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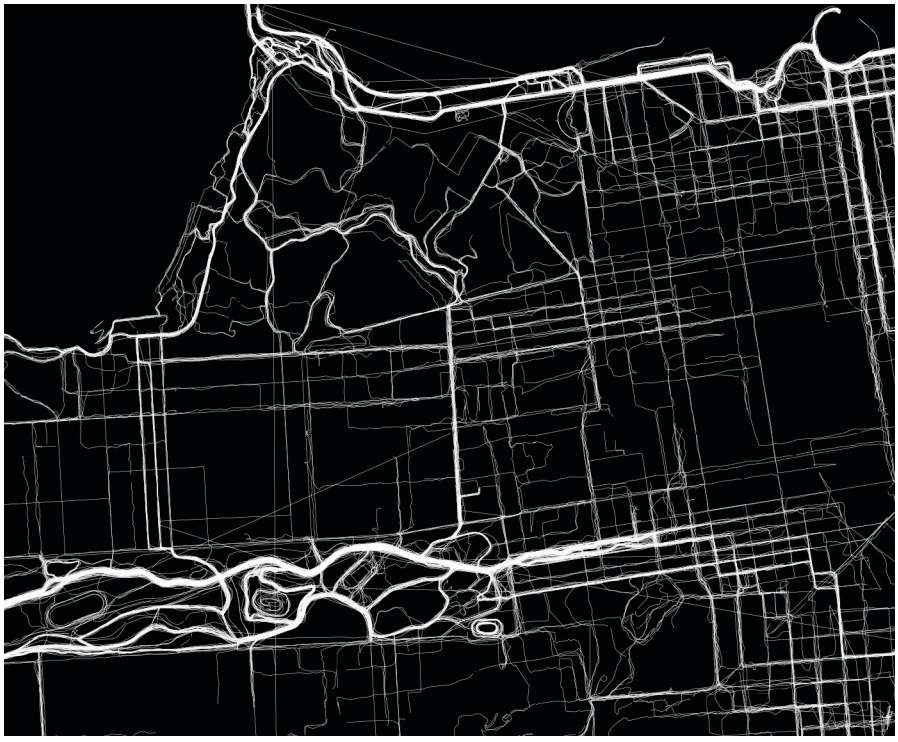
Viewpoint
Is Human Mobility Tracking a Good Idea?

Considering the trade-offs associated with human mobility tracking.

Two years ago, the *Communications* Web site featured a news item reporting on the advances being made in the area of human mobility research.[8] With increasing numbers of smartphones incorporating GPS capabilities, it is now possible to accurately track the locations and movements of individual human beings on a large scale. While modeling and predicting human movement patterns may yield great benefits for mankind, it also has the potential to influence our lives in unexpected and possibly undesirable ways. For this reason, the computing community must carefully weigh the costs and benefits of human mobility tracking, and consider what implications this increasingly common activity may have for our lives and our communities.



A detail of Eric Fischer's visualization depicting MapMyRun public GPS logs from June 13 through August 9, 2011, in San Francisco, CA.

An Invitation to Dinner

Consider the following scenario: After a long workweek, a few of Cho's colleagues invite her to visit their favorite restaurant for a relaxing dinner. Cho tells her friends she will think about their offer, and returns to her office. As the end of the workday nears, a message from an unknown sender appears on Cho's smartphone. She warily opens the message, and is pleased to find a digital coupon that entitles her to a free appetizer at the very restaurant her friends were planning to visit. "Looks like I'm going to dinner!" she thinks to herself. With her digital coupon in hand, Cho walks down the hallway to meet up with her colleagues.

On the surface, this appears to be a winning scenario for everyone involved—Cho gets a free appetizer to share with her friends, the restaurant gets her business for the evening, and the unknown sender of the message earns a modest profit for its targeted advertising efforts. Upon deeper reflection, however, you may feel there is something unsettling about what has happened to Cho. How did the sender know Cho might be visiting the restaurant after work? Has her privacy been violated? Is it unethical or even illegal for an unknown entity to profit from being able to predict her movements?

Tracking Human Mobility

At present, mobile phones provide the best means of gathering information about individual human movements on a large scale.[4] Whenever your mobile phone is on, your wireless service provider records the cellular tower that is currently assigned to handle

VISUALIZATTOIN BY ERIC FISCHER

your requests. Because the service provider knows the location of each tower, it also knows within a certain margin of error what *your* location is at that moment in time. By keeping track of your location, the provider can then easily build a model of your movement patterns.

Until recently, the distance between cellular towers meant that location information gathered from mobile phones was only accurate to within a few hundred meters. The good news for those who wish to protect the privacy of their location and movements is the top four wireless service providers in the U.S.—AT&T, Verizon, Sprint, and T-Mobile—all currently have policies in place to protect customer location information. Indeed, protecting this information may be a point of competition among wireless providers. The latest smartphones, however, include GPS capabilities that allow their locations to be pinpointed with precision. Savvy developers can easily write mobile apps that tie into your smartphone's GPS capabilities, thus allowing parties other than your wireless provider to know your location.

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With accurate GPS data, any of these parties could track, model, or predict your movements, using the results to their own advantage. As the CEO of Google—which makes several GPS-enabled mobile apps—remarked, "We know where you are. We know where you've been. We can more or less know what you're thinking about."[13] It is not difficult to imagine this is what happened in the example scenario involving Cho.

How Predictable Are You?

Many of us like to think we are spontaneous and unpredictable, but in reality this does not appear to be the case. In a study involving 50,000 mobile phone subscribers, researchers found they could, on average, accurately predict the movements of individuals 93% of the time.[12] Surprisingly, the movements of every single person in their study could be predicted with at least 80% accuracy, supporting the conclusion that most of us follow simple, highly predictable movement patterns. Given that this study relied on cellular tower data rather than GPS coordinates, we can soon expect GPS-based models of human mobility that are even more accurate.

