

# Predicting Intention of Motion During Rehabilitation Tasks of the Upper-Extremity

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- Newest paradigm: Patient chooses trajectories, physiotherapist/robots assists [Hidler and Sainburg; Lum et al.]
- Goal of BETER REHAB project: assist patient along intended trajectory using a robotic arm

**Traditional**

**Exoskeletons**

**End-effectors**

**Collaborative robotic arms**

## Traditional

- + Personalized
- + Targeted

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- + Low development costs
- + Fast rehabilitation cycles
- More complicated controller
- Knowledge of intention is necessary

## Intention of motion

Several intention models available in literature:

- EMG based Liu et al.; Aung and Al-Jumaily; Kwon and Kim
- EEG based Zhou et al.; Yousefizadeh et al.
- EMG and kinematics Natsakis and Busoniu



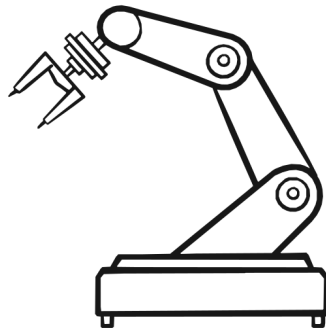
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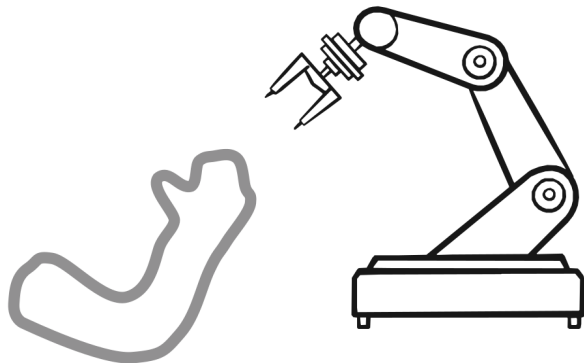
- EMG based Liu et al.; Aung and Al-Jumaily; Kwon and Kim
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However they are all person specific, which is limiting in some cases, e.g. for robotic rehabilitation

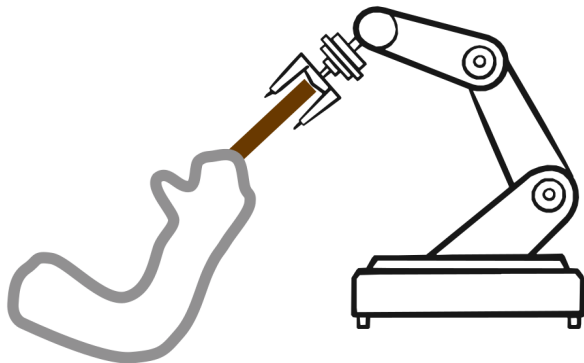
## Robotic rehabilitation::Intention of motion



