PLATFORM FOR THE DEVELOPMENT OF MULTIPLAYER SERIOUS GAMES BASED ON LOCATION

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1. Motivation

A game is a challenge. More than the rules or the technical aspects, games are challenges posed to the players. A serious game differs from the others in the way its challenges go beyond pure entertainment.

This dissertation tries to explore smartphones vulgarization and the growing expansion of location-based services, to introduce new concepts and experiences into serious games.

Although great advances have been made in geographical location, their application to indoor scenarios still faces strong limitations. Thus, the main focus of this investigation is indoor location.

On a different note, communications constraints and requirements are also analyzed in the context of a multiplayer mobile game.

2. Goals

The thesis' main goal was the study and development of a client-server platform for indoor and outdoor location, who could be easily used by location aware applications. Inside this main scope we can highlight some specific goals like:

- Research indoor and outdoor location techniques, their problems and advantages;
- Develop and assess a solution for the location problem;
- Study latency reduction methods for mobile communication;
- Create a client-server prototype that is able to communicate and provide all the necessary information about the game state.

3. Methodology

There are 2 main components in this study: location and communication. The former concerns the study, implementation and assessment of various indoor location methods, with Pedestrian Dead Reckoning (PDR) receiving special attention as it is the one that was implemented in the prototype; while at the same time, exploring GPS for the outdoor solution. Regarding communication, an analysis of mobile network's main bottlenecks was performed, which served as base for different decisions whose arguments are specified in the document.

3.1. Pedestrian Dead Reckoning

PDR is an Inertial Navigation Systems that continuously estimates the subject/object's displacement and, consequently, calculates its actual position. The method's efficiency depends on the sensors (accelerometers, gyroscopes, magnetometers) reliability, that are used in 3 main tasks:

- orientation determination,
- step detection,
- step length estimation.

3.1.1. Orientation Determination

The magnetometer's readings are influenced by magnetic disturbances. On the other hand, electronic gyroscopes don't respect rotations order and have offset and drift errors, making it impossible to calculate orientation by using them alone. However, infinitesimal rotations concept can be used to surpass the first problem, as is done in the Direction Cosine Matrix algorithm [1]. The second gyroscope's drawback can be fixed by using also magnetometers and accelerometers to cancel its errors. Additionally, a magnetic disturbance detection method was implemented to minimize the negative effects of erroneous deviations. As the acceleration magnitude is approximately constant in the space usually covered by a pedestrian, the algorithm uses this property to detect the presence of disturbances.

3.1.2. Step Detection

Unlike most approaches present in the literature (e.g. the 1996 patent [2]), the method used in the implementation doesn't determine its results only by detecting zero-crossings or movements above threshold in the acceleration signal. Trying to better modulate the step effects on the signal, our solution defines a step detection as a complete transition over a determined number of states. Each one of these states has its own transition conditions, with its specificities derived by analyzing the signal and the mechanic of a step.

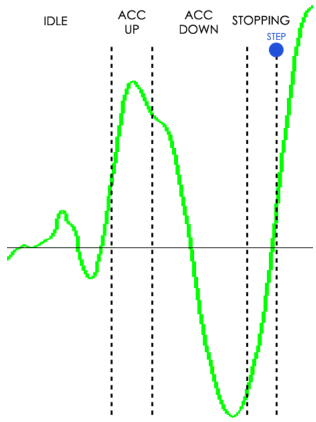

Fig. 1 – Acceleration signal states (after low-pass filter) in one iteration of step detection

3.1.3. Step Length Estimation

Many different factors influence the step length. While some of them are relative to the subject (e.g. height, gender), there are others that depends on the step dynamics (e.g. step frequency, existence of inclinations, walking stairs, direction changes). To better identify this variability, the adopted approach uses various metrics obtained from the acceleration values:

- double integral of acceleration's norm with gravity component removed,
- maximum amplitude of vertical acceleration,
- minimum anteroposterior acceleration,
- step frequency estimation.

During the calibration phase, the weights of each one of these factors are estimated by using multiple linear regression.

3.2. Particle Filters

A particle filter is a technique to implement a Bayesian filter through the use of sequential Monte Carlo methods [3]. This kind of methods is commonly used to estimate the state of systems that are modified throughout time by information with noise/errors. In these cases, the system state is described by a Probability Density Function (pdf) that, in the case of particle filters, is approximated by a set of discrete samples/particles whose distribution correctly represents the original continuous pdf.

The PDR system of this thesis uses particle filters to model the noise/errors in the orientation and step length. Additionally building plans are used in the indoor solution to remove particles with impossible trajectories (e.g. crossing walls). The data from the GPS receiver are used in outdoor situations where they work as additional parameters in the particles weight determination. In our case, these weights represent the likelihood of the true subject's position being the same as the particle, and are inversely proportional to the amount of noise introduced.

Several optimizations to the initial particle filtering algorithm were implemented to grant the particles representativity throughout the execution.

3.3. Communication

There is a strong relation between the communication requirements and the game genre. When creating a platform for serious games, it is not possible to predict the kind of games it will be used for, so the optimization work was focused on the system's reaction to the worst-case scenario. Many of the problems present in the worst-case scenario are greatly increased by mobile network characteristics, which are typically slower and more error-prone than the wired networks. This easily leads to package loss and latency. Considering the circumstances, different protocols (UDP and TCP) were assessed and ways to minimize the negative effects of latency (e.g. dead reckoning) were studied.

4. Conclusions

During the relatively small period of this dissertation, it was possible to construct a solution that implements various state of the art methods. The final solution produced encouraging results, which are properly presented in the thesis document. It was confirmed that our implementation, realized on a platform consisting of: one laptop, one GPS receptor and one Inertial Measurement Unit (3 axis accelerometer, magnetometer and gyroscope), can be used as a solid base, not only for ubiquitous location-based games development, but also for other location-aware products and services. Its usefulness is especially notorious if migrated to a smartphone with the same technologies.

References

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[3] Sanjeev Arulampalam, Simon Maskell, Neil Gordon, e Tim Clapp. A tutorial on particle filters for on-line non-linear/non-gaussian bayesian tracking. *IEEE Transactions on Signal Processing*, 50:174–188, 2001.