Data Driven Motion Generation

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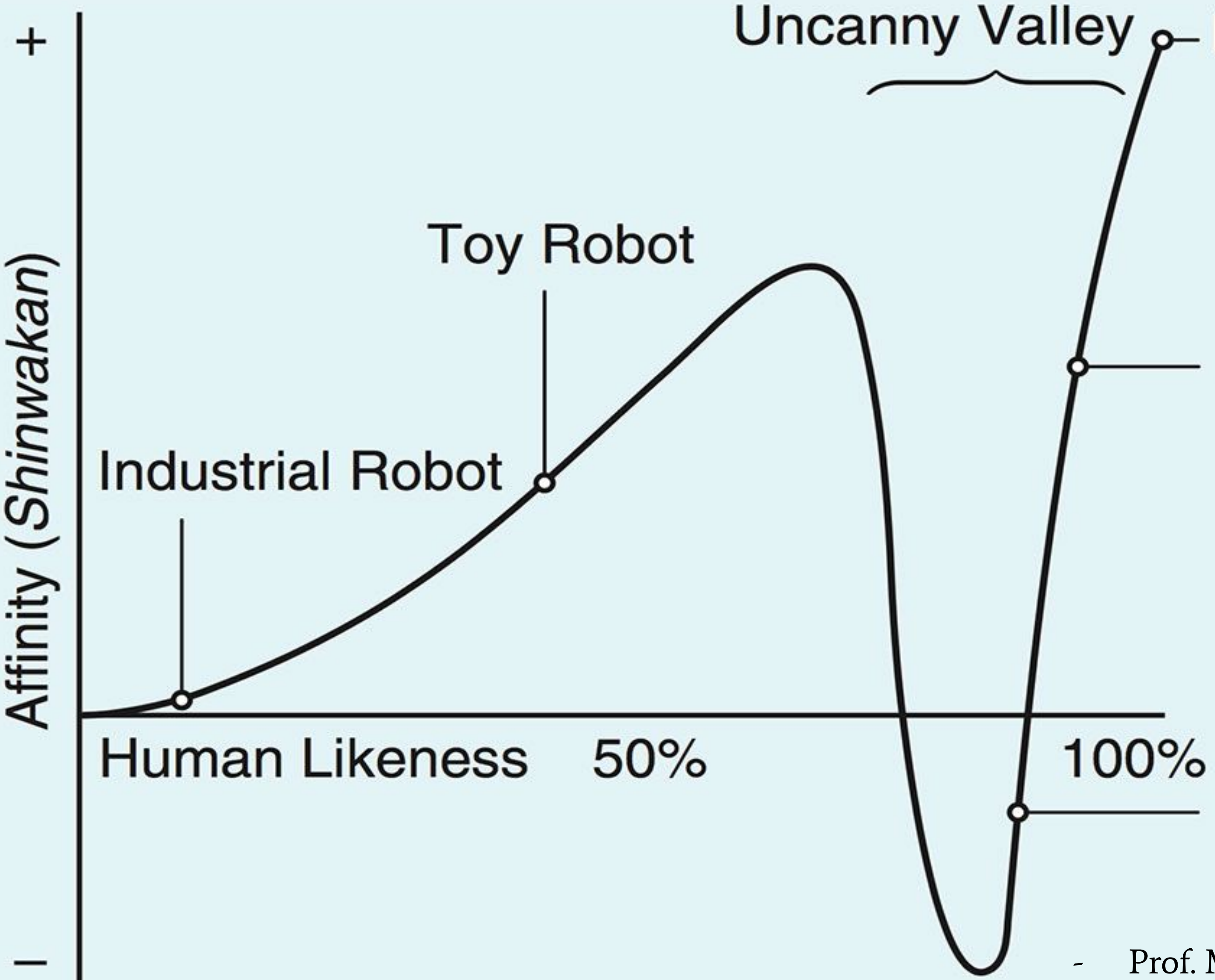
30 March 2021

Agenda

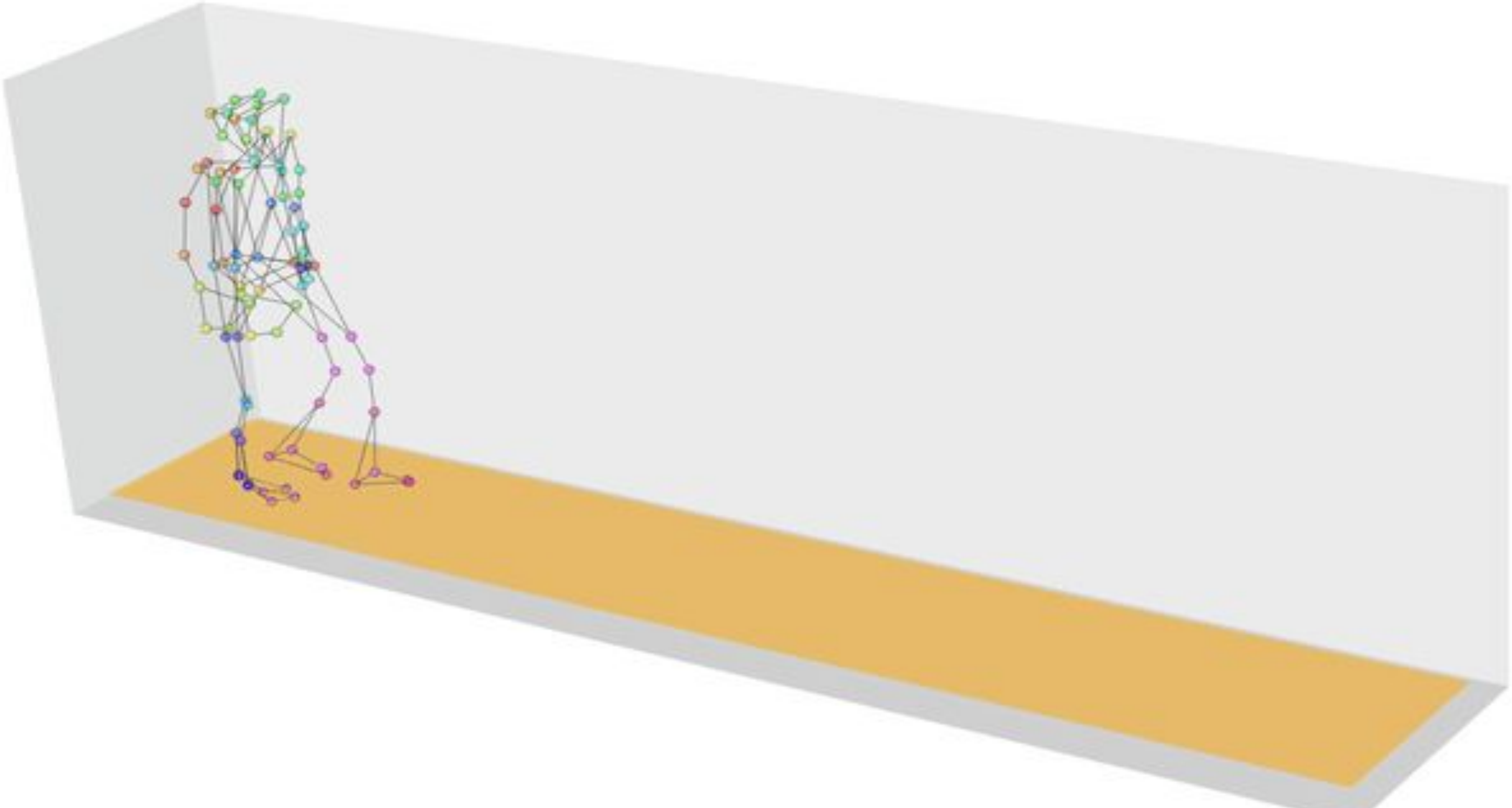
1. What is motion synthesis?
2. Statistical movement generation
3. Training data
4. Breaking down the complexity of movements & temporality
5. Generation algorithms and control techniques


HITLIST

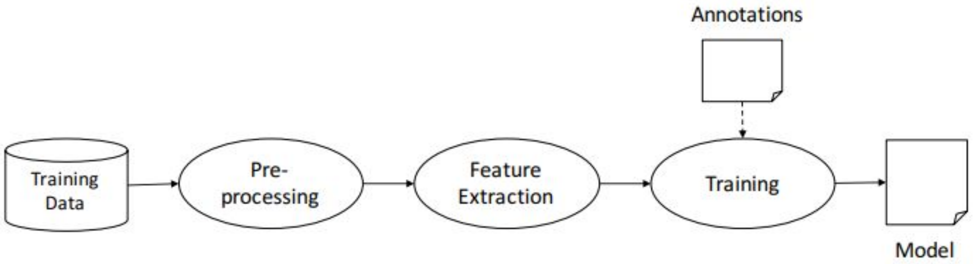


Uncanny Valley

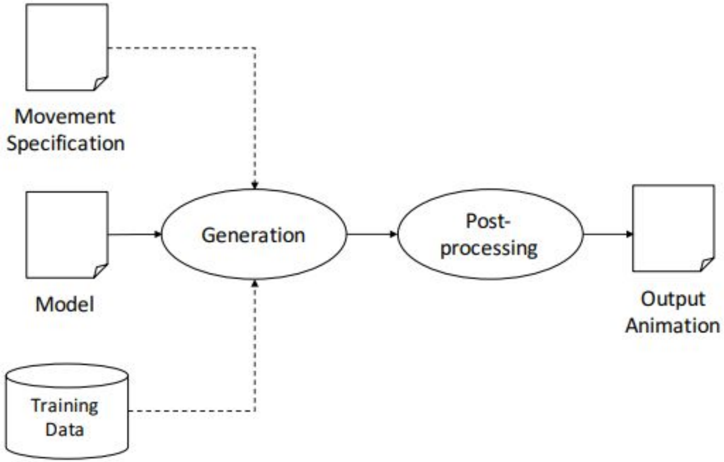
- Prof. Masahiro Mori, Tokyo Inst. of Tech.



