CSE 199 Activity: Ubiquitous Sensors

Introduction

Form groups of three students (with groups of four as necessary to ensure that all groups have at least three students) with the assistance of your instructors. You will perform this exercise as a group. Scores will be assigned as follows:

Score	Criteria
0	Not present
1	Present, but did not participate in a meaningful way
2	Participated, group answers are correct but minimal
3	Participated, group answers are interesting and well-fleshed, showing thought about the scenario and its implications. At least two thoughtful positive and two thoughtful negative points are listed for each scenario.

Directions

Recall our in-class discussion of sensor and communication technologies, and products such as the Google Nest thermostat or Amazon Echo. In this activity, you will explore the implications of ubiquitous physical sensors — both good and bad — in several scenarios. Consider the obvious implications, but try to brainstorm some less obvious implications as well. Your group should spend about ten minutes per scenario, and record your best and most interesting ideas for each scenario.

Example Scenario

Consider a simple connected HVAC (heating, ventilation, and air conditioning) system in a private home. It collects temperature readings from several points around the house, and can direct warm or cool air to the "zones" containing those points. For example, perhaps there is a temperature sensor in each bedroom, a sensor between the kitchen and dining room on the first floor, a sensor in an upstairs hallway, and a sensor in the basement. The HVAC ducting in the walls has gates between the blower and each of the bedrooms, as well as a gate for each floor. The HVAC controller controls a heat pump that can produce warm or cool air, as well as the velocity of a blower that pushes this air through the ducting.

This system is connected to the Internet, and allows the homeowner to configure each temperature zone, set schedules, override the saved configuration temporarily, monitor the energy use of the system, *etc.*

What are some helpful features this system could provide?

Example response: By watching for localized temperature changes versus whole-house changes, the system may be able to save energy by cycling the blower without engaging the heat pump if only some parts of the house are warmer than others, but the overall temperature is near the set points. The system could also monitor for localized temperature changes that require running the heat pump, and notify the homeowner on a smart phone or other device that perhaps a window was left open or a power-hungry device was left active.

What are some problems that could arise if an unauthorized person could access the temperature data?

Example response: Suppose the homeowner enjoys cooking, and prepares a nice meal at home several nights a week using the stove and oven. It is likely that, at least in some seasons, the temperature sensor near the kitchen would register a rise in temperature that was not reflected on, say, the bedroom sensors during this cooking. A malicious observer might notice this (perhaps by writing a program to look for occasions where the sensors do not follow a similar trend) and note that it usually happens at around 6 P.M. a few times a week. By monitoring for weeks when this does not occur, the attacker may be able to identify that the homeowner is away for an extended period of time.

1 Connected Vehicle

Think about a modern, connected automobile that has an in-dash computer providing a variety of features utilizing Internet connectivity, as well as a security and emergency response system capable of automatically contacting the manufacturer in the event of theft or an accident. Between them, these systems have a high-speed mobile data connection, a generous touch screen display, and the following sensors:

- In-cab microphone for phone or emergency audio
- GPS/Galileo/GLONASS global position
- All information available to the instrument cluster (speed, engine temperature, crankshaft RPM, *etc.*)
- Back-up camera

To collect some of this data, it is connected to the data bus on which the emission control and engine control systems communicate with the engine and its sensors. It controls the in-cab entertainment, and is connected to the speaker system.

What are some helpful features this system could provide?

What are some problems that could arise if this system were compromised? Do any of them endanger human life or limb?

Traffic cameras

An intersection in a commercial district has traffic cameras mounted on the poles supporting the traffic signals. They have radio-frequency speed detectors, infrared cameras for nighttime photography, and visible light cameras for daytime photography. They are used to capture images of the intersection for traffic enforcement, such as speeding vehicles or vehicles failing to stop for red light signals.

The cameras are capable of continuous video capture, but images are stored only when a notable event (determined by the firmware) has occurred. Images, along with vehicle motion data from the speed sensor, are transmitted to a city database via a metro-area wireless network for enforcement.

There are several businesses around the intersection, including:

- A bank with a walk-up ATM
- A drugstore
- A women's health clinic
- An auto parts store

The cameras are not positioned to specifically view these businesses, but portions of the building façades are visible to some cameras, as well as on-street parking in front of the buildings.

Is there any administrative or law enforcement information these cameras could provide other than on moving violations?

Are there privacy concerns with this system? How might they be exploited?

Inventory Management

Imagine a large retail company that has aggressively optimized its operations to minimize the amount of time handling individual products and prevent loss to mishandling or theft. It has large distribution warehouses that receive products from their manufacturers or primary distributors, and they are shipped to individual retail stores from there. Every product is required to be either supplied from the manufacturer with an RFID tag that can be read from a short distance away by automated machinery, or have such a tag affixed upon arrival to the distribution warehouse. These tags are capable of minimal computation, and can change the data they report based on authenticated commands from company-owned machinery.

Tag reading machinery is then set up to read entire trucks as they enter and exit the warehouse or loading docks at the retail locations, and at the registers and retail entrances of the stores. Additional readers are placed in strategic positions around the store so that the motion of goods through the store can be tracked; *e.g.*, a toy is picked up by a consumer in the toy department, then read as it crosses the store through home goods to the grocery and out toward the registers. At the register, goods are checked out by RFID rather than UPC, and entire baskets or carts of goods can be scanned and checked out automatically without passing them over a bar code scanner. All of these readers and writers are automatic systems reporting over the network to a central inventory management server.

When checkout is complete, the RFID tags are sent a command to deactivate, and the customer exits the store with tags that do not respond on the way out.

Aside from the obvious rapid checkout and loss control, how might the information from these systems be used to improve store management?

What problems could such a system, using wireless communication and automated tracking points, introduce?