Engineering a Cost-Effective and Intelligent Kinematic Tracking System Utilizing Machine Learning

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According to the United States Bone and Joint Initiative, each year, 126.6 million Americans suffer from a musculoskeletal injury or disorder lasting over 3 months, resulting in $213 billion in annual care, treatment, and lost wages. However, only 10% of all sufferers received necessary physical therapy treatment, and of these, only 35% completed their recommended treatment program, costing billions of dollars associated with incorrect recovery. The main cause of this issue was the economic and geographic burdens caused by frequent trips to clinics. Most patients were unable to hold this burden, and with a lack of adequate in-home options simply quit. To solve this issue, this project focused on creating an in-home option through the engineering of a novel kinematic tracking system, consisting of parts totaling under $10 per limb. Using inexpensive inertial sensors, the engineered system was able to accurately and reliably map the body's motion in 3D-space in real-time. On top of this, using data from the same sensors, various machine learning models were built that could autonomously recognize incorrect form in key physical therapy exercises like the back squat. After experimentation, the most novel and applicable models were developed by converting the numerical sensor data into image data, giving each motion an image "signature" that could be recognized among noise. Using this, far more patients will receive the physical therapy treatment they desperately need through this affordable, portable system that can model and correct a patient's motion from the confines of their home.