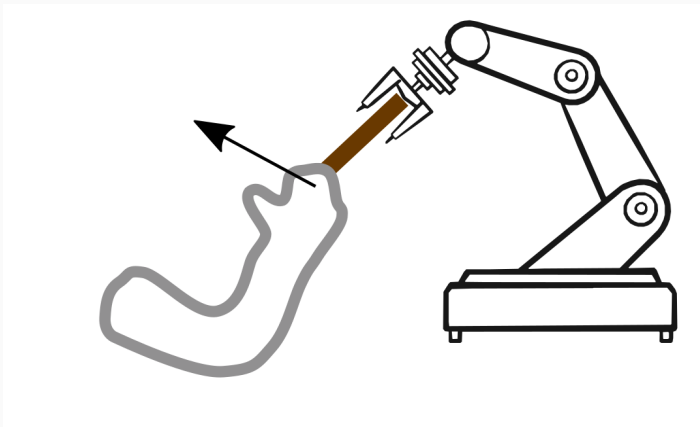
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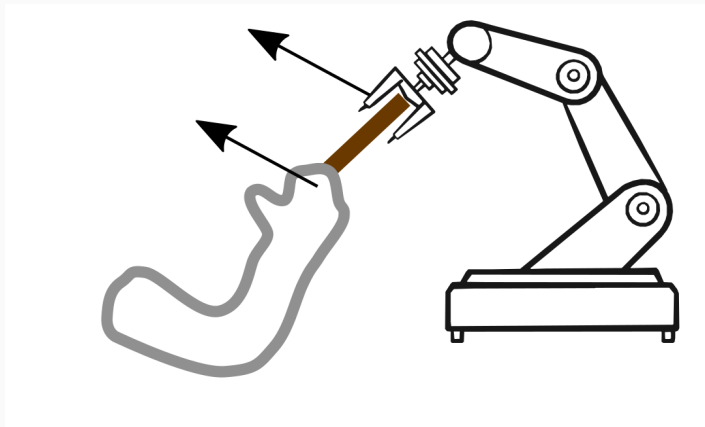
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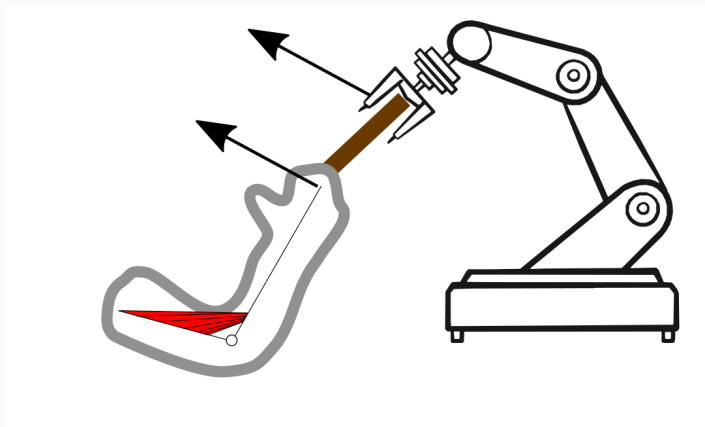
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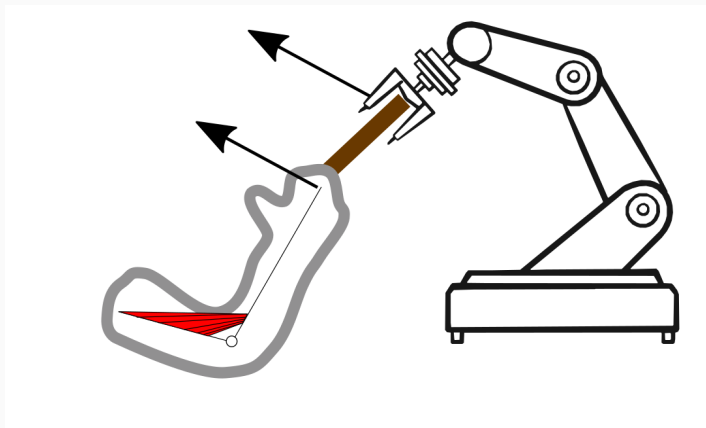
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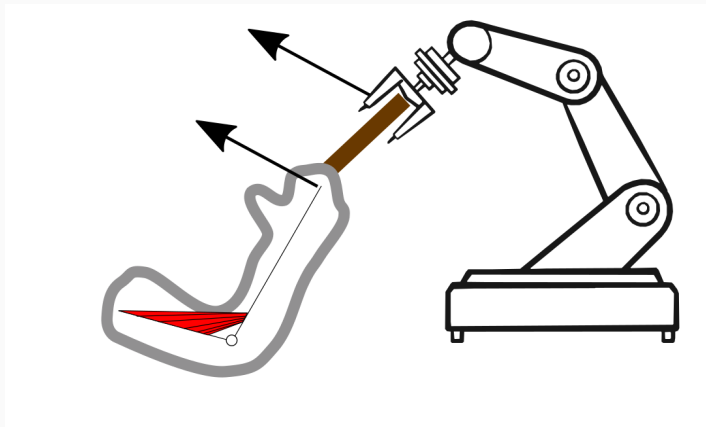
## Robotic rehabilitation::Intention of motion



