Data-Driven
Group and Crowd Behavior

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What determines how people move?

Physics
Mass, inertia, force

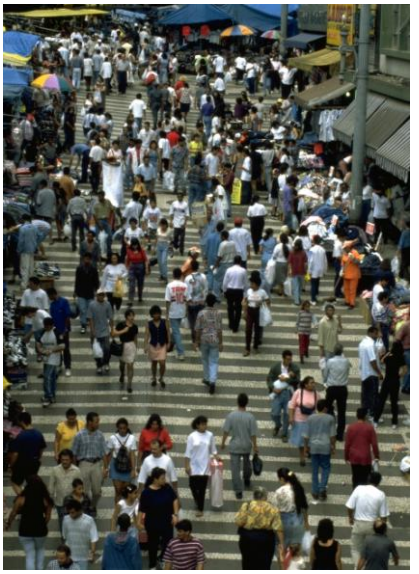
Physiology
Muscle, skeleton, tendon

Culture and Psychology
Style, mood

Group behavior is a complex system

Complex interaction of Individual behavior

Subtle changes of individual behavior may result in **completely different** group behavior



Principles and Observation

Do we need principles that determine group/crowd behavior?

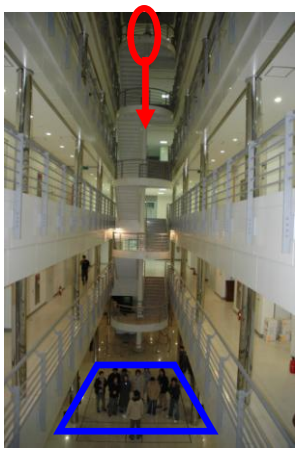
- Rule-based agent model
- social force model
- potential fields

Do we simply imitate what we have seen before?

- Data-driven crowd simulation

Capturing Crowd Data

Record videos from a bird's-eye view



Setup

Recorded video

Tracking pedestrians in video

Making Use of Observed Data

Record-and-playback is not enough

Create something new from canned data

Toolbox for animators/programmers

edit, manipulate, segment, splice, blend, texture, adapt

Visual Characteristics of Crowds

Each crowd exhibit particular "style"