Statistical Movement Generation



Training*



Generation*

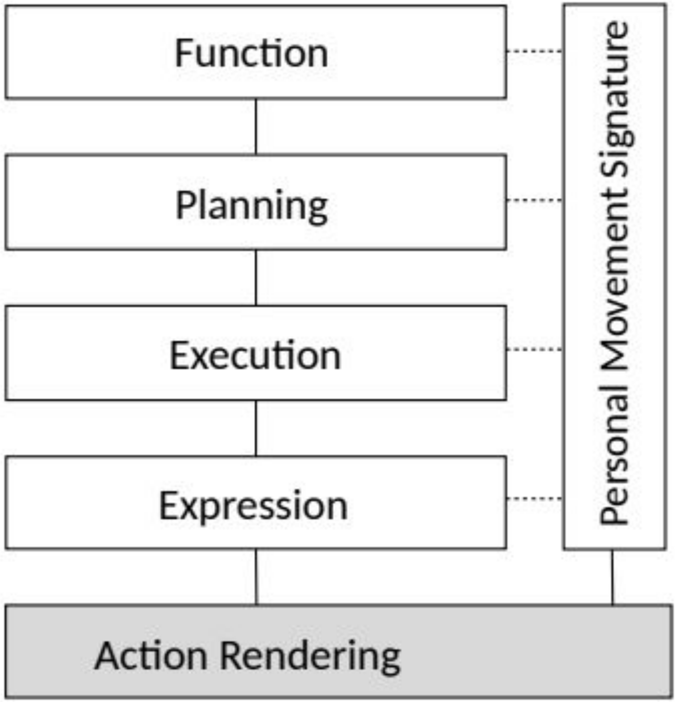
*[Alemi et al. 2019]

Training Data

Choice of Scenarios

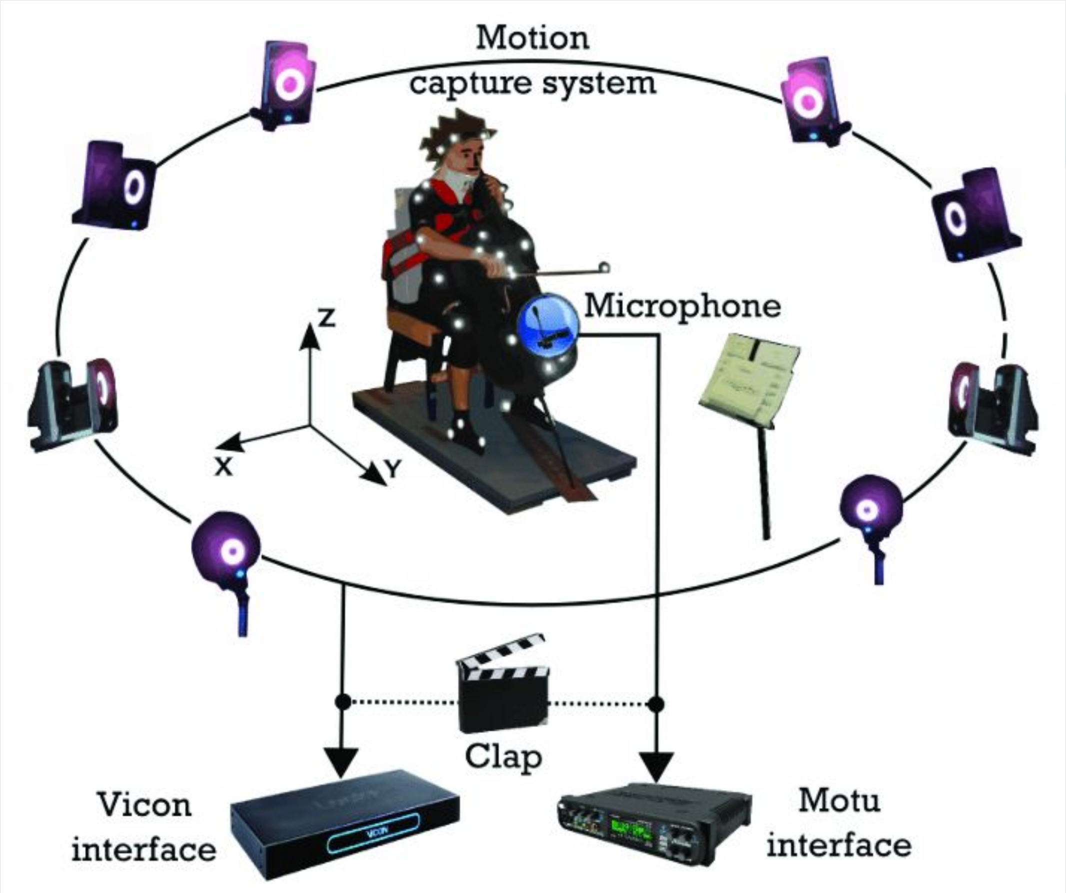
Dance movements (bollywood, hiphop, salsa, ballet);
Sports (kickboxing, tennis, cricket);
Waving a hand while walking, standing, running, biking;
Handshake, smoking, eating, grasping, climbing;
Debate conversations, etc.

Control Factors*



*[Alemi et al. 2019]

Capturing Human Movement*

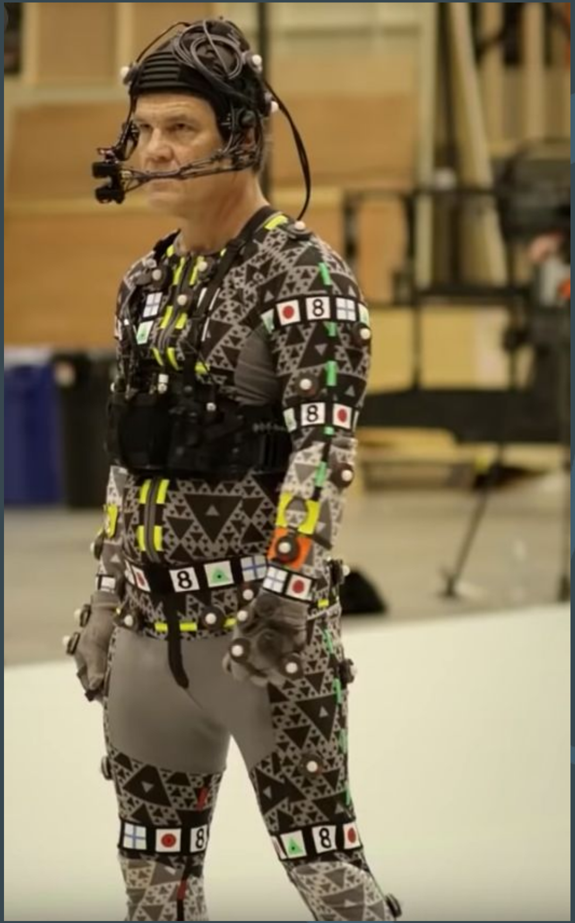


Output data format:

C3D, BVH, Vicon,
COLLADA, FBX

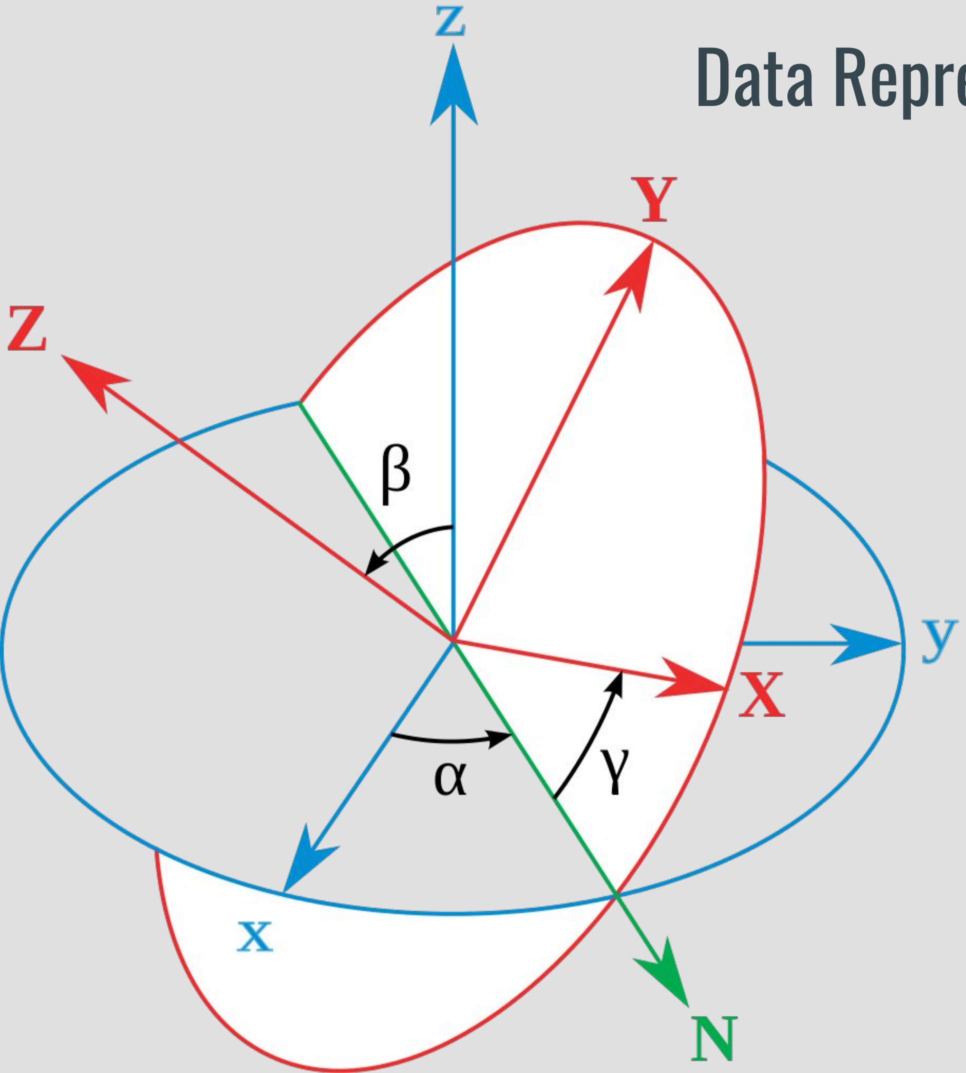
*[Rozé et al. 2018]

Life as a mocap performer

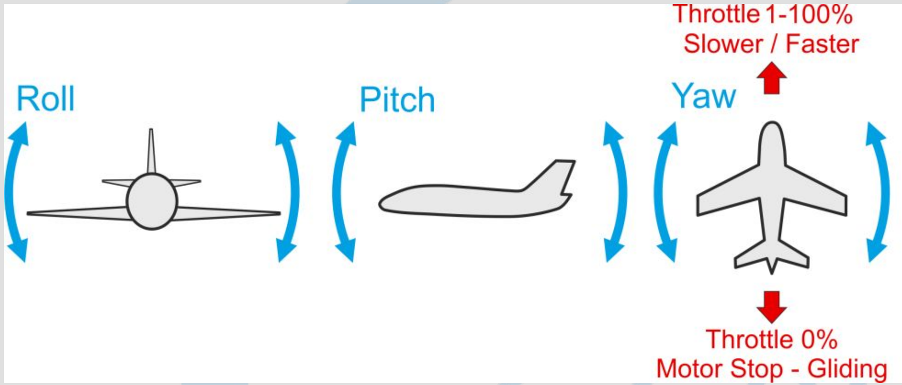


Mocap at KTH:
PMIL (https://www.kth.se/social/group/pmil/)

Data Representation



Euler Angles (blue) to Quaternions (red)



$$p \to q \cdot p \cdot q^{-1}$$

Available Databases

Human 3.6M from Romanion Academy:
3.6M 3D human poses and images; 50Hz sampling from 4 calibrated cameras
Link: http://vision.imar.ro/human3.6m/description.php

CMU Graphics Lab Motion Capture Database
Exhaustive list of actions and varying subjects recorded data in different formats
Link: http://mocap.cs.cmu.edu/

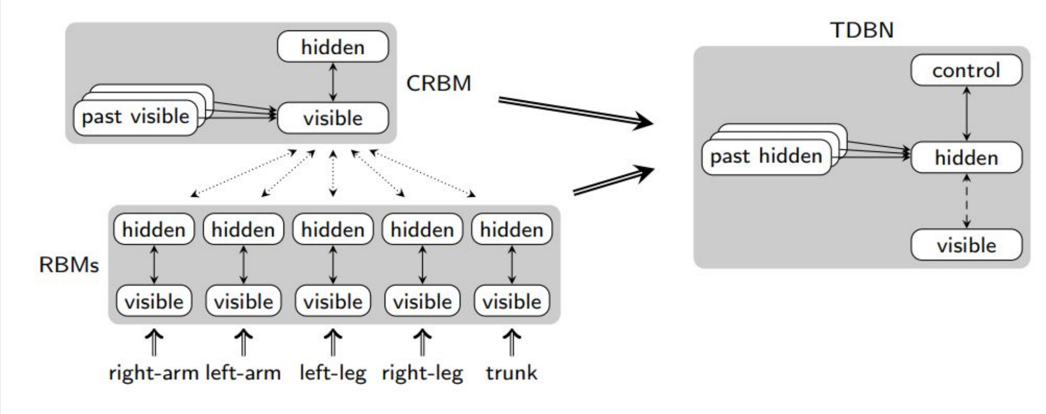
Berkeley Teleimmersion Lab: MHAD
Bio-inspired approach to recognize human movements and movement style for 11 actions on 7 m/ 5 f
Link: https://tele-immersion.citris-uc.org/berkeley_mhad

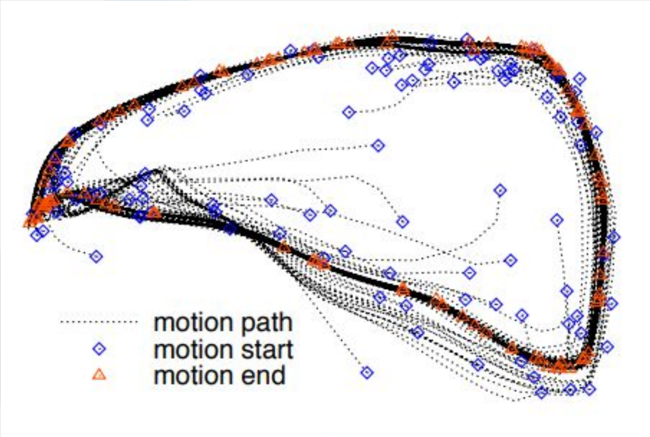
Congreg8 Dataset by ESAL, KTH
Dataset of human and robot approach behaviors into small free-standing conversational groups
Link: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0247364 AND MANY MORE...

