Contextually Aware Autonomous Wheelchair

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Abstract

In partnership with the Taskar Center for Accessible Technology, students at the University of Washington in Seattle are designing and building an IoT device. The device is intended to collect and provide environmental data to the Taskar Center's Autonomous Wheelchair.

Introduction

The Taskar Center's Autonomous Wheelchair is a wheelchair that can be driven autonomously. It uses special routing software to navigate public spaces depending on the user's mobility needs. However, to navigate intelligently, the chair requires environment sensing to drive contextual awareness. The contextual awareness sensor module feeds the wheelchair's on-board computer to aid in decision making for navigation.

The sensor module has an array of sensors for collecting the data. This data will allow the wheelchair to know when to reroute to avoid things such as air pollution, loud noises, UV radiation, sharp inclines, and more. The great thing is that a user would be able to select what their level of comfort is with certain factors, and the wheelchair will use its contextual awareness sensors to minimize the rider's exposure to these factors.

The data being collected will also be uploaded to the cloud in order to support deeper analytics. By collecting this information from an autonomous wheelchair, the team at Taskar can design map information that is more specific and accurate than what is currently available on the market to date.

Table 1. System requirement & specification

Environmental properties	Sensor name	Measurement	Interface	Range
Temperature	BME280	Degree Celsius	I2C	-40 to +85 °C
Humidity	BME280	Humidity percentage	I2C	0-100 %
Light	SI1145	UV index	I2C	0-11
Air quality	CCS811	CO2 ppm	I2C	400-8192 ppm
Surface condition	L3GD20H+LSM303IMU	Pitch, roll, yaw degrees	I2C	-90° to 90°; -90° to 90°; 0° to 360°
Location	Ultimate GPS breakout	Latitude, longitude degrees	UART	-90° to 90°; -180° to 180°
Sound noise	Sparkfun sound detector	Loudness	Analog	0 to 1023
Distance	KY-003 Hall sensor	Magnetic field detection	Digital	0/1

Technical Approach

Data Acquisition

- Used Arduino Uno as our development board
- Added Arduino Prototype shield to connect the sensors
  - Soldered male jumper wires into the custom shield
  - Plugged sensors into the other female ends
  - Allowed sensors to be detachable
- Provided a 5V portable power bank to supply power
- Designed embedded software for the controller
  - Initialized all the sensors
  - Acquired data from sensors continuously
  - Sent the data to a WiFi module

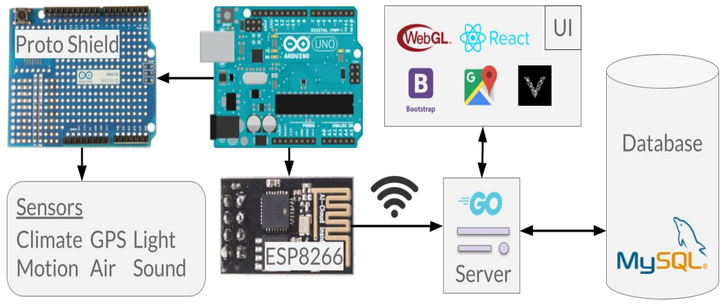


Figure 1. component diagram

IoT Framework

- Incorporated a WiFi device, ESP8266
- Pushed the sensor data in a HTTP POST request in JSON form
- Built a server to process the events
  - Loaded the events into a database
  - Hosted a UI webapp with visualizations

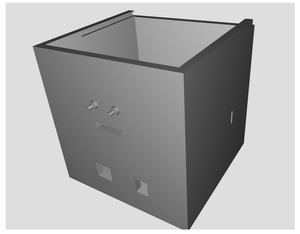


Figure 2. box cad model

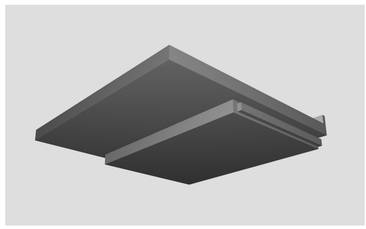


Figure 3. lid cad model

Box Design: We design a box without any screw holes and use 3D printing to print it out. We need to take sensors off repeatedly to debug, so a box without screws is an appropriate choice. Instead, we design the lid to be detachable which fits our desire. We create rod like thing on the box for each sensor so we can plug them in the like buttons. The box is flat on the back so it's easier to mount it on a chair.