Spatial Formation

Density, Regularity, Persistency

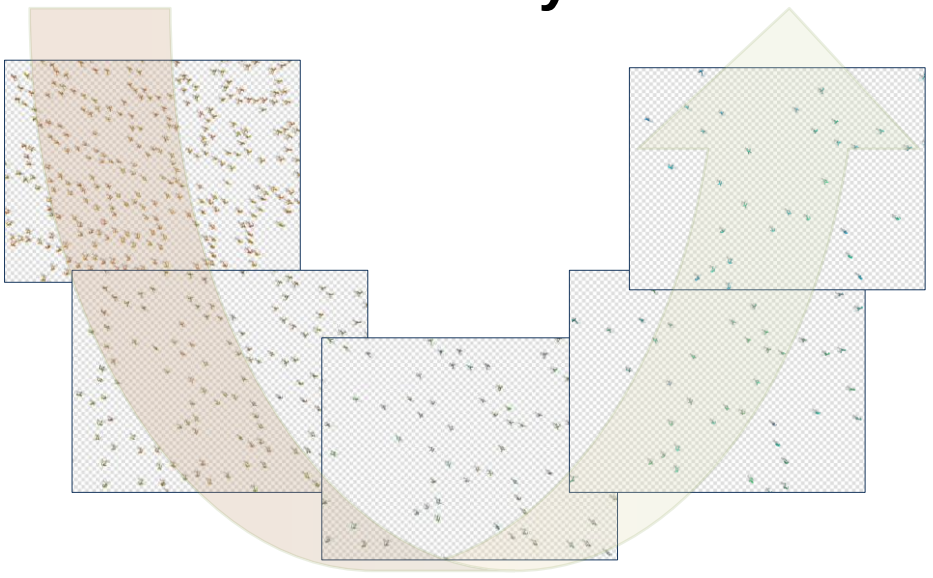
Characteristics of Individuals

Distribution of velocities

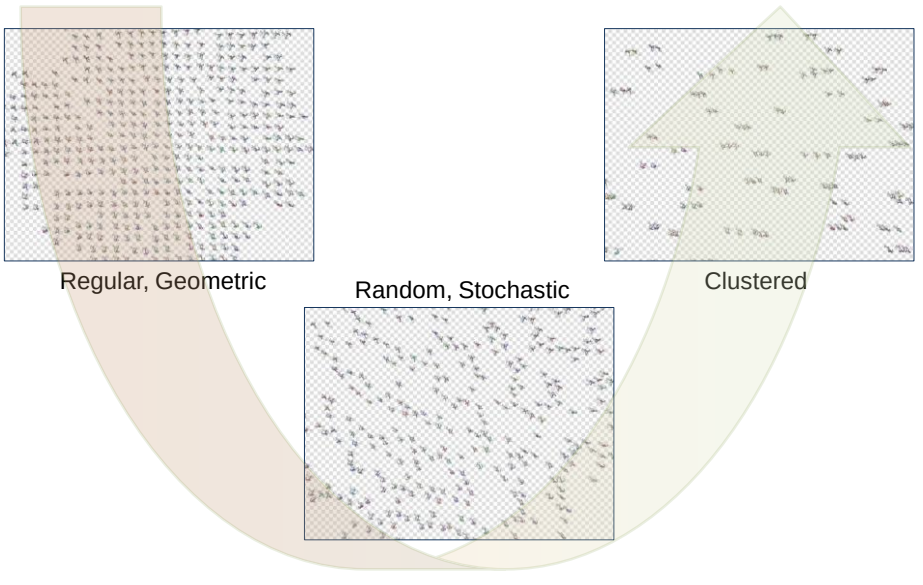
Style of locomotion

Reaction to potential collision

Density



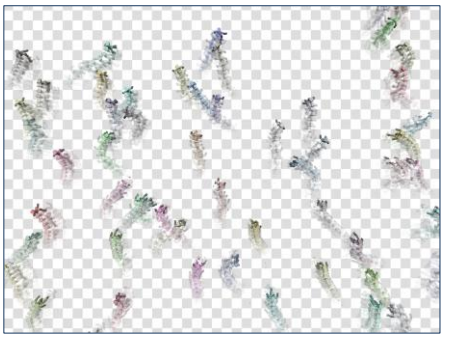
Regularity, Randomness, Clustering



Temporal Persistency

Persistent

Transient



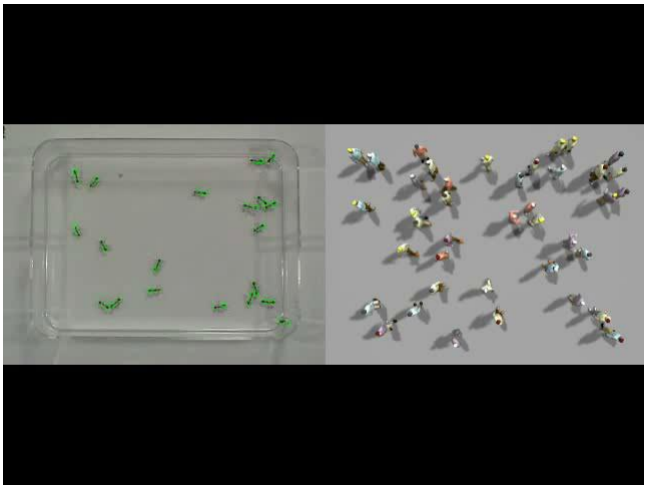
Texturing

Group Behavior from Video: A Data-Driven Approach to Crowd Simulation,
Kang Hoon Lee, Myung Geol Choi, Qyoun Hong, Jehee Lee, SCA 2007

Lining Up

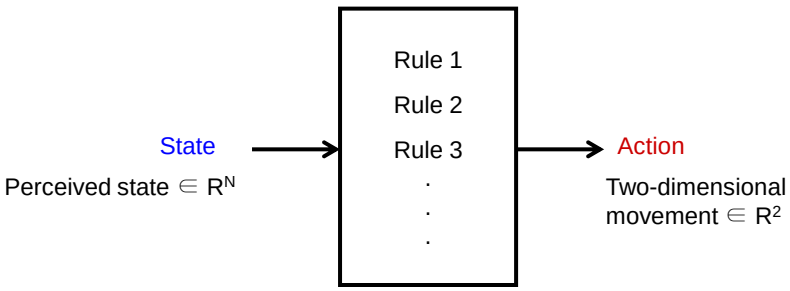
Cluttered Formation

Group Behavior of Ants



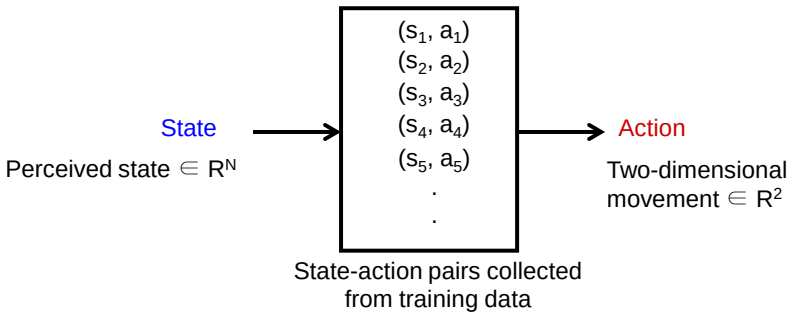
Rule-Based Agent Model

Each agent perceives its **state** and decides the next **action** based on a set of **rules**

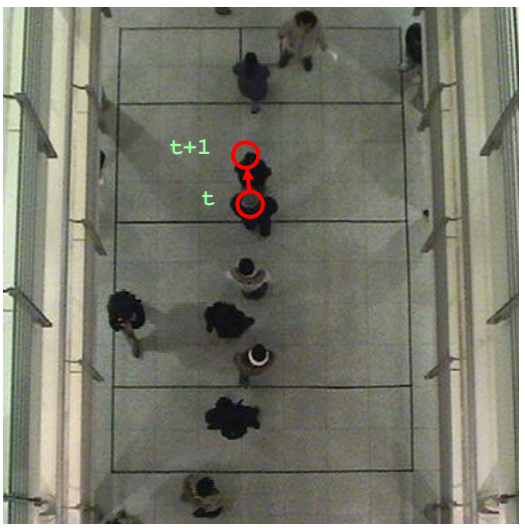


Data-Driven Agent Model

Each agent perceives its **state** and decides the next **action** based on a set of **examples**



