Wind Sensor Final Presentation

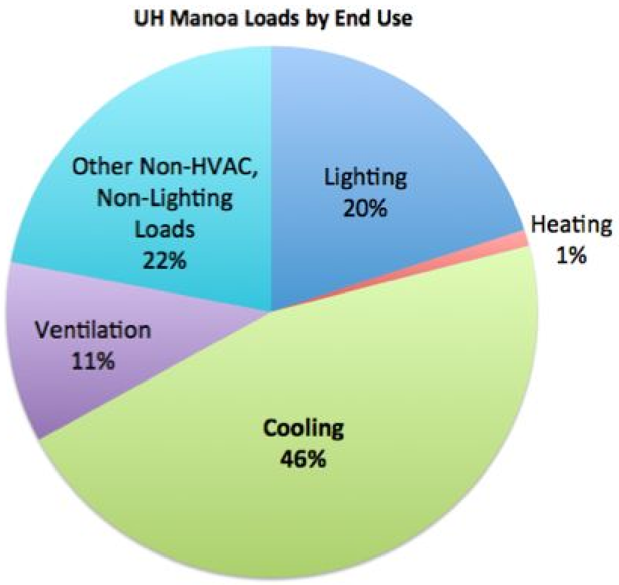
Daisy Green
Jeremy Garcia
Keoni Davey
Advisor: Dr. Anthony Kuh

REIS
RENEWABLE ENERGY & ISLAND SUSTAINABILITY

College of ENGINEERING
UNIVERSITY OF HAWAI'I AT MĀNOA

Motivation

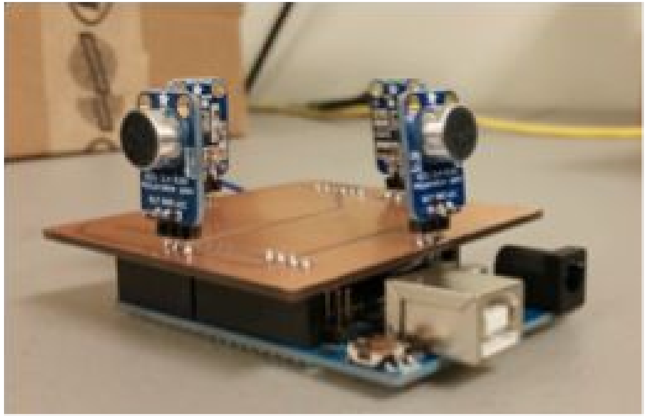
- The costs of air-conditioning and cooling at UH Manoa are high.
- The electricity use for cooling uses 46% of the energy on campus.
- Knowing wind speed and direction can aid in the planning of buildings for natural air ventilation to lower energy use from air-conditioning.



Project Background and Goals

Objective: To build a wind sensor that is low cost, small, reliable, durable, and has no moving parts that detects 2D speed and direction.

