VIS 2015

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MotionFlow: Visual Abstraction and Aggregation of Sequential Patterns in Human Motion Tracking Data

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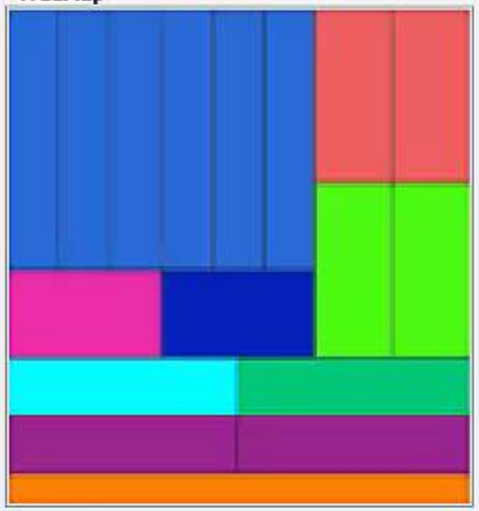
PURDUE ENGINEERING

C DESIGN LAB

UNIVERSITY OF MARYLAND 18 56

TreeMap

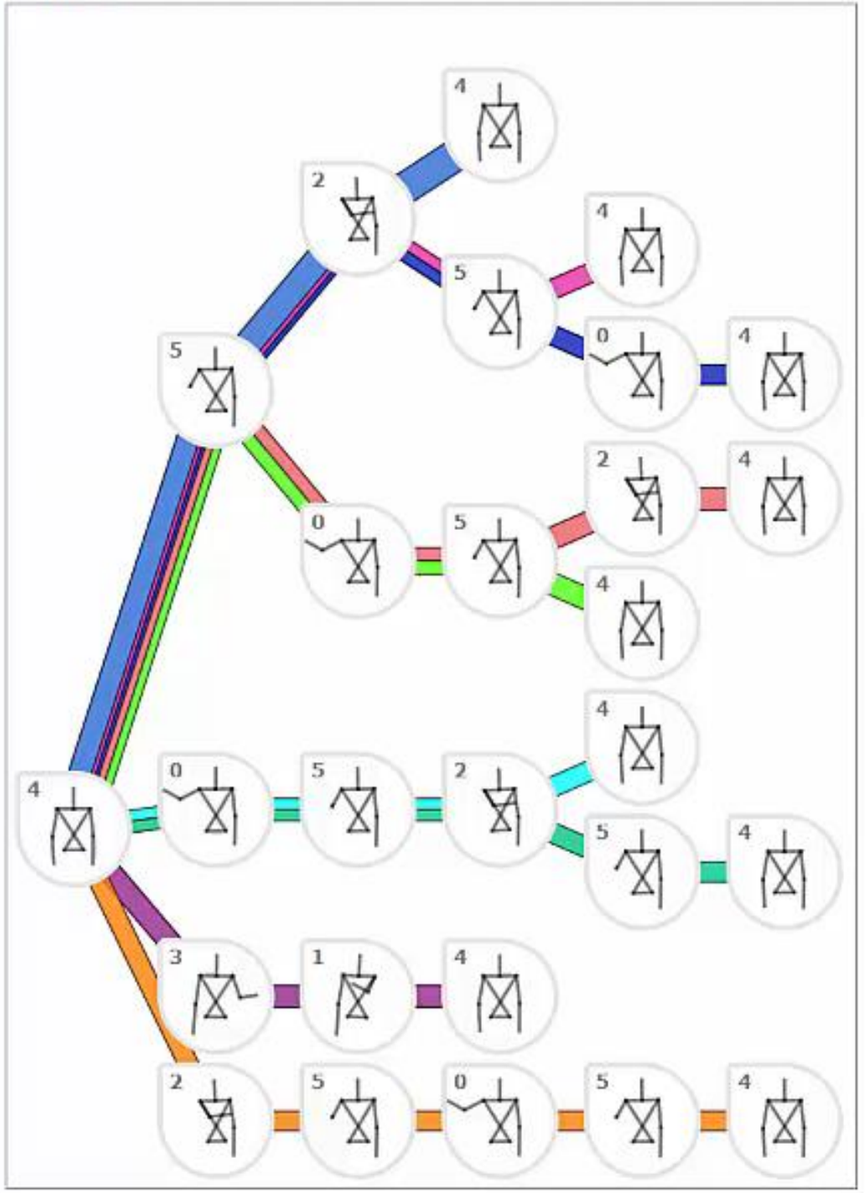


Animation

PoseTrees

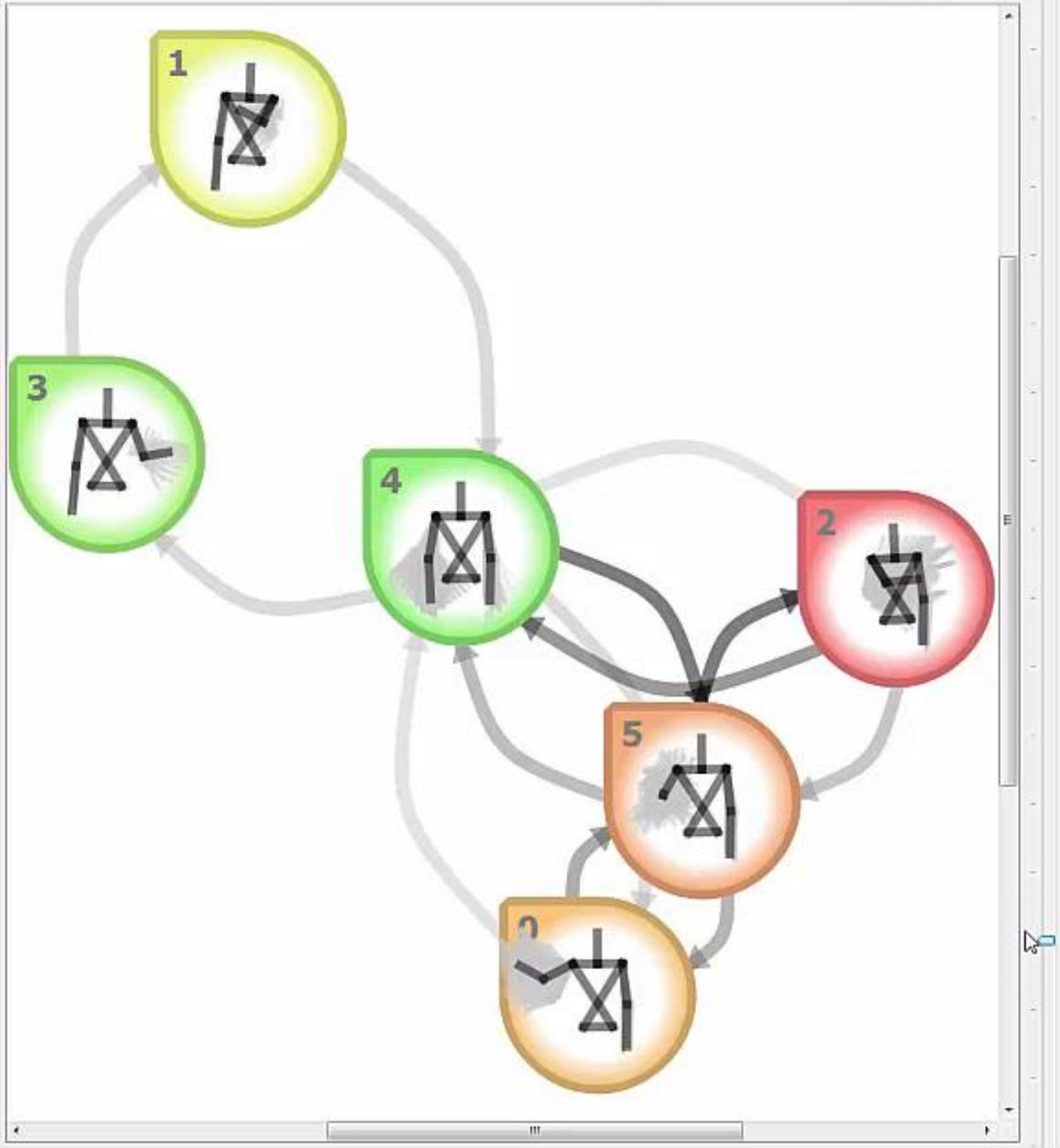
Initial Tree

# of Data: 17

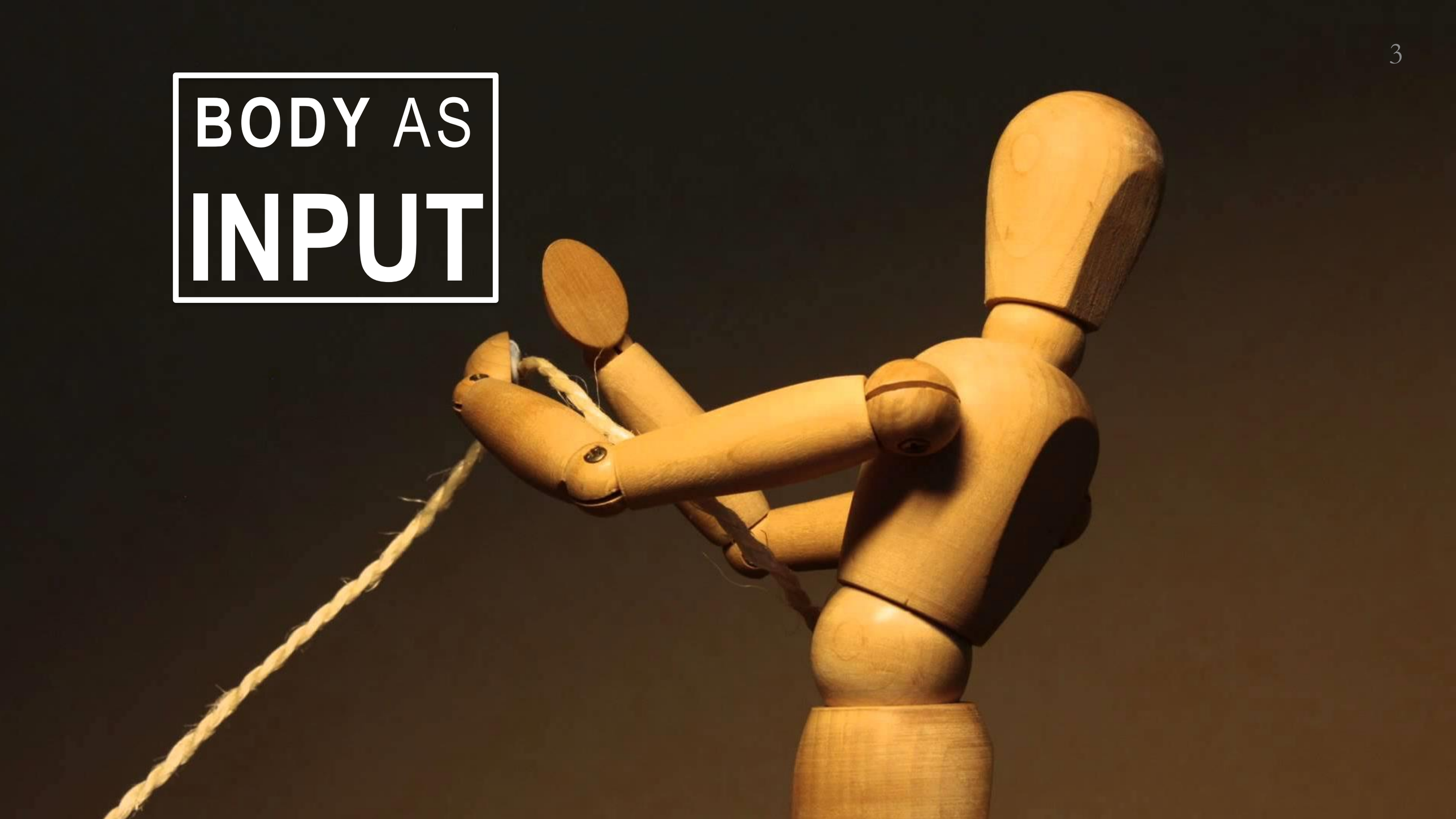


Motion Graph View

# of Cluster: 6 Pose Var.: 0 1



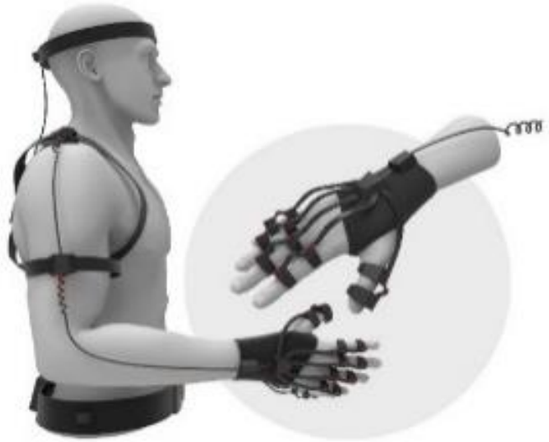
BODY AS INPUT



Tracking the Human Body

Optical markers

XSens



Perception Neuron

Cyber Glove

Wearable sensors

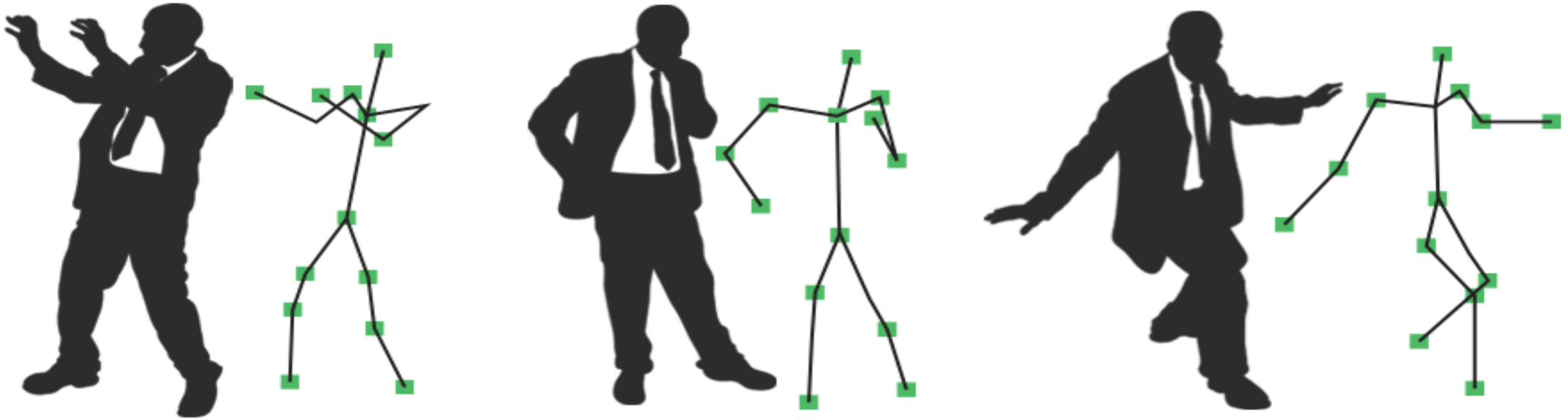
Microsoft Kinect

Leap Motion

Intel RealSense

Vision-based markerless sensors

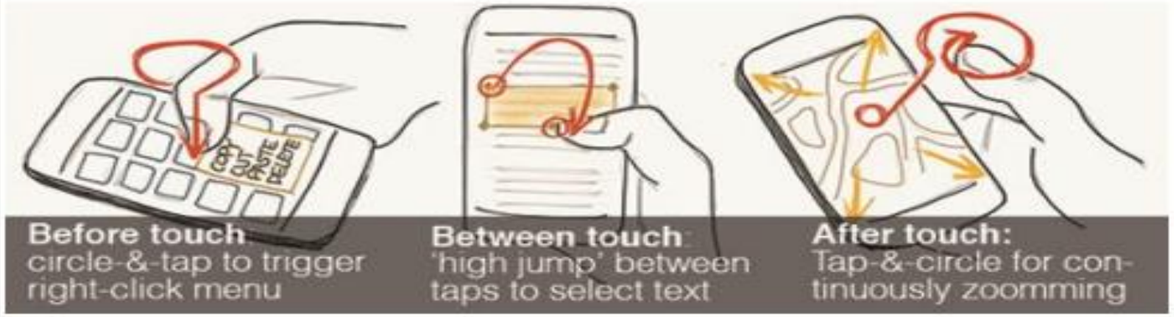
Digitizing Human Motions

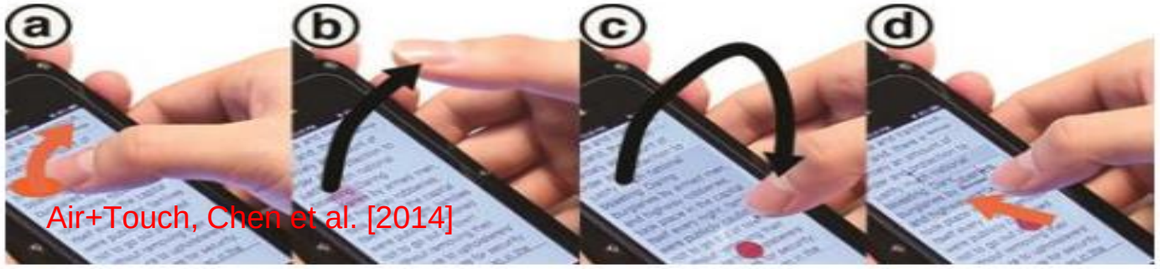


Source: http://southpaw.com.my

Gesture Pattern Studies

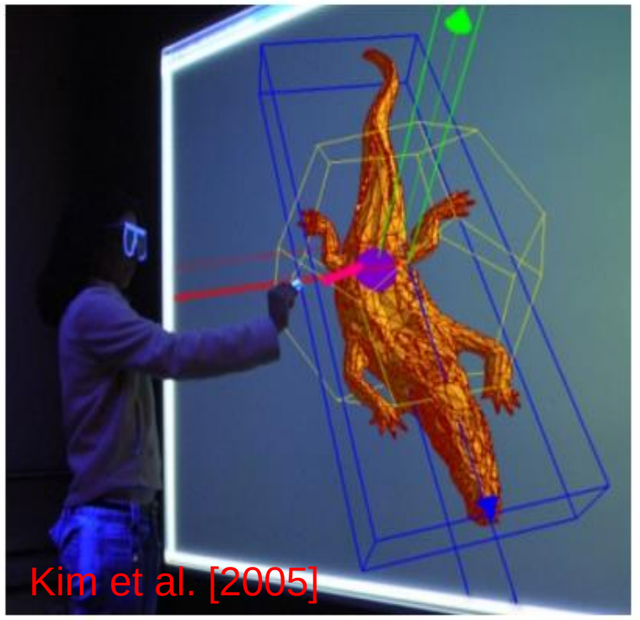
Mobile Interaction



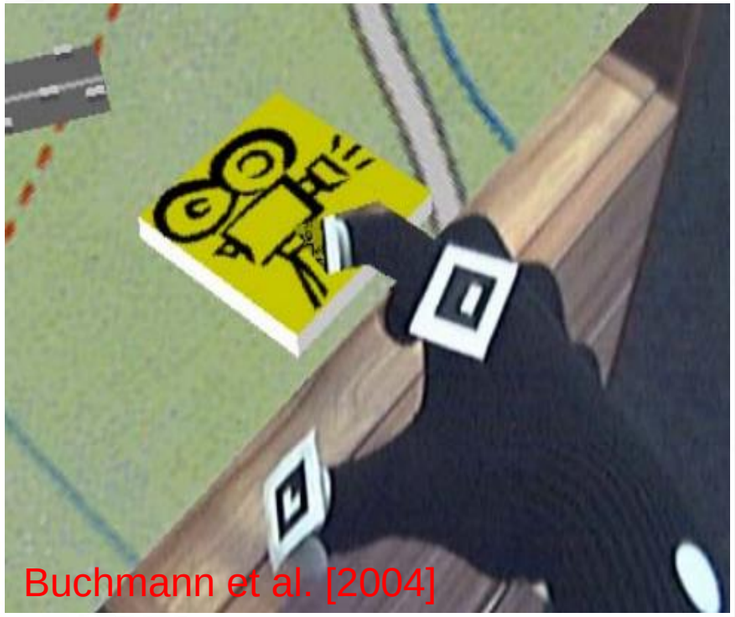


Air+Touch, Chen et al. [2014]