State-Action Trajectories



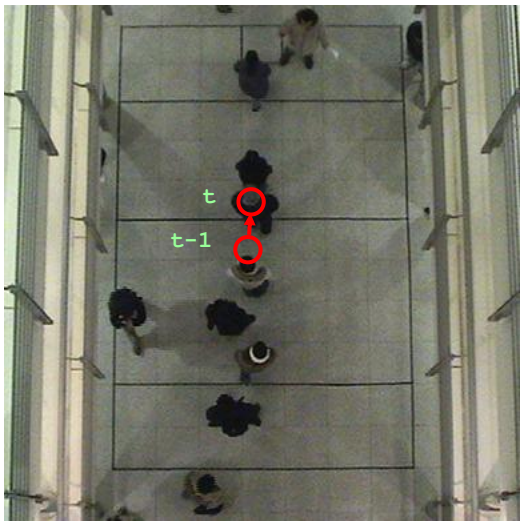
Action

Two-dimensional vector

State

N-dimensional vector from a set of features

State-Action Trajectories



Action

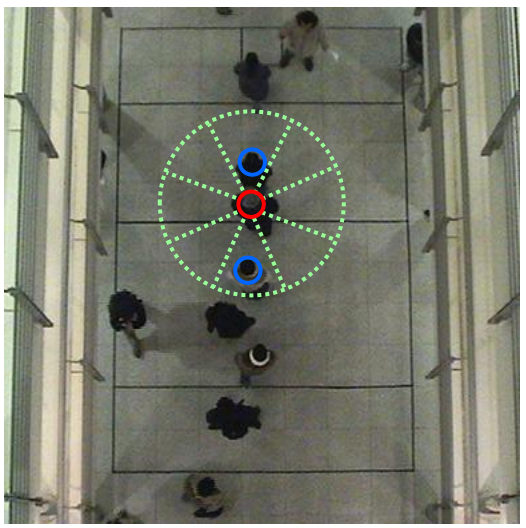
Two-dimensional vector

State

N-dimensional vector
from a set of features

Speed

State-Action Trajectories



Action

Two-dimensional vector

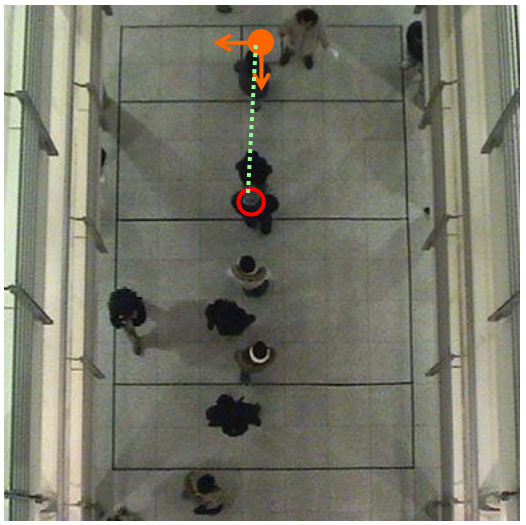
State

N-dimensional vector
from a set of features

Speed

Neighbor

State-Action Trajectories



Action

Two-dimensional vector

State

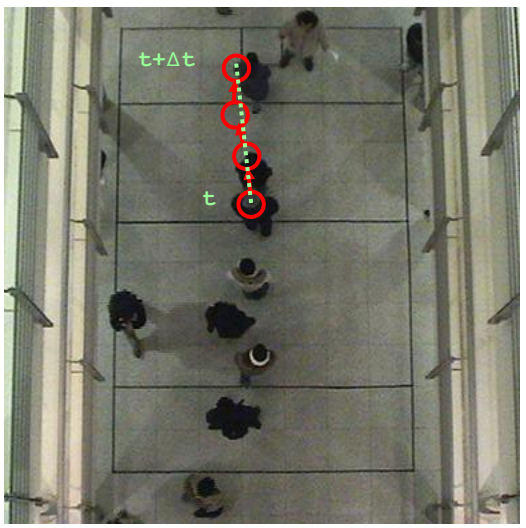
N-dimensional vector
from a set of features

