Jyoti and Bhupat Mehta School of Health Science and Technology
Indian Institute of Technology, Guwahati
781039 Guwahati, Assam, India

Smart bed for pressure ulcers (bedsores) prevention

Sharvani Pokala, K S Ranjith Kumar, Sai Hari Hara Sudheshna Chunduru, Rushikesh Khot

Jyoti and Bhupat Mehta School of Health Science and Technology, Indian Institute of Technology Guwahati, India

Motivation

- Bedsores, caused by prolonged pressure on the skin, are a serious healthcare challenge, leading to severe complications.
- They are often prominent in bedridden or immobile individuals.
- Pressure ulcers significantly increase healthcare costs by demanding prolonged hospitalization, advanced wound care, and manual intervention.
- This highlights the need for automated systems that enhance circulation and reduce time, labor, and costs.

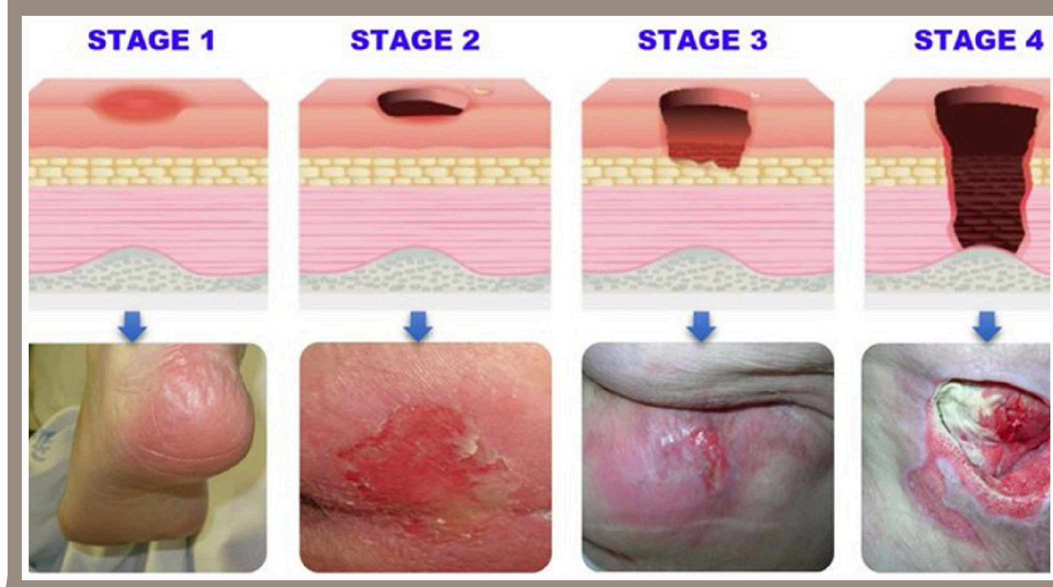


Figure: Stages of pressure ulcers

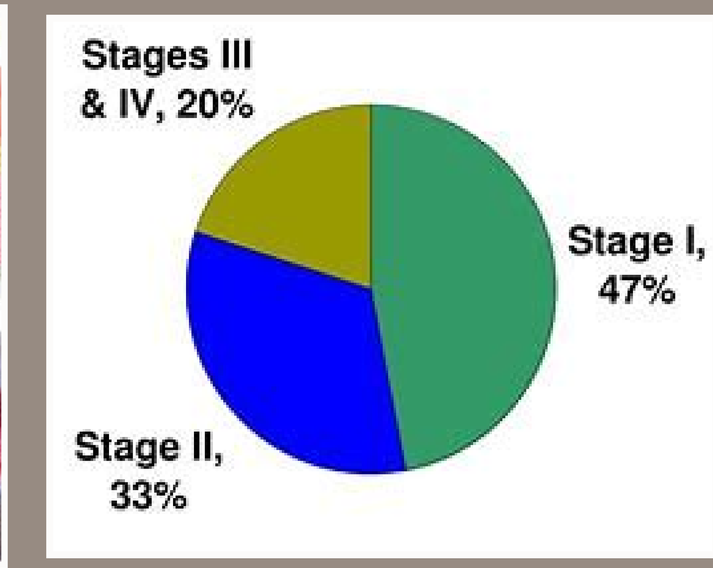


Figure: Prevalence of Pressure ulcers

State of the art technologies available

Paper Title	Disadvantage
IoT-Based Healthcare Monitoring System: Bedsores Prevention	• Requires constant monitoring. • Dependent on internet connectivity
Evaluation of commodity force sensor for building low-cost bed sore prevention mat.	• Can't decide the movements of the patient. • Requires manual intervention.
Medical Robotic Bed to Prevent Pressure Sores	• Expensive due to robotic implementation
Wearable Preventive Pressure Ulcer System Using Embroidered Textile Electrodes	• Not effective for existing severe ulcers.

