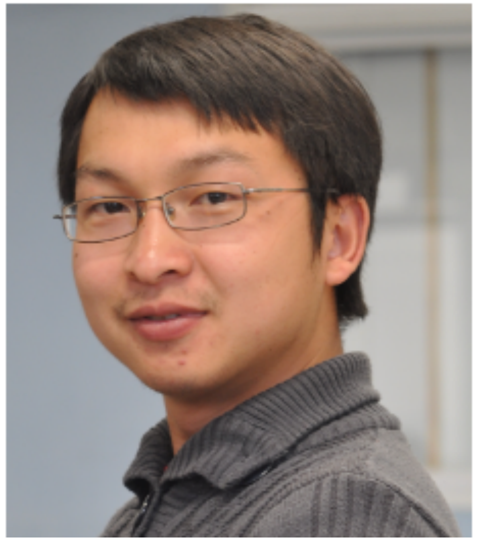
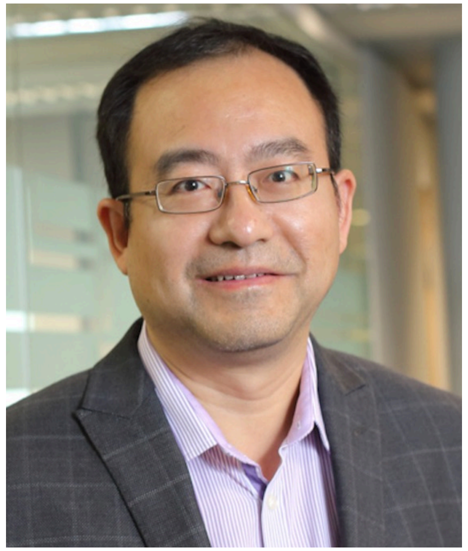
A Vector Field Design Approach to Animated Transitions



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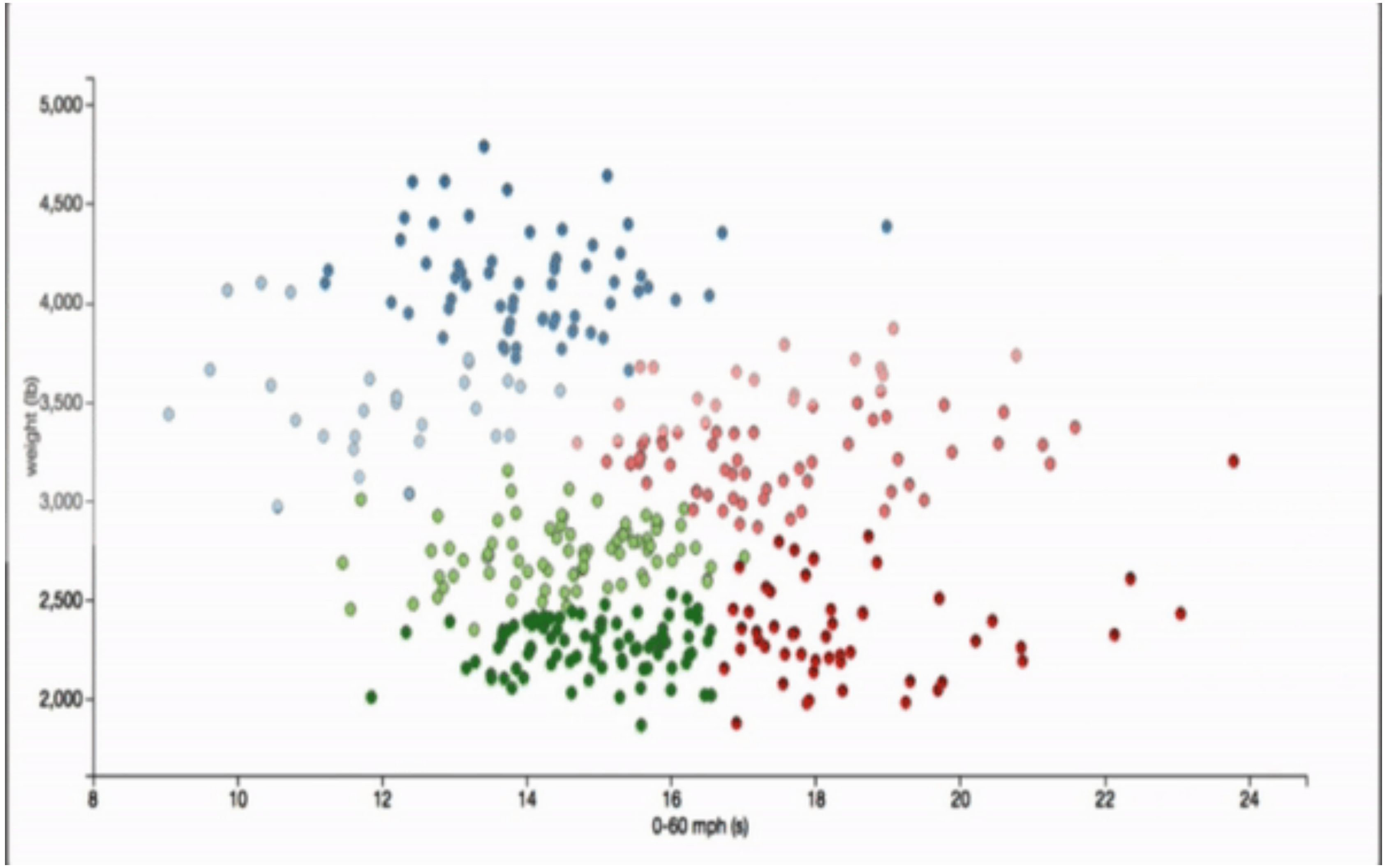
http://home.cse.ust.hk/~ywangct/proj/vf_animation.html

