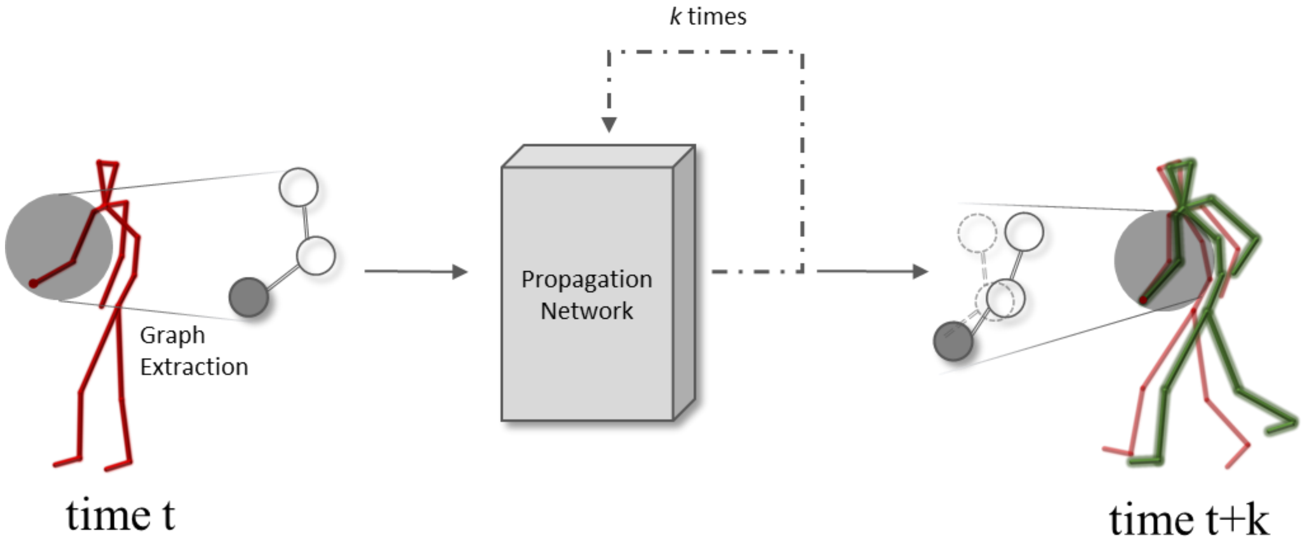
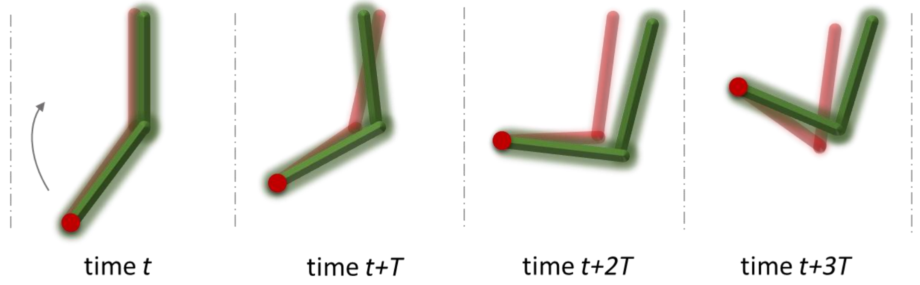
Objective



Aim

- **Predict motion of an articulated human body through a trajectory**.
- Use movement of some joints as reference to evaluate the rest of the joints.



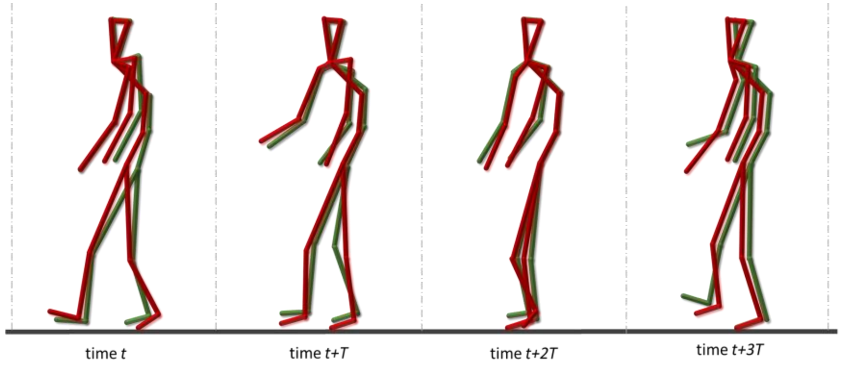
Example predictions of right arm, when right hand is given to the propagation network as the reference point.

