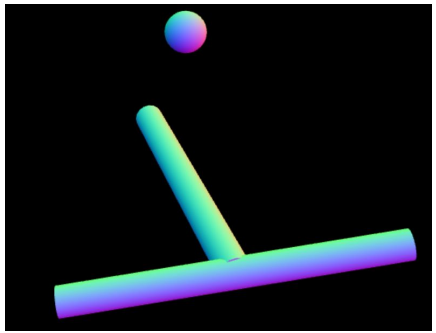
LUMBACARE

Designing a wearable system that tracks and visualizes the movements of joints using IMU sensor for patients during rehabilitation, with integrated pattern detection to improve recovery.



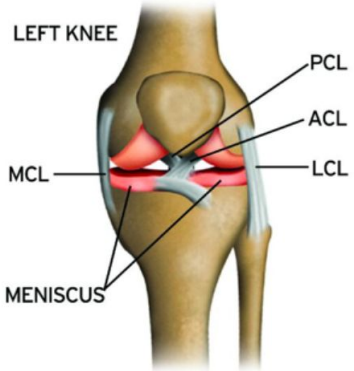
LUMBACARE

Origin Story

June 2023

Injured Playing Soccer

Grade 3 ACL tear
Full Meniscus tear
Partial MCL & PCL Tear



September 2023

Started Rehab

Beginning of a long recovery journey

June 2024

Started LumbaCare

Inspired by recovery journey
Outdated Rehab Equipment
Room for improvement through technology

April 2025

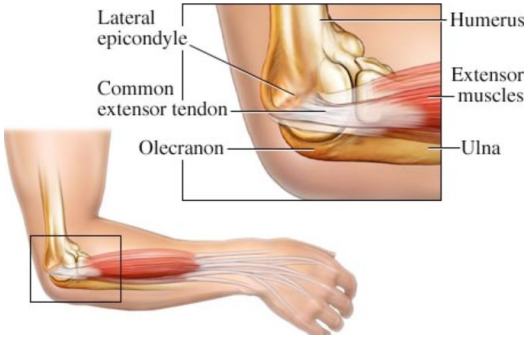
Proof-of-Concept Prototype 1

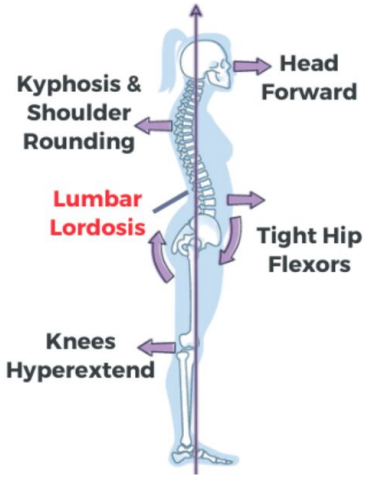
LumbaCare today
Measures joint movements
ML model to learn user movement
Prevents Harmful movement
Encourages healthy recovery

Scale of the Issue

Joint-Related Issues

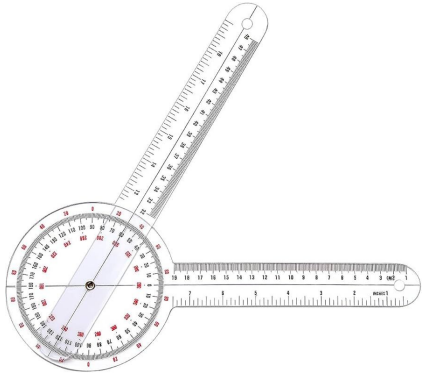
- Knee related: ACL injury
- Back Issues: Lordosis & Kyphosis
- Shoulder
- Hip