This ability to track, model, and accurately predict human movements has important implications for your personal privacy. The reason for this is simple—knowing where you are or where you will be in the near future has value to others beside yourself. Whether it is scientists interested in improving society, corporations interested in profit, or governments interested in enhancing security, knowledge of your movements is a valuable commodity. Given the approximately five billion mobile phone subscribers worldwide,[6] these concerns are by no means inconsequential. It is therefore incumbent upon the computing community to carefully consider how and for what human mobility tracking should be used, as it is we who will largely shape the destiny of this increasingly common activity.

The Good, the Bad, and the Ugly

Human mobility tracking and modeling has great potential to improve the lives of people everywhere. When studied collectively, information about our locations and movements can be used for such noble purposes as reducing traffic congestion, improving urban planning, arresting the spread of disease, or studying interpersonal interactions.[4,9] When coupled with miniature environmental sensors, mobile computing devices with location tracking capabilities can be transformed into nodes on a wide-area sensor network, thus allowing chemical, biological, or radiological hazards to be identified and addressed.[5] We can also benefit directly as individuals from human mobility tracking. Concerned parents, for example, might find comfort in knowing the locations and movements of their children. Similarly, emergency responders could use the GPS coordinates of our mobile phones to come to our aid if we become lost or injured.

Despite the many potential benefits of human mobility tracking, information about our movements could also be used for more controversial purposes. Law enforcement agencies, for example, might track the movements of peaceful protesters, while lawyers might track spouses suspected of infidelity. Insurance companies might adjust your rates based on how often you visit fast-food restaurants, or on how often you exceed the speed limit while driving. Employers might be interested in knowing where their employees go while not at work. As was the case in the example with Cho, marketing companies could also use knowledge of our whereabouts to craft targeted advertising campaigns intended to influence our behavior.

Governments, of course, are also highly interested in knowing our locations and movements. In the U.S., for example, the government has been tracking citizens' international travel patterns for years.[1] Despite several

past failures,[11] federal attorneys continue to argue that the government should be granted access to mobile phone location information without probable cause.[2] Although the courts have consistently rejected these arguments, the implication is clear—governments place a great deal of value on knowing our whereabouts and movement patterns, and are actively seeking a legal pathway to gaining such information.

To Track or Not to Track

As with any new technology that has implications for our personal privacy, human mobility tracking is currently a divisive and highly controversial issue. The future of this activity will therefore depend on how we as a society collectively judge its costs and benefits. On the one hand, concerned citizens, privacy advocates, and organizations such as the ACLU recognize the immense potential for government malfeasance and corporate abuse of this technology.[10] Such concerns should not be ignored or easily dismissed, because the current federal law that governs electronic privacy—the Electronic Communications Privacy Act—does not specifically address human mobility tracking. On the other hand, many scientists, corporations, and individual consumers see immense social and monetary value in this technology. Evidence for this can be seen in the rapid growth of GPS-based services such as Foursquare, Gowalla, and Facebook Places, and in the fact that revenue from human mobility tracking is expected by some researchers to reach nearly $13 billion by 2014.[7]

When coupled with demonstrable scientific and social benefits, the potential for companies to earn so much money from human mobility tracking makes it nearly impossible to imagine a future without it. If the expansion of human mobility tracking is indeed inevitable, then we must collectively be willing to accept the responsibilities that come along with it. First, I believe we owe it to ourselves to further study the impacts of this technology. Further, we must recognize the privacy implications of human mobility tracking, and act ethically when developing location-based services. Finally, we must all remain eternally vigilant against any corporations, governments, or individuals who might seek to misuse or abuse this technology at our expense.

In a sense, we all *choose* to allow these parties to gather information about us.

The Path Ahead

Given the many potentially unethical or otherwise questionable uses to which human mobility tracking might be applied, these activities seem a natural target for legal regulation. Direct government regulation of private-sector human mobility tracking could, however, impede the many efforts in this area that are being directed at genuinely altruistic ends. For this reason, I believe all wireless service providers, mobile app developers, and other computing professionals involved in GPS-based human mobility tracking should take proactive steps toward self-regulation. A good place to start would be the voluntary adoption of a set of principles designed to protect customer location data, such as those proposed in the Wireless Association's *Best Practices and Guidelines for Location Based Services*.[3] Further, although mobility tracking is just beginning to enter the public consciousness, researchers in ubiquitous computing have been studying these issues for several years, and their efforts may prove to be a wellspring of useful ideas. If we as a global community of computing professionals can agree to behave responsibly, then it may be possible to help protect our collective privacy, stave off government regulation, and allow human mobility modeling to develop at a natural pace.

Whether or not researchers, corporations, and governments are able to acquire and benefit from knowledge about our individual locations and movements is largely up to us. In a sense, we all *choose* to allow these parties to gather information about us. By opting to use the mobile technologies and apps that enable our locations and movements to be recorded, we are agreeing, either explicitly or implicitly, to allow others to benefit from our personal information. Once we have lost ownership of our location information, another party may, within the boundaries of the law, use or sell that information for profit without our permission. While for now we might take some comfort in knowing we can flip the switch to "off," the increasingly ubiquitous nature of mobile computing technologies implies they will soon become difficult to avoid.

Conclusion

Ultimately, it appears that if we want to enjoy the many benefits afforded by mobile computing technologies, we must be willing to give up at least some of the privacy that was enjoyed by previous generations. This is, it would seem, the price we all must pay to live in a modern, technology-driven world. C

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