Project Portfolio

2020-23

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Final year

Bachelor of Mechatronics Engineering (Honours)

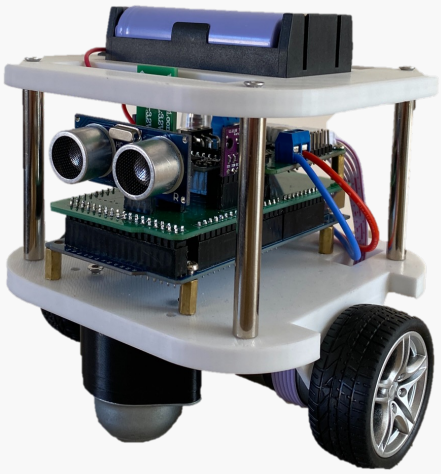
Master of Biomedical Engineering

The University of New South Wales, Sydney

Autonomous Micro Mouse

2023

Summary

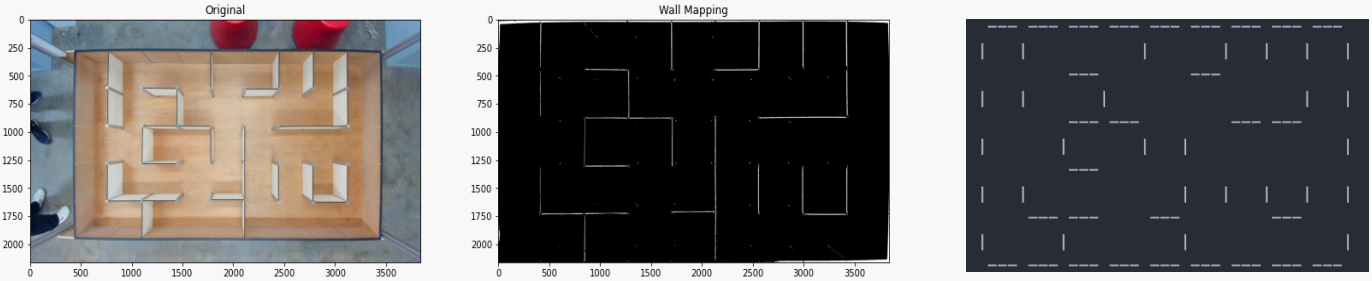


- Autonomous robot which could explore a maze and find the shortest path to a given goal
- Robot design with microcontroller and custom chassis using CAD and 3D printing

Methods

1. Derived a matrix representation for the maze from an existing image using OpenCV (Python)
2. Graph of the maze's connected cells generated from the matrix
3. Shortest path algorithms to solve maze to a given goal
4. LiDAR and IMU to localize robot within maze cells
5. PID movement control with sensor feedback (C++)

Results



Original Image → Masked Image → Ascii Representation

Notable Challenges and Solutions

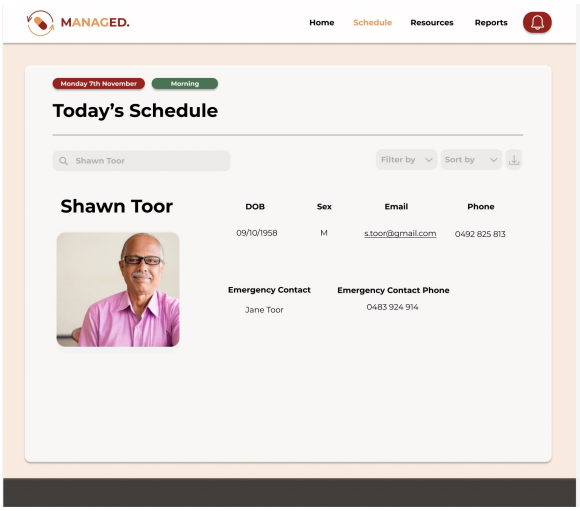
Challenge	Solution
Many loose jumper wires required for each sensor and motor driver	Implemented a PCB centered design to eliminate the need for wires. Sensors connected to PCB via header pins
Difficulty driving straight using only wheel encoder counts	Sensor feedback from an Inertial Measurement Unit (MPU6050) to correct heading using a PID controller
Ensuring Robot does not crash into the walls of the maze	Sensor feedback from onboard LiDAR's and Ultrasonic Sensors to avoid collision
PID Tuning to drive forward specific distance and maintain constant heading during movement	Systematic approach to adjust Kp, Ki and Kd to ensure fast settling time whilst avoiding overshoot
Large main function in Microcontroller program	Separating sensor functions into separate classes and passing by reference to call sensor methods