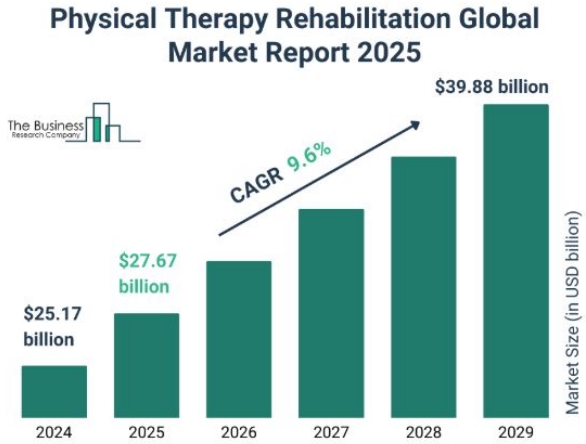
Measurement Technologies

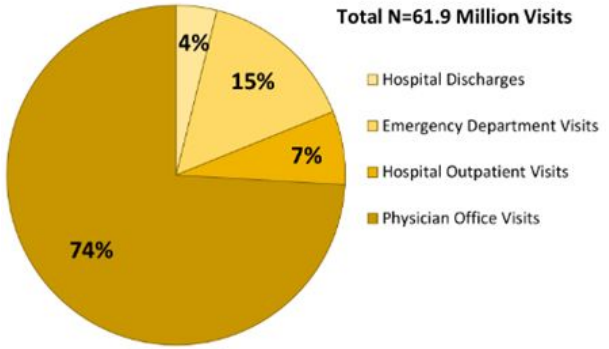
- Goniometer
  - Accuracy +/- 7 degrees
  - Difficult set up/Learning curve
  - Requires at least 2 users
- Dynamometer
  - Highly Accurate
  - Difficult setup
  - Requires at least 2 users



NEED FOR CHANGE

- Increasing Rehabilitation Demand
  - More patients requiring timely intervention
- Outdated Equipment
  - Contributes to slow recovery and inadequate monitoring
- Limited Therapy Time
  - Patients spend only **11.8 minutes** with therapists
- Physical Therapy market growing at CAGR 9%
  - Creating scope for technology & innovation





LUMBACARE

MACHINE LEARNING PREDICTIVE MODEL

Prevents harmful movements and learn patient recovery trends

JOINT TRACKING

Monitors joint angles and motion

HAPTIC FEEDBACK

Provides real-time sensory guidance for proper movement

QUATERNION-BASED ORIENTATION

$$q = [q_w, q_x, q_y, q_z]$$

$$q_w^2 + q_x^2 + q_y^2 + q_z^2 = 1$$

UNIT QUATERNION

$$q = \left[\cos\left(\frac{\theta}{2}\right), \mathbf{n}\sin\left(\frac{\theta}{2}\right)\right]$$ ROTATION ABOUT AXIS N

Derivation of Quaternion-Based Orientation

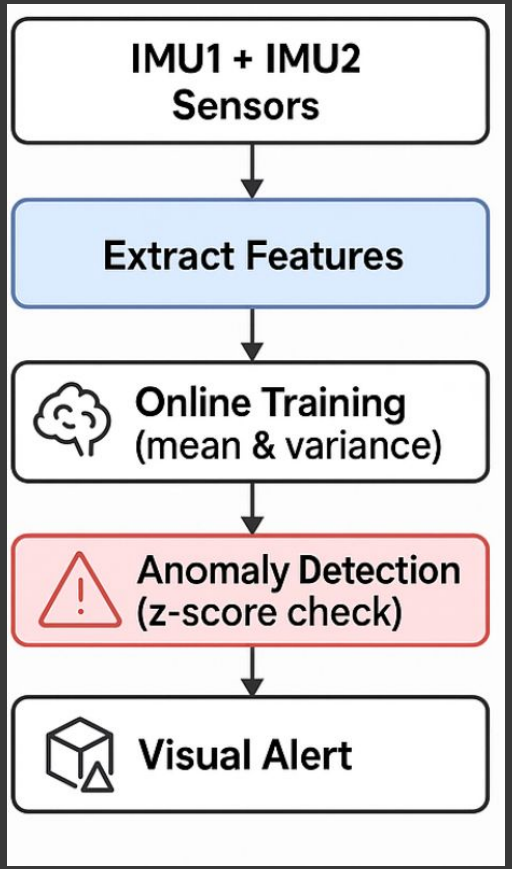
$$\theta = \kappa \ell$$

$$\mathbf{n} = [-\sin\phi, \cos\phi, 0]$$

$$q = \left[\cos\left(\frac{\kappa\ell}{2}\right), -\sin\phi\sin\left(\frac{\kappa\ell}{2}\right), \cos\phi\sin\left(\frac{\kappa\ell}{2}\right), 0\right]$$

