Executive Summary:

According to the American Physical Therapy Association (APTA) there are not enough licensed therapists for the amount of patients seeking therapy, and the services that are offered could be made more financially and tangibly accessible to both parties.
The project aims to develop an **AI-enhanced AR system for physical therapy** that revolutionizes how patients recover from injuries and surgeries. By combining **augmented reality (AR)** for real-time, immersive guidance with **artificial intelligence (AI)** for personalized feedback, the system offers a smarter, more engaging, and data-driven rehabilitation experience.

Problem Statement:

The physical therapy sector is facing a lot of challenges that ultimately need to be addressed and optimized. The latter are divided into two main categories:

On the Patient's Side

- **Cost of Physical Therapy Services**:
  - Many patients perceive PT services as expensive, especially if their insurance coverage is limited or non-existent.
  - High costs may lead to non-adherence to prescribed therapy programs or even avoidance of seeking therapy altogether.
- **Inefficient Access for Remote Patients**:
  - Patients living in rural or underserved areas often face long commutes or a lack of nearby physical therapy practices.
  - This inefficiency makes it difficult for patients to attend regular therapy sessions, delaying recovery and increasing the risk of complications.
- **Engagement with the Rehab Process**:
  - Rehab routines can be repetitive and tedious, leading to low motivation and poor adherence.
  - Lack of gamification, visual progress tracking, or real-time feedback contributes to disengagement, prolonging recovery time.
- **Outcome Measurement**:
  - Patients rarely receive clear, quantifiable updates on their progress, which can demotivate them.
  - Without proper feedback, they may lose trust in the process or fail to recognize incremental improvements.

On the Physical Therapist's Side

- **Adapting Practices to New Technology**:
  - Many physical therapists struggle to incorporate modern tools like augmented reality (AR), artificial intelligence (AI), or motion tracking systems into their practices.
  - This results from insufficient training, high costs of adoption, or reluctance to change traditional methods.

- **Documentation Overload**:
    - PTs are often burdened with excessive paperwork to meet insurance requirements and document patient progress.
    - This administrative load reduces time spent on patient care, affecting overall efficiency and quality of service.
- **Patient Retention**:
    - Retaining patients throughout their prescribed therapy plan is a challenge, as many patients drop out mid-treatment due to costs, inconvenience, or perceived lack of results.
    - High dropout rates not only affect patient outcomes but also revenue for clinics.
- **Tracking Productivity**:
    - PTs face difficulties in monitoring their own productivity or comparing it to industry standards.
    - Lack of streamlined metrics and tools for self-assessment can hinder continuous improvement.
- **Marketing Needs Improvement**:
    - Many PT practices struggle with attracting new clients due to limited marketing efforts or ineffective strategies.
    - With rising competition, clinics that fail to market their unique value propositions may lose business to larger, more established competitors.
- **Preventing Burnout for PTs**:
    - High workloads, physical demands, and stress from managing multiple patients while juggling administrative tasks lead to burnout.
    - This affects the quality of care, increases staff turnover, and further strains already stretched practices.

Solution Description:

Core Features:

On the patient's side:

- **Patients with access to AR compatible hardware:**
    - **Guide Patients through Exercises:** Use AR to overlay visual cues and interactive instructions, ensuring patients perform exercises with correct form and technique.
    - **Increase Therapy Adherence:** Gamify therapy with AR-driven challenges and achievements, making rehabilitation more enjoyable and motivating.

- **All Patients:**
    - **Provide instant correction:** Utilize AI-powered motion analysis to detect errors in posture, alignment, or range of motion and deliver real-time corrections. Can upload videos to receive feedback.

    - **Track Patient's own progress:** Patients will be able to continuously monitor their own performance, offering detailed analytics to patients about how their rehab process is going.
    - **Enable remote and accessible therapy:** Allow patients to conduct effective therapy sessions at home, reducing dependency on in-person visits and improving accessibility.
    - **Access to Documentation:** Allow patients to access their own health record and PT documentation and update it if needed by the professional.
    - **Access to Equipment:** Allow patients to rent certain equipment if need be like elastic bands, box slams,...

On the PT's side:

- **Program planning and updating:**
    - **AI-Assisted Planning:** Use AI to analyze patient data (e.g., movement patterns, compliance) and suggest optimal therapy plans.
    - **Progress-Based Updates:** Automatically adjust the intensity or type of exercises based on real-time performance metrics collected via sensors or AR tracking.
    - **Exercise Libraries:** Provide PTs with a comprehensive, customizable library of exercises they can quickly integrate into plans.

- **Tracking PT's own productivity:**
    - **Productivity Dashboards:** Create a dashboard that tracks key metrics such as the number of patients treated, average recovery time, adherence rates, and patient feedback.
    - **Benchmarking Tools:** Allow PTs to compare their performance against industry or clinic standards.
    - **Automated Reports:** Provide weekly or monthly reports with visual analytics on productivity trends and patient outcomes.

