Multidisciplinary Design of a Vital Signs Monitoring Wheelchair System

Team 65

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Introduction

❖Problem Statement

Patients with mobility challenges face significant barriers to regular health monitoring, as existing systems often require stationary setups and extensive manual processes. This leads to delays in care, reduced accessibility, and increased strain on healthcare providers.

❖ Constraints

Constraint	Unit	Value
Sensors Accuracy	Error percentage	≤6.25%
Wheelchair Width (cm)	Centimeters (cm)	≤70 cm
Wheelchair Weight (kg)	Kilograms (kg)	≤25kg
Push Force (N)	Newtons (N)	≤50 N
Charging Time	Hours	≤2 Hours
Battery Life	Hours	≥7 Hours

❖Final Target Specifications

Specification	Range	Actual Value
Sensors Response Time (s)	3-6s	5.5 s
Wheelchair Width (cm)	50 - 70 cm	60 cm
Seat Height (cm)	40 - 55 cm	40 cm
Weight Capacity (kg)	25 - 150 kg	≤150 kg
Seating Area (m²)	0.150m² - 0.30 m²	0.20m²
Wheelchair Weight (kg)	10 - 25 kg	17 kg

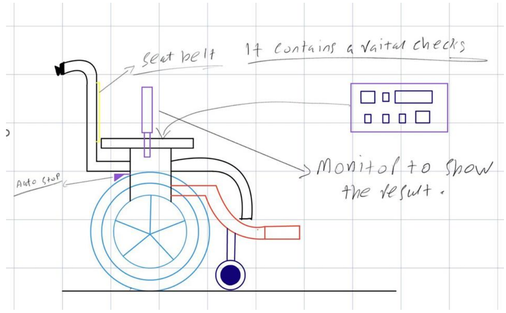
❖Impact

- Enhanced Patient Accessibility: The system reduces the need for frequent hospital visits, offering real-time health monitoring, especially benefiting elderly and disabled individuals.
- Economic Growth: By creating local jobs in system design, manufacturing, and maintenance, the project aligns with Vision 2030 goals and supports regional economic diversification.
- Improved Healthcare Efficiency: Hospitals can streamline operations and reduce crowding, allowing for better resource allocation and improved patient outcomes.
- Environmental Sustainability: Decreased patient transportation significantly lowers carbon emissions, aligning with Saudi Arabia's sustainability objectives and promoting eco-friendly healthcare practices.

Prototype Design

Specification	Our Value
Wheelchair Width (cm)	60 cm
Seat Height (cm)	40 cm
Seating Area (m^2)	0.20 m^2
Wheelchair Weight (kg)	17 kg

The first phase of the prototype sketch



3D illustration of the prototype designed using SolidWorks

Electrical Circuit & Sensors

❖ **Temperature Measurement: (MLX90614)**

$T_{(object)} = ((RAWDATA)/50) - 273.15$

Where: RAW DATA is the unprocessed sensor output in Kelvin.

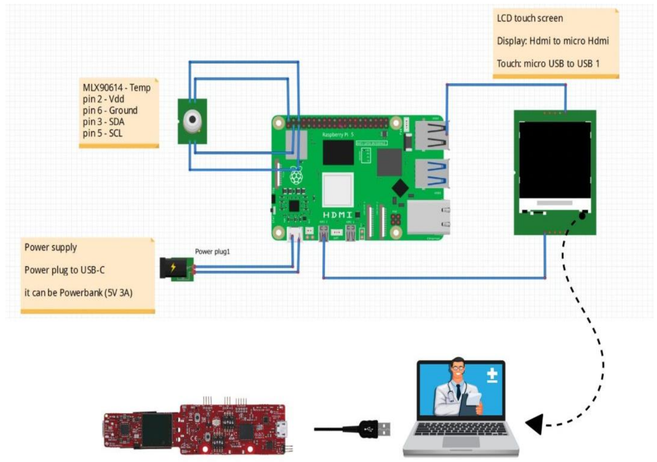
❖ **Heart Rate and Respiration and Blood Pressure: (IWR6843AOP Radar Sensor)**

$HeartRate(BPM) = 60/Timebetweenheartbeats(seconds)$

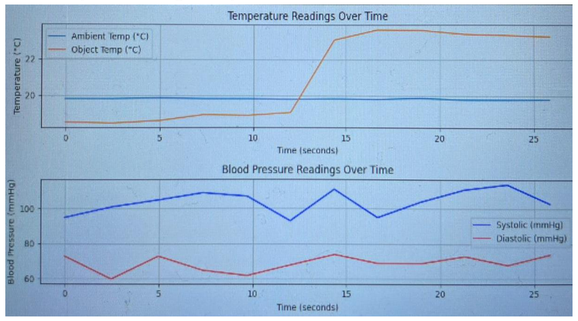
$RespirationRate(BPM) = 60/Timebetweenbreaths(seconds)$

Component	Typical Response Time
MLX90614 (Temperature Sensor)	300 ms
HX711 (Load Cell Amplifier)	50-100 ms
IWR6843AOP (Radar Sensor - Heart Rate)	1-2 seconds
IWR6843AOP (Radar Sensor - Respiration Rate)	2-3 seconds
Raspberry Pi 7-inch Display (Touch)	10-20 ms
Data Display on Screen	50-100 ms

❖ **Electrical Circuit Diagram**



❖ **Sample Readings Graph**



❖ **Measured Vital Checks:**

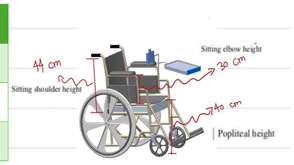
i. **Body Temperature**
ii. **Blood Pressure**
iii. **Heartbeats**
iv. **Oxygen Consumption**

Ergonomic Design & Control Charts

In our project, we decided to choose a **design for the average** since our project will be used in hospitals and it will be designed for public use.

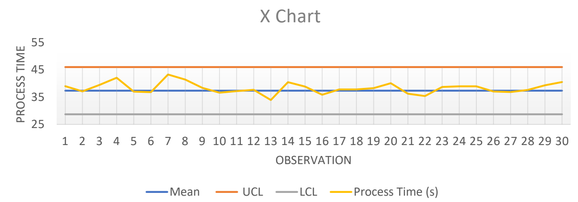
In order to know whether our wheelchair is ergonomically designed or not, we compare the dimensions of the wheelchair with global reference that contains human body dimensions.

Dimension	Male	Female
Sitting shoulder height	42 - 55	38 - 50
Sitting elbow height	23 - 35	20 - 30
Popliteal height	35 - 50	30 - 44



All dimensions fit the ranges from the reference, so we can conclude that the wheelchair is ergonomically designed.

Statistical Control Chart:



Validation & Verification

❖ Sensor Accuracy: The sensors achieved an accuracy of ±0.5°C for temperature, ±0.1% to ±0.2% for weight measurements, and ±2 bpm for heart rate.

❖ Wheelchair Dimensions: The wheelchair's width is 60 cm, height is 85 cm, and weight is 17 kg.

❖ Push Force: The required force to move the wheelchair is 14.7 N on smooth surfaces and 49 N on rough surfaces.

❖ Sensor Response Time: The response times were recorded as 300 ms for temperature sensors, 100 ms for weight sensors, and 1–2 seconds for heart rate sensors.

Conclusion

The project contains advanced sensor technology to provide real-time checking with high accuracy. This innovative system reduces the frequency of hospital visits, thereby optimizing healthcare delivery and improving patient convenience. It promotes inclusivity, enabling elderly and disabled individuals to monitor their health independently.