Patient Management System

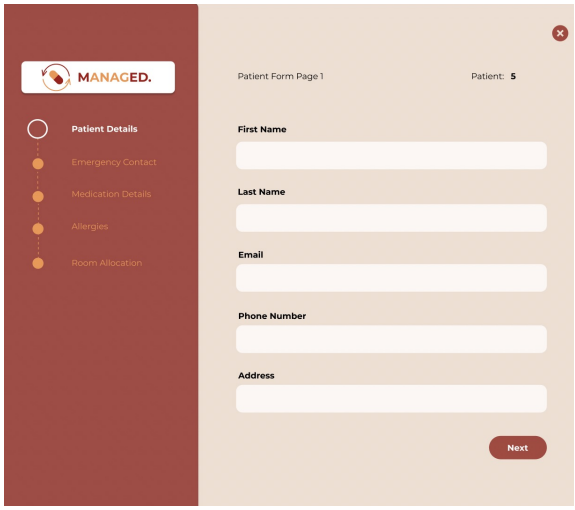
2022

Summary

- Design and implementation of a Patient Management System for a fictitious nursing home.
- The system is displayed to a practitioner in the form of a webpage, where the practitioner can view and edit a patient's health and nutrition plans and requirements for the day.



Patient Summary Page



Patient Registration Page

Methods

1. Database design using Microsoft Access with authentication and access rights
2. SQL queries to fetch data
3. Website planning using and design using Figma
4. HTML/CSS for website aesthetics
5. Project management with appropriate milestones (Gantt Chart)

Notable Challenges and Solutions

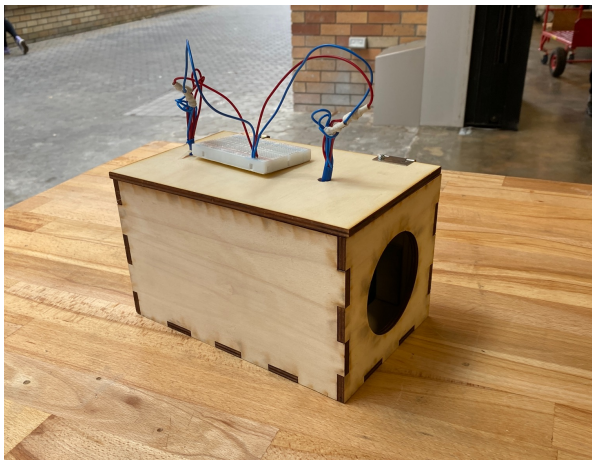
Challenge	Solution
Database design to link a patient's ID to all their information and requirements.	Design of database using Third Normal Form (3NF). Appropriate use of Primary and Foreign Keys to link table information (such as nutrition requirements and allergies)
Integrating database contents into the webpages	SQL Queries made using PHP through an ODBC connection to retrieve data from the database
Scaling web elements for multiple screen sizes	Dynamic styling using CSS to scale elements relative to screen width
Authenticating login user	Login flag in database to check if the user is logged in. Upon login, the flag is updated if access rights permit