Virtual/Augmented Reality



Kim et al. [2005]



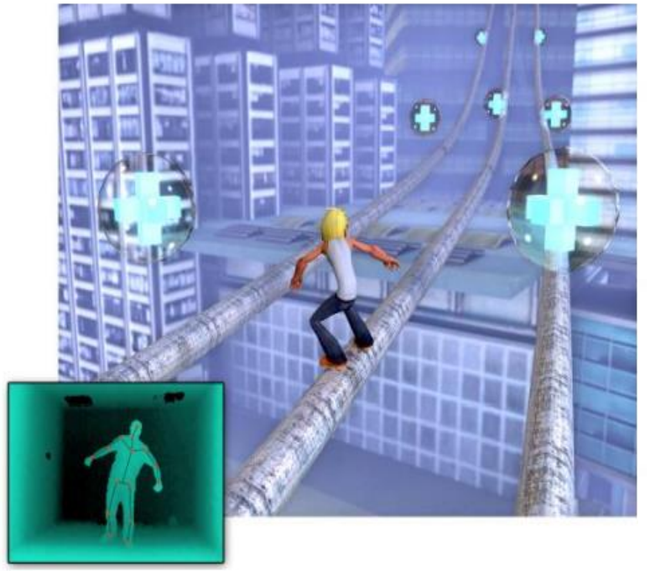
Buchmann et al. [2004]

Automotive Environments

BMW 2016 i7 Series

Entertainment

Xbox 360



Bleiweiss et al. [2010]

Gesture Pattern Studies

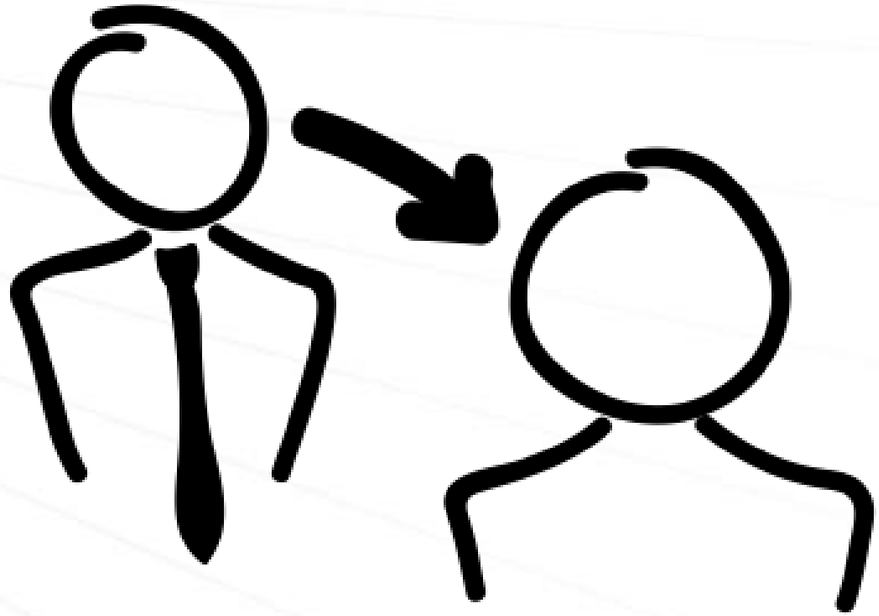
- Natural and intuitive interactions

↓

- Understanding gesture patterns

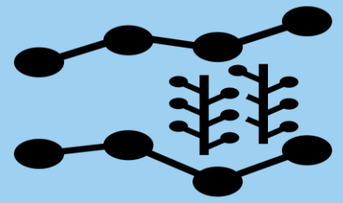
↓

- Gesture pattern studies
  - **Identifying** similar and common gestures
  - **Categorization** of gestures into pattern groups
  - **Gesture vocabulary** design



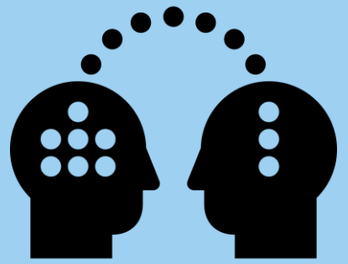
R1: Visualizing
multiple gestures

R2: Investigating
interesting gestures



R3: Identifying
similar/dissimilar gestures

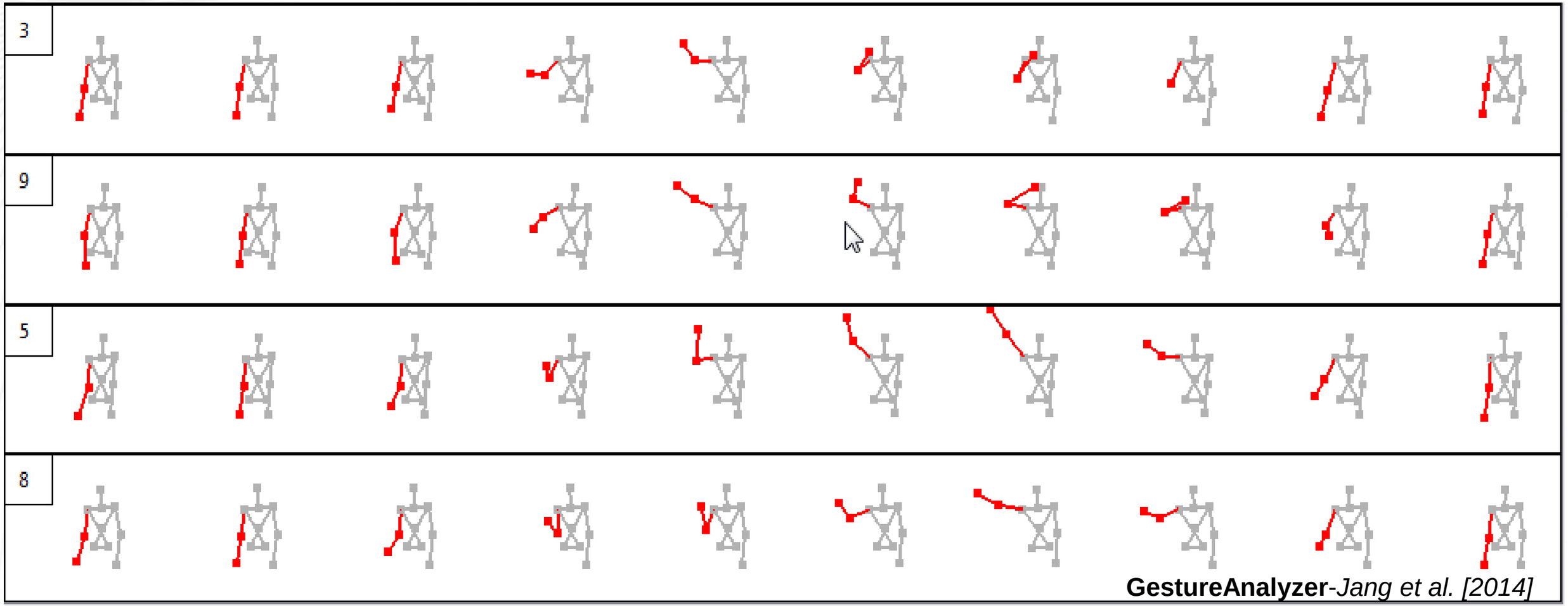
R4: Organizing
gesture database



R5: Sharable and transferrable
pattern analysis results

REQUIREMENTS ANALYSIS
from gestural interaction designer

Visual Analytics for Human Motion Analysis



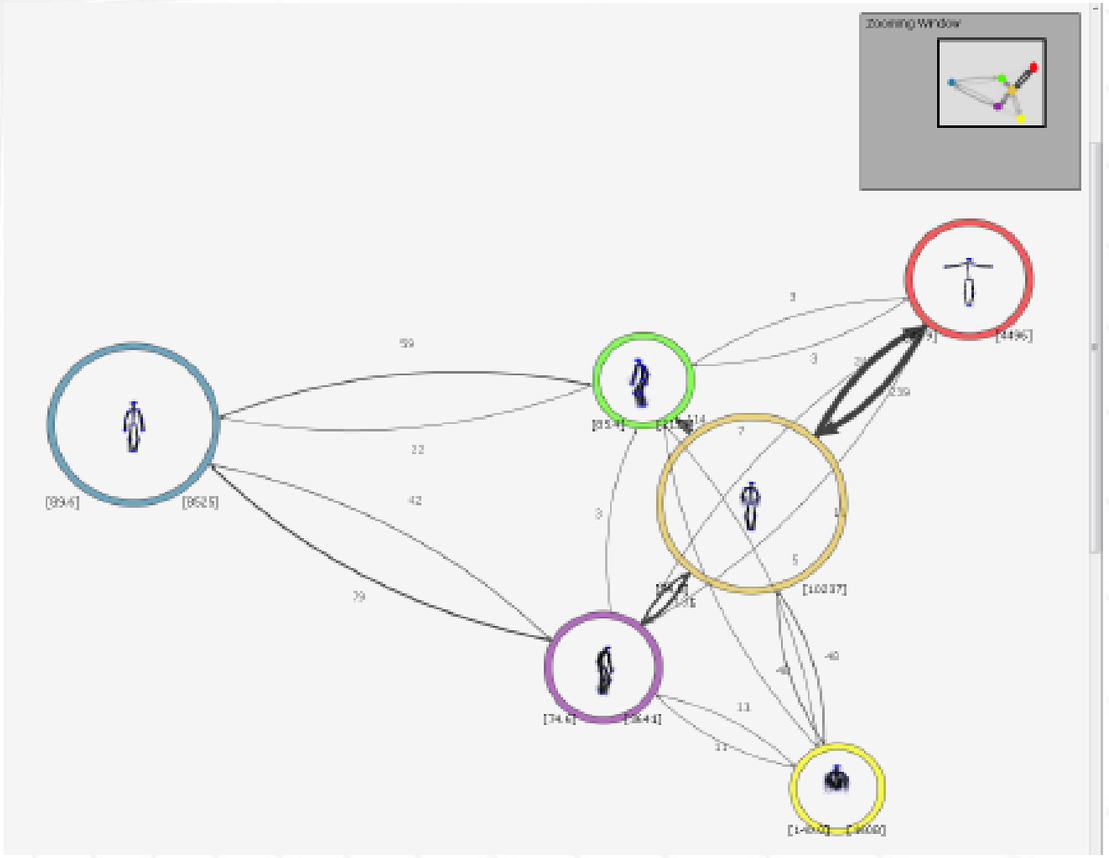
GestureAnalyzer-*Jang et al. [2014]*

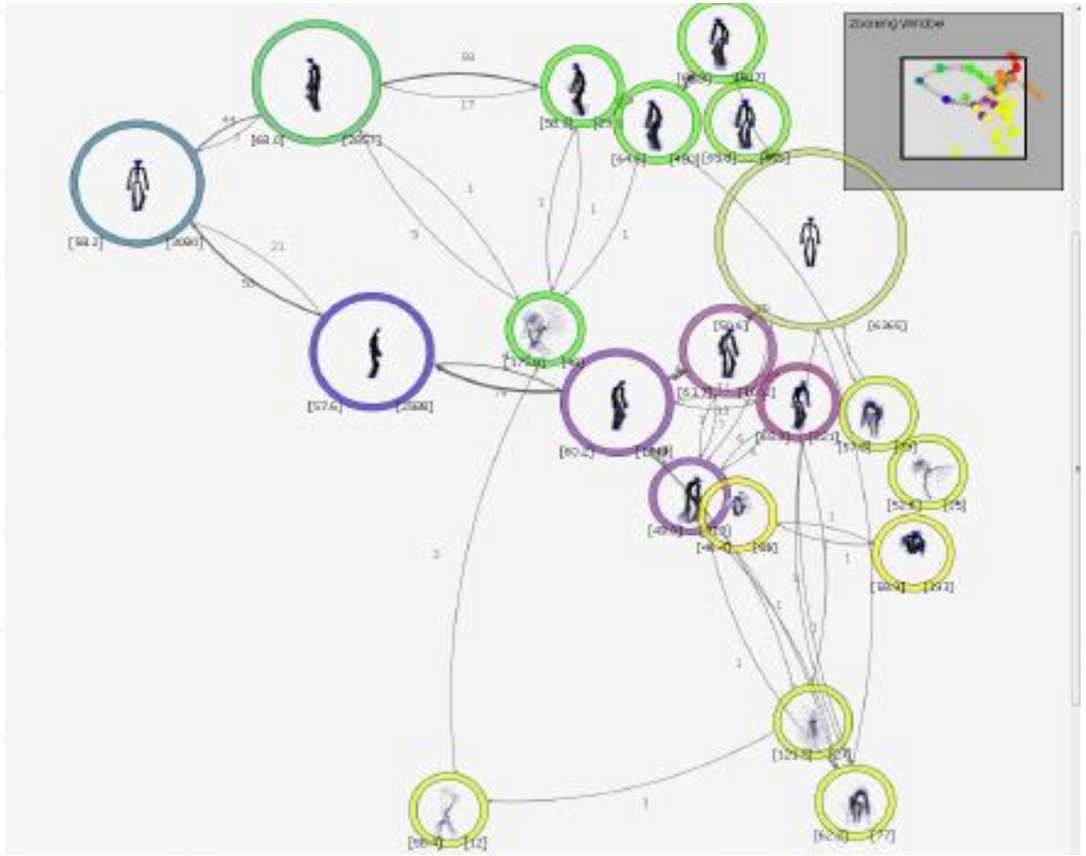
+ **Completed spatio-temporal motion trend**

