Machine Learning in Rehabilitation Robotics

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Data Science Capstone Project with Sunil K Agrawal, Roar Lab of Columbia University

Preventing Older Adults Falls

Every second, an older adult (age 65+) suffers a fall in the U.S.(36 million a year)—making falls the leading cause of injury and injury death in this age group (32 000 deaths a year). One out of four older adults will fall each year in the United States, making falls a public health concern, particularly among the aging population. Working in collaboration with the Roar Lab of Columbia University, the goal of this project is to determine the features that make older people more unstable when going from a sitting position to a standing position.

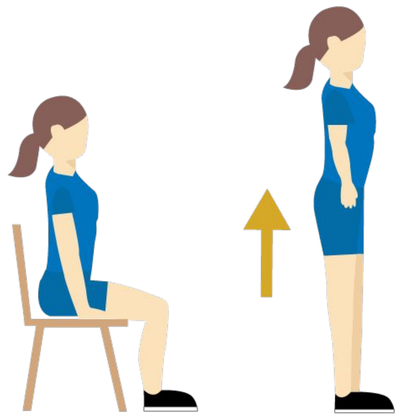


Figure 1. The movement studied

Background information and Methods

We have data from 5 young and 5 elderly adults who performed the sit-to-stand (STS) task. In addition to the baseline condition in which they perform the normal STS, their pelvis was affected by a forward or backward force in other conditions (perturbation). The experiment environment is shown in Figure 2.

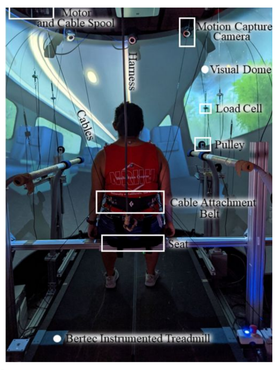
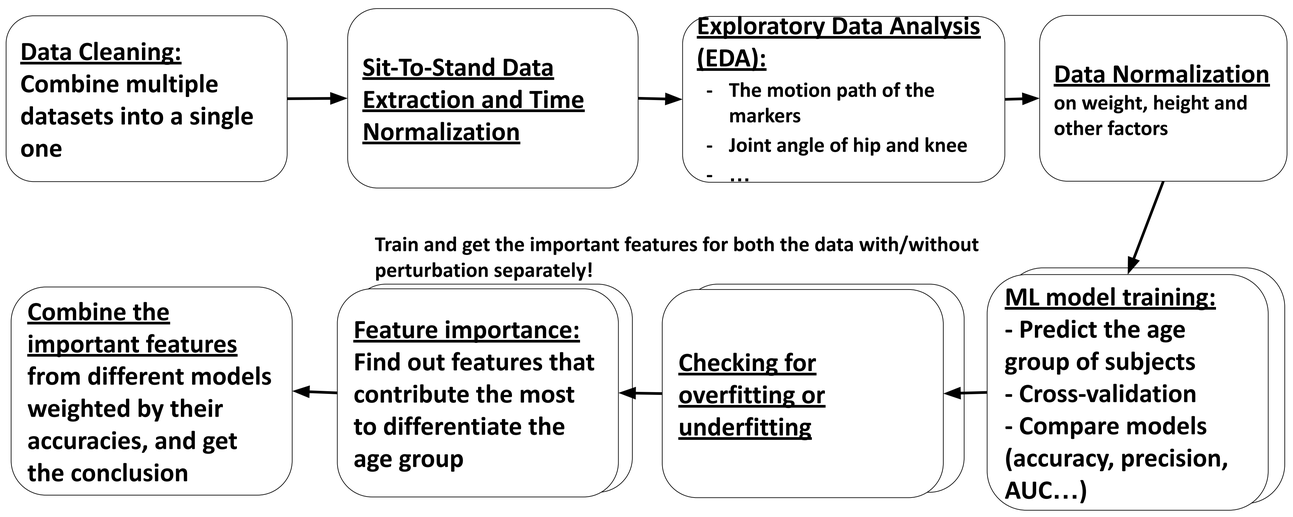


Figure 2. The experiment environment



We focused on supervised learning for the machine learning model as we have the target value (age group) following the methods above. After consideration, we choose to use the following models: Decision Tree; Random Forest; Gradient Boosting; Logistic Regression and SVM

Modeling Results

We performed multiple normalization techniques to increase our model performance and facilitate feature selection, as follows: the dataset with all features normalized by height and weight, the dataset with force plate data normalized by weight only, and the dataset with normalized data transformed by PCA with 10/ 30 important features. We used the following feature selection methods: sequential feature selection, PCA, and manual selection based on knowledge.

We used a validation curve to verify that our mode is not overfitting or underfitting. We ran our benchmark rounds with GridSearch and Leave-1-Out Cross Validation to select our best-performing models.

Overall the accuracy ranges from around 60% to 91% for different models. Support Vector Machine with fully normalized data turned out to be the best model, with over 91% Out-of-Sample Accuracy.

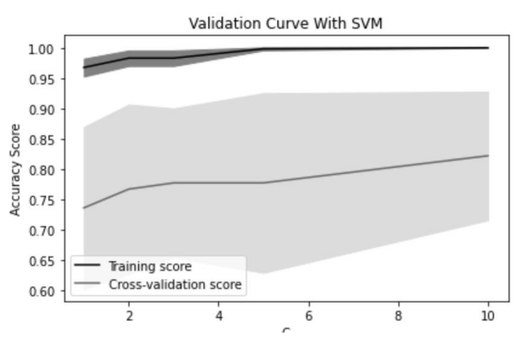


Figure 3. Validation curver example

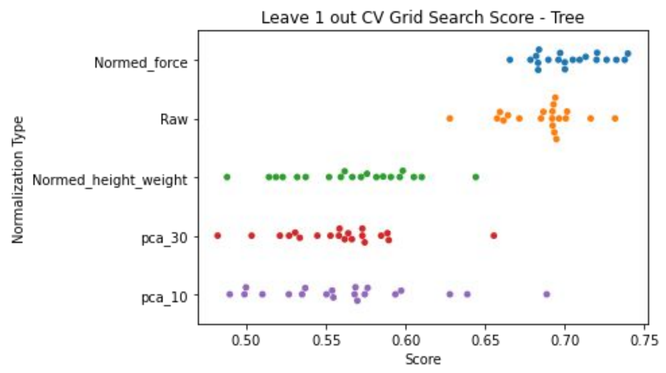


Figure 4. Model Accuracy comparison example

Conclusions and Recommendations:

For all the models we have used to predict the age group, the test accuracy(average from cross-validation) ranges from 60% to 91% for different models.

Overall, older men's movement will become less stable when a perturbation is applied to them. At the same time, the young keep their feet' momentum, knee angle and hip angle in a more stable position even when there is a perturbation.

We expected the performance to increase a lot if the dataset was larger. We hope there can be a further investigation when the data from more subjects are available.

Acknowledgments

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References

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