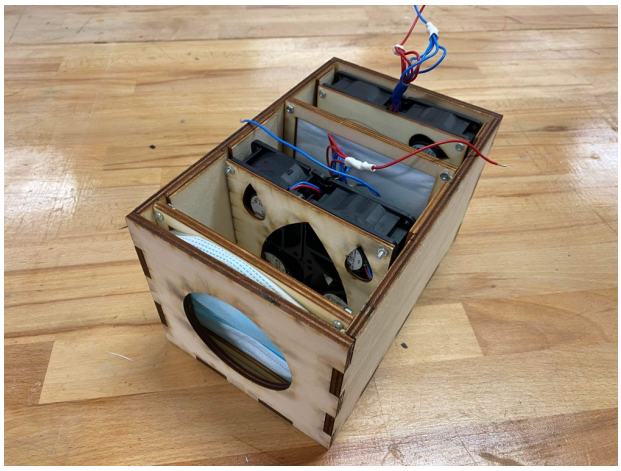
PanBox (Engineering World Health)

2022

Summary

- Extracurricular Engineering Program with Makerere University in Uganda through Engineering World Health to develop a low-resource solution to dust filtration in oxygen-concentrators in Ugandan Hospitals. Currently no solutions designed specifically for dusty environments, in built filters are hard to reach
- Created external filter unit with universal design
- Strong focus on rapid prototyping with limited materials and collaboration
- Exceptional participation in this program landed my role as a Makerspace Ambassador at UNSW





Methods

1. Understanding of various challenges other countries experience due to products being designed for use outside of their country
2. Organised group meetings and discussions for creative solutions to prototype a proof-of-concept design
3. Hands-on experience with tools and materials to rapidly prototype the filtration unit with limited materials
4. Validated design using dust and tissues to test suction properties

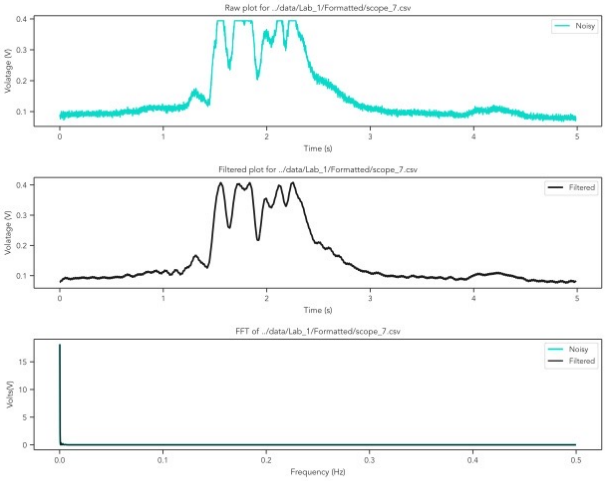
Notable Challenges and Solutions

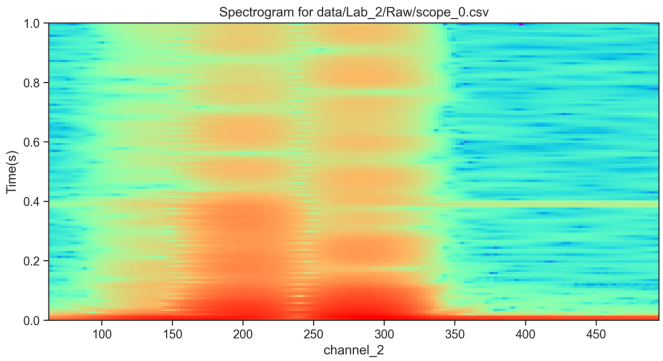
Challenge	Solution
Limited availability of filter materials.	Experimented with various materials such as paper towels and face masks. Face masks proved effective and in high supply due to Covid
Inadequate suction levels to pump enough air through the unit for an oxygen concentrator	Small 60x60mm fans used for initial prototype which can be replaced by two 120x120mm computer fans to generate higher flow rates
Achieving as airtight of a seal as possible to reduce leakage	Laser cut plywood box frame to achieve high precision whilst minimising manufacture time
Time zone differences leading to difficulty organising group meetings	Conducted both synchronous and asynchronous standups-meetings to ensure members in both Australia and Uganda could make valuable contributions

Smart Wearable Technology (ChallENG) 2021

Summary

- Extracurricular student-run project, part of a Vertically Integrated Project (VIP) with the ChallENG Program, leader of the Software Team.
- Identifying spoken words of the NATO Phonetic Alphabet using sensors to detect the skin vibrations on the throat
- As leader of Software Team, developed and implemented several data visualization programs including filtering in Python and using neural networks with TensorFlow to match signal spectrograms