EMG can help us predict the intention of a person - kinematics

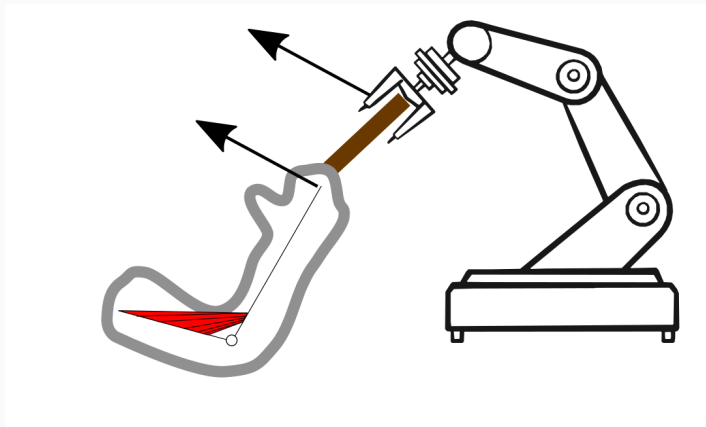


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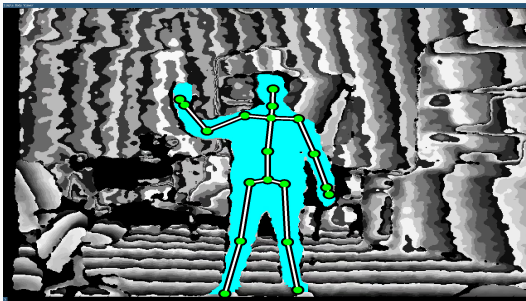


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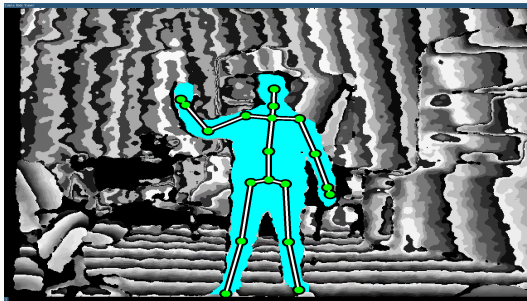
The robot can then assist accordingly

We might not be able to have pre-recorded kinematics of a patient

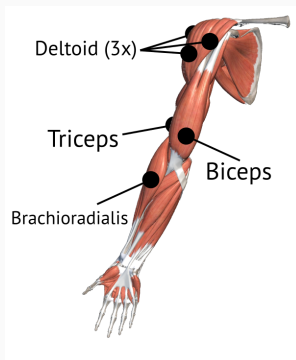
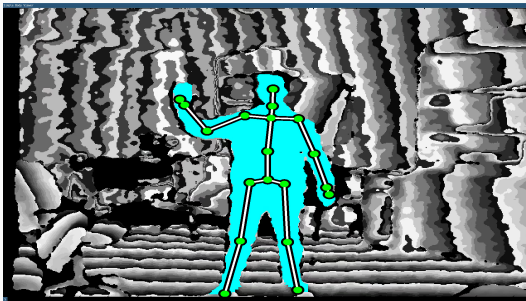
## Intention of motion::Measurements



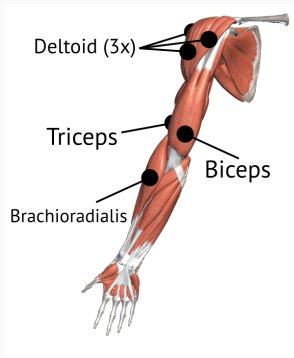
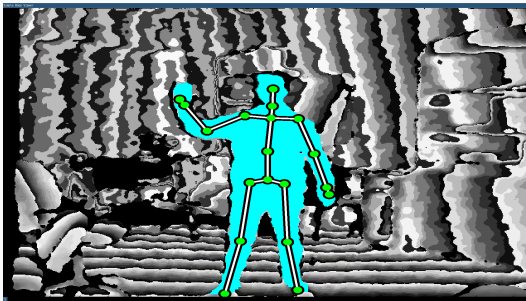
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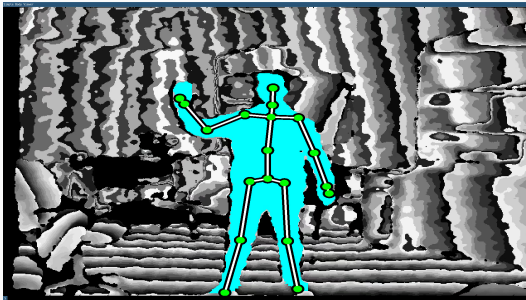
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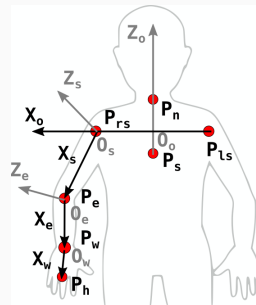
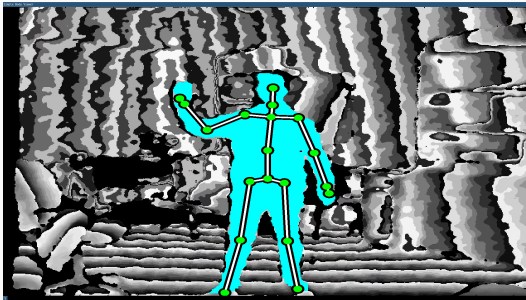
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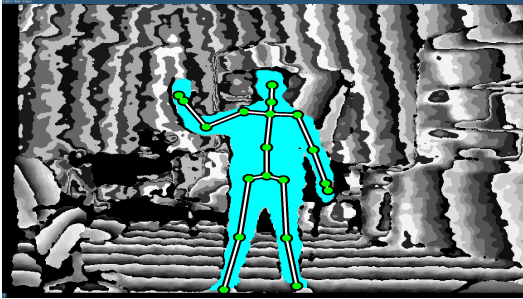