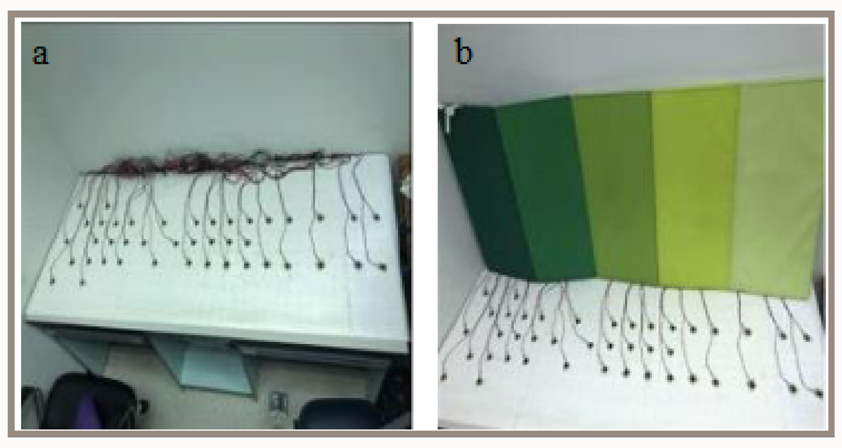


Figure: Wired sensor mat

Figure: Robotic bed

Core technological idea

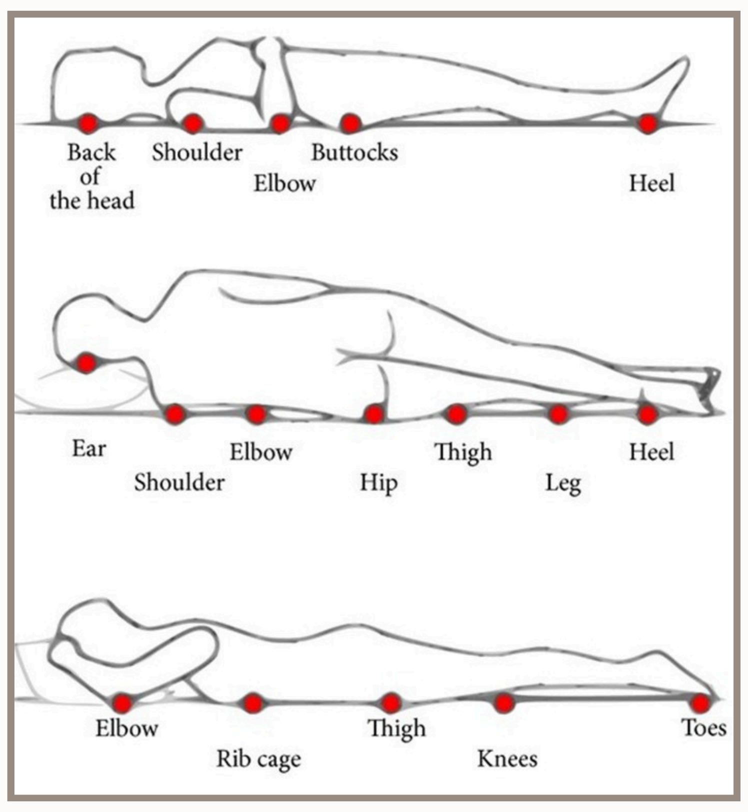


Figure: Key pressure points on different segments of the body

Segment of the body	Weight distribution (for 70kg model)	Force distribution (Kgs)	Approximate area (m^2)	Pressure distribution (F/A) (kPa)	Initial pressure (kPa)	Final pressure (kPa)	Radius of capillary (m)	Length of capillary (m)	Relative blood Flow (ml/sec)
Head and neck	5.3	4.86	0.015	3.177	4.266	3.177	0.0000075	0.001	$-4.86*10^{-16}$
Upper back	13.5	16.79	0.040	4.116	4.266	4.116	0.0000075	0.001	$-6.70*10^{-17}$
Lumbar and pelvic	21.02	21.64	0.165	1.286	4.266	1.286	0.0000075	0.001	$-1.33*10^{-15}$
Thighs	8.8	18.71	0.030	6.115	4.266	6.115	0.0000075	0.001	$8.25*10^{-16}$
Calf	2.5	7.42	0.035	2.079	4.266	2.079	0.0000075	0.001	$-9.76*10^{-16}$
Feet	0.89	0.27	0.005	0.529	4.266	0.529	0.0000075	0.001	$-1.66*10^{-15}$