Methods

1. Collecting data from piezoresistive and triboelectric sensors placed over the throat
2. Filtered and visualized data using Fast Fourier Transforms implemented using Python (shown above)
3. Implemented a neural network using TensorFlow in Python
4. Extensive use of GitHub and good Git Practices
5. Organised weekly meetings and standups

Notable Challenges and Solutions

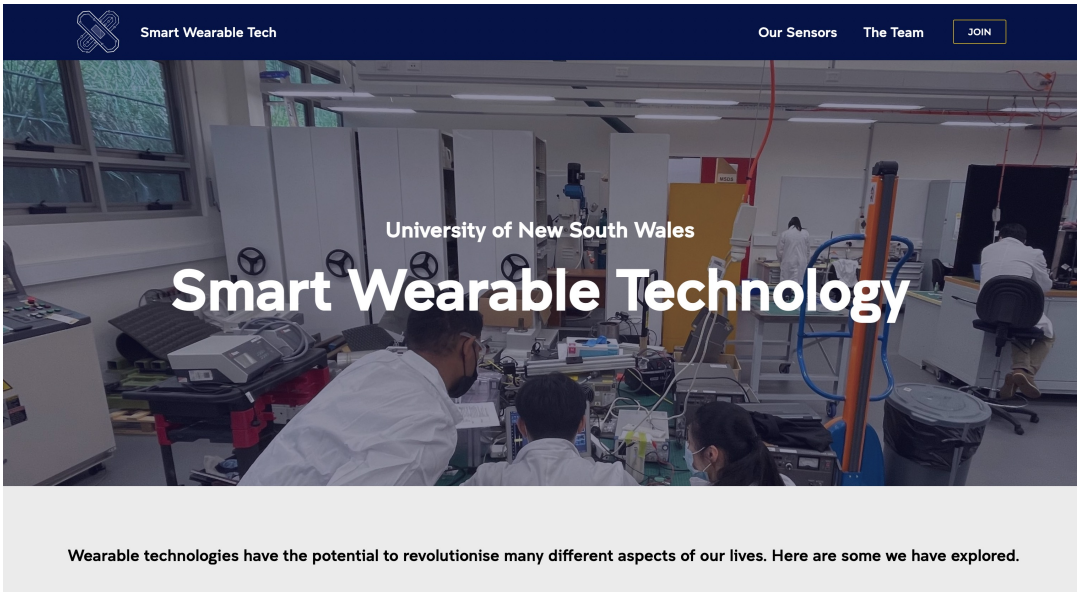
Challenge	Solution
Noisy data collected from labs populated with high frequency noise	Filtering using Fast Fourier Transforms as well as low/bandpass filtering to remove noise
Data collected at inconsistent time intervals	Use of spectrograms to eliminate time dependency
CSV data collected from oscilloscopes had incompatible heading and data formatting for matplotlib library in Python	Manipulation of data using the pandas and csv libraries in Python to format csv files for plotting
Managing team of different abilities and experiences for programming	Initially deciding between MATLAB and Python for analysis, listed pros and cons as well as considering team members' experience levels before deciding on Python as programming language/environment of choice

Smart Wearable Technology Website

2021

Summary

- During the second wave of CoVID-19 lockdown in 2021, took on initiative to lead the Software Team to create a website for Smart Wearable Technology.
- First attempt at a website using ReactJS and HTML/CSS
- There are some minor bugs when viewed on larger screens (laptop is ideal), but most of the react components and pages are properly functioning. A link to the website can be found here



Methods

1. Managed meetings and project management as Leader of the Software Team
2. Introduction to HTML and CSS for styled web pages
3. Introduction to ReactJS framework for web applications
4. Extensive use of GitHub for version control and created logical project and file structure
5. Deployed website using Google Firebase