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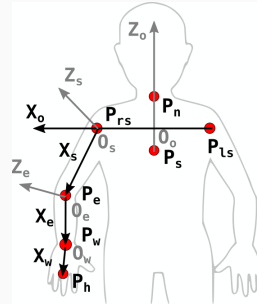




# Intention of motion::Measurements



- Shoulder Abduction
- Shoulder Flexion
- Shoulder Rotation
- Elbow Flexion



## Intention of motion::Measurements

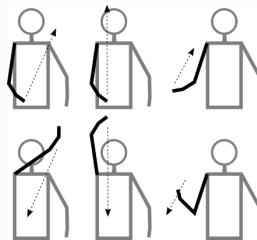


- 5 volunteers (4 male, 1 female)

# Intention of motion::Measurements



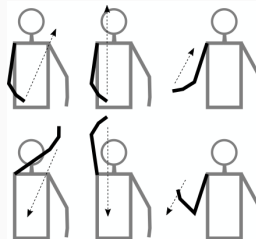
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(Arm raise, Arm cross, Elbow flexion)



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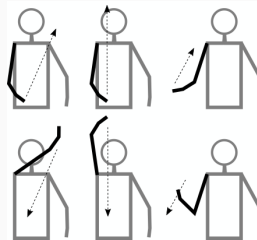
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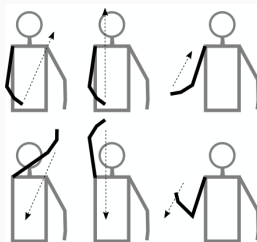
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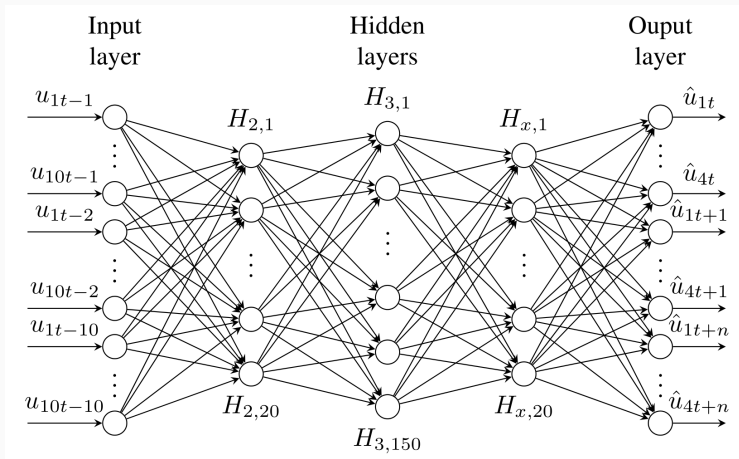
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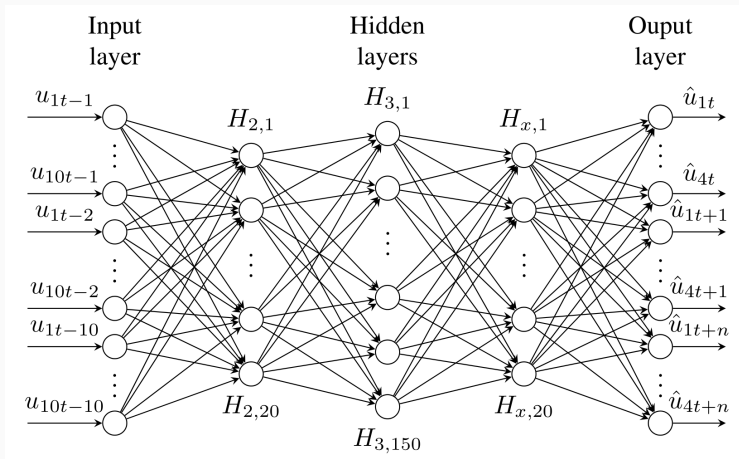
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- LSTM network