− **Visual space / scalability**

− **Redundant pose block**

Visual Analytics for Human Motion Analysis



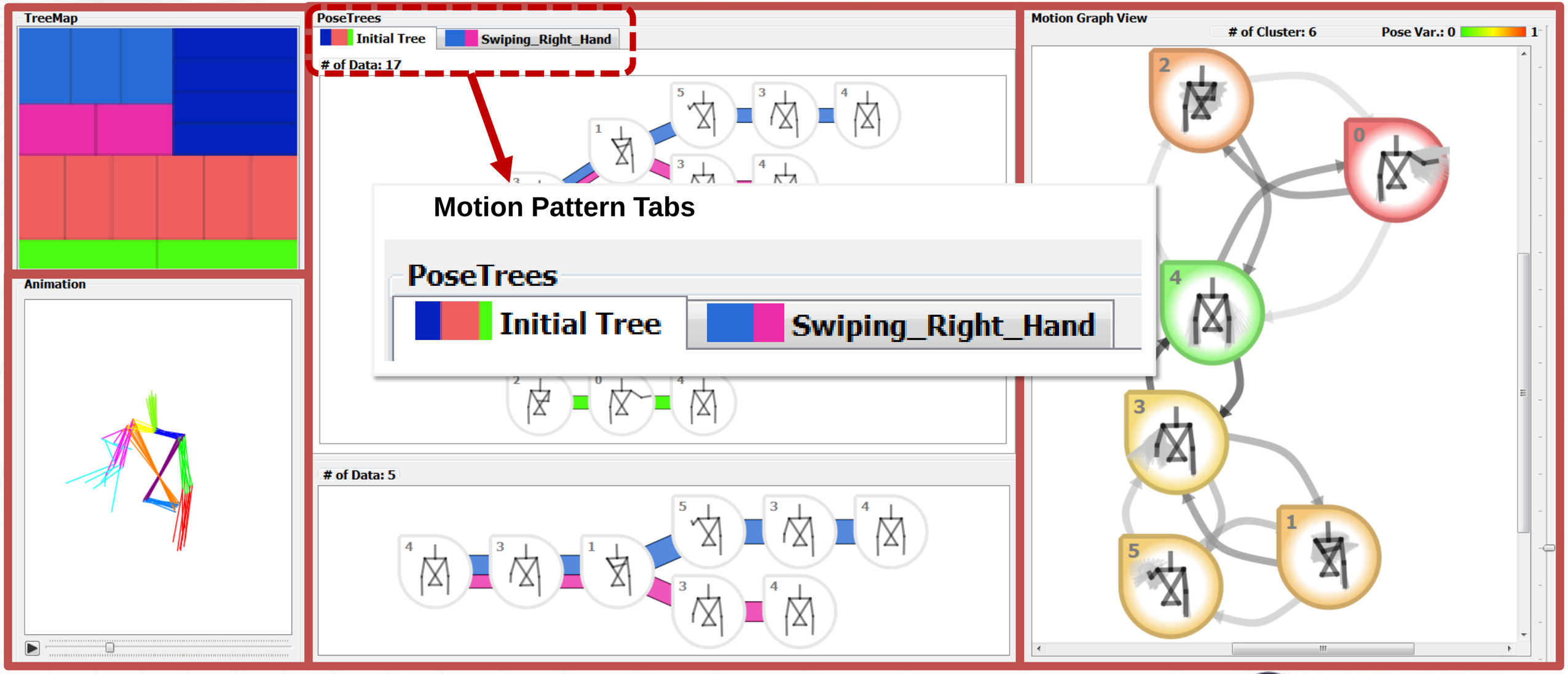


MotionExplorer-*Bernard et al. [2013]*

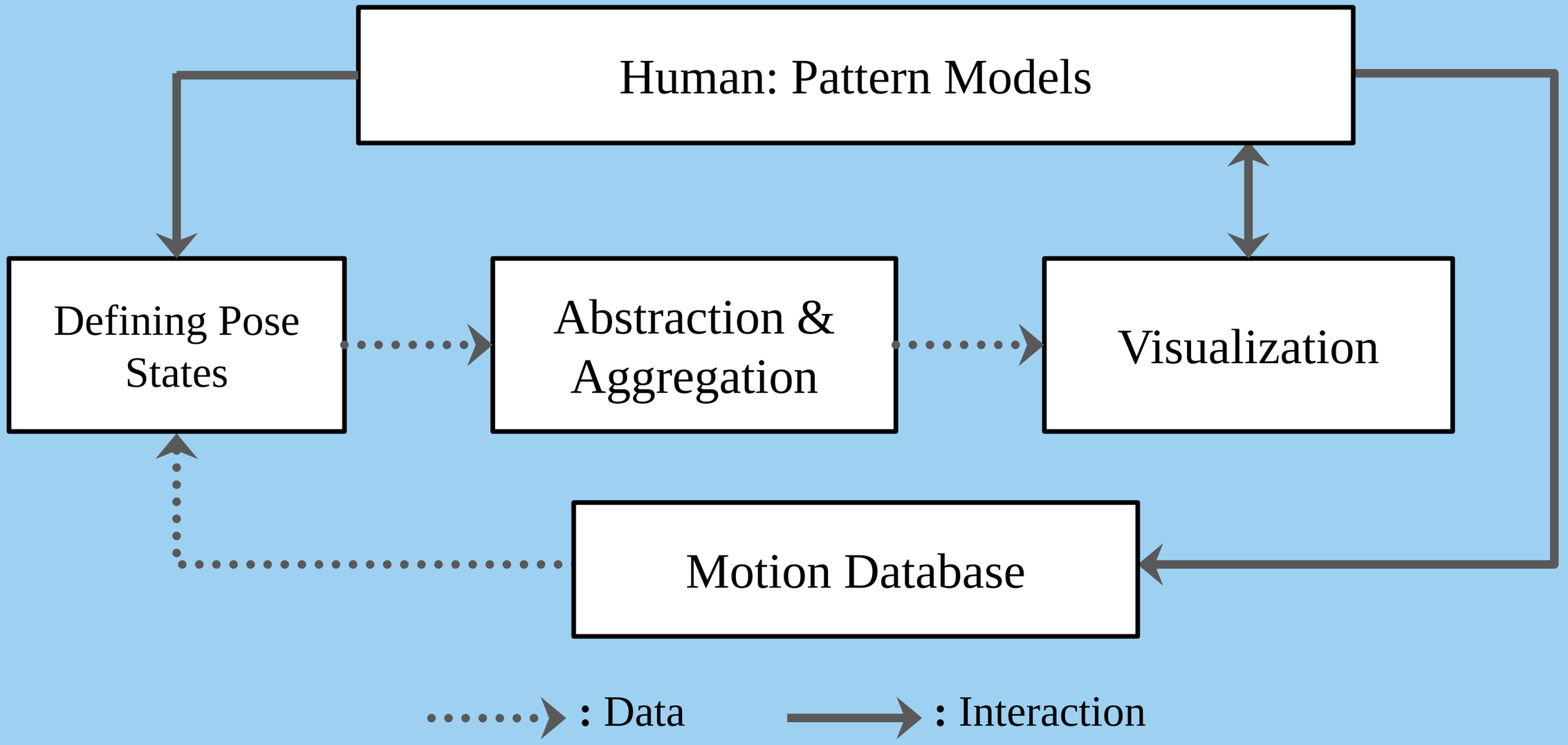
- ✚ Simplified overview
- ✚ Encoding local transitions

- ➖ Incomplete motion trend
- ➖ Edge crossing & cluttering
- ➖ No support for organization

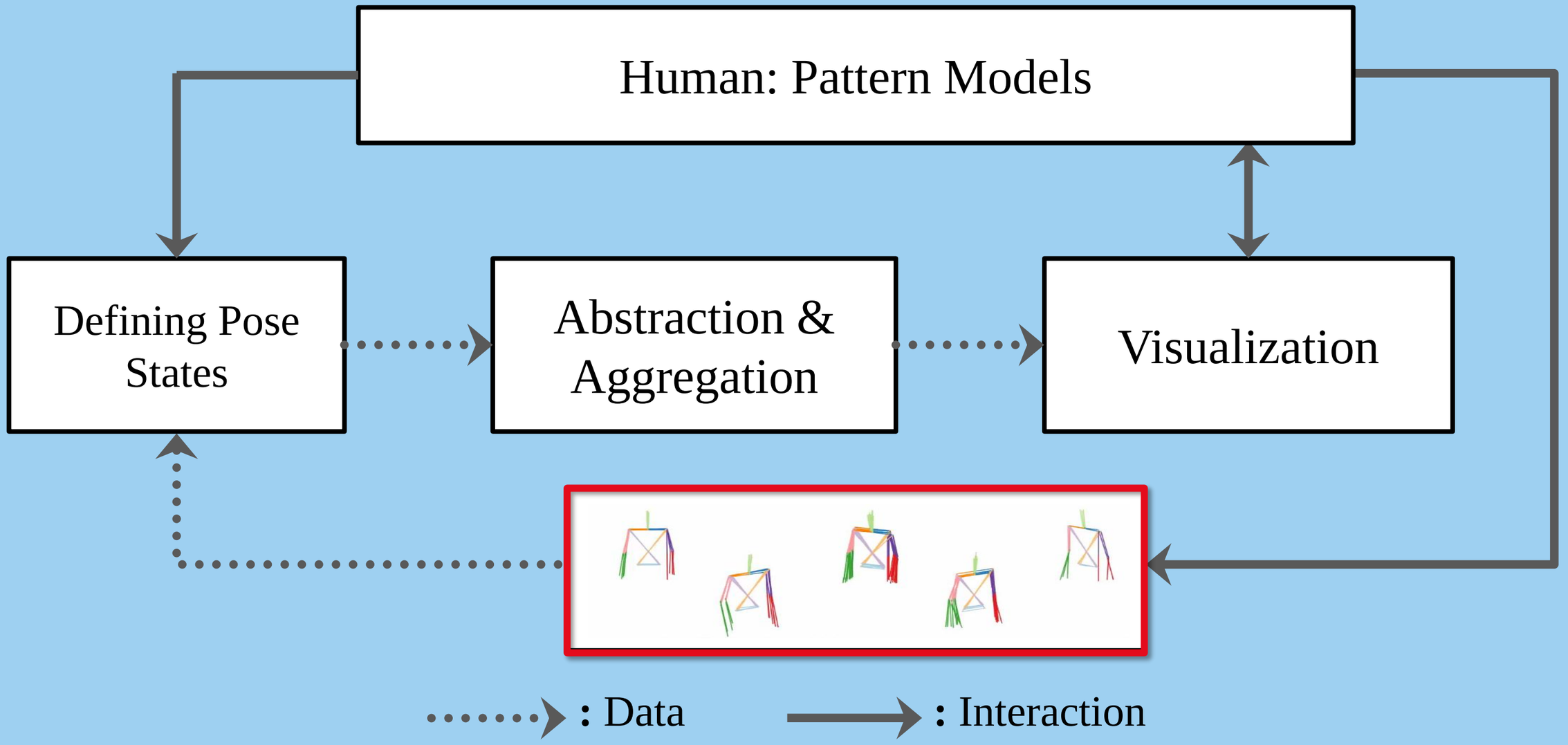
MotionFlow



WORKFLOW


Human: Pattern Models
Defining Pose States
Abstraction & Aggregation
Visualization
Motion Database
: Data
: Interaction