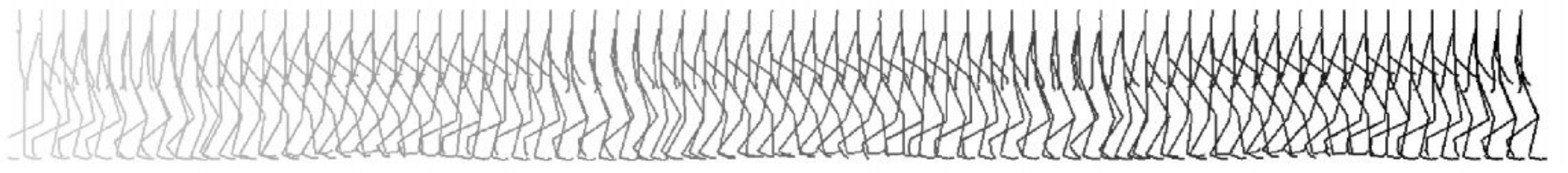
Complexities and Temporality

Breaking down the complexity of movements based on:
Physical structure of human body and Segmenting the time dimension

Allocate different machine learning models to different body parts.[Sukhbaatar et al 2011]
In this, a 2 layer design is made:



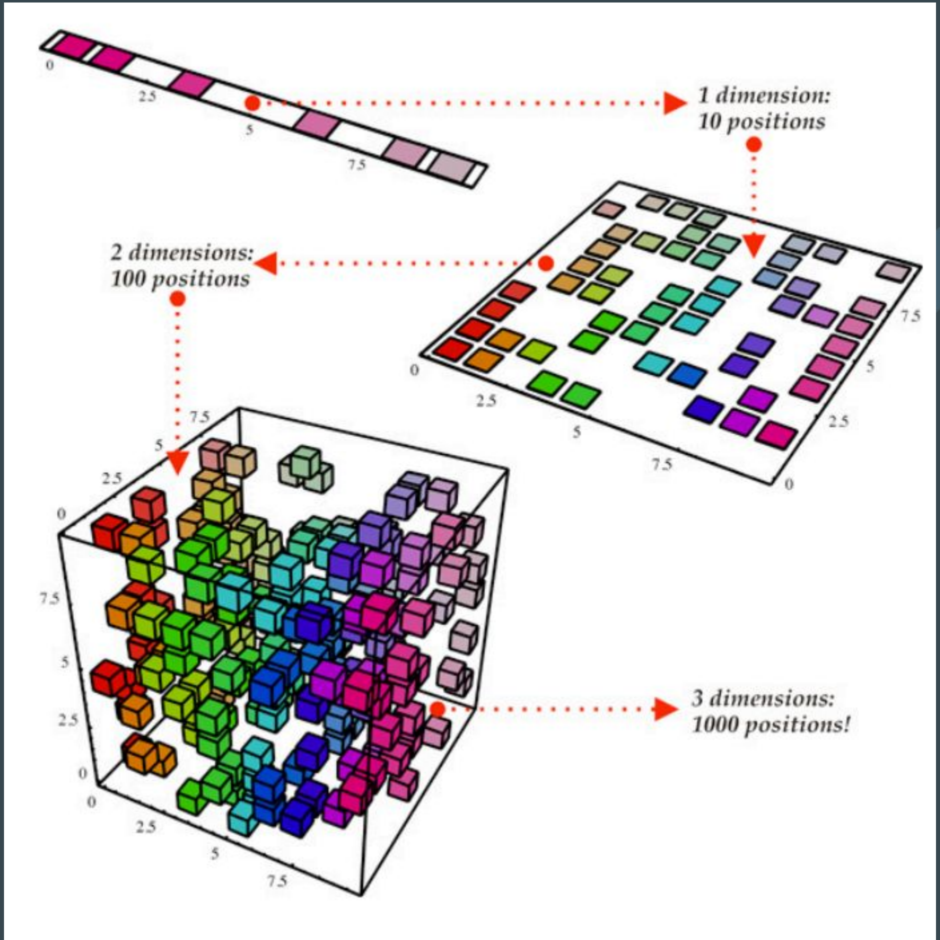




Generative Algorithms

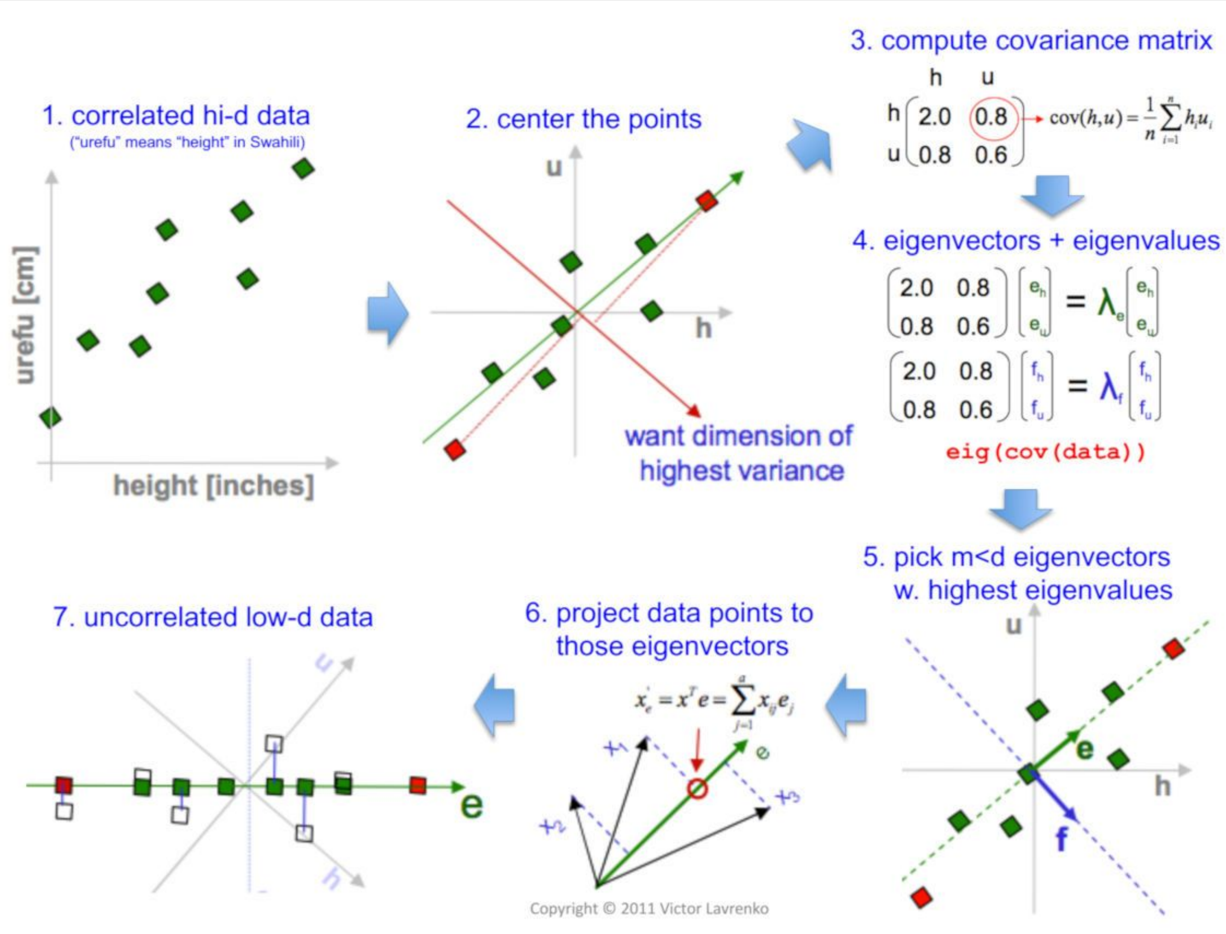
- Dimensionality Reduction
- Gaussian Processes
- Hidden Markov Models
- Artificial Neural Networks
  - Feed-forward neural networks, Boltzmann Machines
  - Recurrent neural networks
  - Convolutional Networks

