Design of a Frozen Shoulder Expert Rehabilitation System
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**Problem & Concept of Operations**

**CONCEPT OF OPERATIONS**
At-home Rehabilitation with Remote Patient Monitoring

Key features:
- Remote patient monitoring by healthcare providers.
- Therapy exercise recommendations based on progress results.
- Healthcare providers can modify exercises as needed.
- Interactive app to guide patients through therapy exercises.
- Objective ROM data capture.
- Muscle activity monitoring.

**Context Analysis**

Buildup of scar tissue restricts movement inside the shoulder joint, resulting in pain and severely limiting range of motion in the arm.

**Prototype Design**

**Prototype Schematic Diagram**

Ergonomic, lightweight device, contains muscle activity sensors and IMU.

**Health App (built with Unity)**

- IMU: Inertial Measurement Unit for motion tracking
- ROM Measurement in 3D Space:
  \[ \text{angle} = \sin^{-1} \left( \frac{\sin x \cdot \sin y \cdot \sin z - \cos x \cdot \cos y \cdot \cos z}{\sqrt{1 - \sin^2 x \cdot \sin^2 y \cdot \sin^2 z}} \right) \]

**IMU Accuracy Verification Results**

The IMU has a high percent error in the beginning of the movement, but as the user moves, it becomes more accurate.

**Results**

**Shoulder Range of Motion Measurement**

**Flexion**
- Max ROM: 100°

**Adduction**
- Max ROM: 50°

**Extension**
- Max ROM: 60°

**Abduction**
- Max ROM: 150°

**Muscle Sensor**

**Healthcare Provider**

**Patient**

**Health App**

**Remote Patient Monitoring**

**Motion Tracking Software**

**IMU**

**Motion Tracking Software**

**Motion Tracking Software**

**IMU Accuracy Verification Results**

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**Results**

**Shoulder Range of Motion Measurement**

**Flexion**

**Adduction**

**Extension**

**Abduction**

**A Wearable Sensor Device and Mobile Application**

**Business Plan**

**Dollar Revenue and Expenses: 2022-2026**

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