Speed

Neighbor

Pivot

State-Action Trajectories



Action

Two-dimensional vector

State

21-dimensional vector
from 4 features

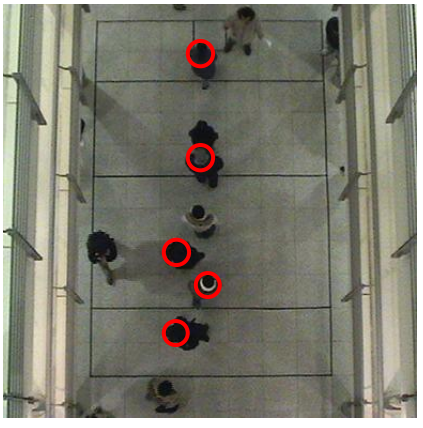
Speed

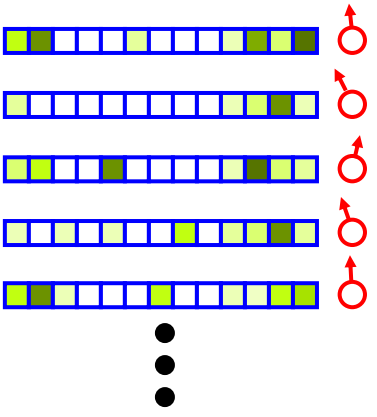
Neighbor

Pivot

Intended
direction

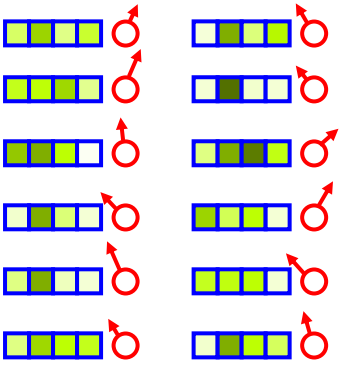
Collecting State-Action Pairs

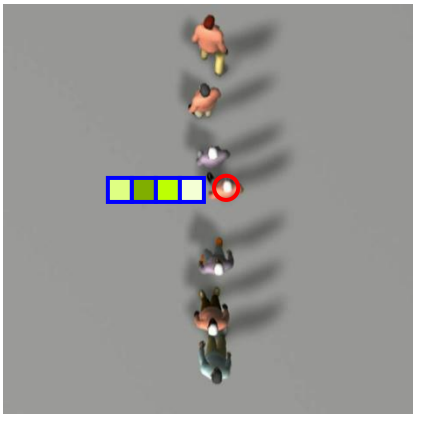




Data-Driven Simulation

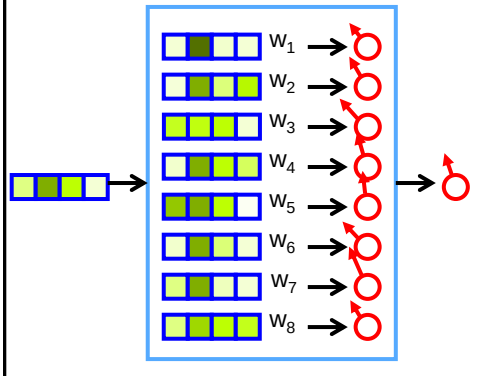
Given the state of each agent,
search similar states from data

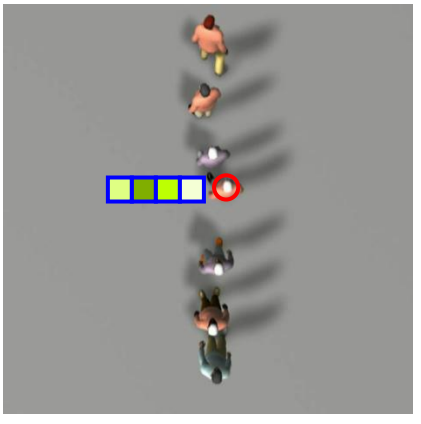




Data-Driven Simulation

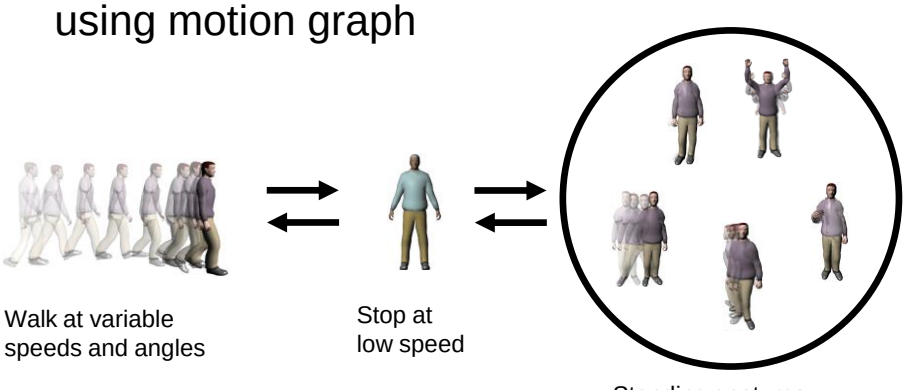
Locally weighted linear regression



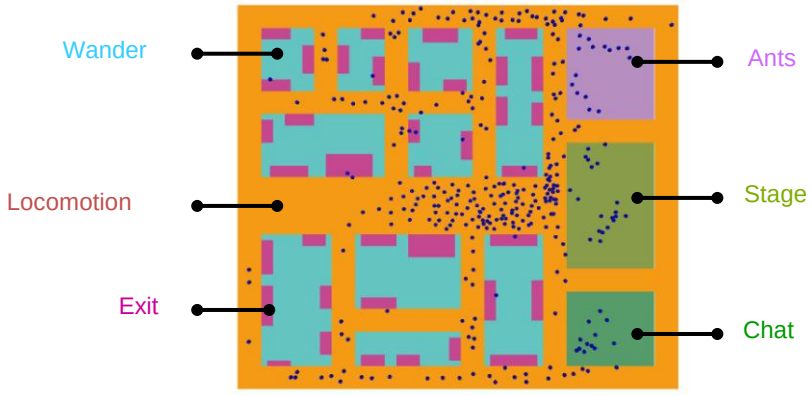


Motion Synthesis

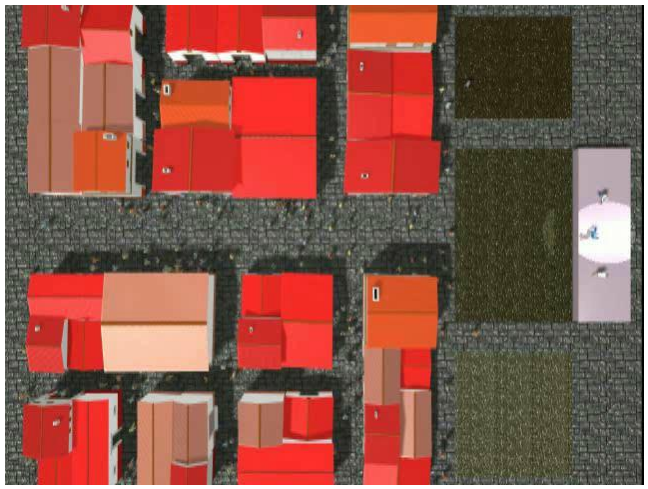
Full-body motion from **2D trajectory** using motion graph