Dimensionality Reduction



Source: https://bigsnarf.wordpress.com/category/thoughts/page/4/

Principal Component Analysis



Source:
https://devopedia.org/principal-component-analysis

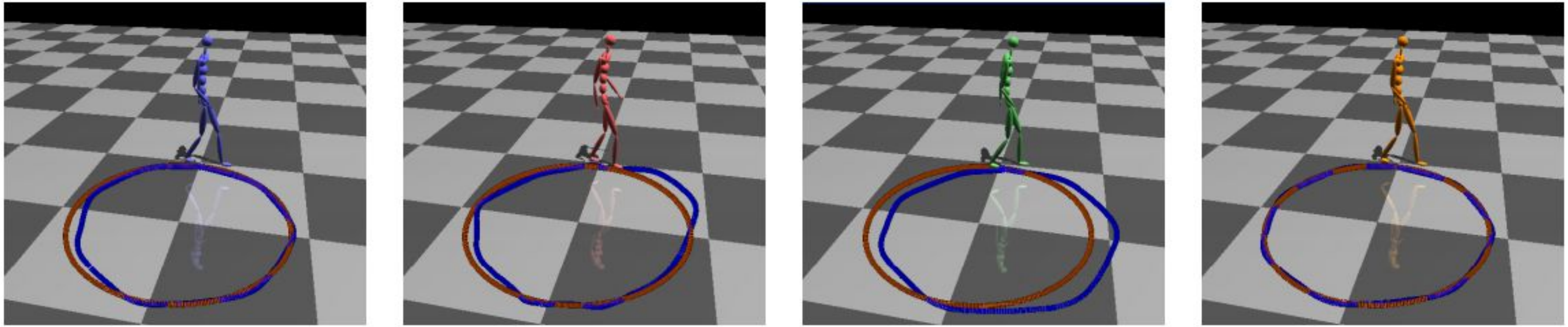


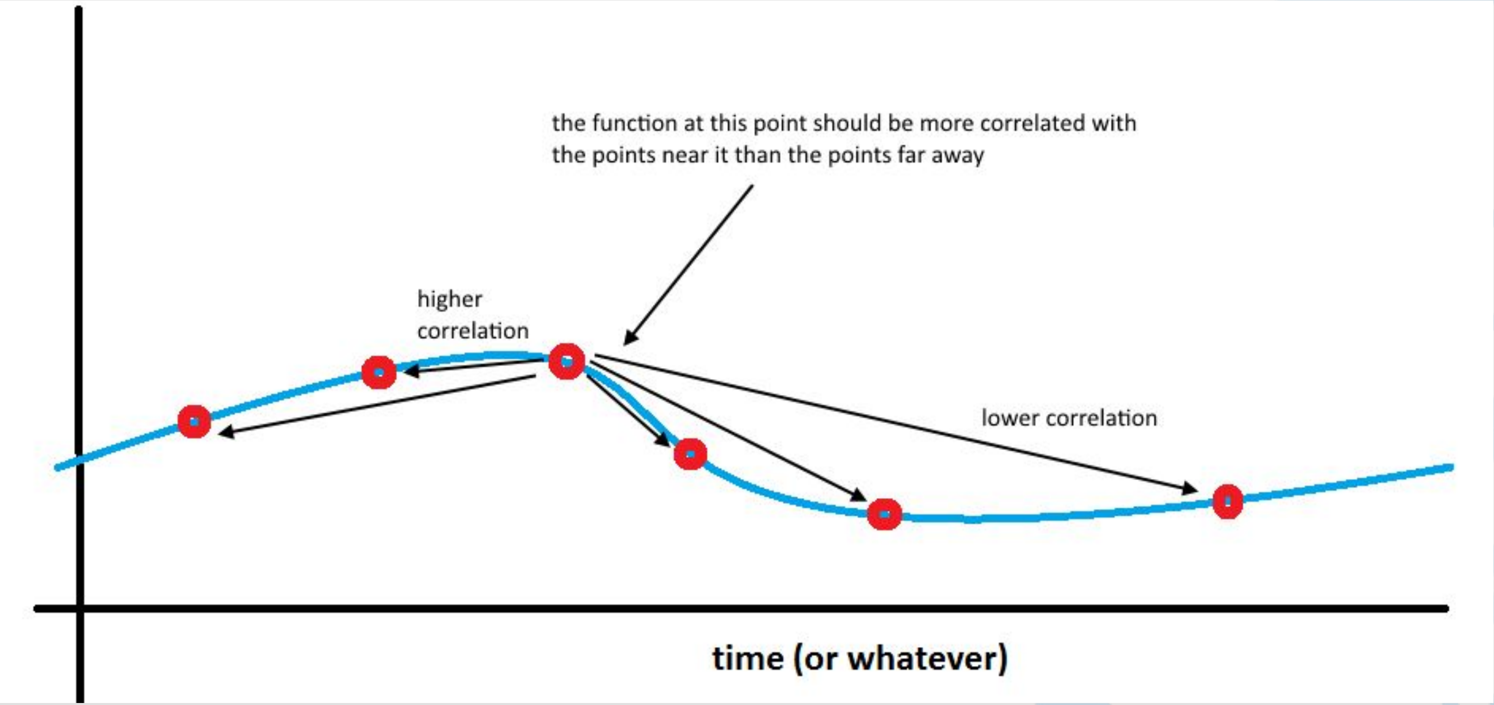
Figure 3: *Comparisons against motion graphs and motion interpolations. The results generated by motion graphs, motion interpolations I, motion interpolations II and our method are shown in left to right. Note that we visualize user-specified paths and synthesized paths in blue and maroon, respectively.*

Motion graphs ++ (Min and Chai 2012)

Preprocessed movement mapped to fixed length low dimensional representation using a PCA. These representations are modelled using Gaussian mixture model (GMM). During generation you draw sample from GMM and project it back to the movement space.

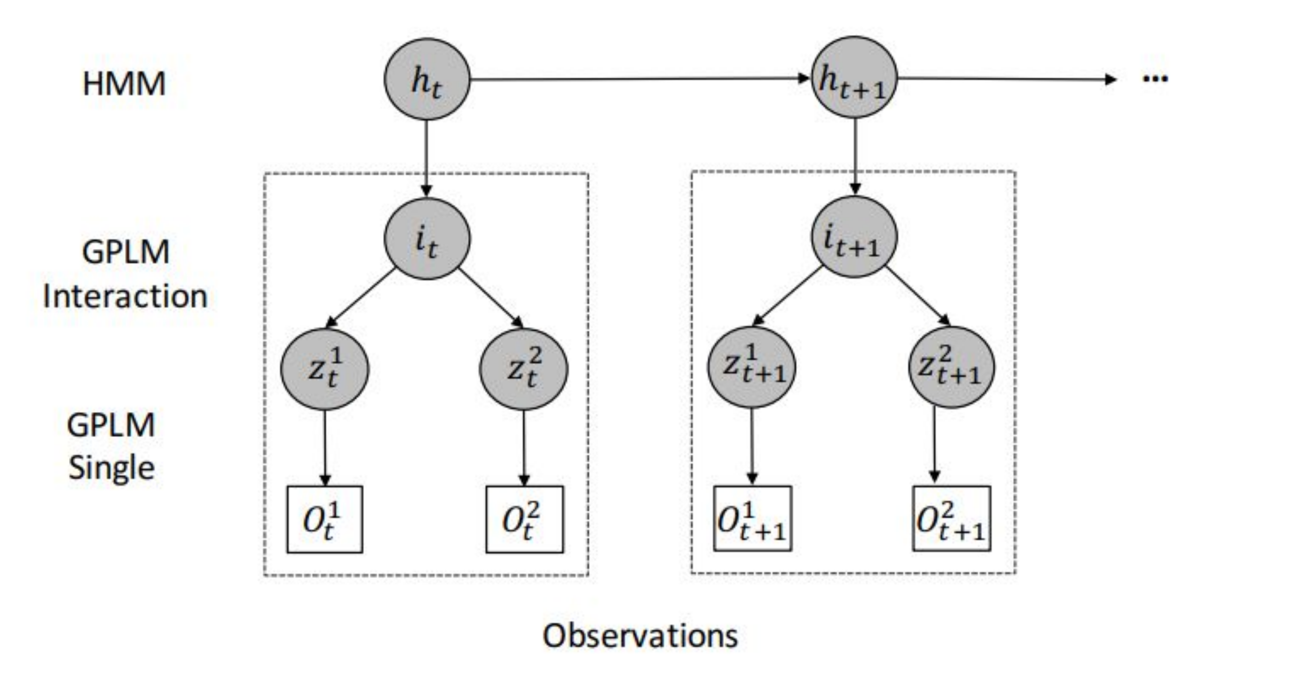
Gaussian Processes

Supervised Learning to solve probabilistic classification problems*



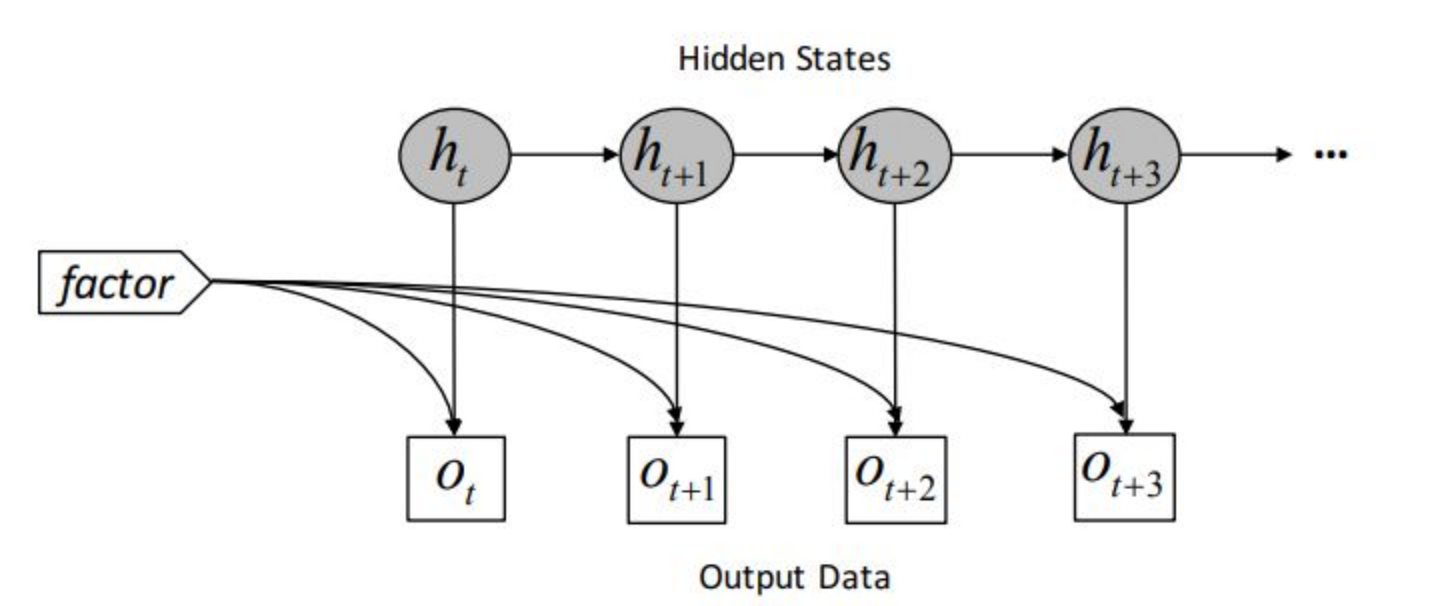
*[scikit-learn.org]