Notable Challenges and Solutions

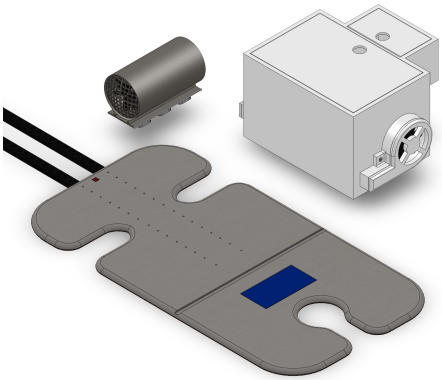
Challenge	Solution
Repeating HTML code blocks to make information cards	Use of React Components to add robustness to the HTML and reuse components
Finding a host to deploy the website	Firebase to deploy website as a react app
Storing data and text to display in the information cards	Text contained within JSON files which can easily be fetched using JavaScript
Designing the layout of the webpage and the navigation/ file structure of the website	Logical structure including a navbar and links to additional pages as well as external links

Cooled Baby Seat for Overheating Protection

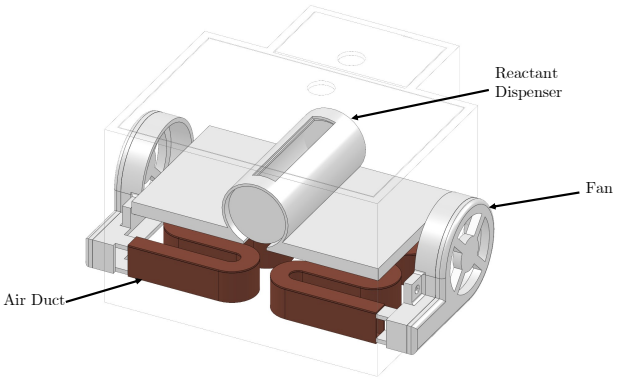
2021

Summary

- There are more than 5000 emergency incidents related to unattended children in vehicles each year in Australia. When a child is left in a vehicle, the cabin temperature can rapidly increase and quickly reach fatal levels
- Introducing a functional baby seat with cooling abilities to keep the child's core temperature stable in the even of being unattended
- The working principle behind the design is to use a cooling mechanism, similar to an instant ice-pack, which would rapidly decrease the temperature of the baby seat in the event of high temperatures as detected by sensors such as an NTC thermistor.



Assembly of Baby Seat



Internals of Cooling Unit

Methods

1. Organised consistent group meetings with structured agendas and meeting minutes.
2. Functional Requirement analysis to identify critical features .
3. Information Axiom analysis to describe in further detail the requirements of the product
4. Detailed research into temperature sensors.
5. Report writing in LaTeX using Overleaf.

Notable Challenges and Solutions

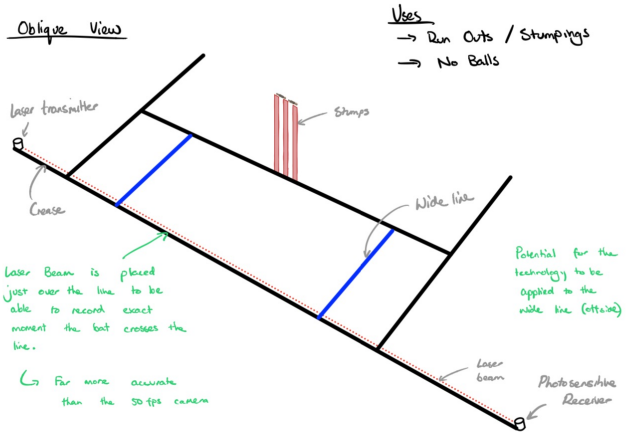
Challenge	Solution
Organising team members' ideas and which ideas to pursue	Consistent group meetings and standups to describe pros and cons for each idea
Technical validation of design	Theoretical calculations using component datasheets and physics principles to provide estimates for energy usage
Creating a useful product whose use can be as widespread as possible	Create a product independent of vehicle choice which can be applied to many models to not limit potential user base
Method of cooling to deliver fast reduction of temperature	Fans were counterproductive (dehydrating the child faster), aircon uses too much power, so one time use ice packs were used (which can be replaced after activation).

