

Issues in Position Determination for Mobile Learners

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Supporting the mobile learning process raises a number of difficulties from a course design, delivery and evaluation perspective. In the case of the delivery component, these difficulties are most acute in those circumstances where educational content should be delivered in a context-sensitive fashion. For the purposes of this paper, discussion is restricted to just one vital aspect of the mobile learner's context: their physical location. Of the technologies that exist for determining physical position, none are guaranteed to provide a position of adequate quality and consistency in all circumstances. In this paper, a review of the prevailing satellite positioning technologies currently available is presented and their suitability for deployment in mobile learner scenarios assessed. Finally, where the quality of the calculated position is variable, the incorporation of a predictive component based on Neural Network techniques is proposed.

Keywords ambient learning; mobile learning; positioning technologies

1. Introduction

Some academic disciplines are distinguished by a significant field work component. While lectures and laboratory sessions are useful for illustrating and studying various theoretical aspects of individual subjects, the need for these to be augmented with further study in real-life environments is of fundamental importance in many disciplines. Archaeology, ecology, geography, and zoology are just some well-known examples. The potential of mobile computing technologies in the broad area of education is well documented [1-2]. However, an essential part of fieldwork is identifying a suitable location that encapsulates adequate features for demonstration and teaching purposes. Hence the need for a positioning technology that can supply sufficiently accurate positions that allows professors to specify exact locations for students to study, as well as enabling students to find the location in question. Consider the case of students finding their way to a specified rock outcrop where their palaeontology professor told them an interesting fossil may be found. If the positioning system used is not sufficiently powerful, they may spend significant time trying to find the fossil in question, if indeed they do find it.

This paper is structured as follows: Section 2 reviews existing techniques in the light of student needs. Section 3 illustrates common scenarios where traditional approaches are inadequate. Section 4 proposes a solution based on Neural Network (NN) technologies that aim to address the need for resilient positioning in hostile environments.

2. Review of Positioning Technologies

A number of positioning technologies exist; for the purposes of this paper, discussion is limited to those based on satellite technologies and wireless telecommunications. Other open and propriety solutions exist but are beyond the scope of this discussion.

2.1 Satellite Techniques

Originally, the potential of using satellites for positioning was discovered during the space program of the 1950s. At present, there are two incompatible Global Navigation Satellite Systems (GNSS) in operation: GPS and GLONASS. A third system, Galileo, is scheduled to be launched in 2008.

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Global Positioning System (GPS) was deployed in the mid 1990s and is the de facto standard for positioning systems at present. It covers the entire earth and supports a wide end-user base including agriculture, maritime and leisure users. In essence, GPS is owned and operated by the US military.

GLONASS was developed by the former USSR in response to developments in GPS. However, it was not fully maintained thus allowing GPS become the dominant system. Currently, GLONASS is being updated; however, it remains under the control of the Russian military.

GALILEO is an initiative of the EU and is scheduled to be launched in 2008. Though similar in architecture and capability to GPS and GLONASS, as well as being interoperable with both, it differs in that it is a civilian system and offers guarantees regarding the quality of the positioning signal.

A recent development in satellite technologies are Satellite Based Augmentation Systems (SBAS). Such systems are essentially an extension of the well known Differential GPS (DGPS) technique where signal correction parameters are broadcast. Well-known SBAS systems include the European Ground Navigation Overlay Service (EGNOS) and the Wide Area Augmentation System (WAAS).

2.2 Wireless Telecommunications Techniques

Wireless telecommunications, particularly cellular networks, have been one of the technological success stories of the last decade. A number of techniques that harness the topology of cellular networks have been identified [3]. The impetus for these developments came from the E-911 directive in which the FCC mandated that all network operators should be able to locate the position of subscribers making emergency calls within certain limitations. The Third Generation Partnership Project (3GPP) has approved four techniques for use in third generation (3G) UMTS networks [4]:

- Cell-ID: Geographical coordinates are associated with the base station in the center of the cell. Thus the subscriber must be positioned within the radius of the cell.
- OTDOA: Observed Time Difference of Arrival (OTDOA) involves the handset measuring a signal from three base stations. Using hyperbolic techniques, the subscriber's position can be estimated.
- UTDOA: Uplink Time Difference of Arrival (UTDOA) is similar in principle to OTDOA but signal are generated by the handset and measured at three base stations.
- AGPS: Assisted GPS (AGPS) may be regarded as a hybrid technique. The handset must be equipped with a GPS antenna. However, the handset must first be informed as to where to look for satellites. On measuring the appropriate signals, the results are then returned to the network for processing and the determination of the subscriber's position.

3. Technology Considerations

Before choosing a technology, the positional accuracy necessary for the realization of an effective teaching session in the field must be identified. Then, the nature of the prevailing environment must be considered.

Positions obtained using wireless network solutions are inherently variable in accuracy as they are directly influenced by the topology of the local network. In urban areas, base stations are plentiful and cell sizes are naturally smaller. In contrast, the cell size in rural areas may be several kilometres across, and it may be difficult to view three base stations simultaneously thus comprising methods such as OTDOA and UTDOA. AGPS will offer position readings of similar quality to GPS, about twenty meters or so. It should be noted that network operators and individual handset models may not support all these techniques.

If the accuracy of GPS is adequate, there is little doubt that it offers an attractive solution, provided students are equipped with GPS receivers. Should twenty meters not be adequate, an SBAS solution will

improve the position reading to about 5 meters or so. As SBAS technologies are increasingly integrated with modern GPS receivers, additional hardware is not required. However, as SBAS does not possess a large number of satellites in its space segment, the possibility of the signal being obscured is quite high. If a wireless connection is available, a service similar to SISNet [5] where the correction signal is broadcast via the internet may be used. However, should it be the case that the SBAS signal is intermittent and the local telecommunications infrastructure is inadequate, a problem arises. If the area is mapped to sufficient level of detail, and local landmarks exist, the problem may be rectified. If not, then other approaches must be considered. It is proposed that Neural Network ((NN) techniques be harnessed for monitoring the SBAS signal, and predicting the correctional data when the original signal is lost.