Figure: Weight distribution at risk points

Factors	Normal range	Micro vibrations (Moderate risk category)	Lateral movement (High risk category)
Pressure (mmHg)	<32 mmHg	32 – 50 mmHg for >30 min	>50 mmHg for >15 min
Temperature (°C)	< or = 35 °C	35 – 38 °C	>38 °C
Humidity (%)	30 – 60 %	60 – 75%	>75%

Figure: Threshold parameters

Implementation & Achievements

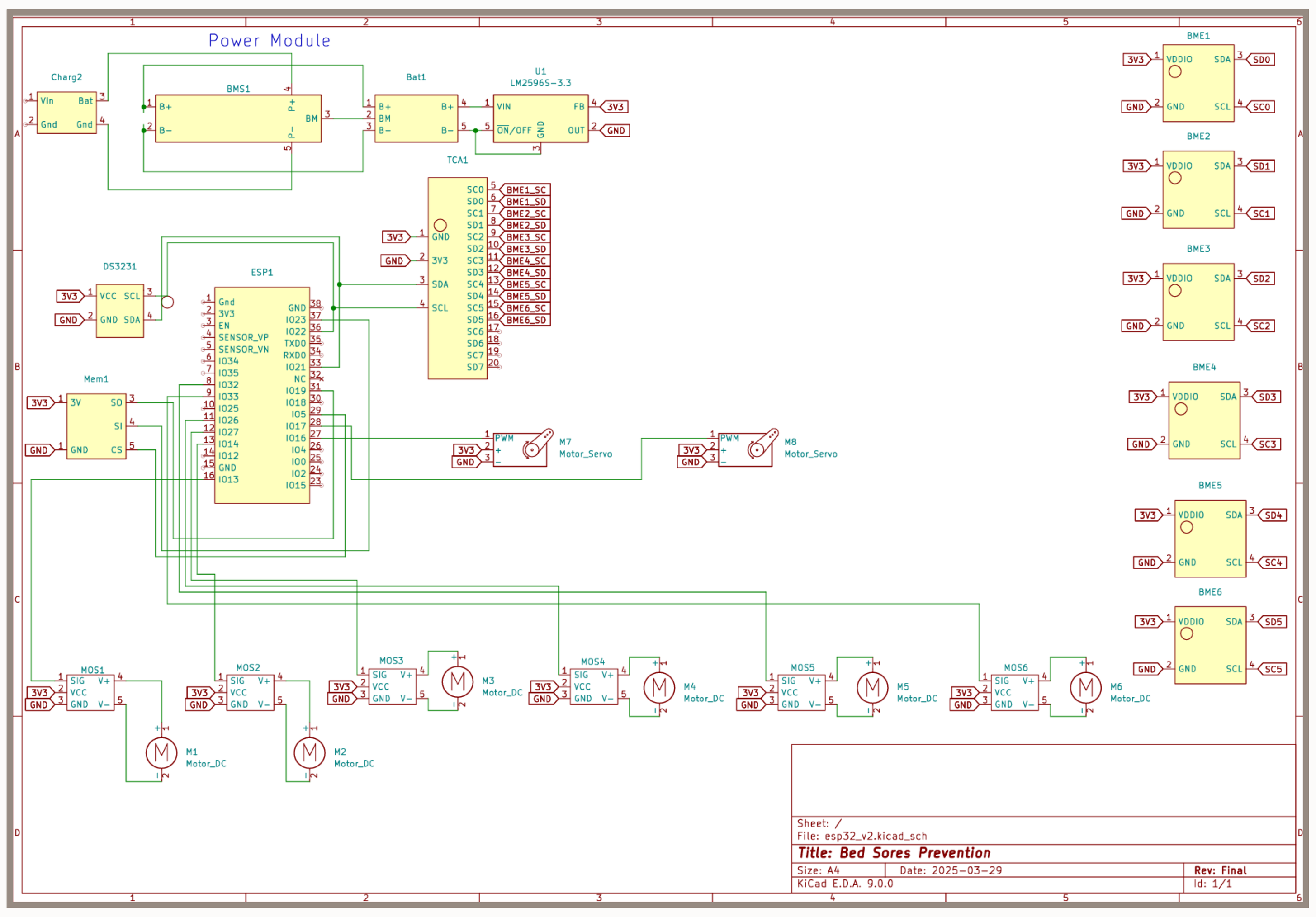
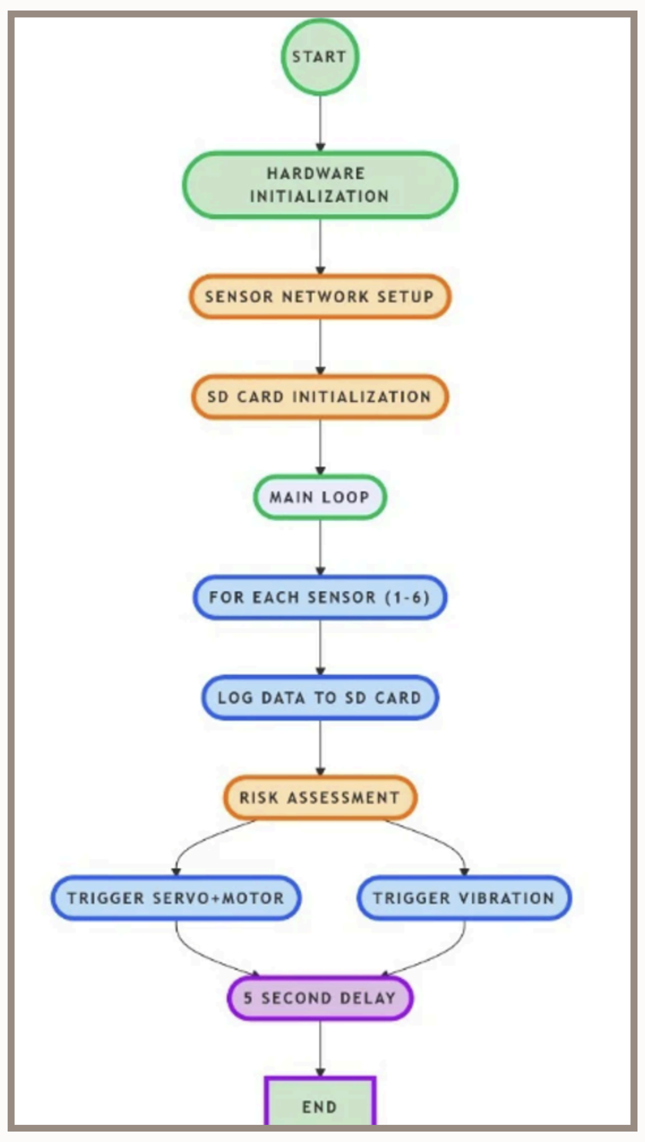