WORKFLOW


Human: Pattern Models
Defining Pose States
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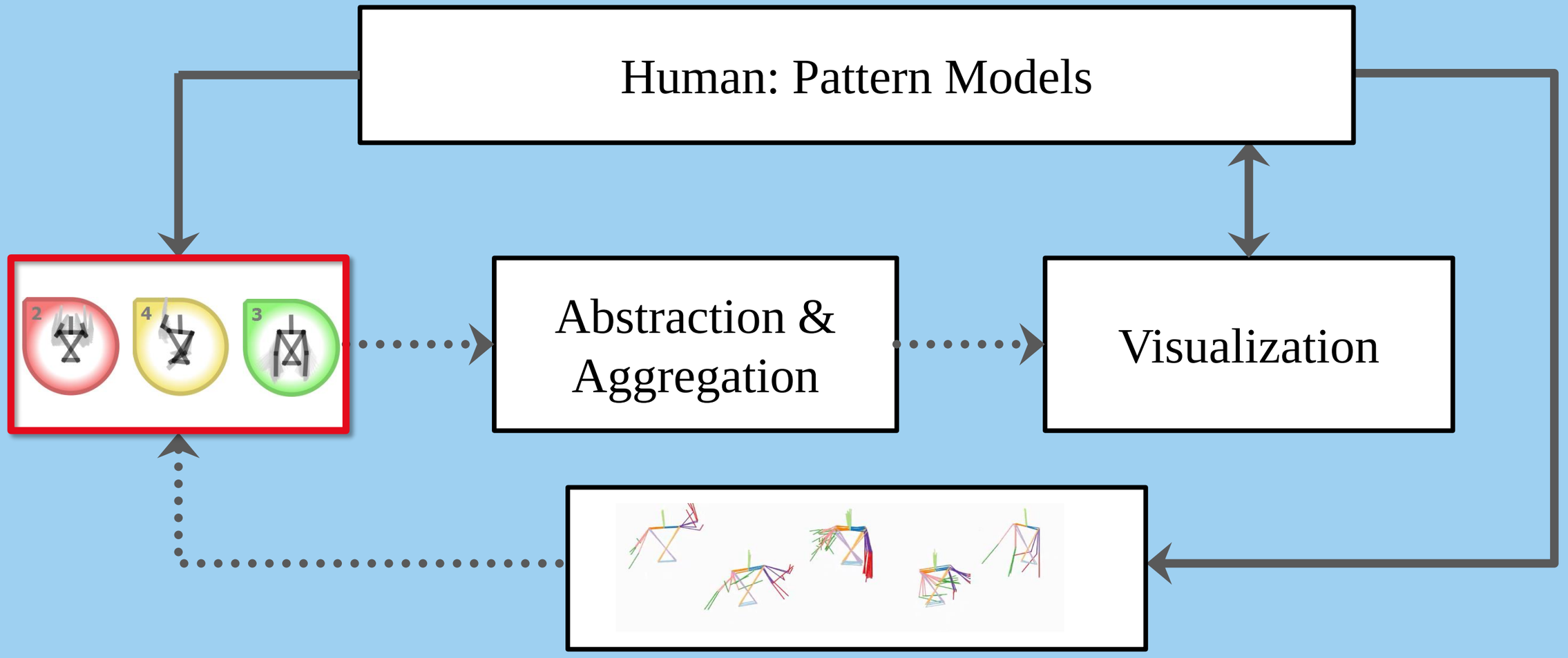
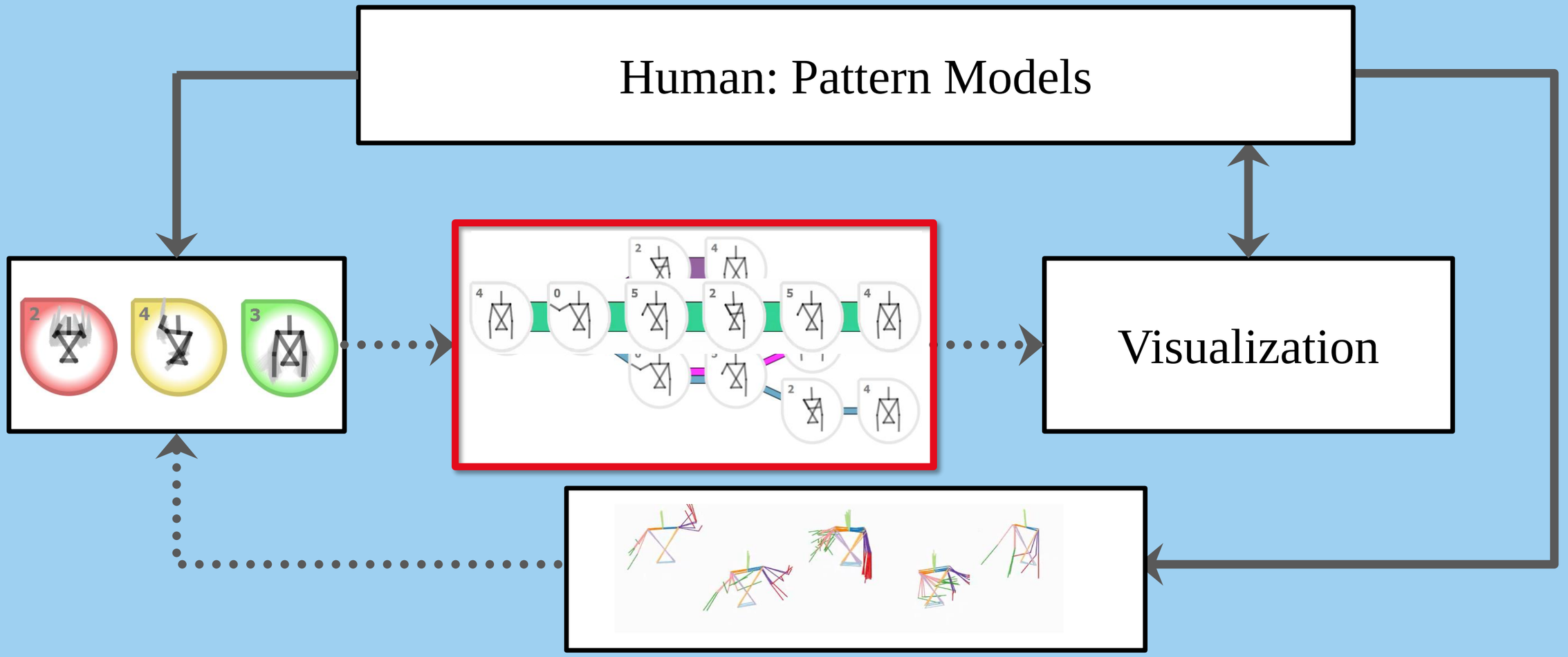
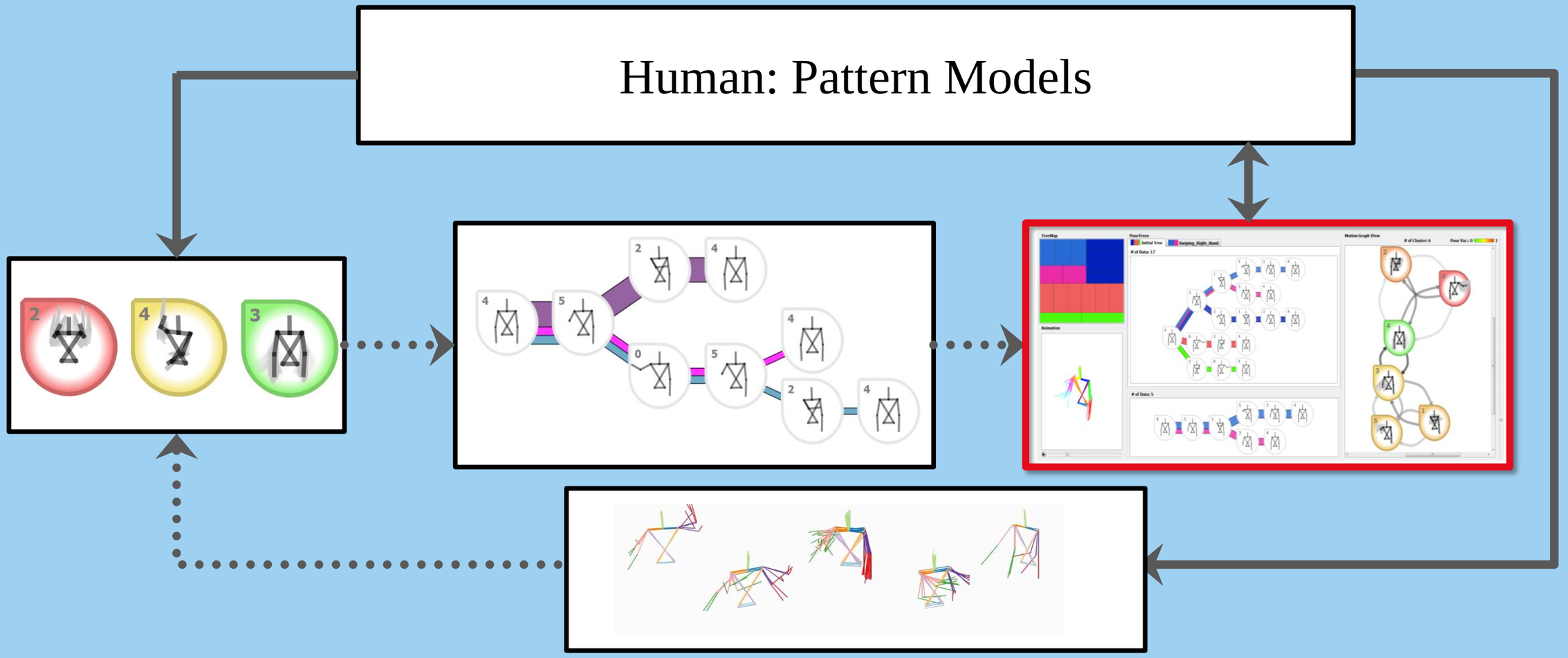
WORKFLOW


Human: Pattern Models
2
4
3
Abstraction & Aggregation
Visualization
: Data
: Interaction