Composition of Clips



Composition of Clips



Group Motion Editing

Direct manipulation of motion clips

Warp, Splice, Adapt, Copy-and-Paste, Group/Ungroup

Preserve the original quality as much as possible

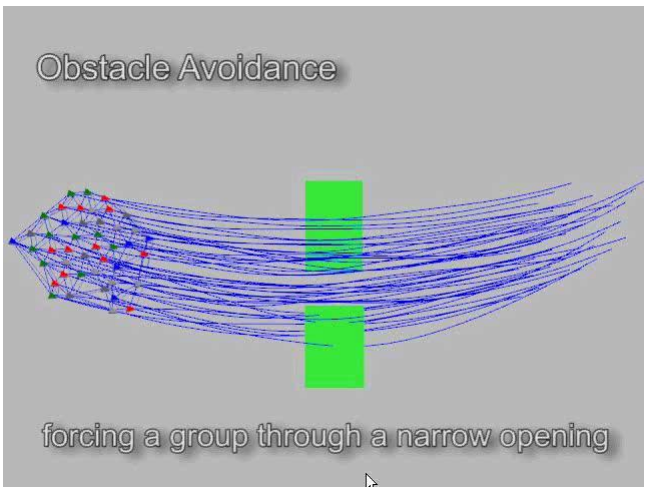
Individual trajectories

Formation

Modeling group motion clips as 3D meshes

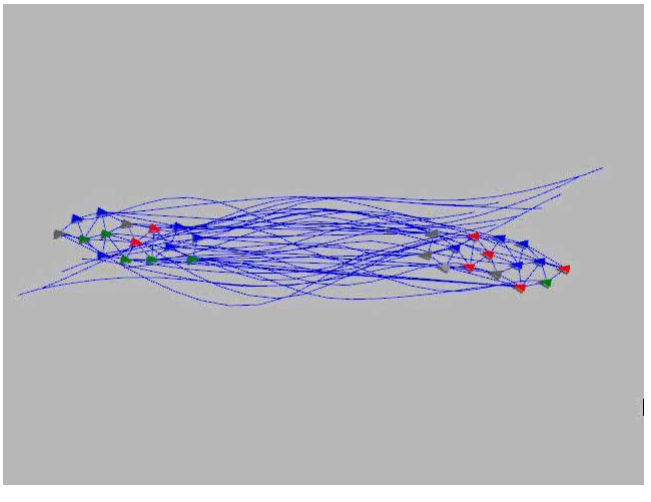
Group Motion Editing, Taesoo Kwon, Kang Hoon Lee,
Jehee Lee, Shigeo Takahashi, Siggraph 2008

Direct Manipulation



Splice

Inhomogeneous Groups



Scissoring

Copy and Paste

Style Transition

?

Interpolating Styles

+

+

$* \ W_1$ $* \ W_2$ $* \ W_3$

?

Why is it Challenging?