- Current design uses four microphones

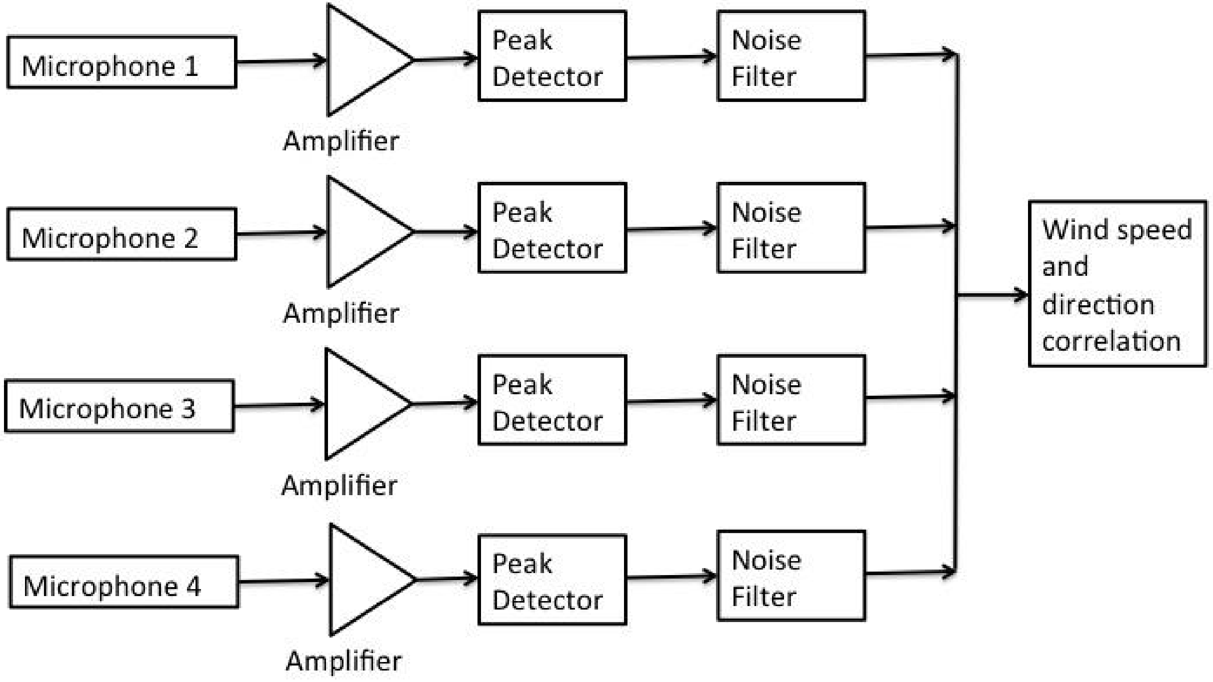


Goals:

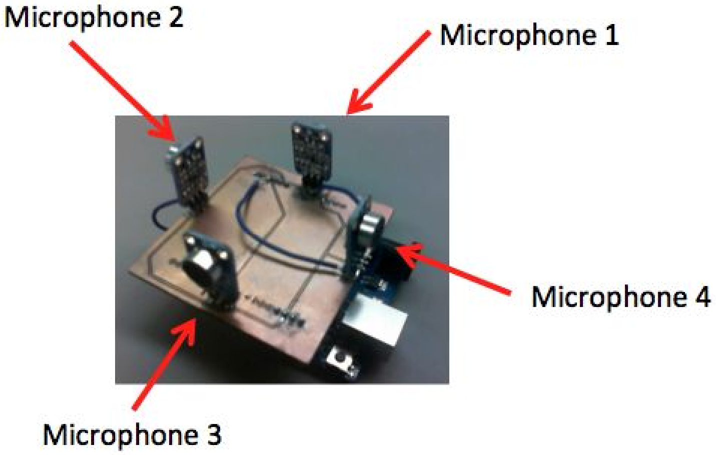
Short term: Have a working wind sensor that can detect 2D wind speed and direction

Long term: Integrate to weatherbox to put on rooftops around campus

Block Diagram - Overall System



Description of Overall Design



Wind speed and direction are outputted as:
“Amplitude at angle theta from mic A to mic B”

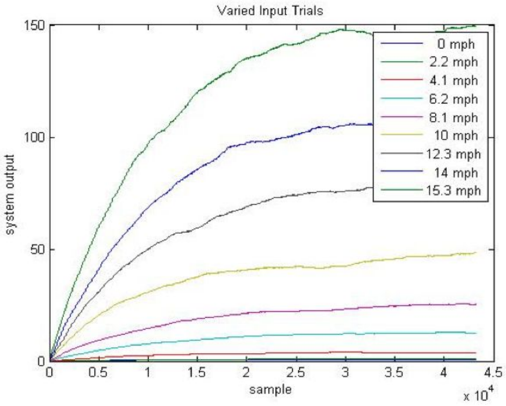
- Use the amplitudes from the four microphones and our developed algorithms to get the predicted wind speed and direction

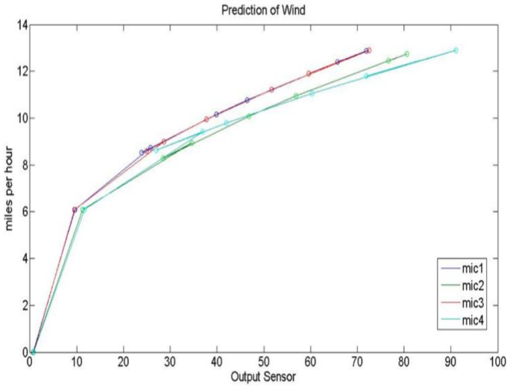
- Costs:
  - 4 x $6.95 for microphone and amplifier breakout board = $27.80
  - 1 Arduino Uno = $24.95
  - Total cost = $52.75