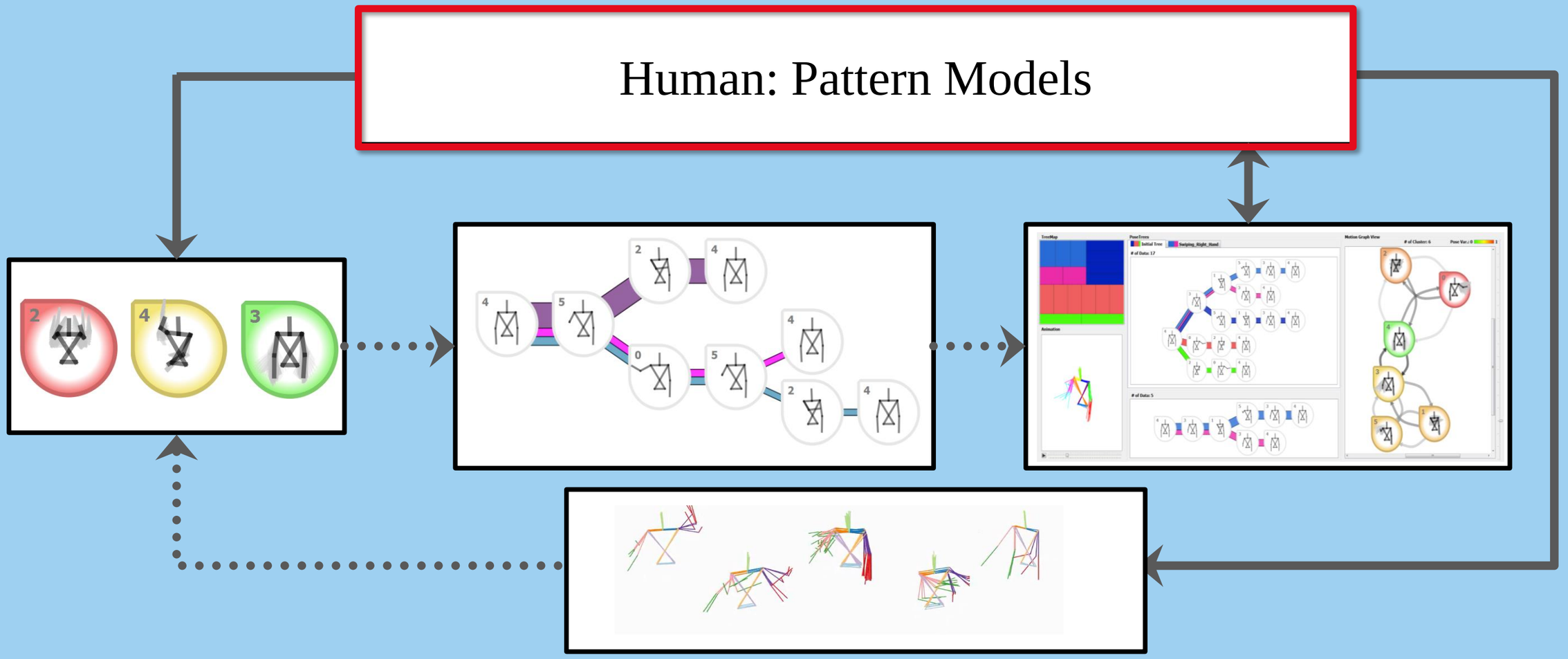
WORKFLOW



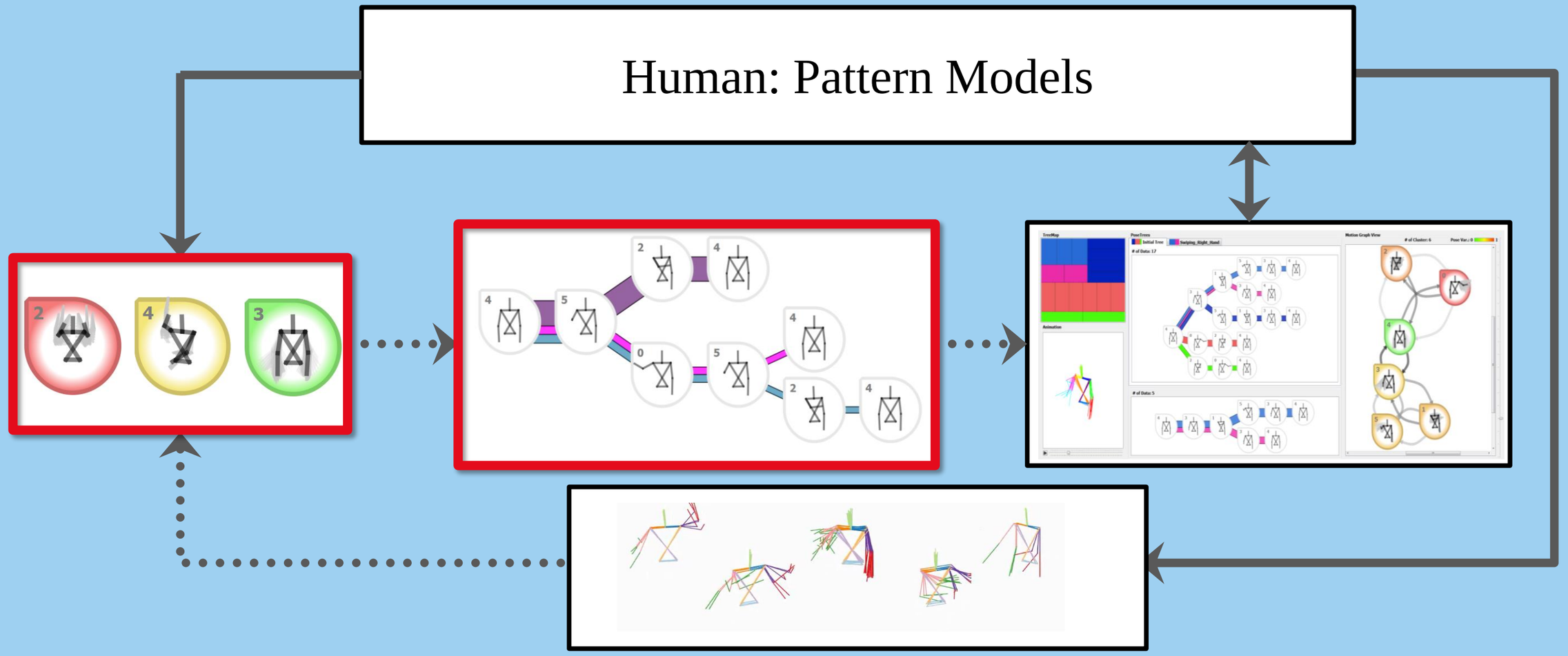
WORKFLOW



WORKFLOW

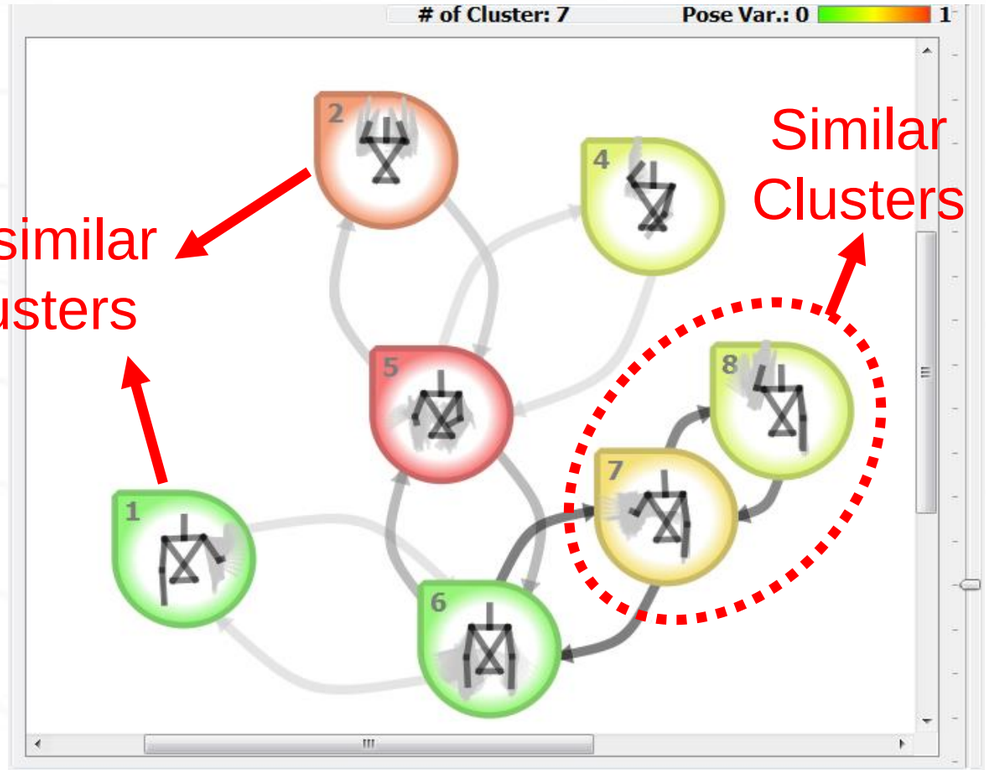


WORKFLOW

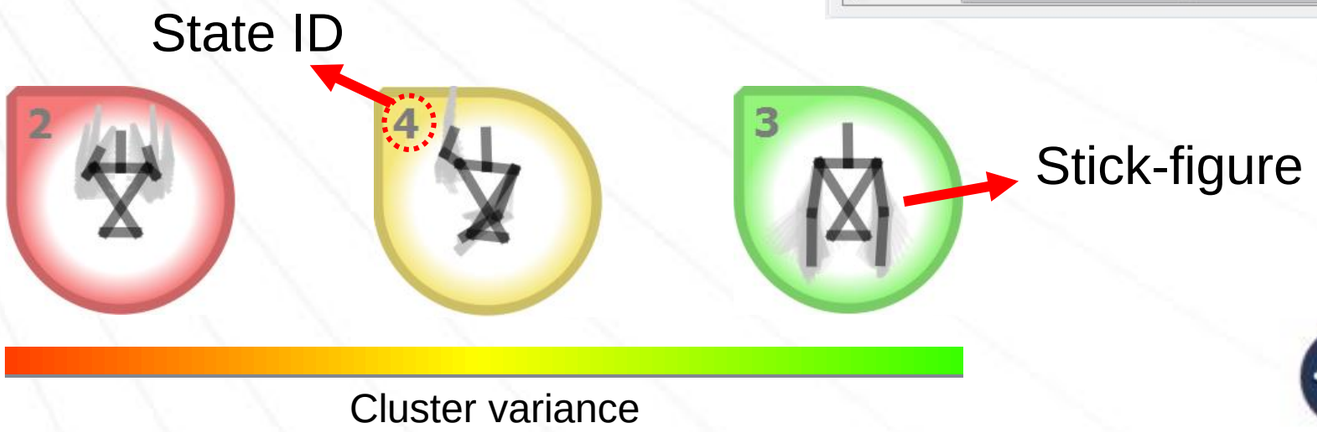


User-Driven Pose State Definition

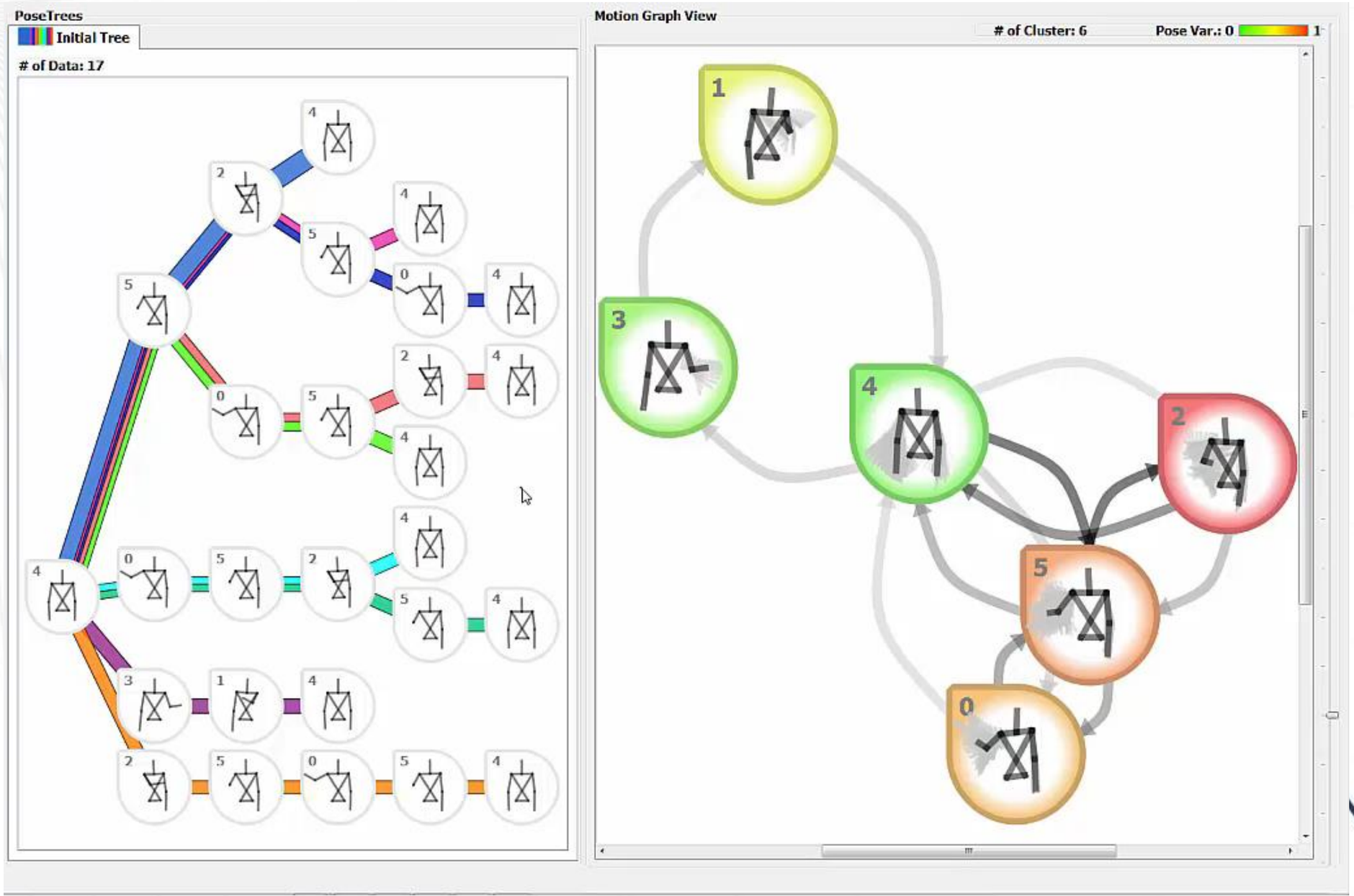
- Pose state graph
  - Interactive K-Means clustering: Global / Local cluster manipulation
  - Force-directed graph layout