Unstructured formation

Random, regular, clustered

Persistent vs time-varying

Crowds are time-series data

Eg) Aggressive pedestrians try to pass each other

Arbitrary number of agents

No one-to-one correspondence

Morphable Crowds

Interpolate models instead of data

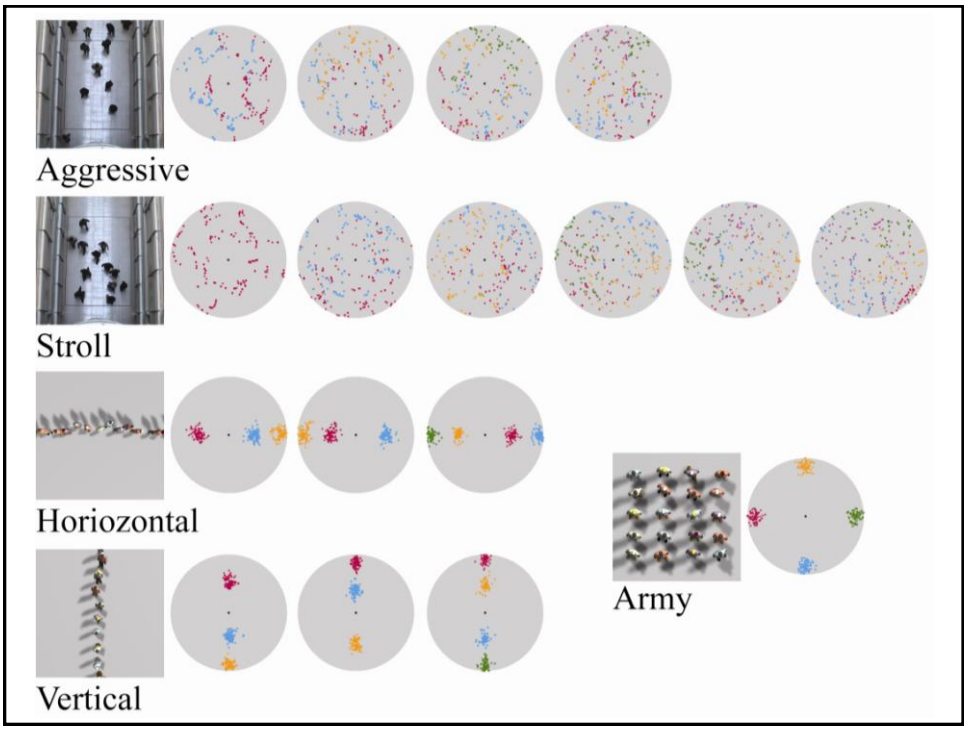
Models should have blendable features

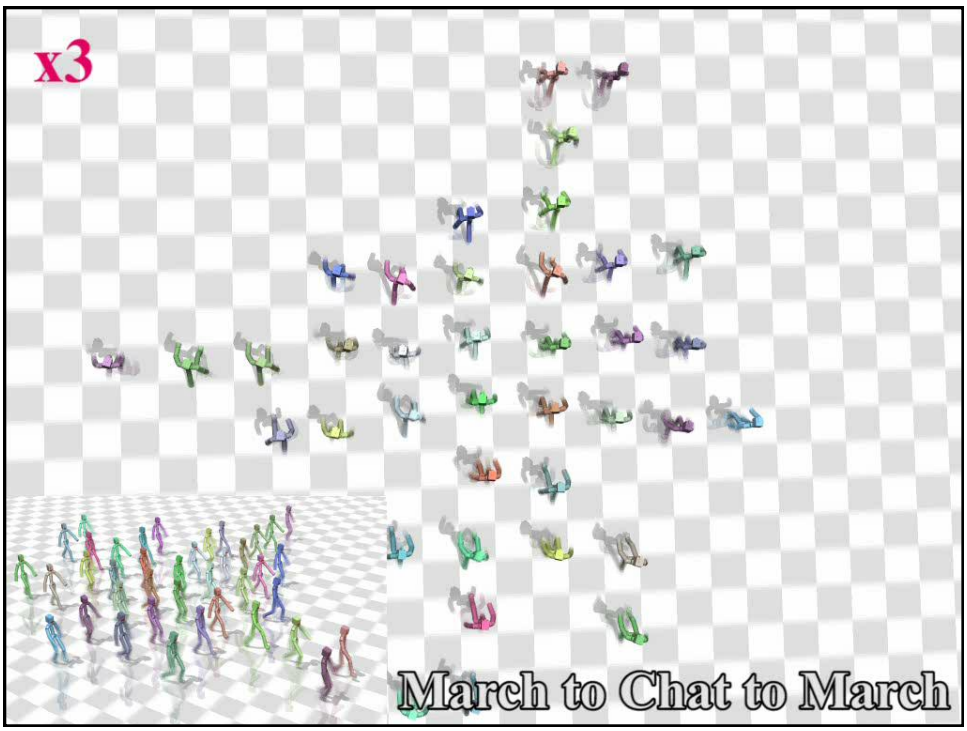
Sampling-based modeling of

high-dimensional neighborhood formation

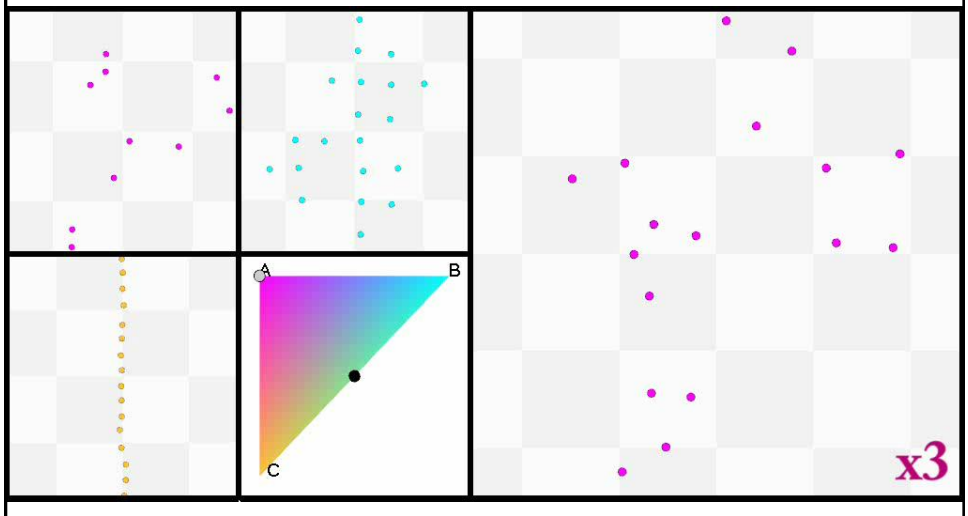
individual trajectory

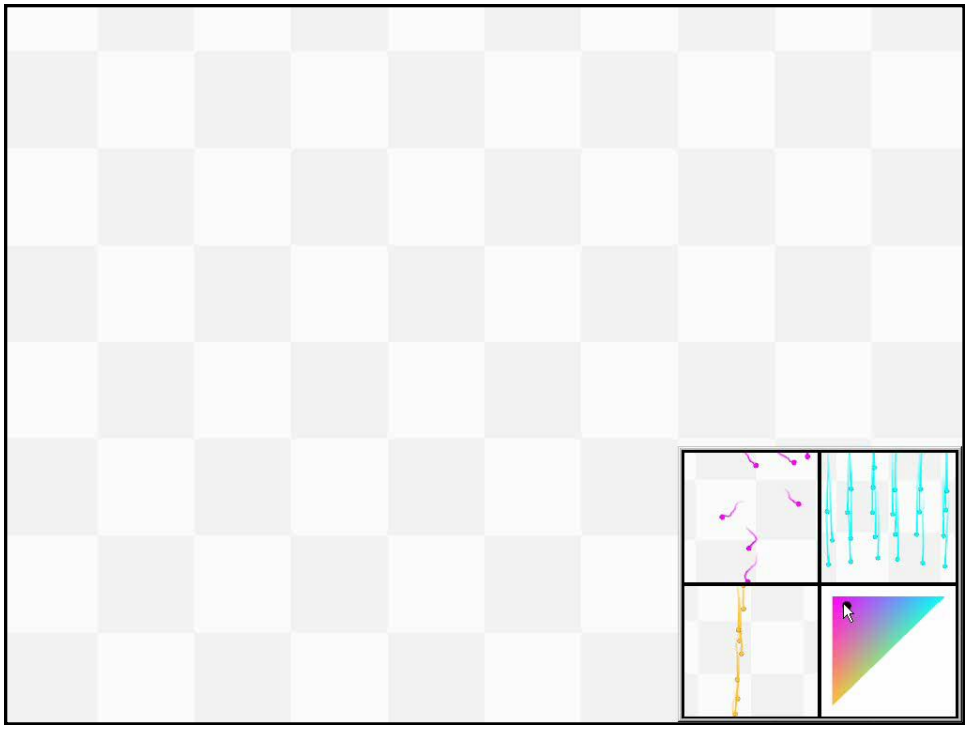
