Research Paper Analysis 3/5/17

Touch & Activate: Adding Interactivity to Existing Objects using Active Acoustic Sensing

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Main Idea: Discusses how signal processing can be used to make an object interactive depending on where the user is touching the object

Sensing:

- Objects each have their own resonant properties (resonant frequencies, natural frequency)
  - Depends on what material, shape, etc. that the object is
- Resonant property changes when an object is touched
- Vibrate the object at a wide frequency range, capture the frequency response using a sensor (accelerometer or piezo-electric microphone), then use Finite Element Method (FEM) to calculate details (machine learning technique)

Hardware Used:

- Piezo-electric vibration speaker - Thrive OMR20F10-BP-310, 0.3mm thick, 21mm diameter
- Piezo-electric microphone - Murata 7BB-20-6L0, 0.2mm thick, 20mm diameter
- Attached to the objects with double-sided tape
  - Would recommend for final prototypes using some sort of glue to keep the devices snugly attached to the container (we may switch this out though if we are trying to do something more portable)

Software Used:

- Sweep Signal Generator - sweeps from 20kHz to 40kHz (inaudible to humans) at a 96kHz sampling rate
  - Option 1: SciPy signal generator: https://docs.scipy.org/doc/scipy-0.14.0/reference/generated/scipy.signal.chirp.html
  - Option 2: Signal generation through MATLAB: https://www.mathworks.com/help/signal/ref/chirp.html
- FFT Analyzer - converts vibrations captured by microphone to resonant frequency response
- SVM Classifier - uses a Support Vector Machine to classify each gesture
  - Option 1: LIBSVM, which was used to classify touch in this study: https://www.csie.ntu.edu.tw/~cjlin/libsvm/
  - Option 2: SVM library in SciKit Learn, a Python machine learning library: http://scikit-learn.org/stable/modules/generated/sklearn.svm.SVC.html

    - Option 3: Processing using MATLAB: https://www.mathworks.com/help/stats/svmtrain.html?requestedDomain=www.mathworks.com
- BASS Library - used for Audio I/O (a .NET library): http://bass.radio42.com/

Additional Things to Consider:

- This paper does not mention/they did not consider how the resonant property would change if there is anything inside the object, so this is something that we would have to test out.
- Elastic modulus of the material (such as gels and clay) didn't work as well for touch sensing
- We need to ensure that our piezoelectric elements are strong enough to be able to transmit the signal and listen across the size of our container
- Symmetrical objects didn't work as well for touch sensing, you'd have to offset the elements a little bit. However, since we are not doing touch sensing this may not be an issue.

Microcontroller Based Automated Water Level Sensing and Controlling: Design and Implementation Issue

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WCECS 2010 Conference in San Francisco, USA

Paper: http://www.iaeng.org/publication/WCECS2010/WCECS2010_pp220-224.pdf

Main Idea: Development of a custom water level sensor that can communicate data online to develop a web and mobile-based monitoring service

Sensing:

- Custom sensor connected to microcontroller that is able to detect water level
- One sensor is placed on the reserve tank
- Four sensors are placed inside of the tank (this would be an issue in our implementation)
- Sensors composed of iron/steel rod, which is connected to ground, and nozzles, which are connected to +5V

Hardware Used:

- PIC 16F84A Microcontroller
    - Product link: http://www.microchip.com/wwwproducts/en/PIC16F84A
- Sensor circuit
- Crystal oscillator (XTAL) 4MHz

Software Used:

- PIC16F84A's microcontroller assembly language
- MPLAB software: http://www.microchip.com/mplab/mplab-x-ide
- Data acquisition server converts data into XML format

Things to Consider:

- This paper focuses more on the hardware setup of their particular microcontroller, and how they configured it to analyze water level monitoring.
- This paper relies on having some sort of reserve tank as well as being able to put the sensors inside of the tank. These are not things we were planning on implementing, since we plan on being able to have many of these devices for many containers, but we can consider using either a reserve tank or placing sensors inside the tank if need be.

Additional Paper:

Acoustic Clamp-On Liquid Level Detection in Case of Transducer Misalignment

Link:

http://ac.els-cdn.com/S1877705815024583/1-s2.0-S1877705815024583-main.pdf?_tid=a63ad9d8-0295-11e7-aa10-00000aacb362&acdnat=1488822922_e15c4f84dfd632d8e18dcccf62fd6123

Main Idea: Unlike the first two papers which focus on the development of a unique system that are able to monitor touch and water levels, respectively, this paper imagines a case very similar to ours. They consider non-invasive fluid level monitoring systems (such as ours) and provide a mathematical analysis warning about potential misalignment and lack of accuracy depending on where you place the sensor.

- In the case of misalignment, the author suggests that: “ In the range of the beam spread, the angle of misalignment (also tilt angle in the following) can be identified and the sound propagation path and corresponding roundtrip time - used for level estimation - corrected by using a simple linear triangulation with at least three single transducers.”