SmartPills

• Detect the number of pills in the bottle, based on high-precision weight measurement combined with an accelerometer.
• Send usage information from the bottle to an Android App, and Configuration commands/data from the App to the bottle
• Unlock the bottle based on fingerprint scan.
Component Breakdown

• Processor
  – mbed LPC1768

• Sensors
  – Accelerometer (ADXL345)
  – 100g Load Cell
  – Fingerprint Scanner (GT-511C3)
Component Breakdown

• Actuators
  – Servo for locking mechanism

• Communication
  – BLE BlueSMiRF Family
Module Breakdown

• Mechanical structure of the bottle and hardware integration (Josh/Parsa)
• Number of pills detection (Josh/Parsa)
• Bottle safety (locking/fingerprint scanning) (Gil)
• Software architecture (Gil/Vicenc)
Mechanical Structure
Unlocked Bottle
3D Printed Prototype
Enclosed Circuits

BLE

Amplifier

mbed

Accelerometer
Load Cell
Amplifier

- Instrumentation amplifier to measure voltage difference between outputs of load cell
Amplifier
Load Cell Summary

• Load cell is much more repeatable than FSR
• There is no creep like with the FSR
• We tuned the gain of the instrumentation amplifier to get the dynamic range necessary to measure individual pills
• Pill weighs about 770mg, 12-bit ADC can measure differences of 0.8mV
• Currently amplifying to about 48 mV/gram = 36mV/pill = 45 adc-units/pill
Bottle Safety

• Only authorized users allowed access to the pill bottle.
• Bottle is locked until a verified fingerprint scan is detected.
• Servo attached to the cap of the bottle, automatically opening after successful identification.
Bottle Safety

• GT-511C3 only responds to commands, must be periodically polled to check if finger is pressed.

• Bottle only “wakes up” the fingerprint scanner after an interrupt from the accelerometer/button wakes it up.

• Fingerprint enrollment initiated by command from Android app
Controller FSM

- **INACTIVE**
  - Activate / Turn on Scanner
  - true / update Android
  - deactivate / Sample Load Cell

- **Wait for Identification**
  - Activate / Turn on Scanner
  - Identified / unlock
  - Counter = 20 / turn off scanner

- **CLOSED**
  - Activate / cancel timer
  - Counter = 20 / lock
  - Reset / Turn on Scanner

- **OPEN ACTIVE**
  - Activate / cancel timer
  - Inactivate / Start timer

- **SAMPLE INACTIVE**
  - Inactivate / Start timer
Software Architecture

• Leverages the mbed-rtos, based on the RTX implementation of the CMSIS-RTOS API.
• 3 threads - Controller, BLE communication, GT-511C3 scanner
• Communicating via RTOS queues.
• All threads are based on a common FsmThread class, implementing an event loop that demultiplexes events in sub-classes.
Software Components

- ScannerFsm (fingerprint sensor), based on a GT-511C3 library by Toshihisa T.
- AdxlModule (accelerometer control), based on the ADXL345 library by Aaron Berk. This module programs the ADXL to drive ACTIVATE/INACTIVATE interrupts.
- Servo module, based on a library by Simon Ford.
Software Components-LoadCell

- Calibrated once on empty by measuring the last voltage bias.
- During each ADC measurement doing average of 10,000 samples.
- Saves history of measurements, sends it to the Android when it pairs.
Android Application

• Android code:

- Modified version of BluetoothChat sample code provided in Eclipse IDE.
- Code distributed under Apache License v2.0.
- Usage compliant with License.
Android Application
Communication

- Message Structure:
  1.) Header = 4 bytes (0xCCCCCCCCC)
  2.) Type = 4 bytes
  3.) Length = 4 bytes
  4.) Payload = (Length) bytes [mult. of 4]
Communication

- Message Types From Android to MBED:
  1. RequestCalibrateMessage
  2. RequestEnrollMessage
  3. SetWeightMessage
  4. RequestUnlock
  5. RequestHistory
Communication

• Message Types From **MBED to Android:**
  1.) NewSampleMessage
  2.) AcknowledgeEnrollMessage
  3.) RequestRemoveFingerMessage
  4.) RequestPressFingerMessage
Things that could be improved...

• Noisy load cell measurements
• Fingerprint sensor is not very reliable
• With a PCB, we could drastically reduce the size of the mechanical design
• Android App could have enhanced user interface
• Add pill usage metrics
Demo

Watch our demo on youtube!
Thank you!
Any questions?