Project Proposal:

Intel RealSense Patient Assessment System

1. Introduction

The proposed project aims to develop an Intel RealSense Patient Assessment System for physiotherapy applications at Instant Physio, a clinic in Tooting established in 2015. The primary motivation behind this initiative is to address the challenge of patient engagement and adherence to rehabilitation programs by introducing objective, measurable progress indicators.

Traditional physiotherapy assessments rely heavily on subjective evaluations by clinicians, leading to variability between sessions. The absence of objective measurement tools often results in decreased patient motivation, inconsistent progress tracking, and suboptimal rehabilitation outcomes [1]. There is a growing need for a standardized, technology-driven solution to provide accurate, consistent, and engaging physiotherapy assessments.

Leveraging Intel RealSense technology, the system will incorporate depth-sensing cameras to track and quantify physical performance metrics. Research has demonstrated the feasibility of using depth-sensing cameras in physiotherapy applications such as real-time gait analysis, range of motion tracking, and posture monitoring [2][3]. By integrating machine learning algorithms and electronic health records (EHR), this solution will enable real-time assessment, progress tracking, and automated report generation, enhancing both patient experience and clinical efficiency [4].

add how this system helps workers/clinicians

Recent advancements in computer vision and artificial intelligence have significantly improved the accuracy of motion capture systems for clinical use [5]. The combination of RealSense technology with AI-driven analysis provides a cost-effective alternative to traditional motion tracking systems, making physiotherapy more accessible and efficient [4].

2. Problem Statement

Physiotherapy relies on progress tracking to assess treatment effectiveness. Currently, most assessments are subjective, leading to inconsistencies between different sessions and practitioners. This lack of standardization affects treatment accuracy and patient engagement. Additionally, manual evaluation methods often result in discrepancies in data interpretation, making it difficult to compare progress over time effectively. The absence of real-time feedback mechanisms limits patients' ability to self-monitor their rehabilitation, potentially delaying recovery.

Who is affected?

- **Patients:** Lack of tangible progress tracking leads to the decreased motivation and adherence to rehabilitation plans. Without real-time feedback, patients struggle to understand their improvements and areas which are needing focus.
- **Clinicians:** Difficulty in quantifying progress results in inconsistent treatment adjustments. Clinicians spend significant time manually recording patient performance, which can lead to inefficiencies in data analysis and treatment personalization.
- **Healthcare Facilities:** Inefficiencies in patient management and data tracking lead to increased administrative workload. Traditional methods require paper-based records or subjective notes, which can create inconsistencies when multiple practitioners are involved in the treatment process.

Why is it important to solve this problem?

- **Ensures More Precise, Data-Driven Rehabilitation Plans:** Real-time tracking allows for personalized treatment adjustments based on accurate patient performance data.
- **Increases Patient Motivation:** Providing measurable progress indicators enhances patient engagement by offering clear, visual evidence of improvements.
- **Reduces Time Spent on Subjective Assessments:** Automation of movement tracking reduces the burden on clinicians, allowing them to focus on delivering targeted interventions.

- **Enhances Treatment Effectiveness:** Integrating advanced tracking methodologies ensures better-informed clinical decisions, leading to improved rehabilitation outcomes and faster patient recovery.
- **Streamlines Data Management:** Integration with Electronic Health Record (EHR) systems enhances accessibility to patient records, reducing paperwork and the likelihood of errors in treatment planning.

3. Aims and Objectives

Aims:

- **Develop an innovative physiotherapy assessment system** that utilizes Intel RealSense depth camera to capture and analyse patient movements with high precision.
- **Improve patient engagement and adherence to rehabilitation** by providing clear, visual progress tracking tools that encourage the patients continued participation.
- **Standardize physiotherapy assessment procedures** to minimize variability between sessions and ensure consistency in clinical evaluations.
- **Enhance clinician efficiency and decision-making** by automating data collection and analysis, reducing manual workload, and ensuring accurate patient records.
- **Seamlessly integrate the system with existing Electronic Health Record (EHR) platforms** to provide easy access to patient rehabilitation data, facilitating better treatment planning and continuity of care.

Objectives:

1. **Develop a Robust Data Collection Mechanism:**
    - Implement Intel RealSense depth-sensing technology to capture key movement data, including vertical jump, range of motion, balance, posture, and gait analysis.
    - Ensure real-time motion tracking with minimal latency to facilitate immediate feedback for both patients and clinicians.
    - Design an intuitive and user-friendly interface that enables patients to interact with the system independently and clinicians to oversee progress efficiently.
2. **Implement Advanced Data/Image Processing and Analysis:**