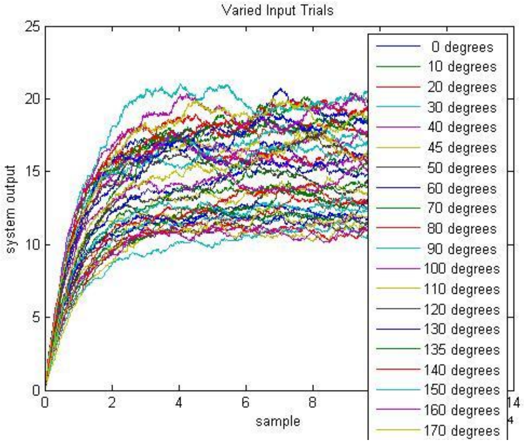
Testing

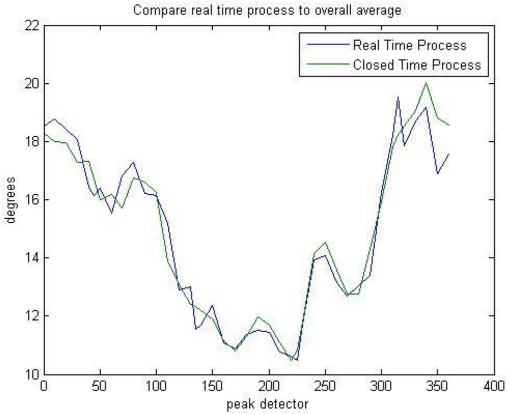
- Raw analog testing
  - Used Arduino analog output to record data for 1 minute
    - Single microphone:
      - Amplitude and angle tests
    - Four microphones:
      - Amplitude and angle tests
- Real time testing
  - Used analysis from analog testing to create algorithm
  - Arduino gets analog data, then processes it and outputs the predicted wind amplitude
- Testing effect of delay
  - Delay must be used when sampling with four microphones
  - Compared effect of different delays on processed results

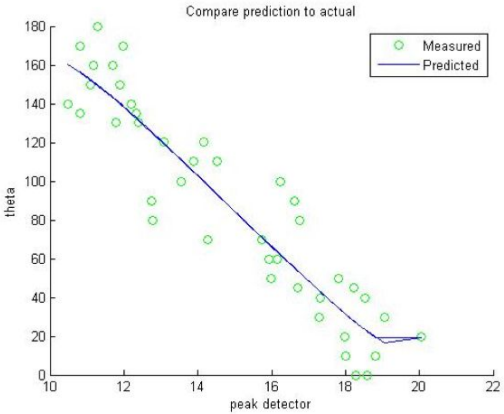
Methods and Procedure











Problems and Solutions

- Problem: Arduino can not read from multiple analog outputs simultaneously
  - Solution: Insert a 1 Microsecond delay in between readings
    - Problem: Down-Sampling/sampling slower causes Aliasing, and sudden changes in winds can't be tracked as fast.
      - Remedy: Lower parameter of moving average
- Problem: High values at low speeds
  - Remedy: Manually fit, fitted equation so 0 maps to 0 and maximum low value fits minimum high value.
- Problem: Mic's actually read louder sounds at certain offsetted angle compared to directly, thus predictions are off if not facing toward a mic and you can't detect angle from the most directed fan.
  - Solution: Detect angle as opposite from worst mics.
  - Solution: Fit the gain vs angle, and then divide the output by the gain of the predicted angle.

Final Status of Project

- Completed this semester:
  - Made a testing station that can rotate 360 degrees
  - Designed a testing PCB board that can test the four microphones
  - Wrote an Arduino code that can get the raw analog data from the four microphones at one time
    - Includes a delay in between each microphone
  - Wrote an Arduino code that can process the data in real time from the four microphones
    - Gives us an amplitude output for each microphone
    - Wrote a test code that gives predicted amplitude and wind speed from those four outputs
    - Wrote a prototype of equation that senses direction with all 4 mics.
  - Updated all documentation, with commented files and functions uploaded to Dropbox

Remaining Problems

- Inaccurate for 0 to 6 mph
  - Not enough data for those speeds
  - Difference in in the output is too small
- No data for over 15 mph
  - Can not test accuracy of these speeds
- Difficult to test reliability of prototype
  - Not able to record real-time results from anemometer we use for calibration, so we must estimate
- Limitations of the Arduino
  - Can only take input from one mic. at a time

Future Improvements

- Use an RMS to DC converter chip in hardware to reduce computation in software
- Build a housing for the wind sensor
- Look more into the frequency domain
- More testing with angles and speeds higher than 15 mph
- For low speeds (less than 6mph) use an amplifier with higher amplification so that low speeds can be distinguished
- Faster chip for sampling
- Filter random outdoor noise

Questions?