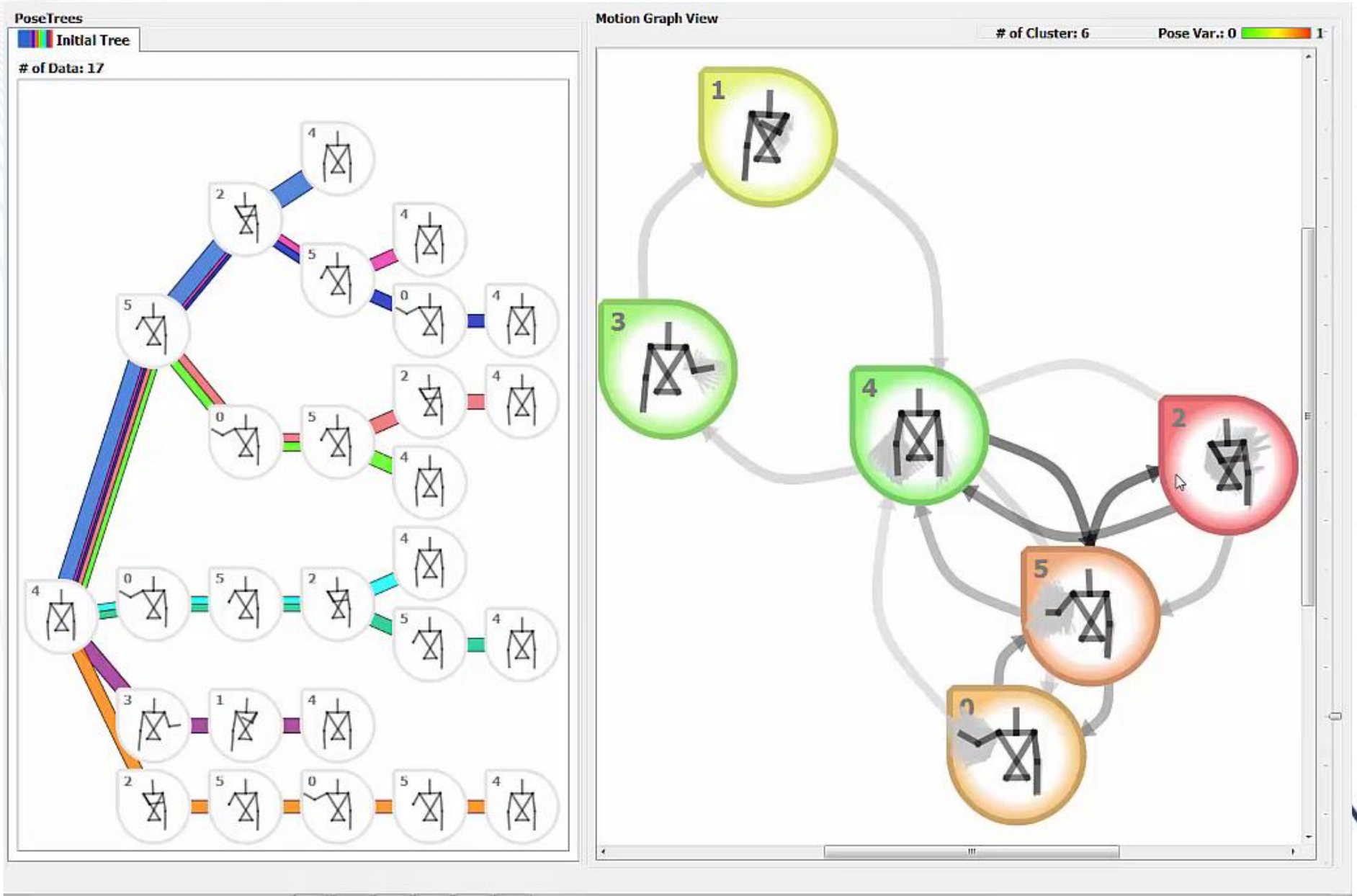
- Poselet



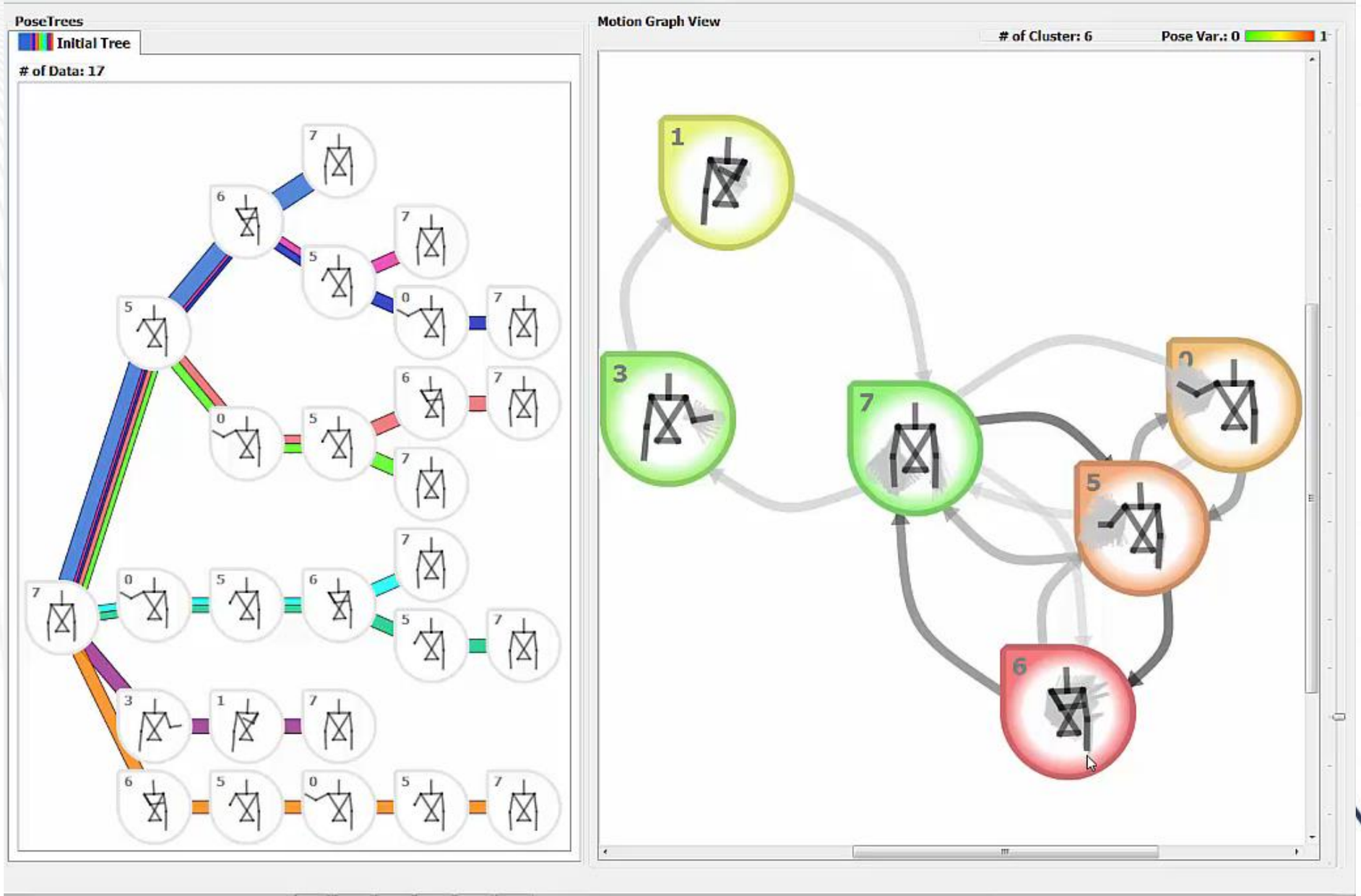
Global manipulation: Slider



Local manipulation: Split/Merge

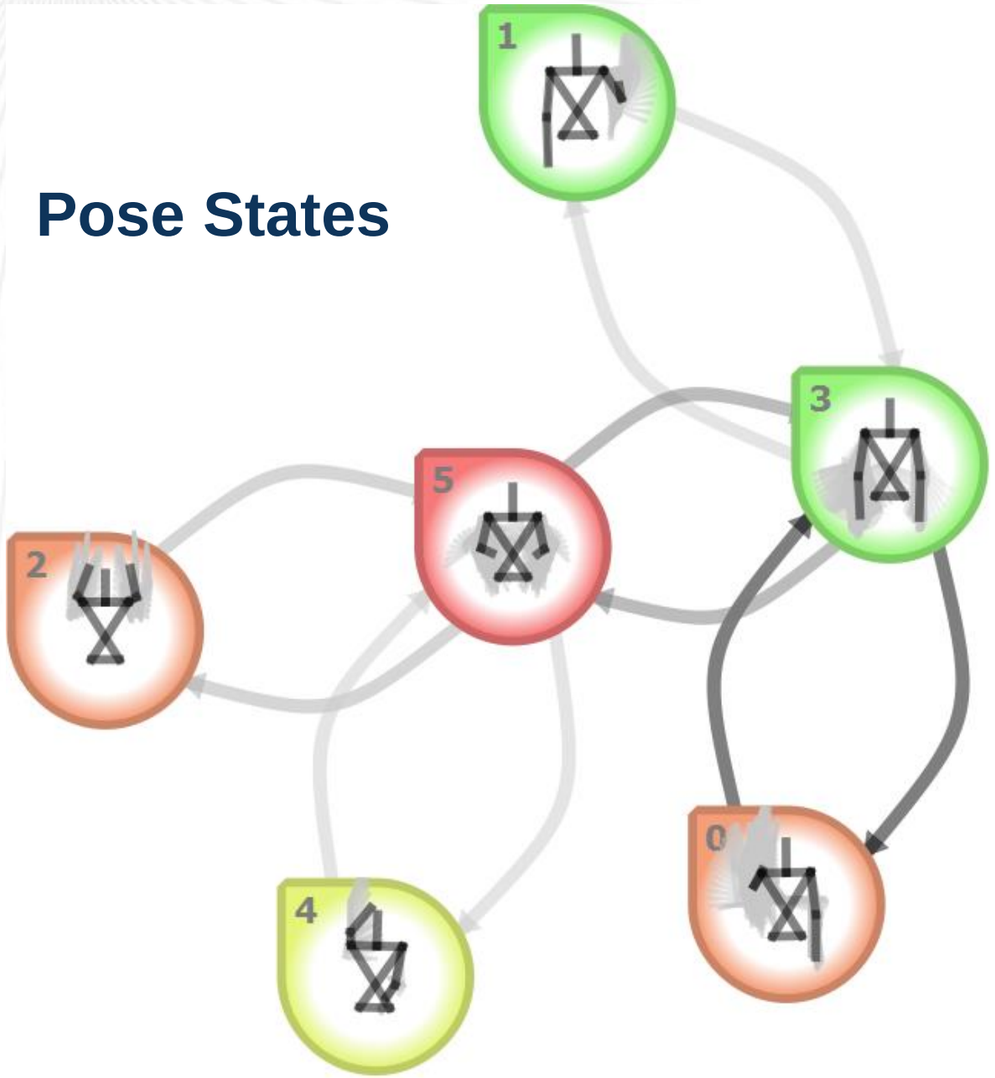


Local manipulation: Lock

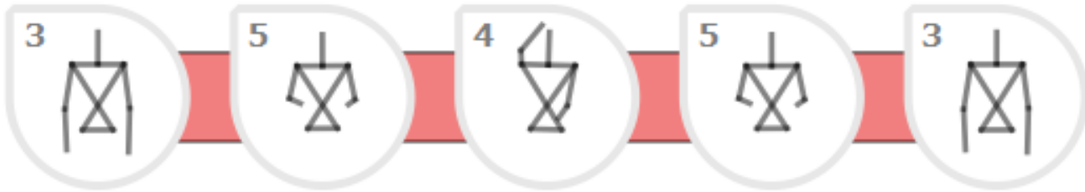


Visual Abstraction

Pose States



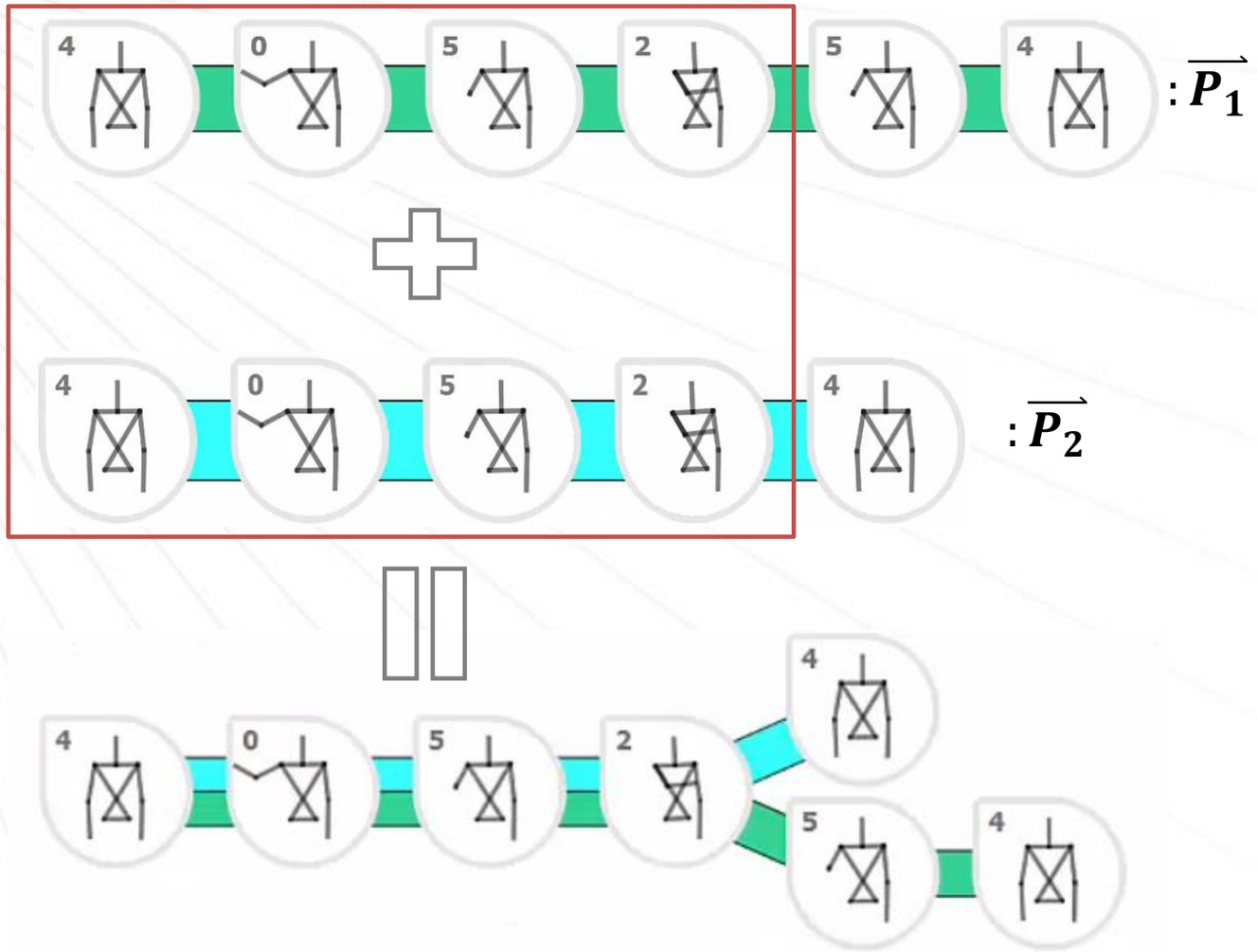
Pose States Transition



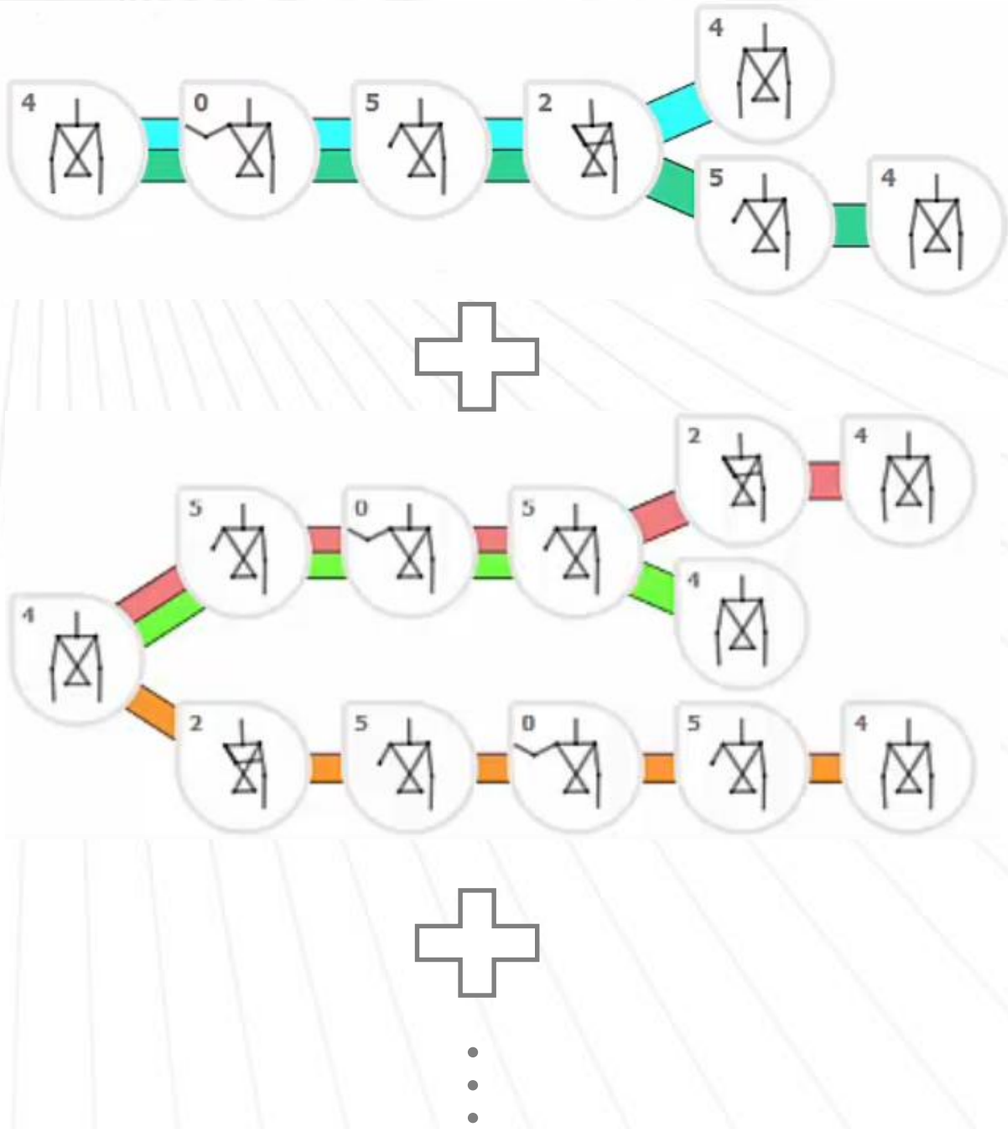
Pose State Occurrence

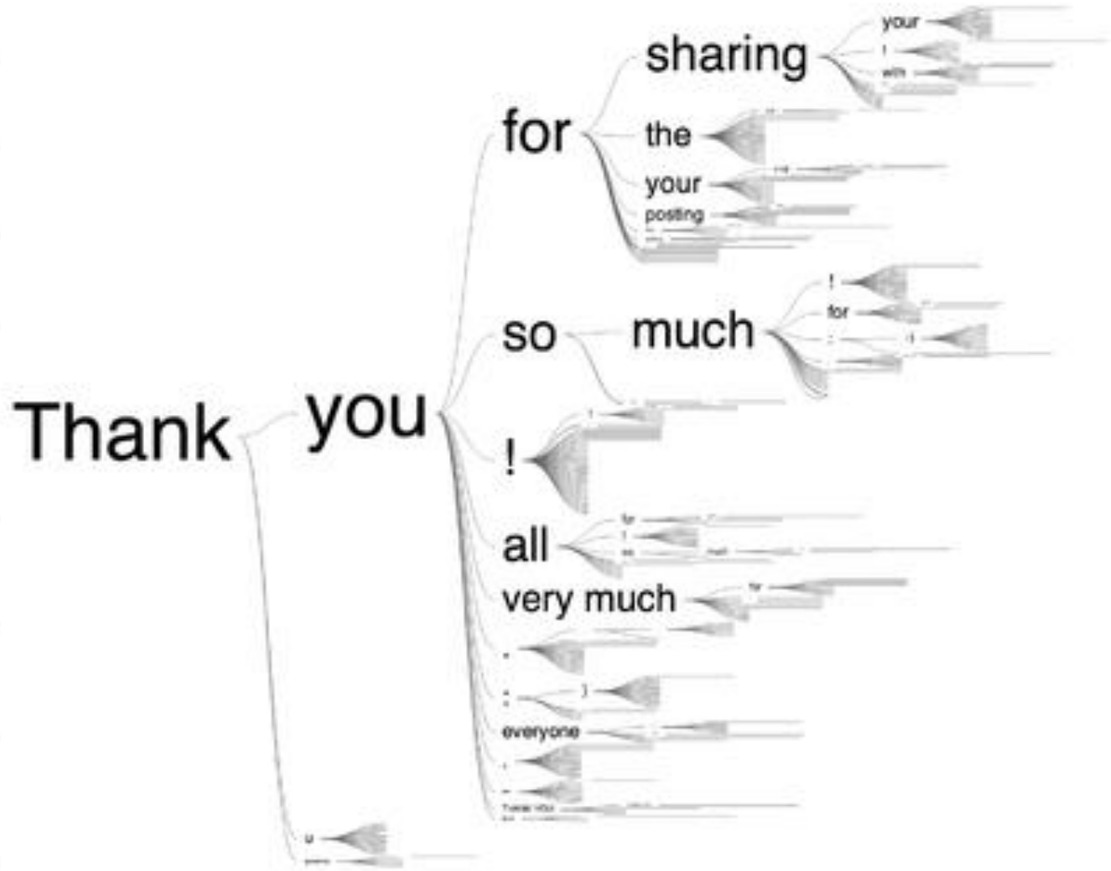
Visual Aggregation

Combine the same pose state transitions



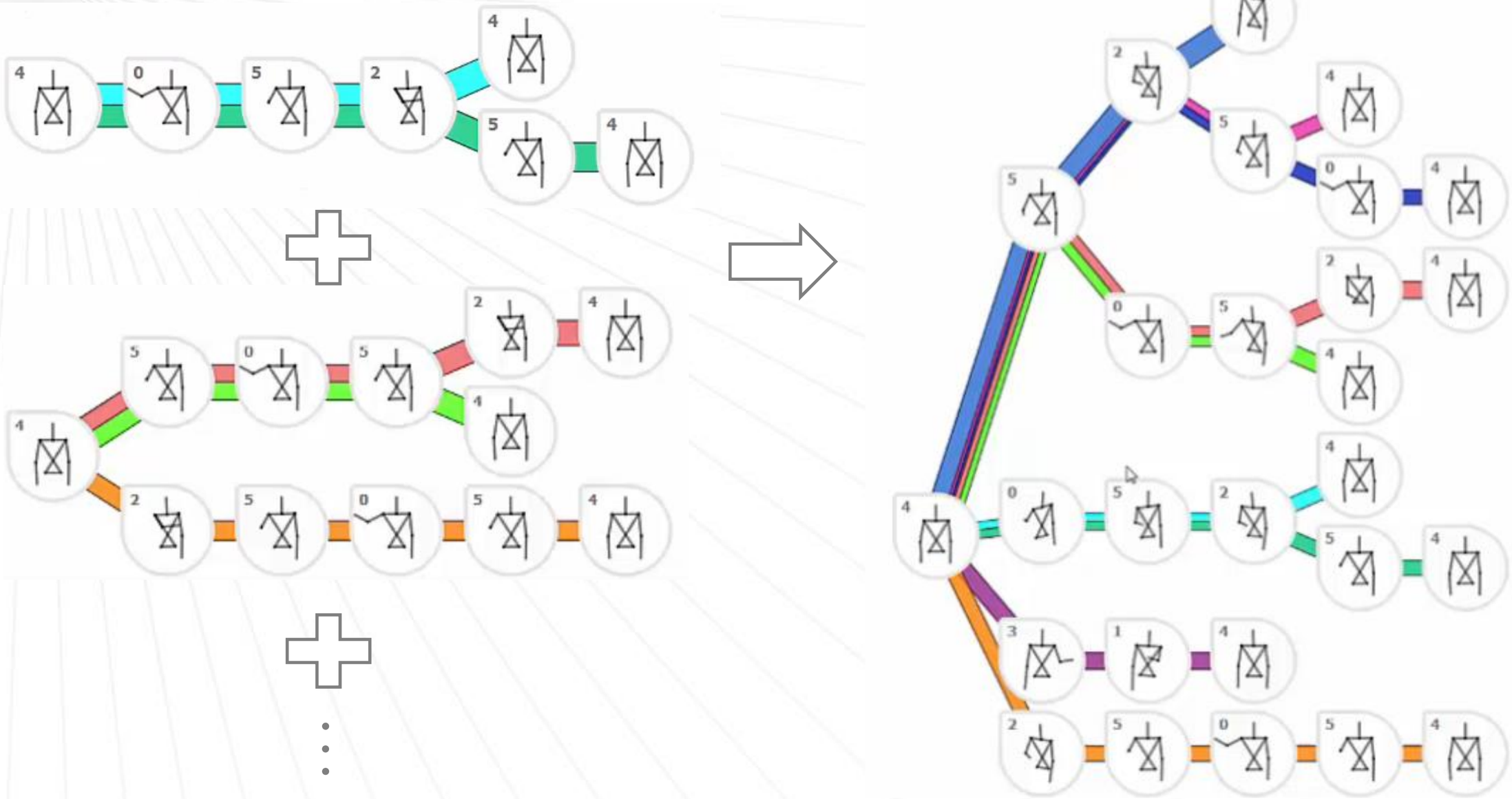
Visual Motion Concordance: Pose Tree