Gaussian Process Latent Variable Model *



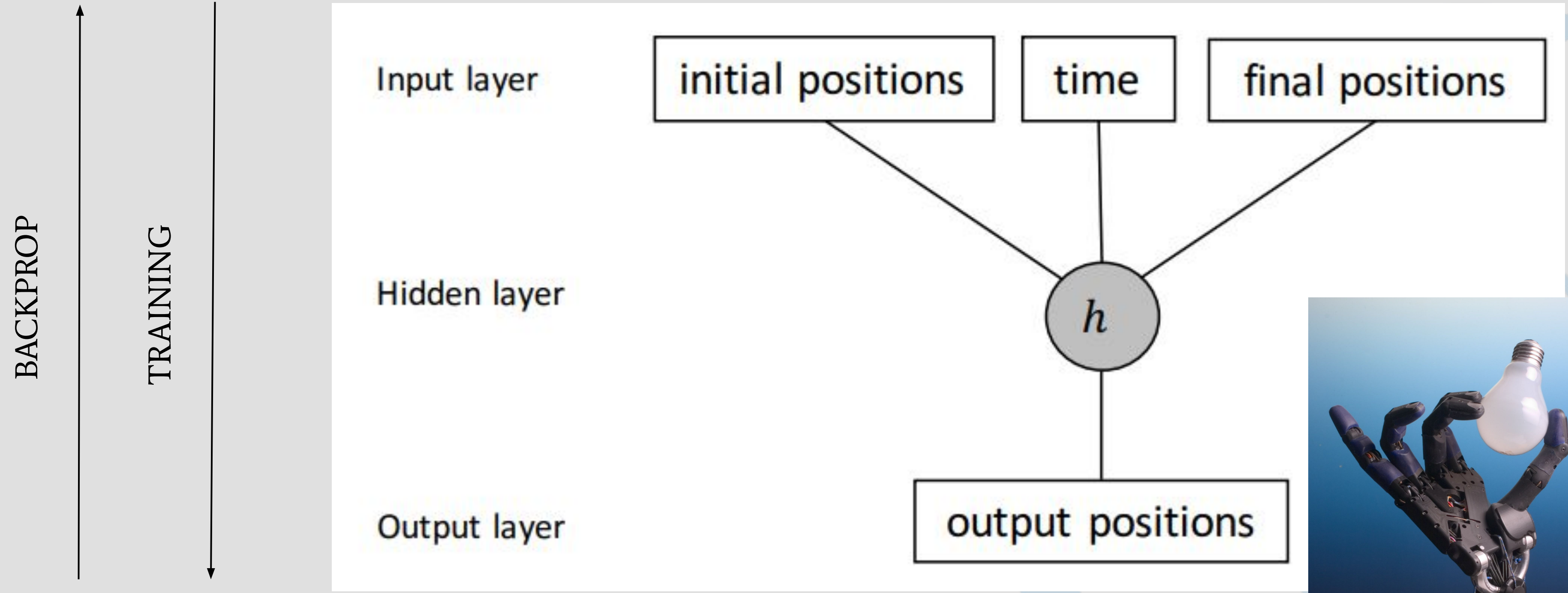
*[Taubert et al 2012]

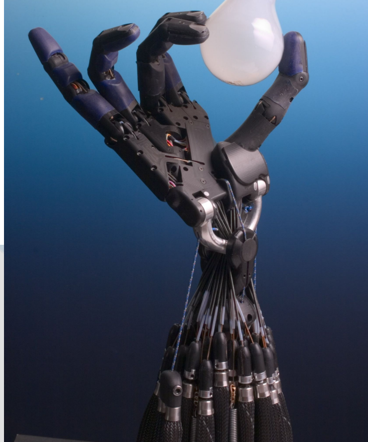
Parametric Hidden Markov Model*



*[Herzog and Krueger 2009]

Artificial Neural Networks

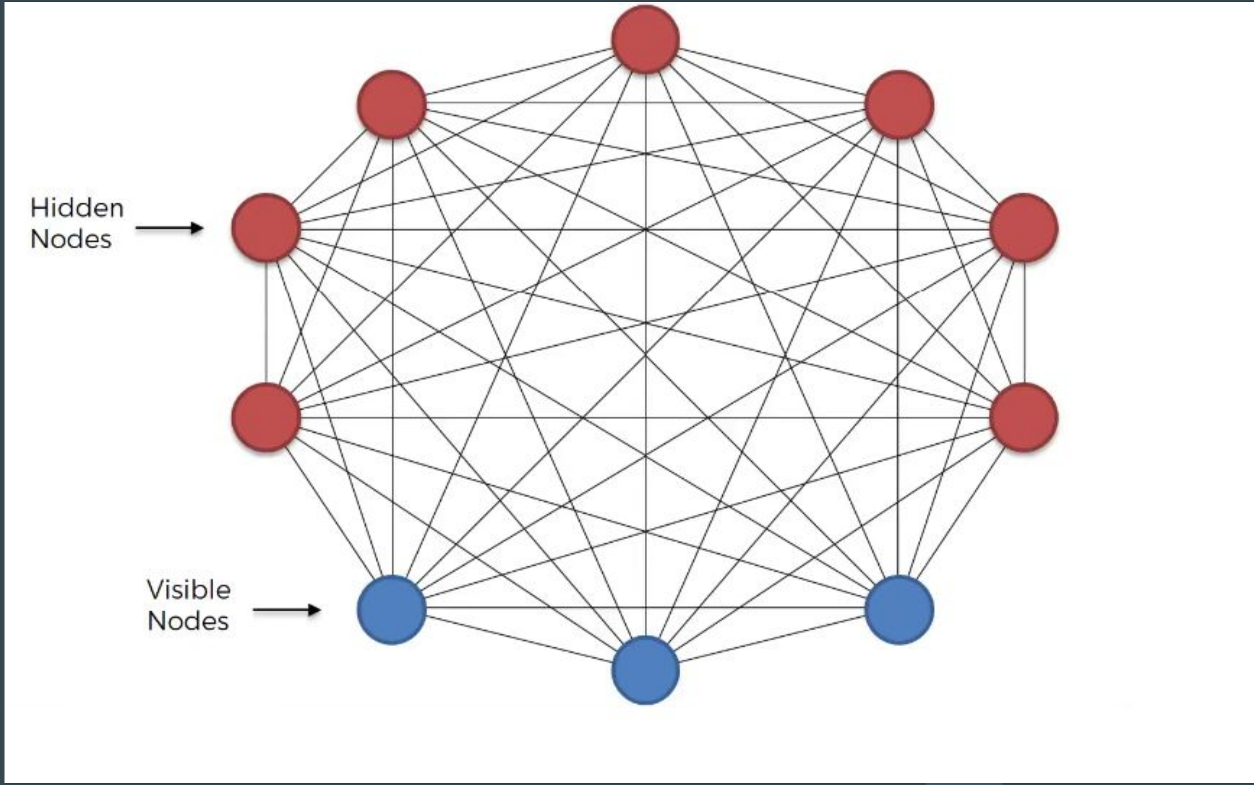




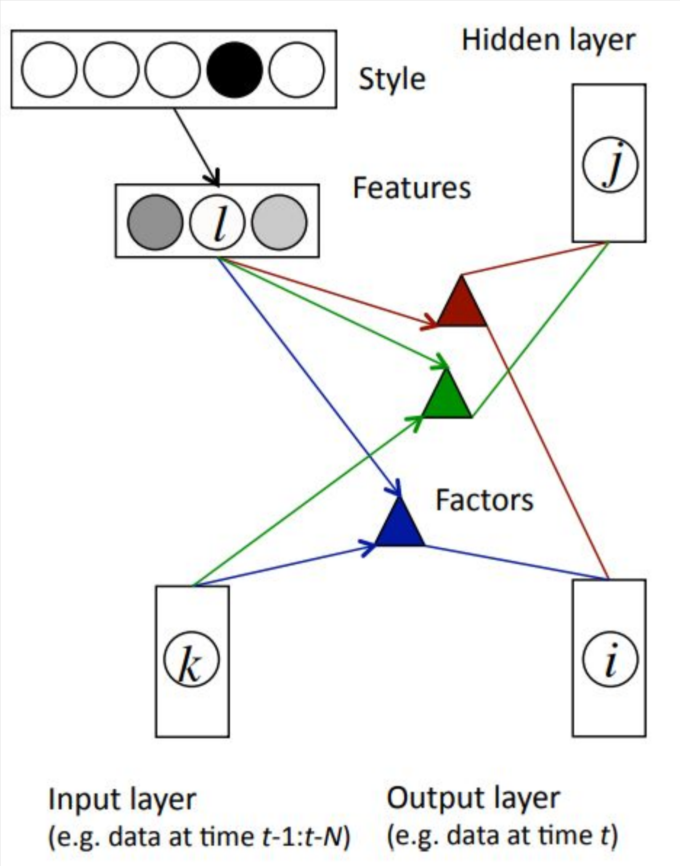
ANGULAR POSITION OF JOINT
AT A PARTICULAR TIME

