1 Introduction

In the past several years, smart-phones have gotten more and more powerful. The ubiquity of these mobile devices has grown along with their computing power. Conservative estimates from the 2000 Census report state that 10% of US workers will be completely mobile, with no permanent office space.[1] As we progress into the new millennium, it is becoming clear that this trend towards distributed work and social environments will only continue. This distribution is starting to generate increased interest in merging the physical world with the digital, as evidenced by recent work by academic institutions such as MIT.[2] This trend will likely continue, bringing a new dimension to data mining and distribution. However, though the need is certainly present and the technology is likely sufficient in current upper-end smart-phones, the necessary systems for this marriage between the physical and the digital are not yet in place.

What if one could leave behind digital data in physical locations, so that data relevant to an individual about their current environment would be accessible to them at the touch of a button? What if someone could almost literally share their day with others, letting them walk through a virtual representation of the places they went, punctuated with both audio and visual data? What if a parent could get an immediate picture of where there child is, or be alerted early on if a watchful algorithm notes that they may
be in trouble? With the GPS enabled smart-phones, these solutions could soon be reality.

The problem is that although smart-phones have become powerful, their battery life and energy usage remain prime concerns. Most of the possible applications described above will only become commonly available if an efficient means of continuously extrapolating the location of a mobile device can be found. This study will explore methods that can be used to achieve this end.

2 Background

Currently, GPS data can be tracked from the iPhone using an application called InstaMapper. This solution uses a primitive adaptive algorithm to regulate how often data is sent to the InstaMapper server. This primitive algorithm does increase the efficiency of GPS tracking on the iPhone; however there are improvements that could be made. For example, the current algorithm can be exploited to quickly drain a mobile device’s battery since it dictates that the GPS system send data to the server every five seconds if the device’s location is being observed by someone. Also, it does not take advantage of machine learning or probability models, which could be used to predict the path of a user based on an individual’s past travel patterns as well as aggregate patterns. Machine learning could also be used to automatically compress travel data by taking advantage of common travel patterns. Using these methods, it would be possible to create a tracking algorithm that is more secure and more efficient than the one employed by the InstaMapper solution.

3 Method

The iPhone has been chosen as the platform for this study as it is one of the official development platforms of the university’s Center for Mobile Computing (CMCA). Additionally, unlike the CMCA’s other official development platform, the iPod Touch, the iPhone contains the necessary hardware: a GPS system. Finally, the iPhone is popular enough that the deliverable should have a widespread impact.

During the first phase, data will be gathered about the energy efficiency
and resolution of the InstaMapper algorithm by comparing the performance of an iPhone running the InstaMapper algorithm with the performances of an iPhone running an algorithm that sends a continuous stream of GPS data and an iPhone running no GPS program. The capabilities of the on-board GPS system, such as its latency and margin of error, will also be tested at this time.

During the second phase, a secure scheme for transmitting location data wirelessly will be worked out. One of the primary concerns with such tracking systems is that they will be used by less than honorable individuals to cause harm to others. This concern must be addressed before all others. Also during this phase, the interface and overall design of the deliverable will be planned out, and a preliminary energy saving algorithm utilizing machine learning will be created.

During the third phase, better energy saving algorithms will be developed and implemented as new ways of saving energy while still maintaining the appearance of a continuous flow of data to the server are discovered. Movement data will be recorded, fed into a machine learning algorithm, and analyzed for patterns in order to improve the performance of the algorithm. The privacy of the transmission will also be thoroughly tested and improved upon.

During the fourth phase, the deliverable will be implemented using the algorithm developed in phase three. The HCI design created in phase two will also be used and altered during this stage if necessary. Actual users will be observed interacting with the end product and these observations will be noted in the study and used to improve the HCI element of the deliverable.

4 Product

If successful, the end product of this study will be a system that allows users to record their movements throughout the day, and that allows others to remotely view where they are located.

- The program is started on the iPhone and runs in the background until the user terminates it.

- The program sends GPS data to the remote server at the rate dictated by the energy-saving algorithm developed in phase three.
• If a friend of the user wishes to locate the user, they may query the server to find out where their friend is.

• At the end of the day, the user will be able to log on to the server and review their day as recorded by their GPS device. If they choose, they may save this data as a supplement to a virtual entry in a personal journal or as useful training data for others.

This GPS information may also be used in conjunction with a program such as Google Earth to aid visualization, schedule planning, and create “virtual walkthroughs.”

5 Benefits

Being able to stream GPS data from a mobile device in such a way that energy is conserved will open the door for many possibilities. A few of these possibilities are the widespread creation and use of location-sensitive data, enhanced co-ordination between geographically separated people, and the easy creation and sharing of “virtual walkthroughs.” This technology could also prove useful to fields such as sociology, where the simple and easy tracking of the migration patterns of individuals and groups of individuals may provide useful insight into different social phenomena. This could also be used in the field of information systems to create smart planning software that uses past travel data to help maximize the efficiency of a business or individual. Another possible application would be in the field of education. A random passerby or student might notice a strange sculpture or building and inquire their iPhone or other GPS enabled device about it. The device would know their location already and could easily pull up a sizeable chunk of relevant data. The data could be anything, from something as simple as a few lines of text, to a detailed history and analysis of the object, replete with text, pictures, and video. These use cases are only a small handful of the possible applications. Enterprising minds nearly always find many, many innovative ways to use new technology.

Besides these benefits to the world at large, this project could also help generate greater interest in the university as a whole and jumpstart our newly christened Center for Mobile Computing Applications (CMCA). The deliverable would likely prove interesting to many and useful to even more. The research would also be interesting to the Association for Computing
Machinery (ACM) and would likely result in some attention being given to the school in one of their publications by way of a scholarly article regarding this project. Many of the articles in their recent publications deal with the same issues of cyberspace-realspace interaction and mobile computing that this study will be addressing.

Additionally, I would benefit from the opportunity to work with mobile architecture, an opportunity that is not currently available at this institution. The world is fast becoming mobile, and it is important that we become familiar with the devices. This is one of the same reasons that our fledgling CMCA was instated.

Finally, this study will also benefit those who become involved with the CMCA in the years to come. The first generation of those who will be developing for the iPod Touch and iPhone, the CMCA’s chosen platforms, will be inexperienced freshman. By breaking this ground before they enter the CMCA, their transition into the world of mobile computing will be made easier, as this study will generate lot of helpful documentation. Even more importantly, a strong precedent for developing in these environments will have been set.

6 Result

This study will culminate in the release of an Open Source model for creating energy-efficient GPS driven mobile applications, as well as a scholarly article to be submitted to the publications of the ACM.

7 Proposed Budget

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<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>iPhone</td>
<td>The development platform.</td>
<td>$199</td>
</tr>
<tr>
<td>AT&amp;T Data Plan</td>
<td>Apple requires that a two year service contract with AT&amp;T be purchased along with the iPhone.</td>
<td>$840</td>
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<tr>
<td>Student Stipend</td>
<td></td>
<td>$3500</td>
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References


