Human Motion Estimation for Interactive Rehabilitation

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TEAM S24-37

Abstract

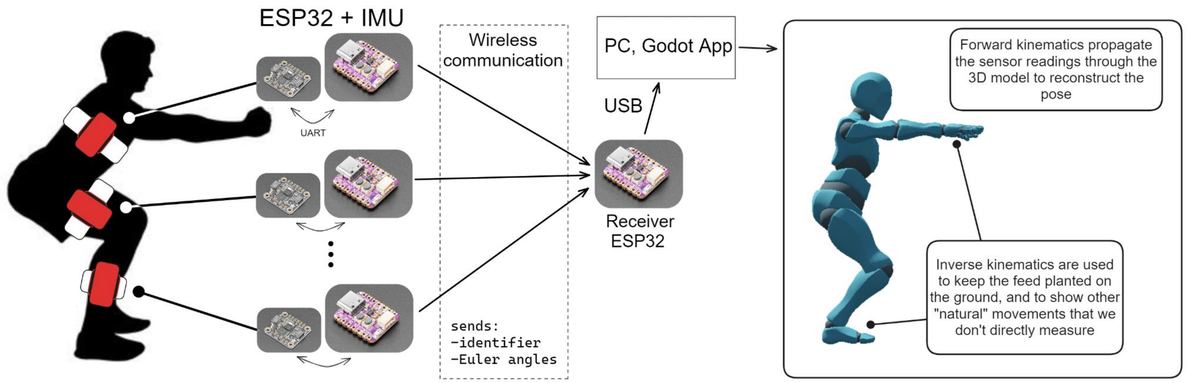
Sarcopenia is a musculoskeletal condition characterized by a loss of muscle and strength that affects a large portion of the elderly population globally. The condition can only be treated with physical therapy [1]. However, not everyone who could benefit from PT is able to use it, either due to cost or location [2]. The goal of our project is to provide a low-cost, at-home alternative to PT, using small integrated internal measurement units (IMUs) to track limb movements using inverse kinematics. This is paired with our software, which guides the user through different therapeutic exercises based on their goal, and gives them feedback on their performance. The results, although preliminary, indicate that this method can help patients reduce the effects of sarcopenia, and provide a way for progress to be tracked over time.

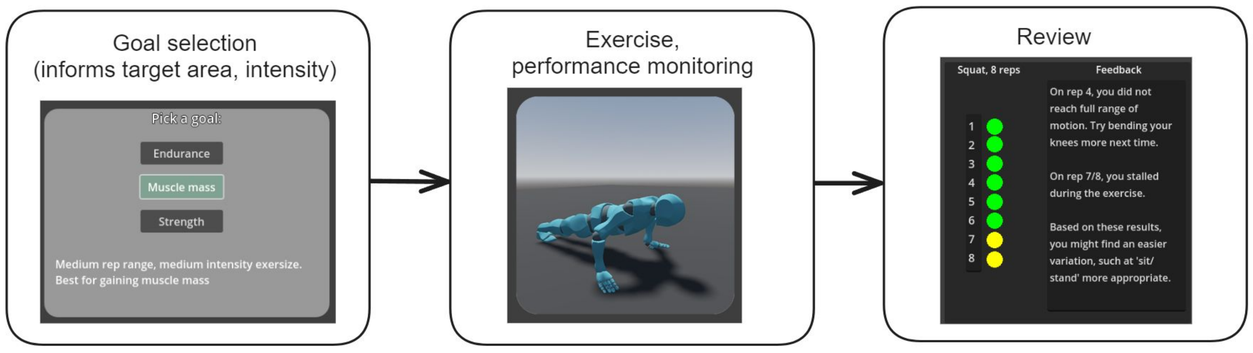
Problem Formulation & Challenges

The main challenge is to treat sarcopenia at home in a cost effective way. We aim to simulate the experience of physical therapy by guiding users through exercise, and providing feedback based on some measure of performance

- ❏ How to accurately track a person's pose without restricting their movements?
- ❏ How to interpret sensor readings to determine how well an exercise is being performed?
- ❏ How to convey feedback to help users perform better?

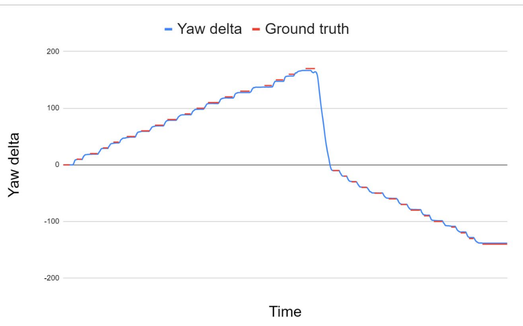
Proposed Solution

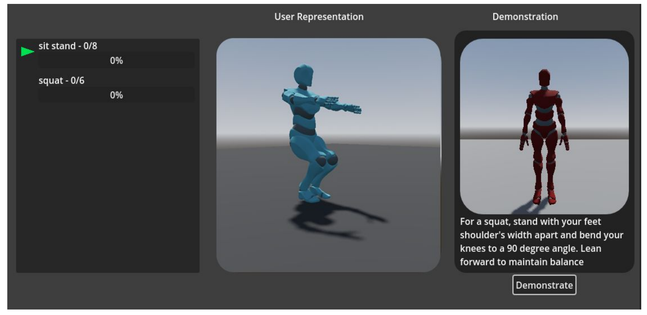




Results

- ❏ IMUs output a yaw, pitch, and roll angle
- ❏ Testing showed that the performance of the sensor is within tolerance for our use case
- ❏ Measurements are calibrated to match the reference frame of the 3D model





Dashboard for the user that details the current routine, visualization of the user, and demonstration with proper form

Training: We guide the user through a selection of exercises that are proven to address the effects of sarcopenia at different stages [3]. Targeting a range of body parts helps users gain strength to complete everyday tasks. To address the different stages, we include variations of exercises at different difficulties:

- ❏ Sit-stand / Squat (lighter/more intense)
- ❏ Wall push-up / Regular push-up
- ❏ Curl

Demonstrations of the exercises are shown to the user, along with tips for proper form.

App: A session starts with the user selecting goals that determine the parameters of the exercises. After the user completes the exercise, they will be shown a summary that details how they performed in each one and gives advice on how they can improve. Performance is characterized by difference from the ideal form we specify in code. Depending on performance, it may also suggest easier variations.

Future Work

- ❏ Wider variety of exercises by using more than 3 sensors
- ❏ Custom printed circuit board for decreased size and cost
- ❏ Conduct experiments with human participants to validate viability of approach

References

[1] Walston JD. Sarcopenia in older adults. Curr Opin Rheumatol. 2012
[2] McCallum CA. Access to physical therapy services among medically underserved adults: a mixed-method study. Phys Ther. 2010
[3] T. D. Law. Resistance Exercise to Prevent and Manage Sarcopenia and Dynapenia. Annual Review of Gerontology and Geriatrics. 2016