- **Automating the documentation process:**
    - **Voice-to-Text Documentation:** Use AI-powered speech recognition to document sessions in real-time.
    - **Pre-Filled Templates:** Provide dynamic templates that autofill patient details and common treatment notes.
    - **Data Integration:** Automatically pull patient data from tracking systems (e.g., wearable devices or AR platforms) into reports.
    - **Compliance Checks:** Automate verification to ensure documentation meets insurance and legal requirements.
- **Increasing patient retention:**
    - **Gamified Therapy Sessions:** Incorporate AR-based games and challenges that make therapy engaging and rewarding.
    - **Progress Visualizations:** Show patients their improvement through intuitive graphs and visuals, increasing motivation.
    - **Engagement Alerts:** Use AI to monitor engagement and send personalized reminders, encouragement, or incentives to patients who miss sessions or show signs of disengagement.

    - **Flexible Access Options:** Offer remote therapy options (via AR or video guidance) to ensure patients can continue therapy from home.

- **Improving PT exposure:**
    - **Online Presence Tools:** Develop platforms where PTs can showcase their services, success stories, and patient testimonials.
    - **Social Media Integration:** Offer automated tools to post progress updates, informative content, and therapy tips to engage potential patients.
    - **Referral Programs:** Create systems to incentivize current patients to refer new clients.

- **Preventing Burnout:**
    - **Workload Balancing:** Use AI to allocate patients and appointments more efficiently, ensuring fair workloads.
    - **Task Automation:** Automate repetitive tasks like documentation, appointment scheduling, and progress tracking to free up time for patient care.
    - **Peer Support Communities:** Create online or in-app forums where PTs can share experiences, challenges, and solutions with colleagues.

Market Analysis:

- **Target Audience:**
    - Patients recovering from surgery or injuries.
    - Physical therapy clinics and therapists.
    - Elderly individuals or those with chronic conditions.
    - People with no access to traditional therapy options.
- **Market Size:**
    - 8-9 patients a day per PT.
    - Assuming PTs work normal business hours and 5 days a week.
    - Assuming PTs work all year long.
    - More than 240,000 PTs nationwide.
    - An estimation of 9,600,000- 10,800,000 patients in the US

Product Development Plan:

Key Points:

- Objective: Develop an AI-powered AR platform that guides physical therapy exercises, provides real-time corrections, and tracks progress.

Phases:

1. **Research and Ideation:**
    - Study existing AR and AI tools (e.g., Mediapipe, OpenPose, ARCore/ARKit).
    - Research physical therapy practices and compliance factors.
2. **Prototype Development:**

- Develop a minimum viable product (MVP):
    - A simple app for skeletal tracking with visual feedback.
    - Basic physical therapy exercises with corrective feedback.
- Integrate AI models for movement detection and correction.

3. **Feature Refinement:**
    - Add advanced features:
        - AR overlays for precise guidance.
        - Wearable or IoT integration for enhanced tracking.
        - Progress tracking dashboards for patients and PTs.
    - Develop compatibility with smartphones, AR headsets, and non-AR devices.
4. **Testing:**
    - Collaborate with physical therapists to validate exercise routines.
    - Conduct beta testing with patients to ensure usability and effectiveness.
5. **Launch:**
    - Roll out the product in phases (e.g., pilot programs in rehab clinics or PT practices).
    - Gather user feedback to iterate on features.

<u>Business Plan:</u>

1. **Key Points:**
    - Vision: Revolutionize physical therapy by combining AI and AR for accessible, engaging, and effective rehabilitation.
2. **Target Audience:**
    1. Primary Users:
        - Patients undergoing physical therapy.
        - Individuals needing at-home rehab (e.g., post-surgery recovery, chronic pain management).
    2. Secondary Users:
        - Physical therapists and rehab clinics.
        - Fitness trainers and wellness centers.

3. Revenue Streams:

1. Subscription Plans:
    - Monthly/annual subscriptions for patients.
    - Premium plans for clinics offering advanced analytics.
2. Licensing:
    - License software to clinics and hospitals.
3. Device Sales or Integration Fees:
    - Partner with wearable sensor companies.
4. Freemium Model:
    - Basic features free, with in-app purchases for advanced features or additional exercises.

4. Competitive Advantage:

- AI-driven real-time corrections personalized to each user.

- Compatibility with both AR and non-AR devices.
- Integration with wearable sensors for better accuracy.

Challenges:

- Short term: Develop the AI motion tracking and feedback system.
- Mid term: Integrate motion tracking with AR and non AR compatible hardware
- Long term:
    - Develop the AR environment for physical therapy sessions
    - Design the platform with the other features on it

https://github.com/kensunjaya/arduino-motion-tracking-with-py-cv2/tree/main