Boltzmann Machines

Generative Unsupervised Model

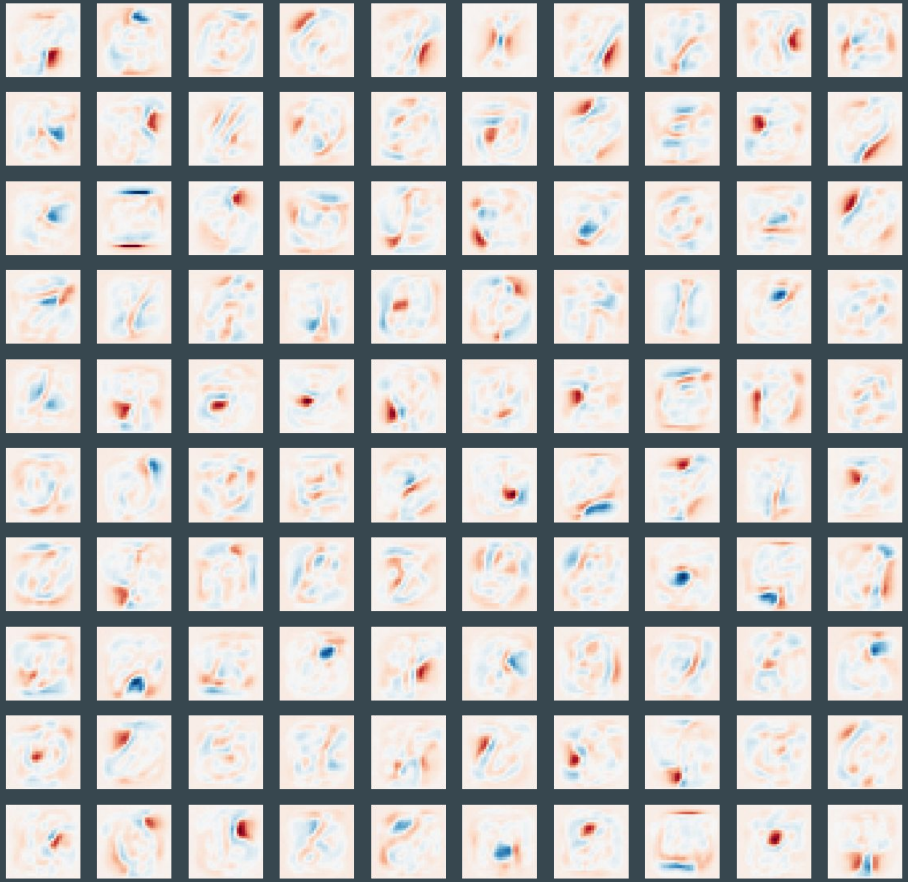


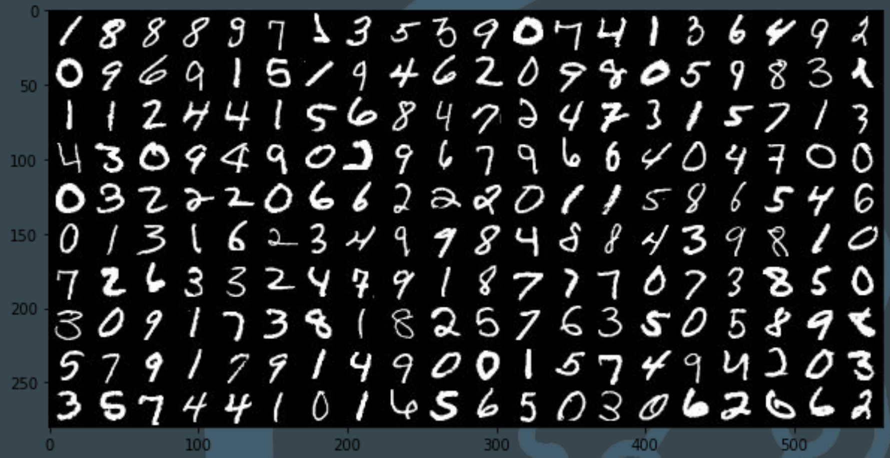
Factored Conditional Restricted Boltzmann Machines (FCRBM)*



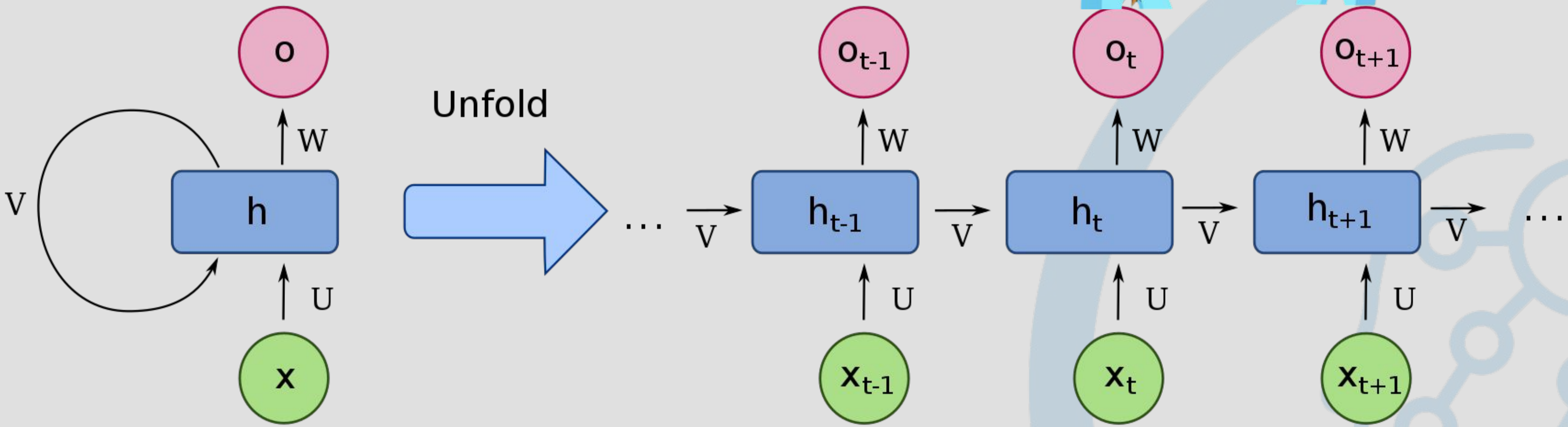
- * [Geoffrey Hinton 2009]