Background

Animated Transitions

- They are pervasive in data visualization
- They show the general switching between two visualization views



Animated Transition Tasks

- When using animated transitions, users often want to
  - Track the movement of individual data points
  - Track the movement and evolution of point clusters

It is challenging due to the essential dynamic changes of data!

Motivation – Psychology Studies

- Two key observations from psychology studies:
  - *Coordinated motion*
    - Points in the same group should move together with similar trajectories[1] **(the law of common fate)**
  - *Crowding avoidance*
    - Putting data points too close to each other can result in identity confusion[2]

[1] S. Yantis, "Multielement visual tracking: Attention and perceptual orga- nization," Cognitive Psychology, vol. 24, no. 3, pp. 295–340, 1992.

[2] S. L. Franconeri, J. Y. Lin, J. T. Enns, Z. W. Pylyshyn, and B. Fisher, "Evidence against a speed limit in multiple-object tracking," Psycho- nomic Bulletin & Review, vol. 15, no. 4, pp. 802–808, 2008.
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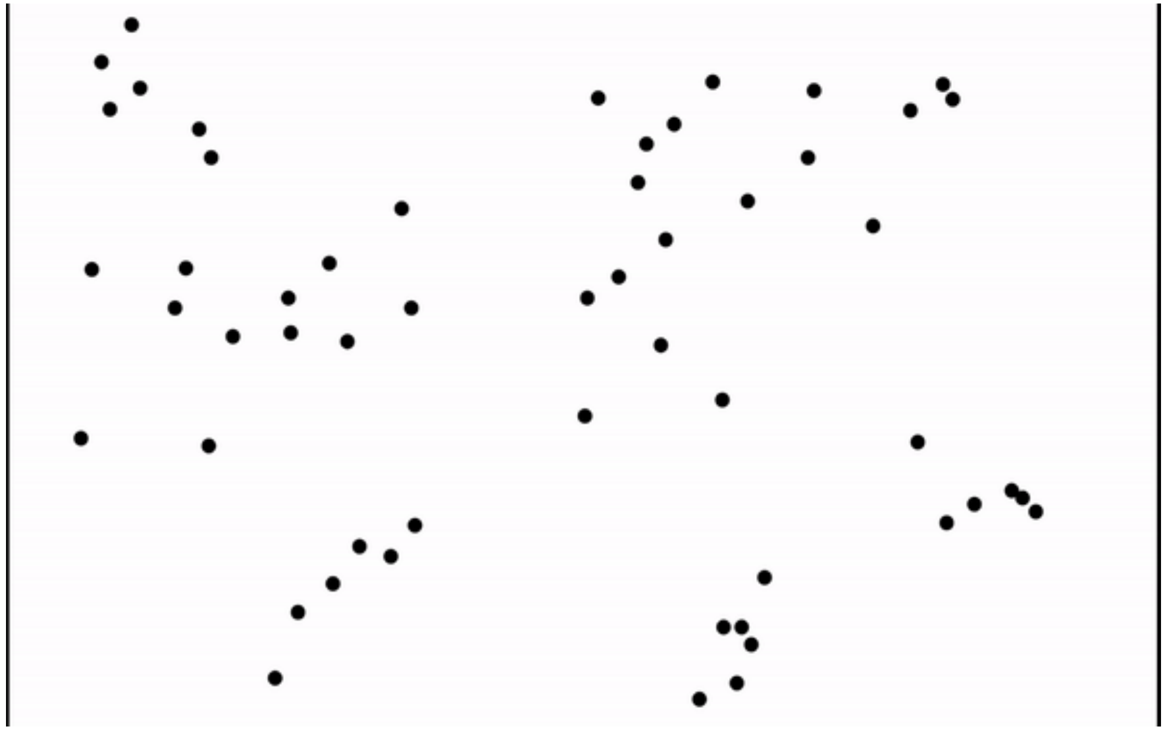
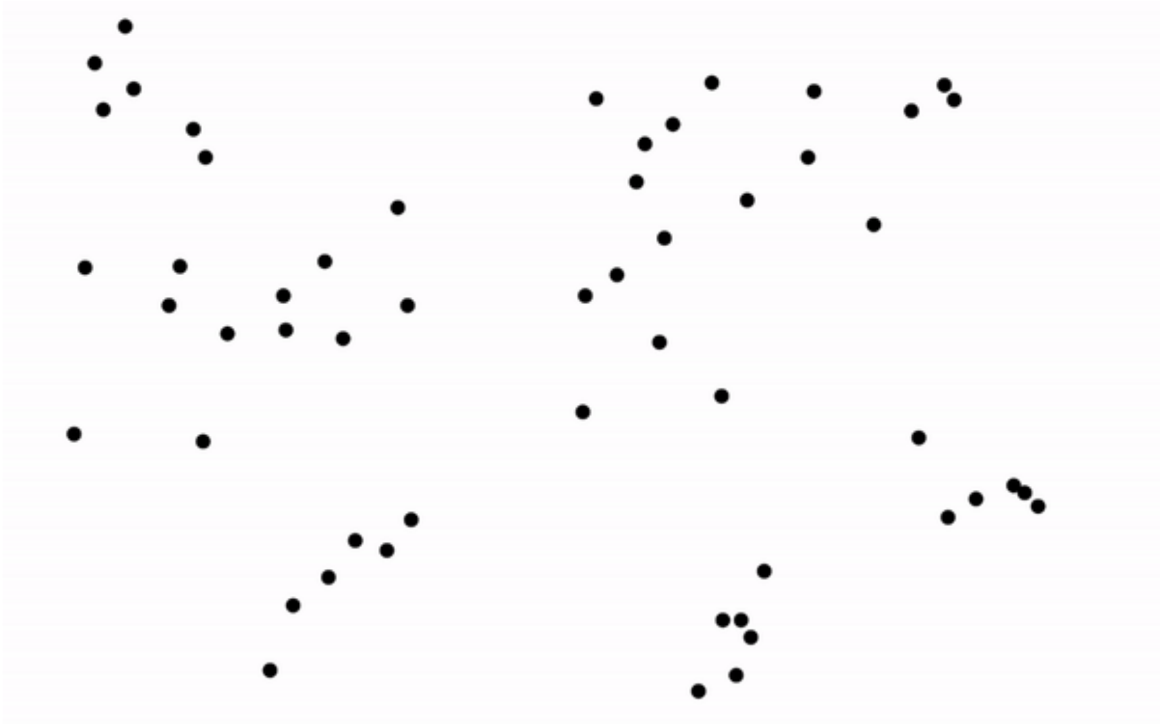
Motivation – Related Work