Approach

- We wish to develop a model that investigates the joints and their relations.
- Joints and relations have kinematical similarities with each other, relatively. **We expect accurate generalization using propagation networks[2]**.

Environment

- KIT Whole Body Language dataset[1].
- Consists of 3D positions of the joints for multiple frames, for 4000 different movement trajectories.



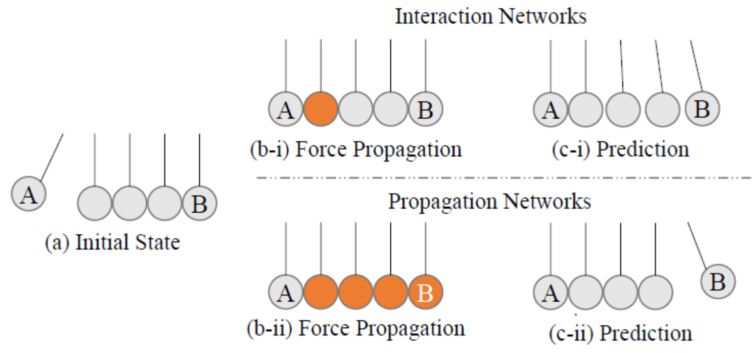
Example predictions of the whole body. Green lines represent the predictions, the red lines represent the actual links.

More detailed information about the underlying network can be found in **#wed03_2** channel in Slack [3].

Proposed Model

Propagation Networks

- **Effects** of objects and relations **propagate to whole graph**, more and more with each propagation step.



Li, Wu, Tenenbaum et al. "Propagation Networks for Model-Based Control Under Partial Observation" in *ICRA 2019* [2].

Step 0:

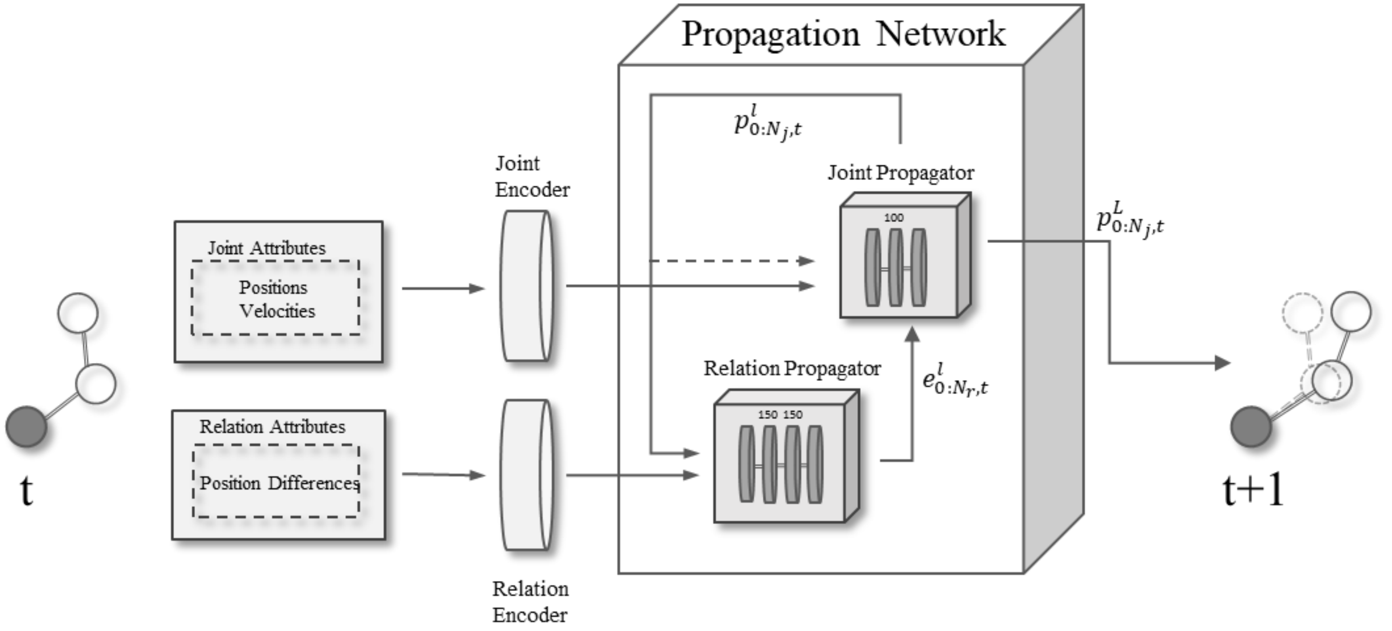
$$c^j_{i,t} = f^{enc}_J(j_{i,t})$$
$$c^r_{k,t} = f^{enc}_R(r_{k,t})$$