$$R(q) = \begin{bmatrix} 1-2(q_y^2+q_z^2) & 2(q_xq_y-q_wq_z) & 2(q_xq_z+q_wq_y) \\ 2(q_xq_y+q_wq_z) & 1-2(q_x^2+q_z^2) & 2(q_yq_z-q_wq_x) \\ 2(q_xq_z-q_wq_y) & 2(q_yq_z+q_wq_x) & 1-2(q_x^2+q_y^2) \end{bmatrix}$$

MACHINE LEARNING MODEL



Real-time machine learning algorithm to detect unusual joint motion based on live **IMU sensor data** .

Training Phase :

Collects data to compute mean (mu) and variance (var) for each feature.

Uses Welford's online algorithm for real-time stats:

- Incremental mean: mu[i] += (x - mu[i]) / nSeen
- Variance: var[i] += (x - mu[i]) * (x - mu[i])

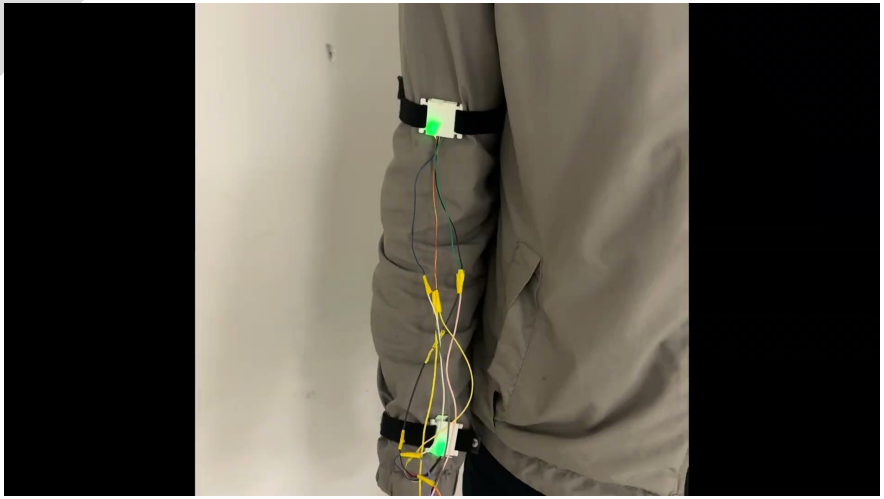
Detection Phase :

- Calculates Z-scores: z = |x - mu| / sqrt(var)
- Flags anomaly if Z-score > Z_THRESHOLD (4.0)

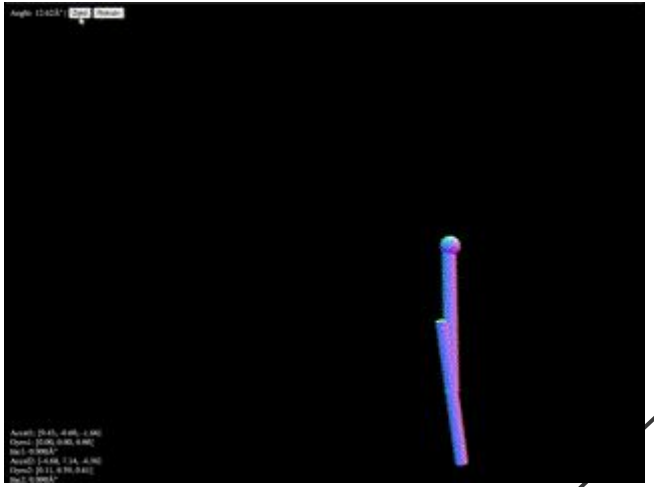
For our simulation,

- Data trained over 30 seconds
- Alerts if joint angle exceeds 30° (visual warning).