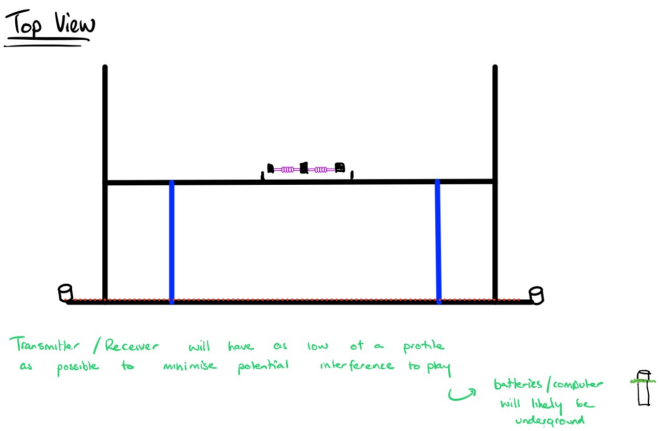
Run-Out Detector for Cricket

2020

Summary

- A proof-of-concept project to determine whether a batsman is run out in cricket. A run out is a form of dismissal where the batsmen fails to make his ground before the opposition break the stumps with the ball
- Currently, run outs are most often determined by examining camera footage which is severely limited by frame rate. Often, the deciding moment is within two frames and hence inconsistent decisions are made
- This project aims to remove camera limitations from the decision-making process and instead introduce a light based, electronically operated system to determine run outs. The initial prototype was made using Arduino; however, a new and faster iteration is being planned using IR LED's and phototransistors.





Methods

1. Identified real-world problem with significant consequences in professional sport
2. Researched light detection methods (LDR, Laser diodes, Phototransistors)
3. Further experiences with electronic components and sourcing electronic components from online (Digikey, JayCar, etc.)
4. Experience with Arduino and prototyping

Notable Challenges and Solutions

Challenge	Solution
Sensitivity of Light dependent resistors to ambient light	Enclose LDR in casing, use laser diode as the baseline level of light (lower intensity indicates batsmen inference and hence not out)
Speed of response of sensors	Future iterations to include faster microcontroller (e.g ESP32 or STM32) for more accurate detection
Laser diodes offer a distraction for players due to high light intensity	Use of infrared light (IR LED's) out of range of human sight

Smart Pedometer

2020

Summary

- As an introductory Arduino project, designed and created CAD models for a smart pedometer. A physical circuit was also created using an Arduino UNO, an LCD and an MPU6050
- Basics of Arduino programming and circuitry, as well as an introduction to CAD using Fusion 360 and basics of I2C communication.
- Pedometer could distinguish with relative accuracy the difference between walking and running and informed the user on their progress towards a daily goal of 10,000 steps.

Methods

1. Researched I2C Communication Protocol
2. Interface Arduino with sensors (MPU6050) and modules (LCD).
3. Building prototype on a breadboard with jumper wires
4. Fusion 360 to model the casing for the pedometer
5. Verification and Validation using a series of real-world tests to test accurate step counting and rejection of false positives.

Notable Challenges and Solutions

Challenge	Solution
Gyro Drift made MPU6050 measurements more inaccurate over time, leading to incorrect and unstable readings.	Read gyro values for the first 10 seconds of operation with the sensor laying flat, calculate approximate rate of change and compensate by adjusting readings by scale factor.
Defective LCD screen on first attempt.	Various debugging techniques, both software and hardware, including adjusting potentiometer, checking solder connections and reinstalling libraries. Once all failed, it could be determined the unit was defective. Replacement worked fine first go.
Sketching and Dimensioning in Fusion360 to create custom geometries.	Learned basics of parametric design, including sketching, fileting, mirroring etc.
Finding appropriate thresholding values for an accurate step count between running and walking.	Experimented with a variety of threshold values for IMU measurements, narrowing the threshold until sufficient accuracy.