

Towards a More Interactive Virtual Coach for Rehabilitation Exercises

Problem

For rehabilitation, clinical tests require direct, visual observation of patient's exercises, but:

- tests are **time-consuming**
- therapists have **limited availabilities**

The adoption of rehabilitation monitoring system remains a challenge due to:

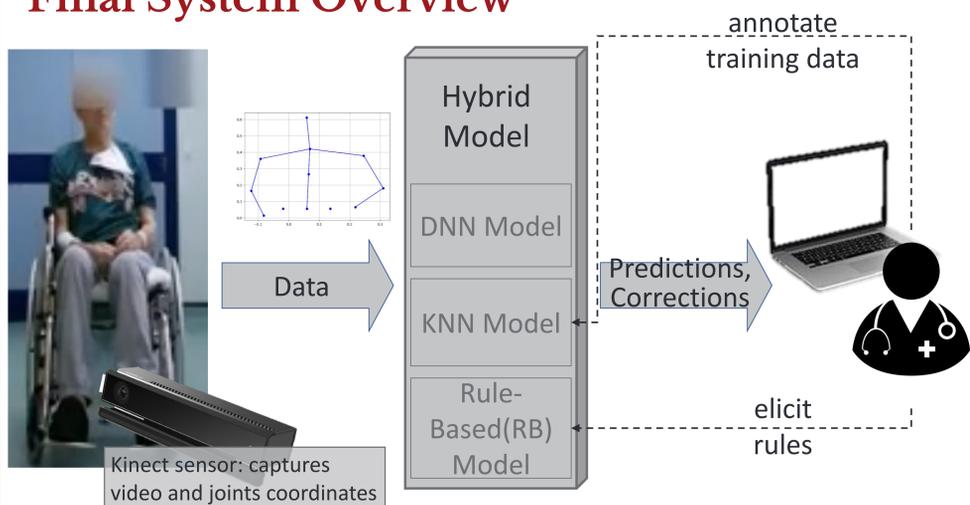
- the lack of **user-centered designs**
- **opaqueness** of the machine learning algorithms[1]

Solution

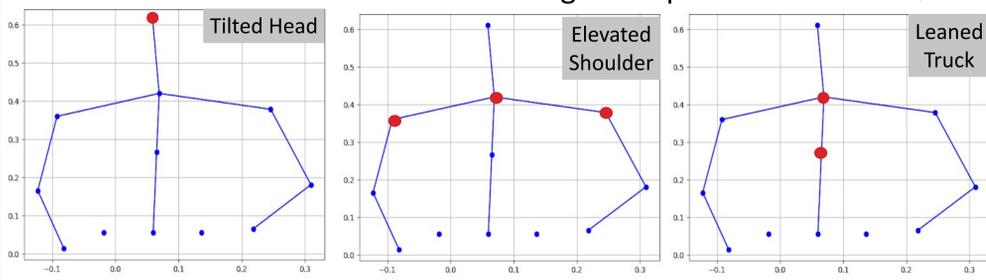
Virtual Coach for patients with musculoskeletal and neurological diseases, that:

- identifies the **compensations**
- provide **feedback & corrections**

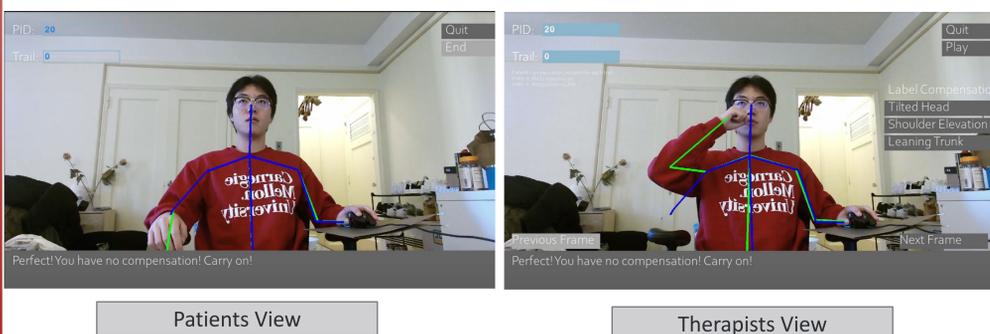
Final System Overview



Patients are instructed to raise their wrists to their mouths as if drinking water as an exercise for elbow flexion[1]. The hybrid model then **identifies** and **corrects** the following 3 compensation: ● Relevant joints



User Interface



Model Comparisons

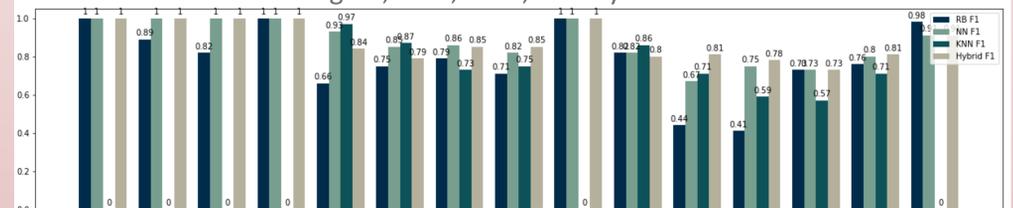
	Performance	Explainability	New-patient Friendly
RB		X	X
KNN	X		
DNN	X		X
Hybrid	X	X	X

Performance: For each patient(15 total), we applied **leave-one-trial-out cross validation**(10 trials/patient). For patients that do not have labeled compensation, KNN can not be applied.

Explainability: Predictions can be used to generate corrections(e.g. identified head tilted to the right can be corrected with keep head to the left)

New-patient friendly: The patient-specific KNN requires training. The patient specific RB has default values when training is absent. DNN is a universal model for all patients.

F1 Comparisons for Spine Compensation Detection among RB, KNN, DNN, and Hybrid Models



Our Hybrid Model has:

- Comparative performance as NN when NN has good performance
- Better performance than NN when NN has low performance(patients 11&12)

Future Works

- Include more rehabilitation exercises
- Get therapists insights on generated corrections
- Conduct user studies with patients
- Explore corrections beyond textual feedbacks
- Use computer vision to eliminate the need of Kinect sensor and thus make the system more accessible

Takeaways

To facilitate Human-AI interactions for AI systems that supplement expert's decision making and correct non-expert's behaviors, it's essential and valuable to analyze the task itself to construct a hybrid model that has both good performance and clear explainability.

References

- [1] Lee, M. H., Siewiorek, D. P., Smailagic, A., Bernardino, A., & Bermúdez i Badia, S. B. (2021, May). A Human-AI Collaborative Approach for Clinical Decision Making on Rehabilitation Assessment. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (pp. 1-14).
- [2] Lee, M. H., Siewiorek, D. P., Smailagic, A., Bernardino, A., & Bermúdez i Badia, S. (2020). Co-Design and Evaluation of an Intelligent Decision Support System for Stroke Rehabilitation Assessment. *Proceedings of the ACM on Human-Computer Interaction*, 4(CSCW2), 1-27.