SIMULATIONS

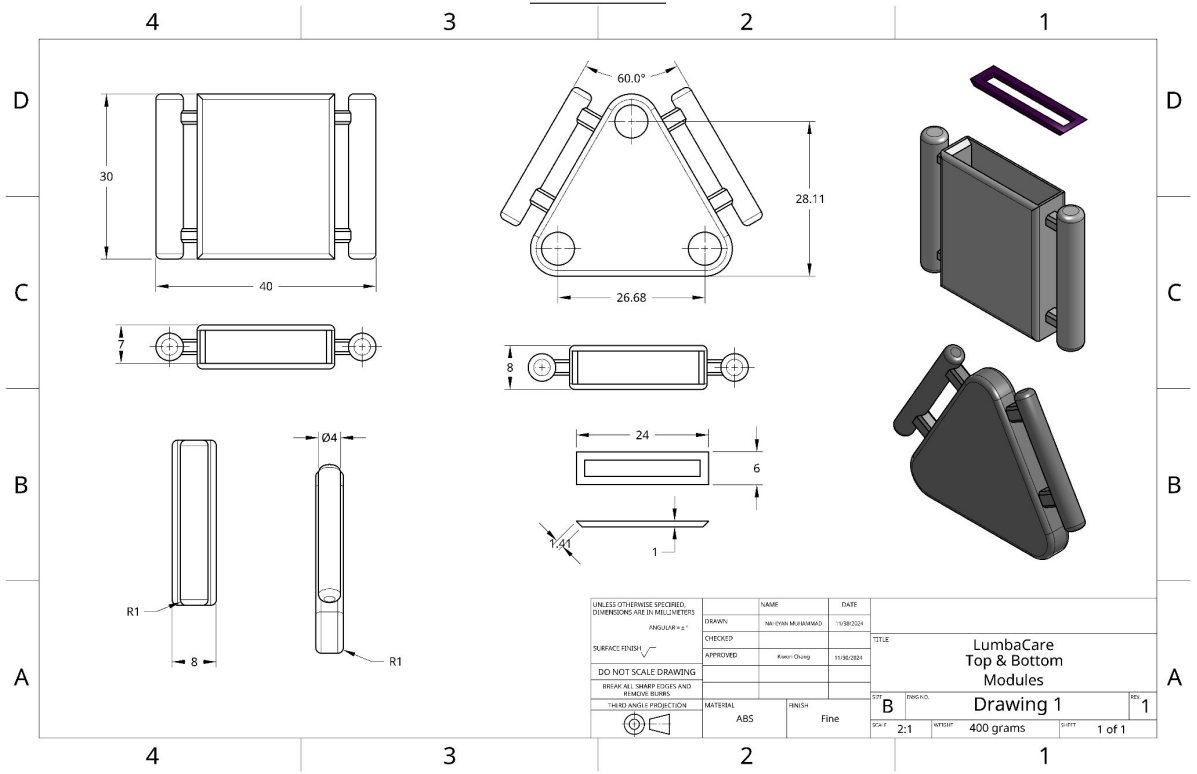


Arm Simulation Trial

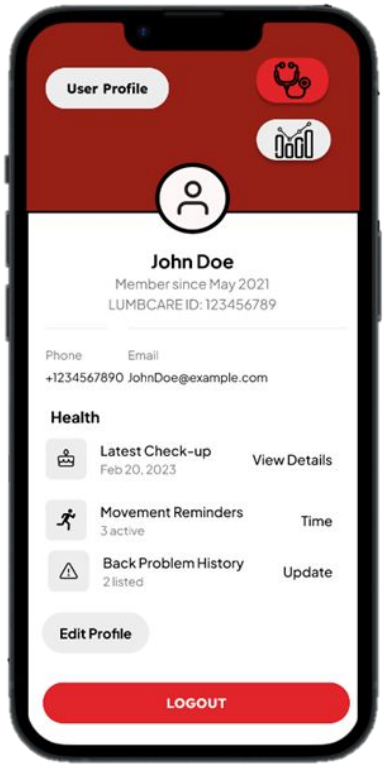


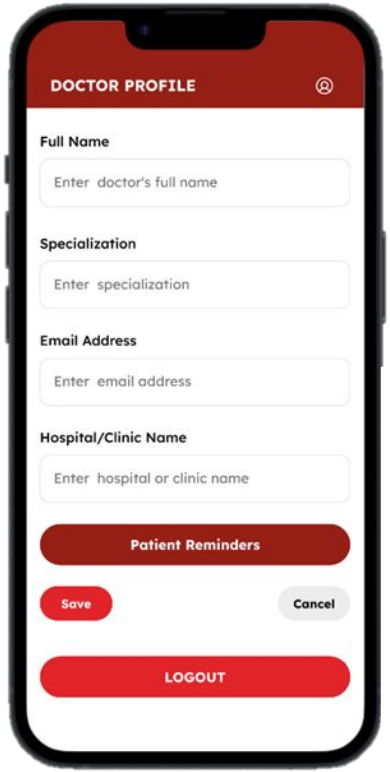
Knee Simulation

Form Factor


4
3
2
1
D
C
B
A
30
40
7
60.0°
28.11
26.68
8
24
6
1.41
1
Ø4
R1
8
R1
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
ANGULAR = ±°
SURFACE FINISH
DO NOT SCALE DRAWING
BREAK ALL SHARP EDGES AND REMOVE BURRS
THIRD ANGLE PROJECTION
NAME
DATE
DRAWN
NAHYAN MUHAMMAD
11/30/2024
CHECKED
APPROVED
Kwon Chung
11/30/2024
MATERIAL
ABS
FINISH
Fine
TITLE
LumbaCare
Top & Bottom
Modules
SIZE
B
DWG NO.
Drawing 1
REV
1
SCALE
2:1
WEIGHT
400 grams
SHEET
1 of 1

User Interface





ADOPTION

- Partner with clinics for pilot testing
- Target rehabilitation centers and telemedicine platforms
- Expand to at-home users with an app-guided wearable system
- Focus on personalized recovery and improved patient outcomes

COMMERCIALIZATION

- Manufacture devices at $10 each
- Sell devices at $20 each
- Offer SaaS subscriptions for clinics
- Pursue data service opportunities
- Secure patents for technology protection
- Obtain FDA Class II clearance for healthcare adoption

Expanding access through wearable rehab