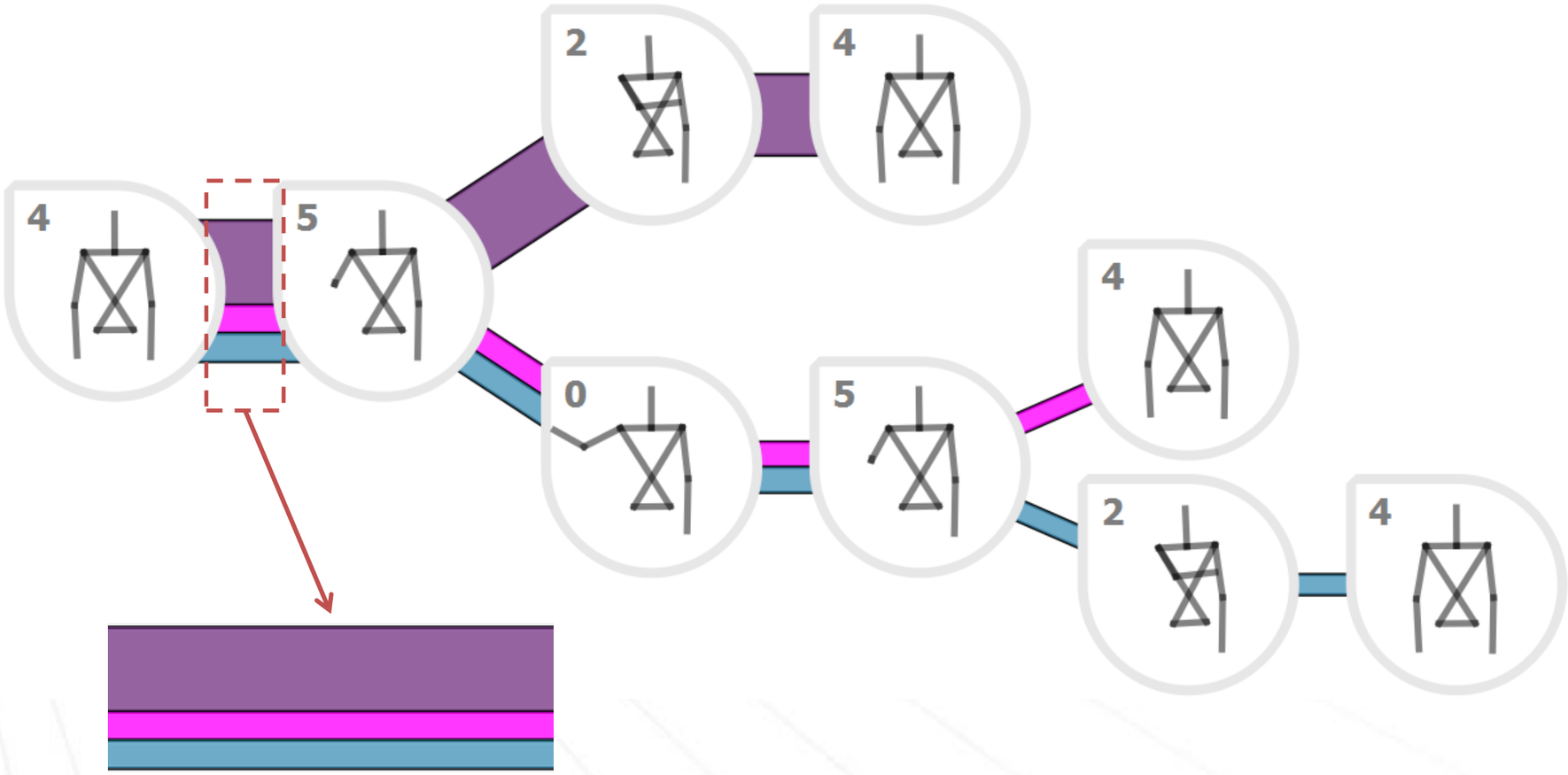
Word Tree - *Wattenberg and Viégas [2008]*

Visual Motion Concordance: Pose Tree



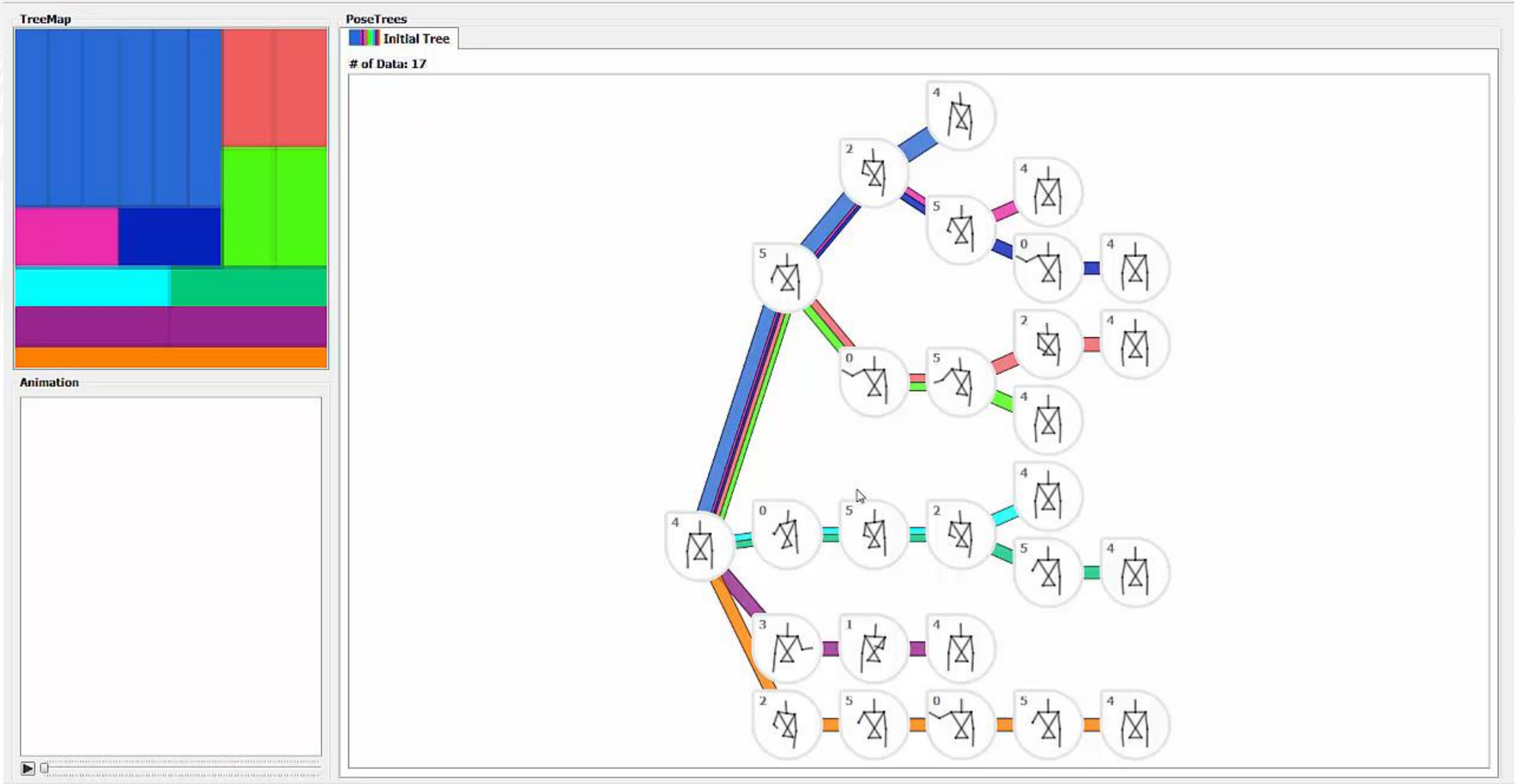
Visual Motion Concordance: Pose Tree

- Edge: Flow Visualization

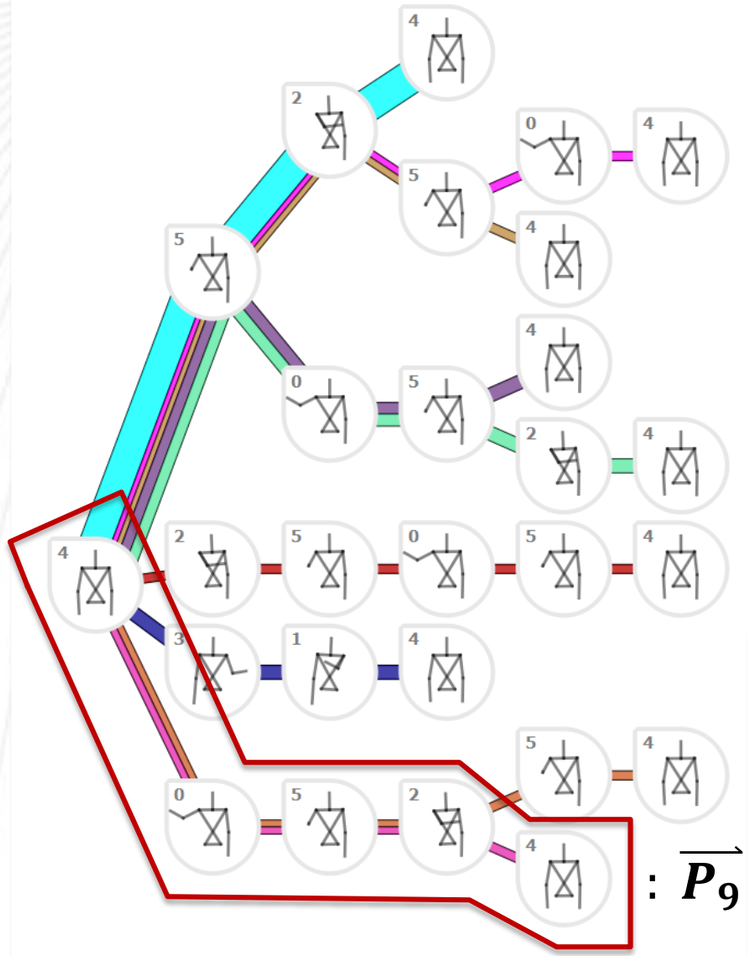


Thickness: Transition Frequency

Pose Tree – Navigating Tree



Search Similar Motion Pattern



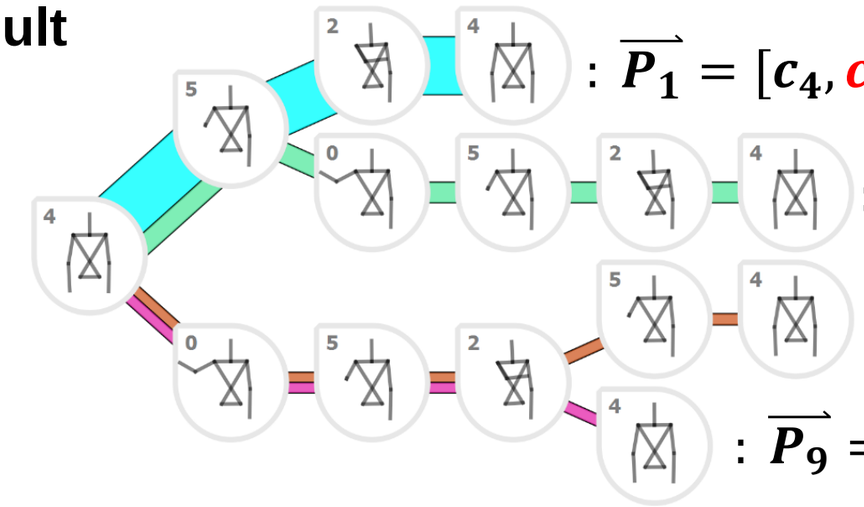
Frequent Sequential Pattern (FSP) Mining

Create

Query $\overrightarrow{P_9}$

Bag of FSPs

Result



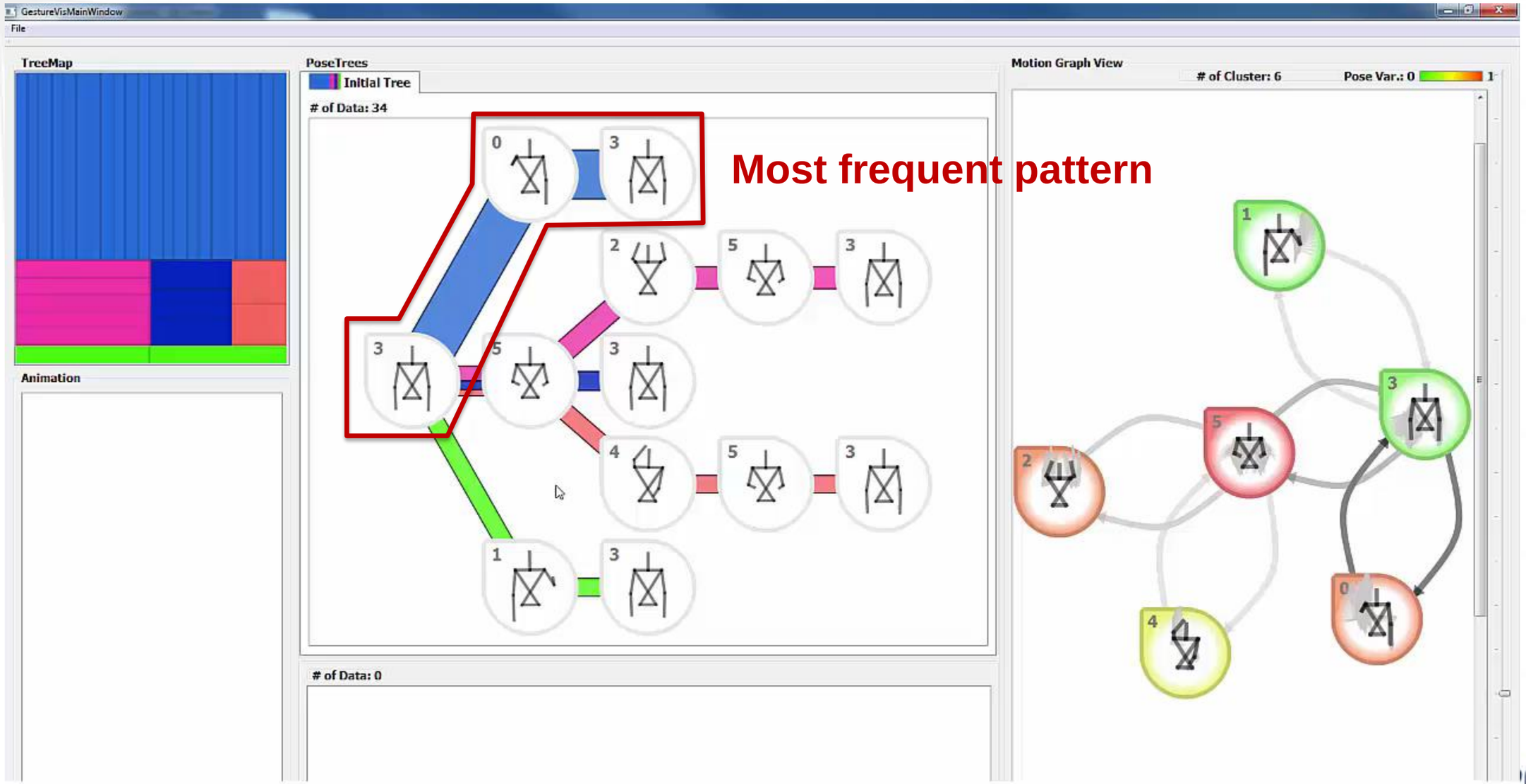
$: \overrightarrow{P_1} = [c_4, c_5, c_2, c_4]$