# Intention of motion::LSTM network structure



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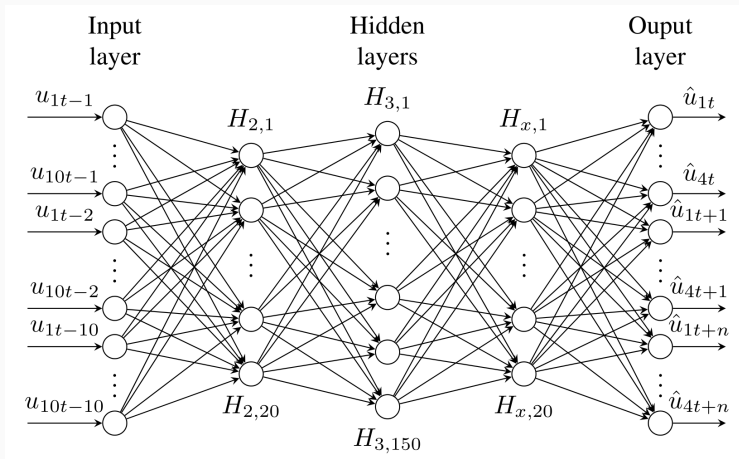


$(6+4) * 10 = 100$  inputs

(EMG + kinematics)



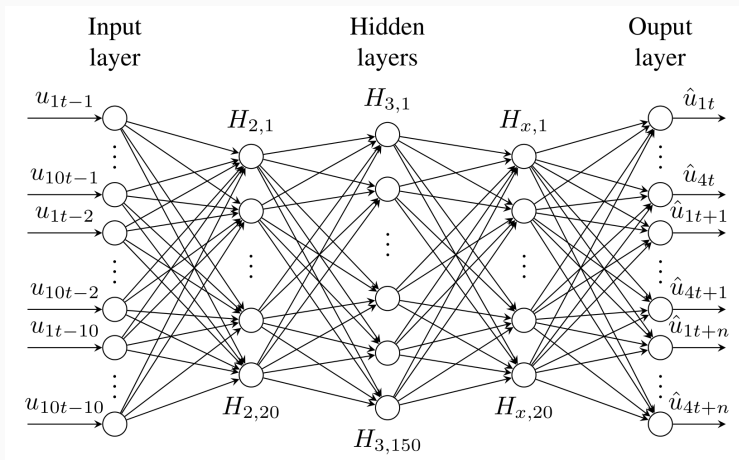
# Intention of motion::LSTM network structure



$(6+4) * 10 = 100$  inputs  
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20 - 150 - 20 nodes  
on 3 hidden layers