4. A Neural Network Approach

Artificial Neural Networks (ANN) are highly parallel systems that process information. They do this through many interconnected units that respond to inputs through modifiable weights, thresholds, and mathematical transfer functions.

The ANN structure comprises of the neurons, neuron connection weights and neuron layers. The starting point for most ANNs is a model neuron, consisting of multiple inputs and a single output. The neurons are interconnected but the connections are not equal, as each connection has a connection weight. That is, each input is modified by a weight, which multiplies with the input value. It is these weights that give the ANN the ability to recognise patterns. If the weights are adjusted, then the ANN will recognise a different pattern. Hence, the aforementioned weighted connections are integral to the functioning of the ANN. There are two main types of weighted connections, each associated with a different behavior: Feed-forward connections; and Feed-back connections.

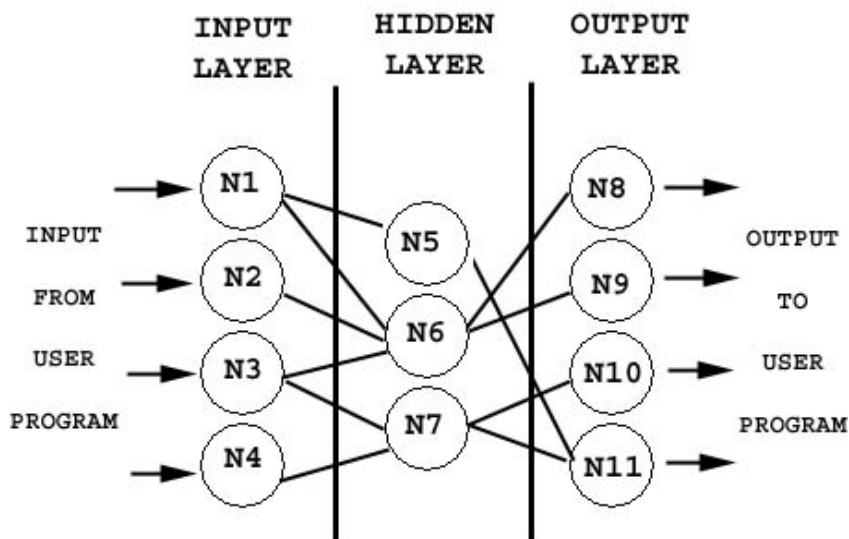


Fig. 1 Neural Network Layers. In this ANN example, there is one hidden layer. Input is received from the user program by the input layer. The input layer then presents this pattern to the hidden layer. Finally the user program collects the pattern generated by the output layer. The connections, which are formed between the neurons, are also displayed in the diagram, e.g. Neuron (N1) is connected to both Neuron 5 (N5) and Neuron 6 (N6).

Feed-forward networks are static. Data from neurons of a lower layer are propagated forward to neurons of an upper layer. Signals flow from inputs, forward through any hidden units, eventually reaching

the output units. This type of network is said to be static because it exhibits stable behaviour. Feed-back networks are more dynamic as they have bi-directional data flow. With this type of network, data is brought from neurons of an upper layer back to neurons of a lower layer as well as in the traditional feed-forward direction.

A number of researchers have considered the merits of utilizing NN techniques for predicting and ultimately improving GPS performance. Chansarkar [6] successfully demonstrated that a neural network implementation can be used to compute position in a GPS system. An ANN with sufficient training and the correct algorithm can make remarkably accurate predictions. As new raw navigation data is generated and incorporated, the resultant accuracy improves. Jwo [7] demonstrated that the software implementation of an NN-like processor would be able to determine the navigation solution almost instantaneously.

For the cases of intermittent and prolonged signal loss, two solutions may be considered. The first concerns the use of two services provided by the European Space Agency (ESA): EMS (EGNOS Message Server) and SISNet. EMS stores hourly records of GPS correctional data over a significant time period, and this repository is continuously being augmented. Thus an up-to-date repository is available for training a NN and using it to generate correctional data for a future time period. These predictions can then be broadcast to the end user, at regular intervals. In the palaeontology class example mentioned in the introduction, it is envisioned that the lecturer would be able to provide access to this correctional data for the students searching for the rock outcrop.

A second approach that is being investigated is more challenging. This involves the deployment of the actual NN software on the mobile device itself; something that has been unfeasible until recently as NN technologies are notoriously computationally intensive. This NN would monitor both the navigation and correction signals in real-time, and using these signals, prepare prediction models for use during outages of the correctional signal. With this approach, students would be able to search for fossils in their own time, as long as they had the required equipment. Joone [8], a Java framework for developing NN applications, is being used, as this offers the necessary functionality as well as being easy to integrate with legacy Java applications and, in particular, mobile applications.

This project is ongoing and the next stage involves the ascribing of confidence levels to predictions. Following this, the performance of the system on real-mobile devices will be investigated. Performance will be considered from a positional accuracy prospective as well as via dynamic resource monitoring on various mobile devices.

5. Conclusion

An accurate and reliable provision of location information is essential in mobile learning. Ongoing advances in location provision via satellite and telephony offer significant opportunities for enhancing existing field study modules and exercises. However, it is inevitable that there will be places and occasions where such technologies do not function adequately. In such circumstances, the use of Neural Network techniques shows considerable promise as an enabling technology for handling those scenarios where traditional approaches do not always operate satisfactorily.

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