$: \overrightarrow{P_5} = [c_4, c_5, c_0, c_5, c_2, c_4]$

$: \overrightarrow{P_8} = [c_4, c_0, c_5, c_2, c_5, c_4]$

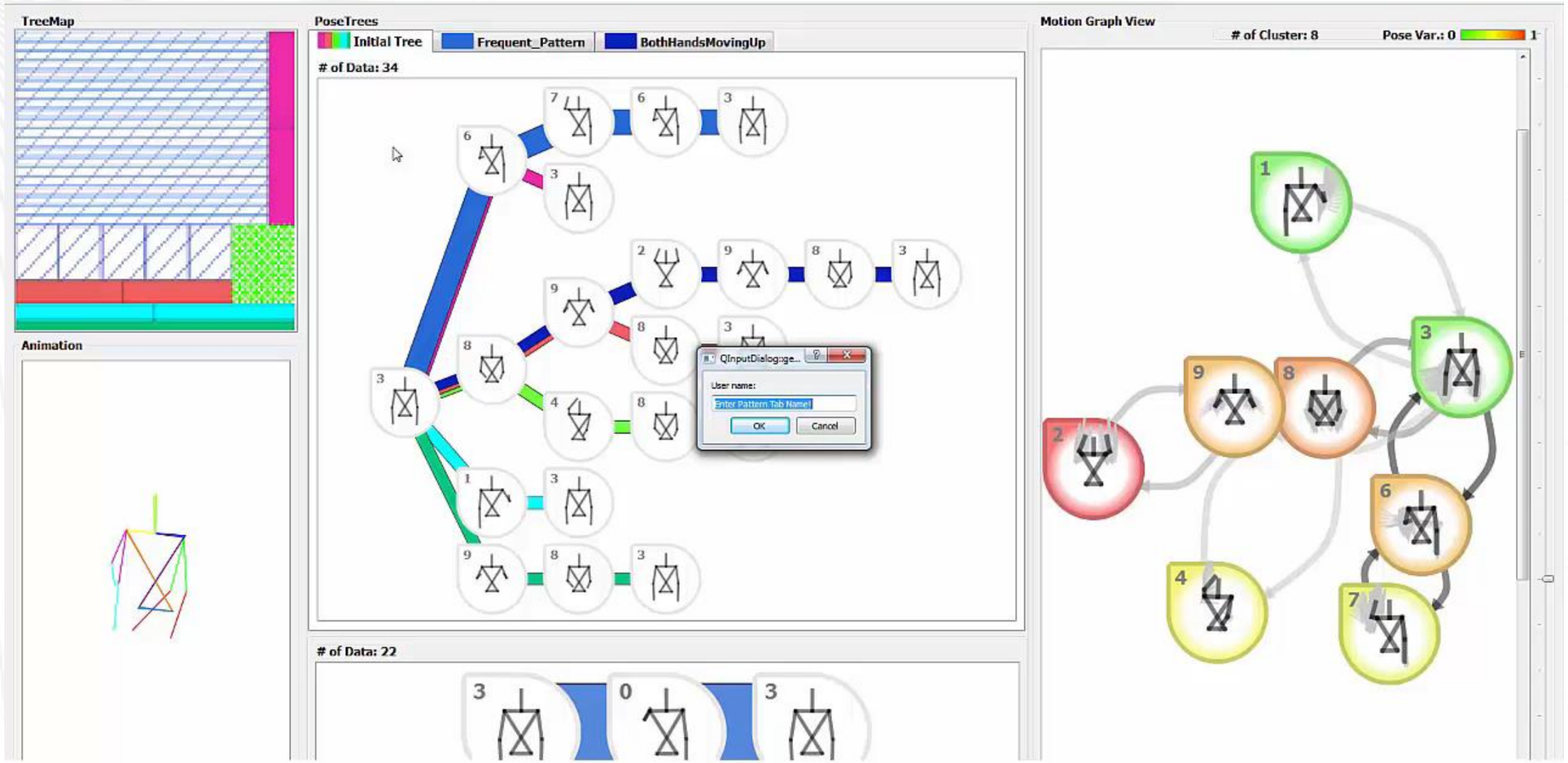
$: \overrightarrow{P_9} = [c_4, c_0, c_5, c_2, c_4]$

Example Scenario: Creating a Gesture Pattern



Progressive Motion Data Organization

Example Scenario: Progressive Organization

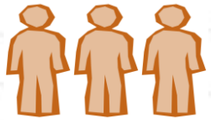


Progressive Organization of Motion Patterns

X 10 Speed

Evaluation: Expert Reviews

- **Goal**: Evaluate usability of MotionFlow in practical analysis tasks
- **6 Participants**:



Interaction designers

Human motion analysts

- **Tasks**:
  - ✓ **T1**: Generating ***representative pose states***
  - ✓ **T2 & T3**: Identifying and exploring most ***common*** (T2) and ***unique*** (T3) motion patterns

  } 34 clips of 6 gesture styles

  - ✓ **T4**: ***Organizing*** unlabeled motion data into a meaningful set of motion patterns

  } 68 clips of 12 gesture styles

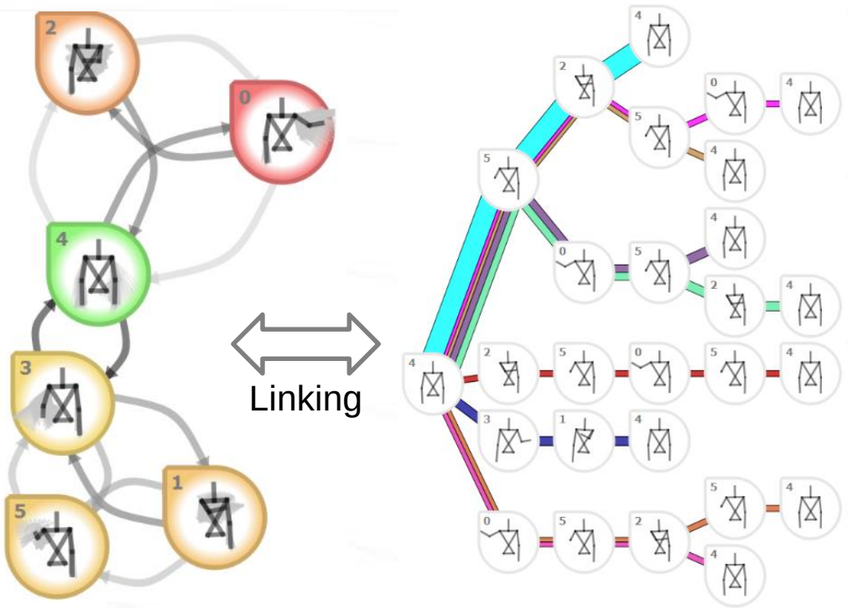
  - ✓ 13 of 7-Likert scale questions & 7 of open-ended questions

- **Data**: Gesture database recorded in elicitation studies [Jang et al. 2014]

Results

Pose-state graph view

- Generating **user-driven pose states**
- Linking with Pose Tree view
  → **Understanding** contexts of pose states in gesture pattern
  → **Organizing** gesture patterns

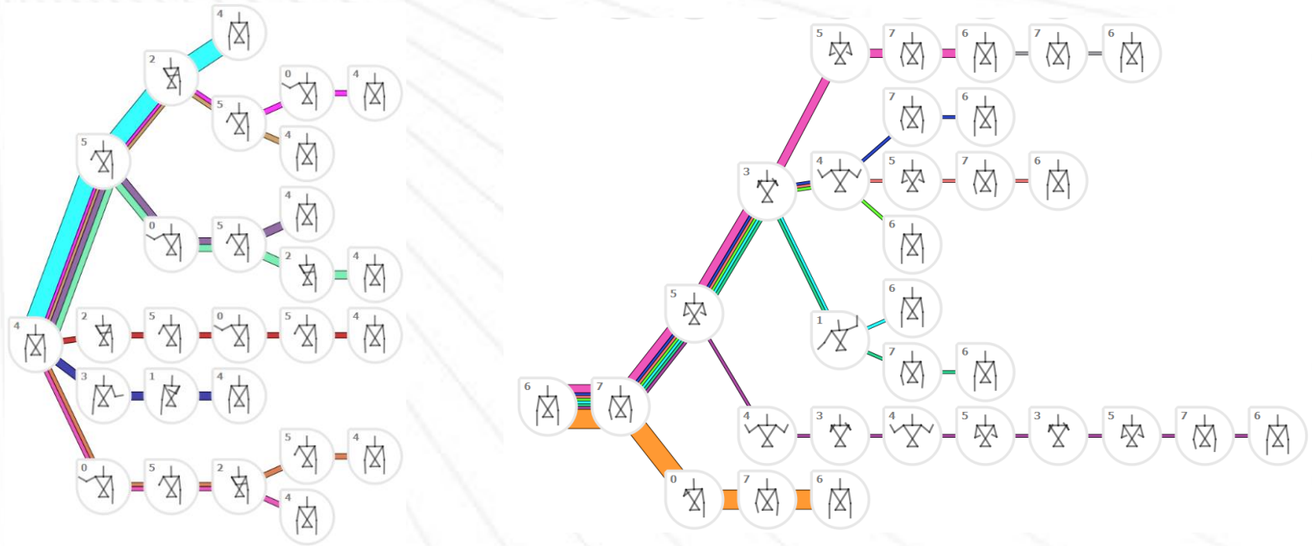


Role of animating gestures

- Animation **cannot be replaced** by *Pose Tree* and *Pose-State Graph* visualizations
- But **integrating** with them greatly supports **sensemaking process**

Limitations

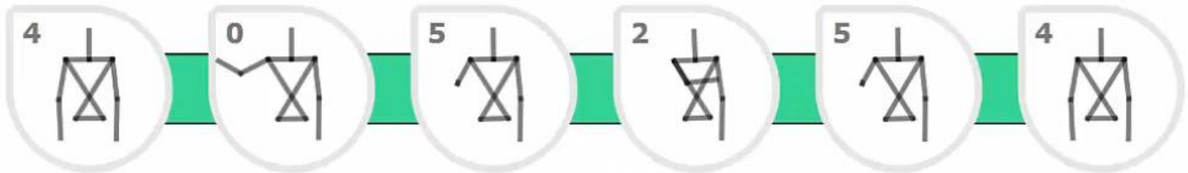
- Scalability
  multiple root nodes, large number of sequence patterns



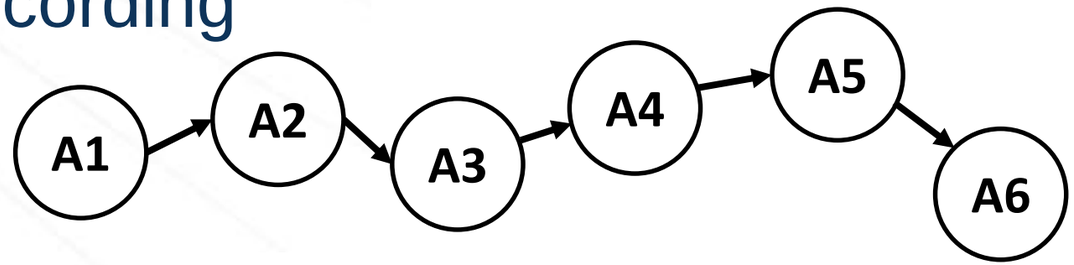
Pose Forest ?

Search and navigate
multi-tree structures

- Analysis of a long period of gesture recording



Pose States Transition



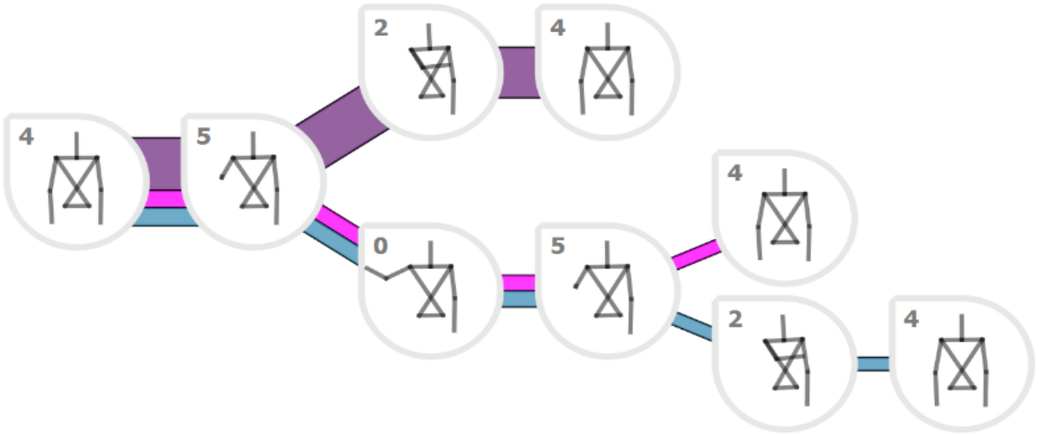
Action States Transition

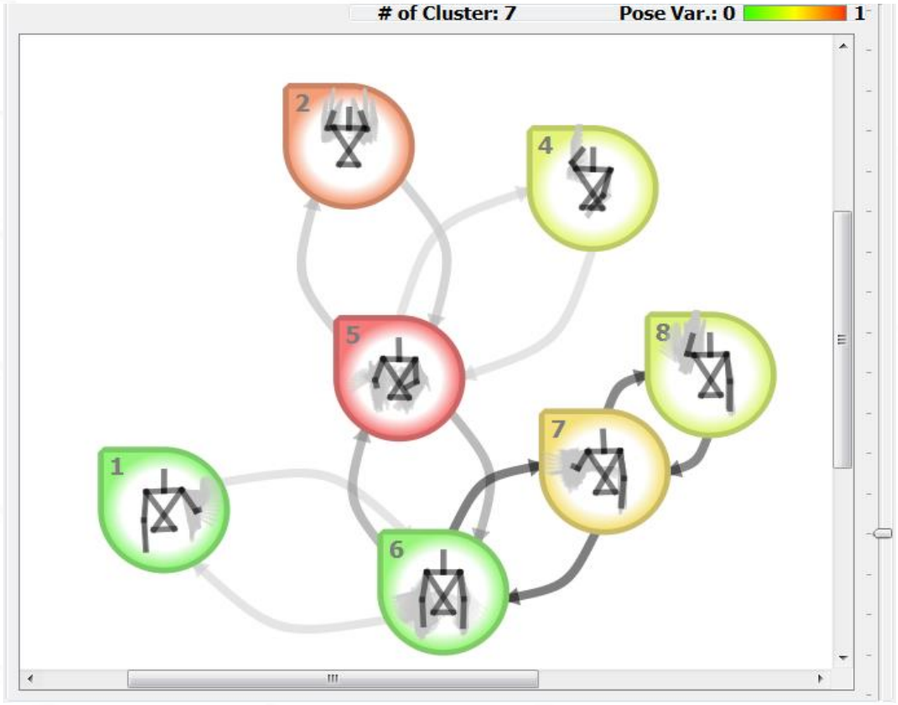
Conclusions

MotionFlow:
Easy to learn/use and effectively support pattern analysis

Pose Tree:
Complete motion trends

Flow visualization:
Transition frequency





Local/global clustering manipulation:
User-defined pose states reflecting human perception and data context

Acknowledgments

Donald W. Feddersen Chaired Professorship
Purdue School of Mechanical Engineering

CMMI-1235232
CPS-1329979

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School of Electrical and Computer Engineering (by courtesy)
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