# Intention of motion::LSTM network structure

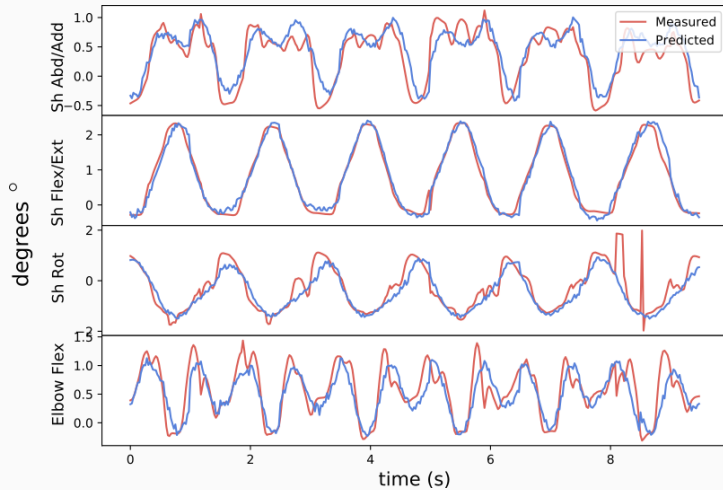


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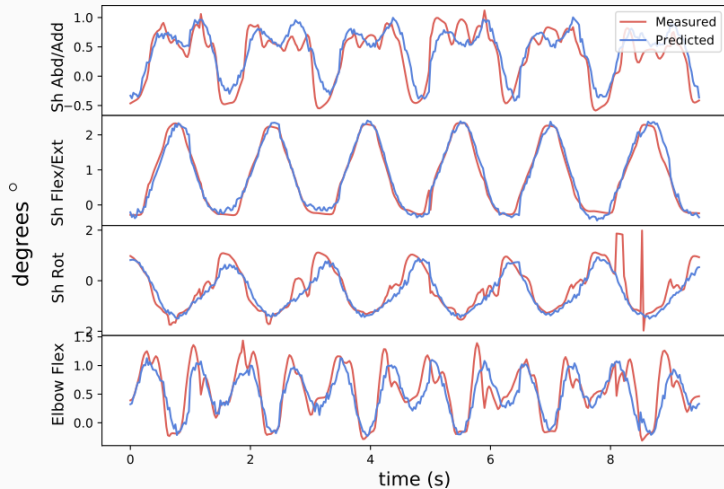
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$4 * n$  outputs (kinematics)  
( $n$ : prediction steps)

# Intention of motion::Subject specific prediction

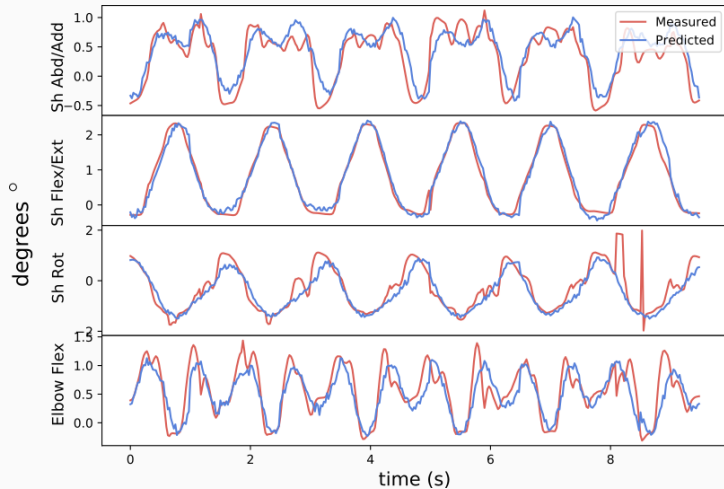


# Intention of motion::Subject specific prediction



RMSE as a metric for accuracy

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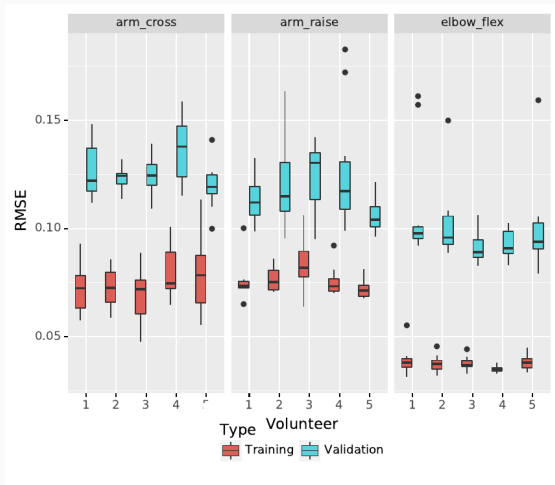
RMSE as a metric for accuracy

Prior measurements are necessary (person specific model)

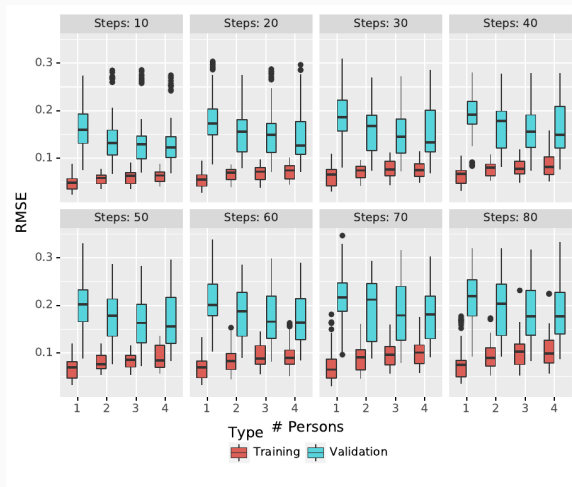
Leave-one-out training

# Intention of motion::Generic Prediction

Leave-one-out training



# Intention of motion::Sensitivity analysis





- Prediction is realistic and real-time

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- Accuracy increases with more subjects

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- Accuracy increases with more subjects
- Predicted intention more accurate than pre-defined trajectories

# Acknowledgment

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Questions?

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