- Two representative methods of animated transition



Linear Transition



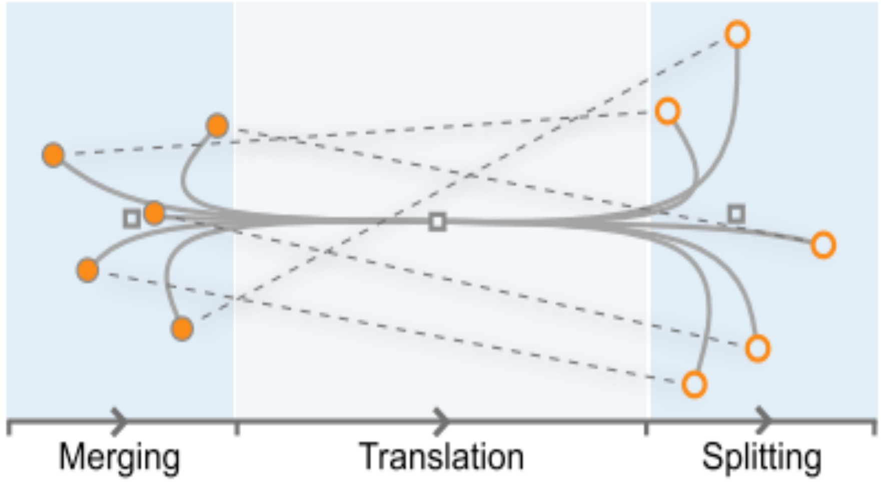
Bundled Trajectory[3]

[3] Fan Du, Nan Cao, Jian Zhao and Yu-ru Lin . "Trajectory bundling for animated transitions." *CHI*, 2015.

Motivation – Related Work

- Two representative methods of animated transition

	Linear Transition	*Bundled Trajectory*[3]
Coordinated Motion	✗	✓
Crowding Avoidance	✗	✗



[3] Fan Du, Nan Cao, Jian Zhao and Yu-ru Lin . "Trajectory bundling for animated transitions." *CHI*, 2015.

Can we enhance coordinated motion and avoid crowding simultaneously in animated transitions?

Our Approach

- Animated transition based on **vector field design**

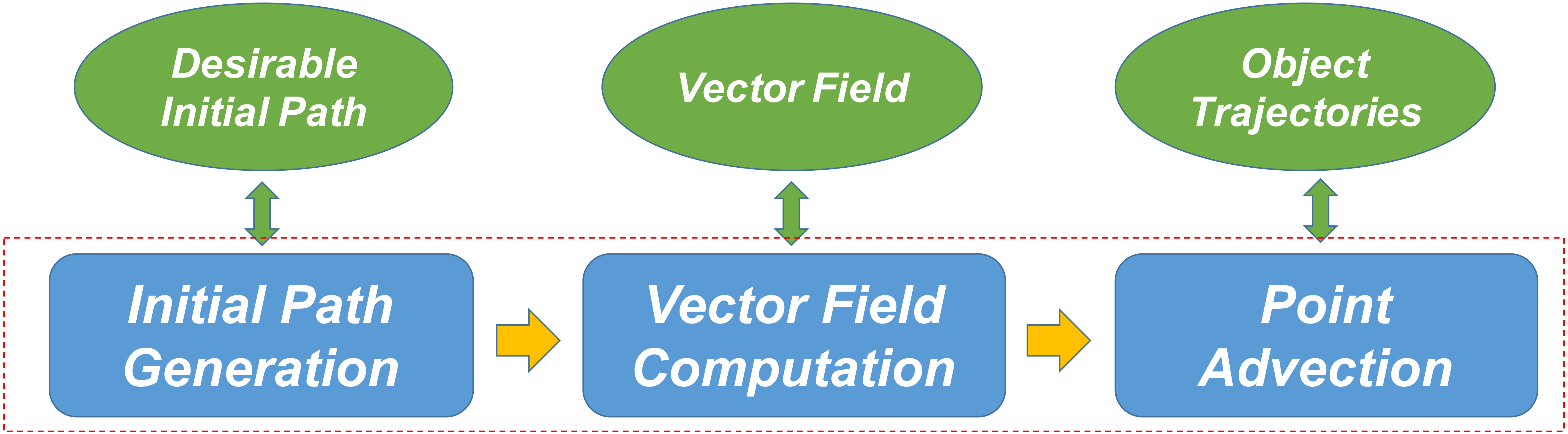
  - *Input*: the start and end positions of clustered points