Step $l=1,\dots,L$

$$e^l_{k,t} = f^l_R\left(c^r_{k,t}, p^{l-1}_{h,t}, p^{l-1}_{i,t}\right)$$
$$p^l_{i,t} = f^l_J\left(c^j_{i,t}, \sum_{k\in R_i} e^l_{k,t}, p^{l-1}_{i,t}\right)$$

Output:

$$j_{i,t+1} = p^L_{i,t} \qquad k = 1 \ \dots \ N_r \qquad i, h = 1 \ \dots \ N_j$$



Implementation Details

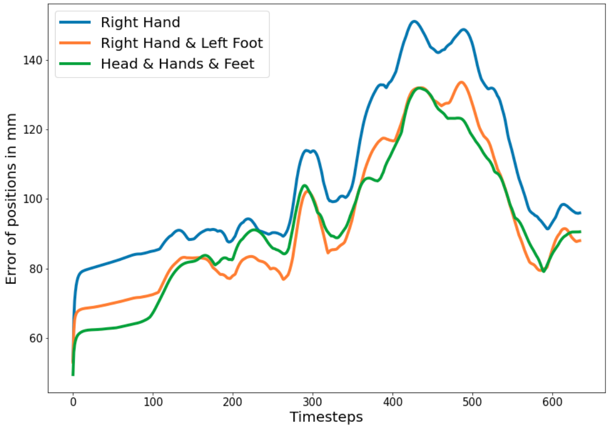
- **Joint encoder** f^{enc}_J is an MLP with 3 hidden layers of 150 neurons and it takes joint positions and velocities ($j_{i,t}$).
- **Relation encoder** f^{enc}_R is an MLP with 1 hidden layer of 100 neurons and it takes vectoral distance ($r_{k,t}$) between the corresponding joints that has the relation k.
- **Joint propagator** f^l_J is an MLP with 1 hidden layer of 100 neurons.
- **Relation propagator** f^l_R is an MLP with 2 hidden layers of 150 neurons.

The model is trained with two walking trajectories. In each of these trajectories, reference points' and other links' predictions' positions and velocities are given as the joint attributes and the relation attributes are extracted from these joints. The model is trained in each frame with the target being the ground truth positions of the links in corresponding frame.