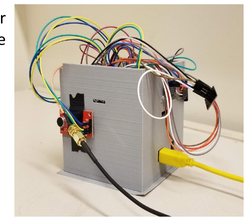
Results

Figure 4. HTTP entity

```
POST /sensor HTTP/1.0
Host: 10.19.74.124:3027
Accept: */*
Content-Type: application/json
Content-Length: 512

{"data":[{"name":"hall","value":1},{"name":"sound","value":47},{"name":"roll","v
alue":86.90},{"name":"pitch","value":-2.19},{"name":"head","value":333.03},{"nam
e":"eCO2","value":150},{"name":"VOC","value":0},{"name":"temp","value":20.44},{"
name":"humid","value":51.94},{"name":"visible","value":262},{"name":"IR","value"
:262},{"name":"UV","value":0.03},{"name":"lat","value":0},{"name":"lng","value":
0}],"time":"2000-2-1 00:00:00"}
```

Figure 5. sensor appliance



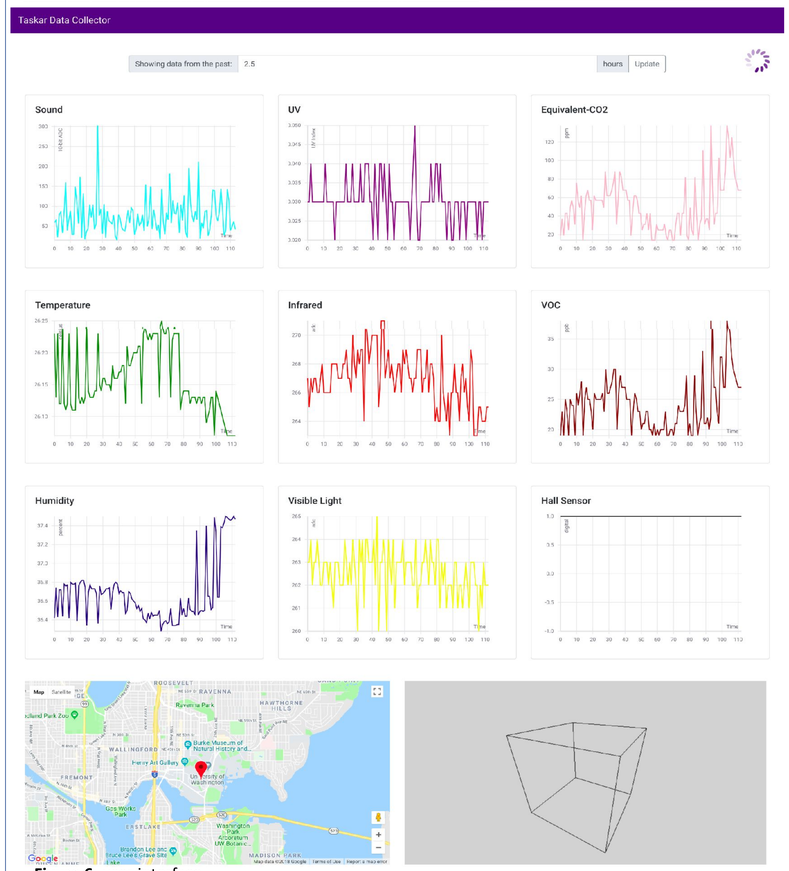


Figure 6. user interface

Conclusions

We design a contextual awareness sensor module for Taskar Center's Autonomous Wheelchair. The sensor module takes care of the temperature, humidity, light condition, air quality, surface condition, and sound noise around the wheelchair. Our design includes software and hardware components for collecting data, a container box to hold our devices, a user interface that provides continuous data plots for analysis.

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