

4. THE ECO-DRIVER PROTOTYPE

As an example for a driver game, we present a prototype called “Eco-Driver” using automotive sensor data to make car driving more ecological. By driving in a smart and adequate way, average fuel consumption can be reduced by about 20% [lr10]. Behaviors such as changing gears late, revving up the engine, perpetual starting and braking, running air conditioning and driving with unnecessary weight or low tire pressure tremendously push up fuel consumption. As playing the game is directly connected to driving more ecologically friendly, an intrinsic motivation is built up by reducing driving cost, as well as an extrinsic motivation based on a “best of”-list, where the driver is in competition to others.

Before describing the implementation details of the system, we briefly explain the game concept: In short, the driver competes with others and with himself for the smallest fuel consumption on a given route. Besides the positive effect on the environment, this will also have an impact on his purse. The motivation introduced by competition and the perspective of becoming “famous” among the people who drive the same routes can help to overcome prejudices against driving eco-friendly. To accomplish this we use a server-based, route-dependent high score list based on an “eco-drive” metric.

To calculate the metric’s value, firstly the data relevant for measuring the fuel consumption (mass air flow rate, vehicle speed, long term fuel trim) has to be read out of the car sensors. Secondly, this information is combined with the current location determined by a GPS device on the client (at the moment this is a tiny computer). The result then is sent to the server. When the vehicle reaches the end of the route, the server calculates the average fuel consumption and stores it in a database. This data is matched with the data of other people and the client is notified about the current high scores on this route.

To interact with the game, the mobile device serving as client in each player’s vehicle has a small touch-screen near the steering wheel giving access to the most important game functions and information. Of course the amount of interaction to be provided by the player is required to be minimal, as the driver has to focus on the road and on saving fuel. Therefore, the interaction interface of the application is reduced to two context-sensitive buttons. Before starting their trip, the user logs in and automatically gets notified by a message in the game UI when being close to the start point of one of the predefined routes. Hereupon, the system asks if the driver wants to take part in the game. If he chooses to do so, the device starts collecting the data from the car sensors and sends it to the server. While driving, the game UI displays the current and average fuel consumption and the remaining

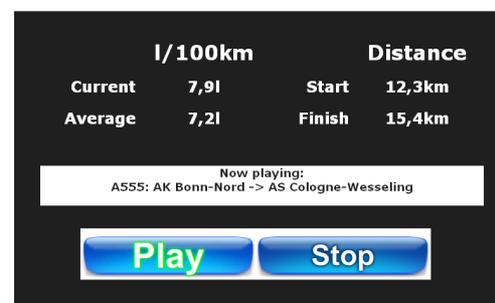


Figure 1. A close view on the game's user interface

distance to the finish (cf. Figure 1). When the track is completed, the current personal and global high scores for this route are shown in the game UI, motivating the driver to beat his own or others' fuel consumption record next time.

5. ARCHITECTURE

This game is laid out as a client-server application with a thin client. Nearly the whole game mechanics is located on the server except for the detection of the approximation to start or finish. This system of a thin client has the advantage that we can change much of the game's mechanics on the server without having to change the client's code.

Sensor information, as for example the current device position, is queried directly via JavaScript. To query location information a W3C standard is already available [pop08]. The integration of other sensors into the browser environment is planned [tf10], but not available yet. Therefore, we provide a JavaScript interface to the car sensor data by means of a signed Java applet, which accesses the device's serial data port and interprets the incoming OBU data. By defining the API between the JavaScript application and the Java applet on a domain level as opposed to a technical level, we abstract from concrete sensor implementations and anticipate a direct support by the JavaScript execution environment, i.e. the device's browser¹, in the future. In addition, this provides a protection layer for the car sensor bus.

By choosing the browser as our application's execution environment, we intended to achieve a certain independence of used devices and operating systems. Furthermore, the setup and update procedures are simplified and network communication features are innately provided. Since the application is heavily based on external data and communication between players, i.e. an established Internet connection, and having a mobile client in mind, we designed the application as client-server application with a thin client. Therefore, dynamic adaptation of game mechanics can be accomplished without extending the client application, combining flexibility in game design with optimization for device caches. Practically, the client part of the application is only responsible for sensor data collection and user interface visualization. This design harmonizes well with existing mobile game framework approaches like AMoGA [shtm09].

6. CONCLUSION AND OUTLOOK

In this paper, we have introduced the idea of using car sensor information as context input for mobile games, and thereby created a new genre of unobtrusive, pervasive games played by the car driver while driving. As an example for such a game, we presented the prototype "Eco-Driver".

There are many ideas to extend the prototype game by adding new features and integrating more car sensor data. For now, the routes you can play the game on are predefined, but it would be a nice feature, if the player would be able to define routes himself, for example his daily commute to work. To make the choice of starting and ending point easier and more intuitive for users, the integration of georeferenced data to relate GPS coordinates to street names and places is envisioned. An additional map view would provide the opportunity to reveal the whole playing route to the user so he can plan his way of driving. Currently, the fuel consumption metric is calculated based only on the values of three sensors without regarding other contextual criteria like the type of the engine, the weight of the car, the time of day, surroundings and weather conditions, mileage of the user this day etc. As these criteria have an enormous effect on fuel consumption they should be included in the computing in the future, assuming that sensors to collect this information exist. Since cars by particular manufacturers do not support reading out the mass air flow sensor, alternative methods to calculate fuel consumption on the basis of other sensors can be implemented. A completely server-driven architecture would have the effect of reducing the client and its power-

¹ Some years ago, the only possibility to read out GPS sensor data from a Web-Application was to use technical indirections like the described signed Java-Applet bridge or workarounds like local based dedicated web-servers. Nowadays, location queries are directly defined in the W3C HTML-standard [pop08] and first desktop and mobile browsers implement this functionality and the related privacy maintenance frameworks.

consumption, but would cause more communication during times when the player is logged in but not actively playing.

Playing games at the wheel of a car while driving of course implies side-effects that need to be considered: As we know from studies about the usage of cell phones and navigation devices while driving [box09], operating technically demanding equipment can draw off the driver's attention from steering the car and therefore lead to dangerous situations. To counter this impact on driving safety it is important to provide a clean and uncluttered user interface that contains only the necessary information and only requires a minimum amount of interaction. Furthermore, we imagine that there may even be positive effects on driving from having an unobtrusive occupation like our game: For many people, driving a car has become a very mechanical and more or less unconscious activity, so having something suitable to do might augment the driver's vigilance and therefore facilitate a more conscious style of driving.

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