TAMPERE UNIVERSITY OF TECHNOLOGY

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Low-cost ultrasound measurement system for accurate detection of container utilization rate

MIPRO2018

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Introduction

- Waste management company wanted to know the utilization rate of its containers
- The aim was to develop this process so that the surface level of the containers could be monitored via a cloud service
- The ultrasound technique was found to be suitable to this case

Introduction

- Distance measurements with an ultrasound sensor are based on transducer technology
- Temperature is the most important environmental factor
- A reliable ultrasound measurement system prototype based on open source and low-cost components
- The prototype was expected to be able to measure within a margin of error (10 mm) given by the company

Background

- The topics related to this study was searched mainly using Google Scholar and Researchgate network services
- The objective was to find an ultrasound sensor suitable for use with the Arduino Uno and the Raspberry Pi 3
- Three papers was chosen because they contain same ultrasound sensor

Background

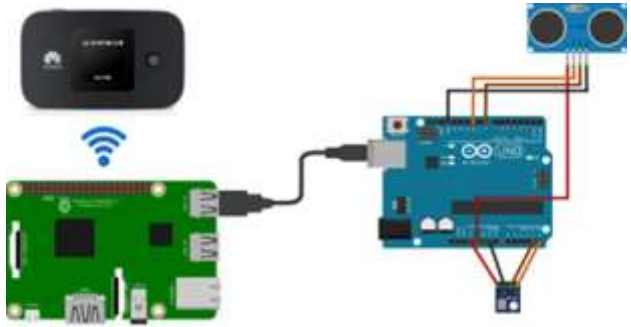
- Saraswati et al. did not take temperature into account and got largest systematic error of -4 cm
- Suleiman et al. did take temperature into account and got largest systematic error of 2 cm
- Nakatani et al. did take temperature into account and got largest systematic error of -8,9 mm

Measurement system

- The measurement system consists of a Arduino Uno, Raspberry Pi 3, HC-SR04 ultrasound sensor, BME280 temperature sensor, and a Huawei 3G / 4G wireless modem
- Affordability, low power consumption, size, customizability and cost-effectiveness

Measurement system

- Devices
- Raspbian
- Libraries
- Python



Experiments and analysis

- The measurement was carried out at a temperature of 5.4 to 5.6 ° C and the humidity remained between 77.2 and 79.8 %
- The average systematic error of the results was -2.0 mm and the largest systematic error is -8.3 mm

Experiments and analysis

- Welch's t-test analyze the means of the two independent groups
- Measurement error could be met at a risk level of 0.05 when the tolerance should be increased to 9.0 mm

Measurement error	Risk level		
	0.05	0.01	0.001
3,0	36 (75.0 %)	33 (68.8 %)	31 (64.6 %)
4,0	38 (79.2 %)	34 (70.8 %)	34 (70.8 %)
5,0	45 (93.8 %)	43 (89.6 %)	41 (85.4 %)
6,0	44 (91.7 %)	43 (89.6 %)	43 (89.6 %)
7,0	45 (93.8 %)	45 (93.8 %)	44 (91.7 %)
8,0	46 (95.8 %)	46 (95.8 %)	46 (95.8 %)
9,0	48 (100 %)	46 (95.8 %)	46 (95.8 %)
10,0	48 (100 %)	48 (100 %)	48 (100 %)

Discussion and future research

- The aim was to test the accuracy of the results that the system produces. It can be said that results were accurate enough for the use case
- As a future study, measurements could be made using multiple sensors, different surface materials, shapes and temperatures

Conclusion

- Prototype met its goal of staying within a margin of error of 10 millimeters when measuring the utilization rate of waste containers
- The result of the study is that it is possible to implement a reliable and accurate ultrasound measurement system with low-cost components