CS 234/334 Lab 2: Continuous Sensing and Battery-life

Distributed: January 15, 2013

Due: Tuesday January 24, 2013 in class. No late assignments.

Overview

This lab will expose you to continuous sensing, its impact on battery life, and thinking the new opportunities continuous sensing presents for mobile applications. ***The lab requires collection of 72 contiguous hours of data, so it is critical that you start right away.*** Its likely that initial "starts" of this period may have setup or collection problems, so its critical to monitor the collection and sample the data to make sure all is going well. Please read all three problems before beginning to work on Problem 1 as the problems are connected, and overall planning may be helpful. Assignments with less than 72 hours of data will receive significant deductions

Problem 1: Hypothesis and Data Collection

We will use the "funf-in-a-box" framework which automates configurable data collection, uploading, and aggregation, allowing rapid prototyping and exploration of behavior. Go to the funf.org website and setup google/dropbox accounts, explore the menus for different sensors, durations, and frequencies for the data collection. Experiment with several different sensors, and sensor data settings, generating applications, and uploading them to your android device. Make sure the data is being uploaded correctly, and that you can successfully unpack it, and put it into a database system or spreadsheet for later analysis in problems 2 and 3.

Funf supports an incredibly wide range of sensors, and very flexible duration and periodicity, so some forethought is needed to design an experiment – and not be simply drowned in a sea of noisy data. You will need to explore different sensor settings, and the data returned by different sensors to understand how to set the settings effectively. It's important to have a hypothesis you're going to test (in a slightly larger area you're interested in exploring) to focus your exploration. Note that its not surprising for the hypotheses proposed by researchers to be wrong in this space! So, don't be afraid to propose something that seems reasonable, make sure the data collection will allow you to draw strong conclusions, and don't be suprised if the results contradict your hypothesis. Here are some examples – but *we encourage you to formulate your own* – either as a variation of these or from scratch.

Scenario #1: Location, Time, and Motion
- Sensors: Location, Motion – accelerometer, rotation, gyroscope, others
- Hypothesis: Physical activity is physically and temporally clustered. Beyond that what can you say about phone activity, other activity, in these clusters? Could you use this to optimize battery life on a Fitbit/Nike+ sensor?

Scenario #2: Usage style, intensity, and Time
- Sensors: Screen, Orientation, running application, location?, proximity?
- Hypothesis: Type of usage depends on time of day, if true, what can you infer about likely other correlated attributes – such as what the smart phones are being used for?

Scenario #3: Wireless Network Coverage and Crowding

Sensors: Cellular and Wifi network, Bluetooth, location
Hypothesis: Users spend most of their time well-covered by cellular, and often with a large number of Wifi networks and Bluetooth devices. How does the number of networks available vary with time of day? Strength of coverage? (how to estimate) With location? How many Bluetooth devices are in range? What does this mean for network crowding, security, applications?

Scenario #4: Mapping a life
Sensors: Location, Social, Motion
Hypothesis: A person's life can be decomposed into a periodic set of activities and behavior strongly structured in location, time, and activity. Can you analyze and identify periodic modes, and explain what fraction of the overall activity they account for?

Scenario #5: Localized Traditional Phone use
Sensors: location, call log, sms
Hypothesis: Traditional phone use is clustered around particular locations in a person's life... and time.

1.a. Design a 72-hour continuous sensing experiment based on a hypothesis, and a set of data sensors, periodicity, etc. Describe the hypothesis. Justify the configuration as sufficient to support/refute the hypothesis. Collect the data. (Hint: check which sensors your mobile device has before deciding on a hypothesis! The API demonstration APK can be used for some of this. Also, if you are collecting wifi and Bluetooth data, you need to make sure these services are "on".)

1.b. Evaluate your hypothesis, based on an analysis of the data, which analyzes several dimensions of complications. Was the sensing intervals and coverage sufficient? Are there sources of noise in the data / did you have to exclude outliers? (presumed measurement error) Are there gaps or lost data? Would your conclusions be stronger if you had the ability to run the experiment for longer? (how long) For a larger population? (how many)

Problem 2: Continuous Sensing and Battery-Life

Continous sensing is widely recognized as enabling a broad range of new commercial applications (i.e. the explosion of interest about health, security, traffic monitoring, etc.), but is also enabling dramatically richer scientific observations – personal behavior, social behavior, habitat/environment. The power of continuous sensing is in its ability to collect data at fine resolution in time, and pervasively – because of miniaturized sensors, the devices can be remarkably tiny. However, battery life remains a critical limit. In this problem, we will use your long-term sensing data (be sure to collect battery level). Be sure to indicate the maximum storage capacity of your battery, and use that number to normalize the energy consumption numbers.

2.a. Using the battery level data, collect the interval information for battery cycling, such as how many times is the device charged in the measurement period? Is there any discernible pattern? What is the peak charge achieved? What is the minimum charge achieved?

2.b. Given the data, what insights can you draw about smartphone battery life? At high activity levels, what types of battery lives are realistic? What types of activity levels and activities are correlated with large energy use? What types of battery life are realistic at

these activity levels?

2.c. Can you estimate the impact of the Funf sensing application on the battery life? (its largely considered to be a little ineffcient). How does it vary with the number of sensors and their frequency and duration settings? It might help to reinstall Funf with only the battery probe or to run a control period without funf running on your device for comparison.

Problem 3: Continuous Sensing and Visualization

A major challenge for continuous sensing data is the presentation of the large resulting quantitities of data. However, visual presentation of the data is often critical not only for analysis and understanding, but also to communicate the insights to others in a clear and concise fashion.

3.a. Take your continuous sensing data, and create a visualization that presents its temporal structure (shows the data evolution over time), perhaps graphs, or inferred paths over a map, or plots of data points. Explain why this visualization is insightful and supports or refutes your hypothesis, and several other insights one can draw from this.

3.b. Create a visualization of the data the presents another dimension of structure for the data, such as location clustering, low-battery clustering, temporal (not linear, but maybe time of day) cluster plots, etc. Explain why this visualization is insightful and supports or refutes your hypothesis, and several other insights one can draw from this.