01

Affordable & Portable

Affordable, remote rehab system delivering personalized care to all patients.

02

Remote Monitoring

Tracks recovery remotely, reducing need to come to therapy centers physically

03

Personalized Feedback

Real-time feedback enables personalized therapy for diverse patient needs

04

Accelerates Recovery

Early detection of abnormal patterns enables timely intervention, improving outcomes.

THE TEAM

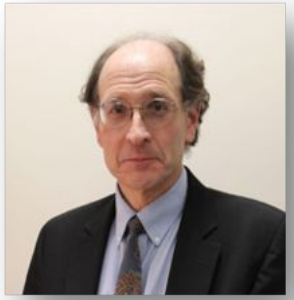
Team

1. Nahiyan Muhammad
Mechanical & Computer Engineering

2. Essoha Kadambaya
Mechanical Engineering

3. Adam Mhal
Computer Engineering

Advisors



Prof. Ray Nagem

Associate Professor Mechanical Engineering

Coordinate Geometry, Accelerometer Calibration

30+ years of industry experience/ expertise in Cartesian Coordinate

Dr. Anna Rubakhina

Board Certified PT, DPT, OCS, FAAOMPT

Device Placement, user pain points, feedback

10 years of PT experience Expertise in Back, hip, and ACL injuries

Prof. Pavan Bhavsar

Associate Professor Mechanical Engineering

PCB Design, Circuitry component analysis

Research in the design and calibration of sensors

Thank you for your time

Any Questions?