Morphable Crowds, Eunjung Ju, Myung Geol Choi, Minji Park, Jehee Lee, Kang Hoon Lee and Shigeo Takahashi, Siggraph Asia 2010


Aggressive
Stroll
Horiozontal
Vertical
Army

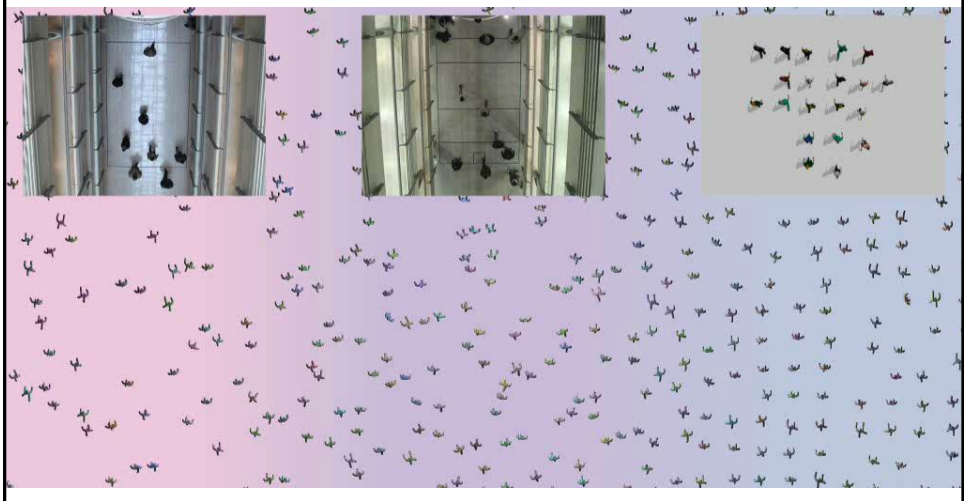

x3
March to Chat to March

Three-way Interpolation

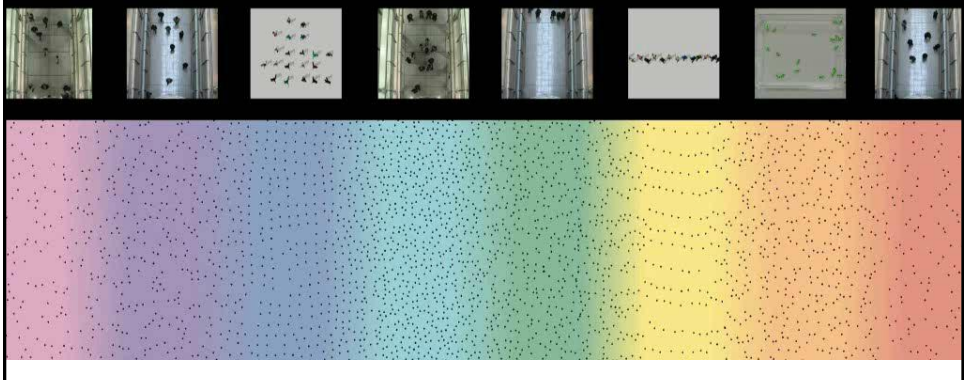




Spatial Transition



Spatial Transition



Wrap Up

Data-Driven Crowd/Group Behavior

- Immediacy of control
- Direct manipulation over fine details

Group motion as a primary entity

- Texturing, style transfer, scissor/stitch
- Interactive editing, copy-paste, group/ungroup
- Blend, interpolate