Figure: Circuit diagram for the prototype

Flowchart



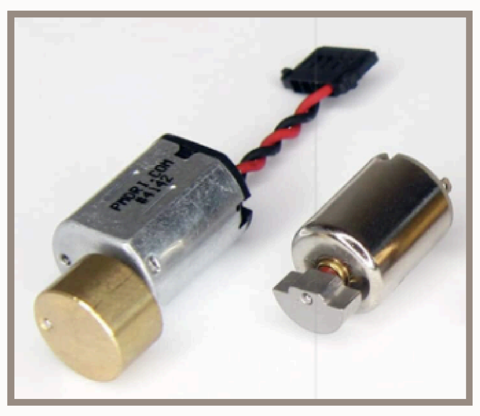


Figure: Vibration motor

Specifications	ERM Coin motor	Precision micro driver
Voltage rating (V)	3 V DC	12 V DC
Current rating (mA)	80 to 120	66
Rated speed (rpm)	10,000	12,500
Frequency (Hz)	166.6	208.3
Diameter (m)	0.01	0.08
Width (m)	0.0034	0.0034
Weight (Kg)	0.001	0.0008
Eccentricity (m)	0.002	0.0012

Segment of the body	Force (N)	ERM coin motors required	Precision micro drivers required
Head and neck	47.7	22	5
Upper back	164.7	75	16
Lumbar and pelvic	212.3	97	20
Thighs	184	84	18
Calf	72.8	33	7
Feet	2.6	1	1

Figure: Vibration motors required after calculations

Reflection & Conclusion

- Gained hands-on experience in developing a smart bed prototype using tools like KiCAD, Fusion 360, and ESP32 with MicroPython, integrating electronics and mechanical components effectively.
- Addressed a critical healthcare issue—pressure ulcer prevention—by designing a solution that combines sensor data, threshold analysis, and targeted vibration therapy to improve patient outcomes.
- Learned to select and interface electronic components based on power and functionality, and performed circuit assembly, debugging, and testing in a lab environment.
- Gained experience working in interdisciplinary teams combining biomedical engineering, design, and clinical application perspectives.

Outlook

- Apply patient-specific data to train ML models for tailored prevention.
- Develop a user interface (UI) to display real-time data and generate analytical plots for insights.
- Enhance therapeutic outcomes by integrating antimicrobial patches at targeted pressure points
- Optimize ergonomic support to maximize comfort and efficacy.

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