Example: RBM on MNIST



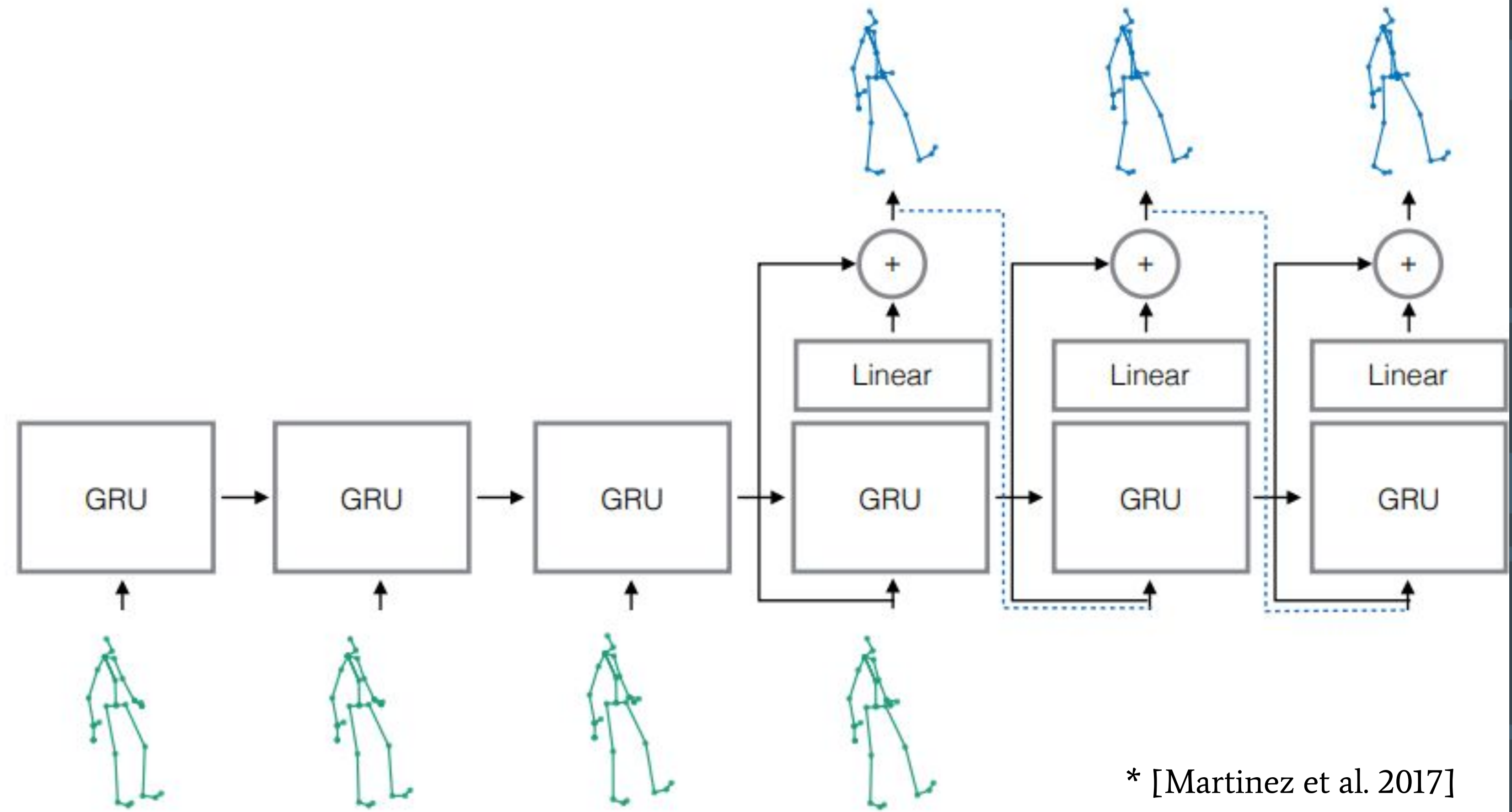


Recurrent Neural Networks



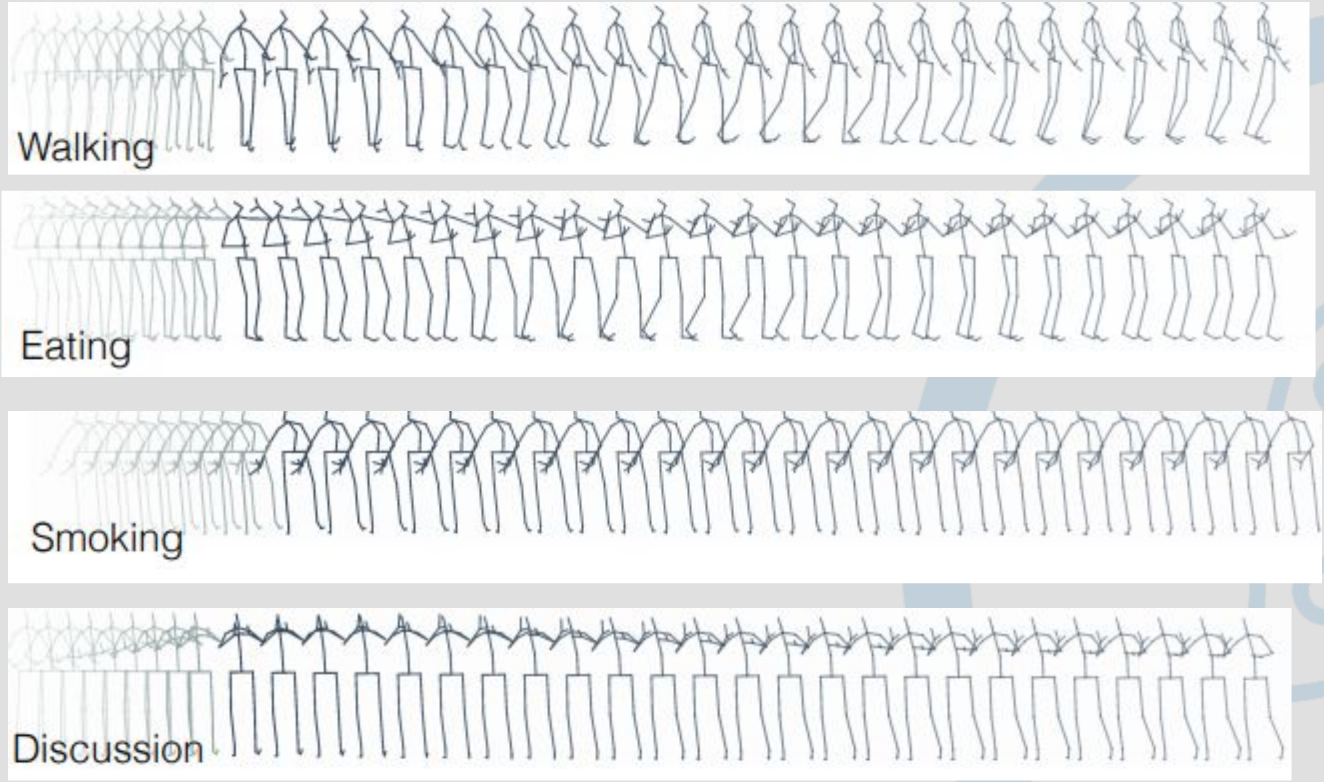
Higher order RNNs: LSTM, GRU, Bi-directional, etc.

Residual Recurrent Architecture*

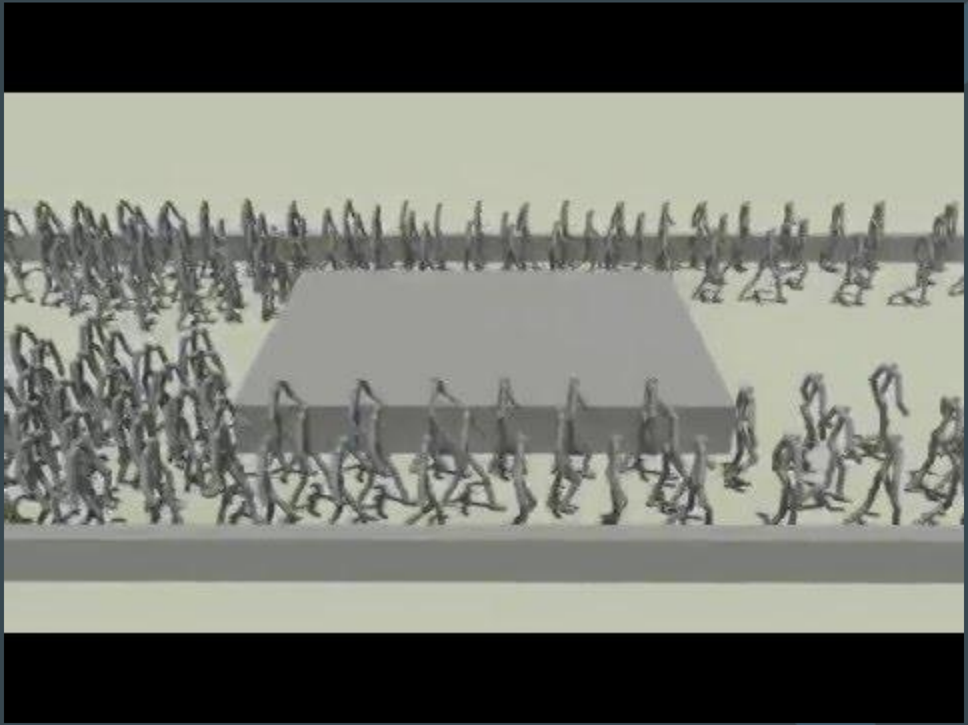


* [Martinez et al. 2017]

Results



Convolutional Networks
[Holden, Saito, Komura SIGGRAPH 2016]



QUESTIONS?

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