Combine Principle and Observation

Learning principle from observation

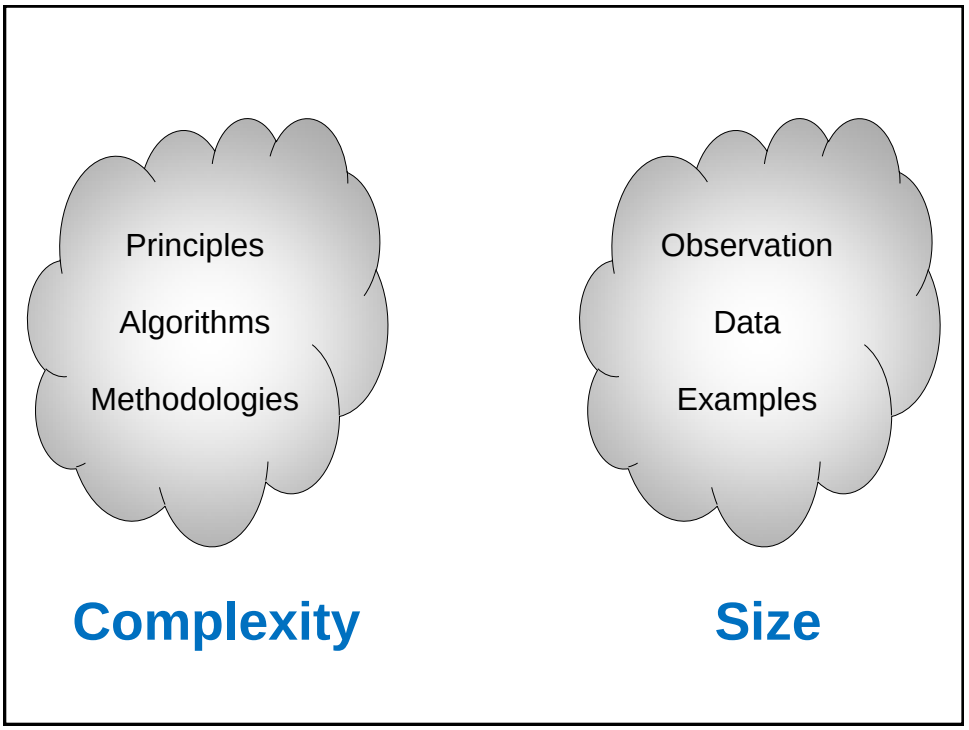
- Capture symmetry, regularity, and patterns in data

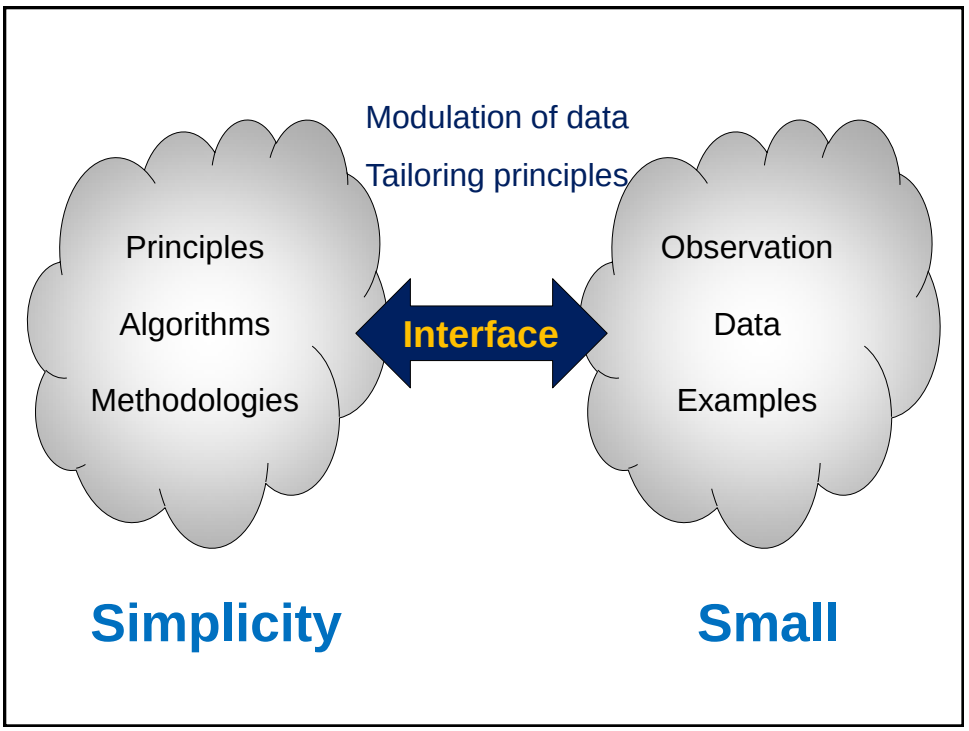
Observation drives principles

- Data-driven physics simulation

Principle guides data manipulation

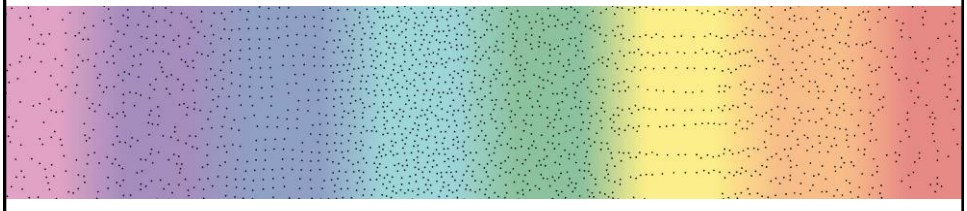
- Motion editing using physical properties


Principles
Algorithms
Methodologies
Observation
Data
Examples
Complexity
Size


Modulation of data
Tailoring principles
Principles
Algorithms
Methodologies
Interface
Observation
Data
Examples
Simplicity
Small

The papers and videos are available at **SNU Movement Research Lab**

http://mrl.snu.ac.kr



Collaborators

Eunjung Ju, Myung Geol Choi, Kang Hoon Lee
Taesoo Kwon, Minji Park, Shigeo Takahashi