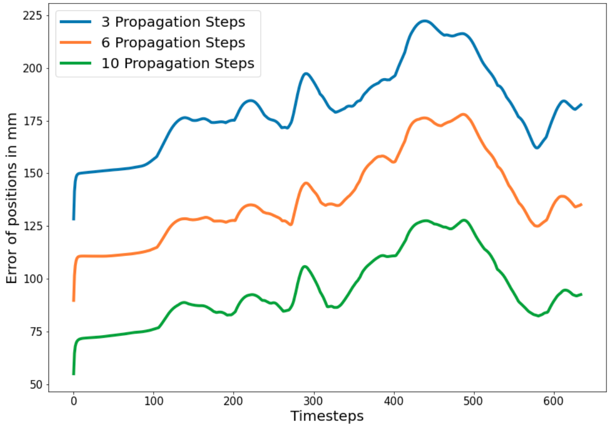
Results

The accuracy of the model depends on

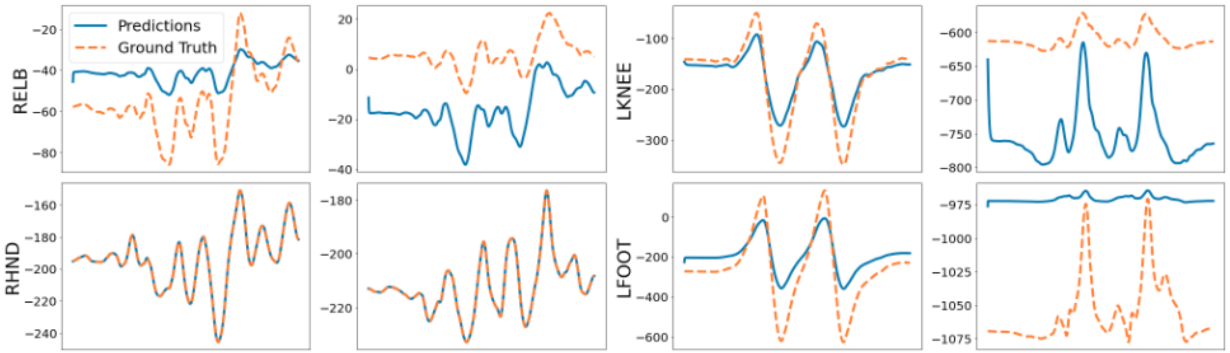
- **The number and extend of the reference points**
- **Number of propagation steps.**



The average error (mm) when different points are given as reference points in training. ***The error increases as the number of reference points decreases.***

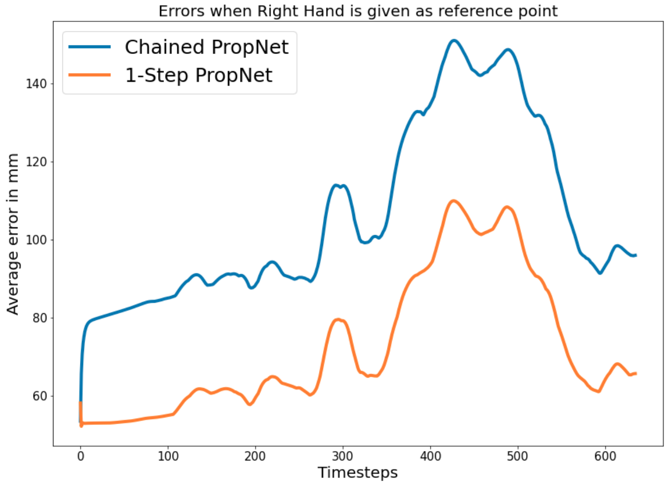


The average error (mm) of models that are trained with different number of propagation steps. ***The error increases as the number of propagation steps decreases.***



Positions of different joints (mm) through a trajectory when right hand is given as the reference point in training. RHND, RELB represent right arm's hand and elbow, LKNEE and LFOOT represent left leg' knee and foot. ***Further joints from the reference point are predicted less accurately.***

- The model is trained in every frame by chaining the predictions back to back with each other. How does this effect errors?



Average errors (mm) with 1-Step PropNet, where the joint attributes are taken as the ground truth in each timestep, and with Chained PropNet where the predictions are used as the joint attributes in each timestep. ***The error is lower when ground truth is used in each timestep.***

Future Work

- Comparison of the proposed model with some state-of-the-art implementations and referenced works for human motion prediction and graph neural networks.
- Performing an ablation study to investigate the sub-units of the system, better.
- Generalization of the model with different human bodies.

References

[1] C. Mandery, Ö. Terlemez, M. Do, N. Vahrenkamp and T. Asfour, "The KIT Whole-Body Human Motion Database", International Conference on Advanced Robotics (ICAR), pp. 329 - 336, 2015

[2] Li, Wu, Tenenbaum et al. "Propagation Networks for Model-Based Control Under Partial Observation" in *ICRA 2019*

[3] A. E. Tekden, A, Erdem, E. Erdem and M. Imre, M. Y. Seker and E. Ugur. "Belief Regulated Dual Propagation Nets for Learning Action Effects on Groups of Articulated Objects" in *ICRA 2020*.