    - Utilize state-of-the-art machine learning algorithms to analyse movement patterns and identify potential issues in patient mobility.
    - Develop predictive models to estimate patient recovery timelines based on historical and real-time assessment data.
    - Incorporate automated anomaly detection to alert clinicians about irregular movements or deviations from expected progress.
3. **Develop a Comprehensive Progress Reporting and Visualization System:**
    - Generate detailed performance reports that include graphical comparisons of past and present assessments to highlight improvement trends.
    - Implement a personalized dashboard for patients and clinicians to access performance summaries and tailored rehabilitation recommendations.
    - Enable automated summary generation to support clinical decision-making and facilitate communication between healthcare providers.
4. **System Integration and Usability Testing:**
    - Seamlessly integrate the assessment system with electronic health record (EHR) platforms to allow for centralized patient data management.
    - Conduct rigorous usability testing with physiotherapists and patients to refine system accuracy, usability, and overall effectiveness.
    - Ensure adaptability for different physiotherapy use cases, including post-surgical recovery, stroke rehabilitation, and sports injury rehabilitation.

4. Legal, Social, Ethical, and Professional Considerations

· **Legal Compliance:** The system must follow data privacy laws like GDPR (General Data Protection Regulation) and HIPAA (Health Insurance Portability and Accountability Act) to keep patient information safe. This means ensuring that only authorized users can access the data and that all patient records are securely stored and managed.

· **Ethical Considerations:** It is important to be transparent with patients about how their data will be collected and used. Patients should give their permission before their movement data is recorded. The system should also provide fair access to all users without discrimination.

- **Social Impact:** The system should make physiotherapy more accessible, especially for people who cannot frequently visit clinics. It should be easy to use, helping patients track their progress at home while still receiving expert guidance from their physiotherapists.
- **Professional Standards:** The system should align with the best practices in physiotherapy. It should be accurate and reliable so that healthcare professionals can trust the data when making treatment decisions. Clinicians should also receive proper training to use the system effectively.

5. Related work:

This paper [1] explores the integration of virtual reality (VR) and motion tracking technologies in physical rehabilitation of the rotator cuff with two objectives, one to check the integration of these technologies in the Healthcare domain and other to test how video games accelerate the recovery of patients. Using the Oculus Rift DK2 and Intel RealSense, a rehabilitation game is developed for rotator cuff therapy. The game guides patients through abduction and adduction exercises, tracking movement accuracy and providing feedback. Preliminary evaluations by physiotherapists indicate its potential to enhance rehabilitation by improving patient engagement and proprioception. While clinical trials were not conducted, experts noted the system's ability to promote correct movement execution. The study highlights VR's role in rehabilitation and suggests further research on its clinical efficacy.

Artificial intelligence and motion capture technologies play a significant role in evaluating physiotherapy exercises. Research categorizes over 100 studies based on system components, emphasizing the impact of depth cameras like Kinect, which appear in 35% of studies. Machine learning techniques, particularly Convolutional Neural Networks (CNNs), are widely applied, with 44% of cases utilizing them for automated patient performance assessment. The KIMORE dataset remains a popular choice, used in 38% of cases. AI-driven motion tracking enhances rehabilitation efficiency by enabling remote physiotherapy and personalized treatment evaluation, offering a reliable approach for improving patient outcomes [2].

A virtual reality-based system, BiomacVR, enhances rehabilitation by integrating depth sensors and machine learning for precise motion analysis. The system employs a Convolutional Pose Machine (CPM) to track human movement, identifying correct and incorrect physiotherapy exercises. Real-time posture analysis enables accurate assessment of rehabilitation progress and effectiveness [3]. The system supports post-stroke patients through personalized rehabilitation exercises, reducing the need for direct supervision. Depth sensors ensure high accuracy, differentiating between healthy individuals and those with movement impairments. The technology improves patient engagement and clinical assessment, making remote physiotherapy more effective and accessible.

Machine learning-based computer vision is increasingly being used for physiotherapy movement assessment, leveraging depth cameras to capture and analyze human motion. Depth sensors, particularly the Kinect series, play a crucial role in collecting RGB-D and skeletal data for evaluation. Both traditional machine learning techniques and deep learning models contribute to movement analysis, enhancing accuracy and automation in rehabilitation. However, challenges remain, including limited real-world implementation, insufficiently diverse datasets, and difficulties in generalizing algorithms. Future advancements should focus on improving clinical validation, refining data processing techniques, and optimizing AI models for more effective and accessible physiotherapy assessments [4].

The Intel RealSense 3D depth-sensing camera is emerging as a valuable tool for clinical research, particularly in health outcome assessments[5]. Its advanced motion capture, facial tracking, and skeletal recognition capabilities enable precise analysis of patient movements, making it useful in rehabilitation, gait assessment, and mobility monitoring. Compared to traditional, expensive motion analysis systems, RealSense provides a cost-effective and portable alternative suitable for various healthcare settings. While it offers real-time tracking and high-resolution imaging, challenges remain in ensuring data reliability and meeting clinical trial standards. Ongoing improvements focus on enhancing accuracy, usability, and integration into broader medical applications.

References:

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