  - *Output*: transition trajectories of points

  - *Goal*: improve object tracking of animated transitions by enhancing coordinated motion within clusters and avoiding crowding

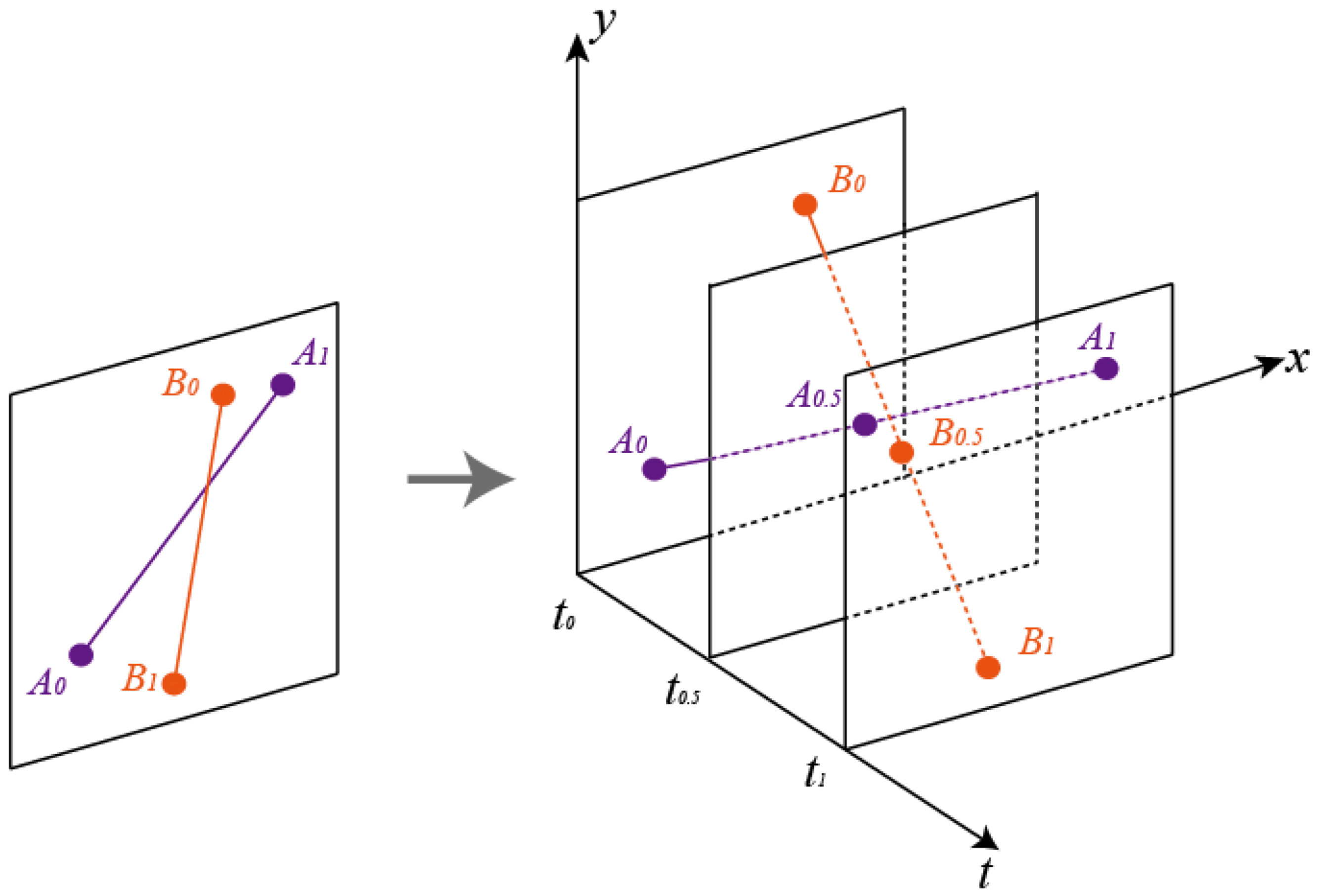
Our Approach

- Animated transition based on **vector field design**
  - General Idea:



Our Approach – Initial Path Generation

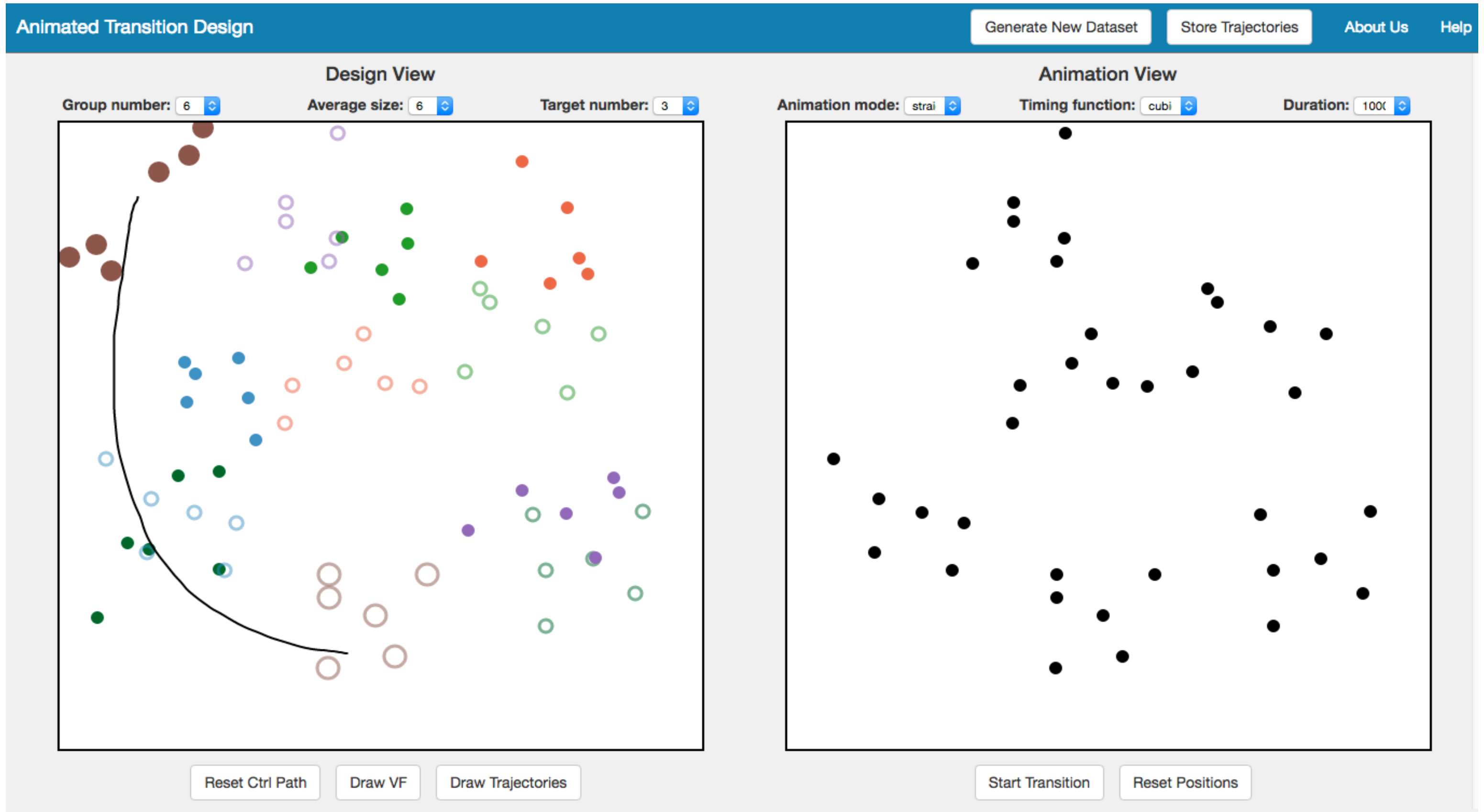
- Automated approach:
  - a force-directed model in 3D space
    - *Repulsion*
    - *Attraction*
    - *Smoothening*



Our Approach – Initial Path Generation

• Manual sketching:

- Designers may like flexible design for animation in certain cases
- A user interface is provided



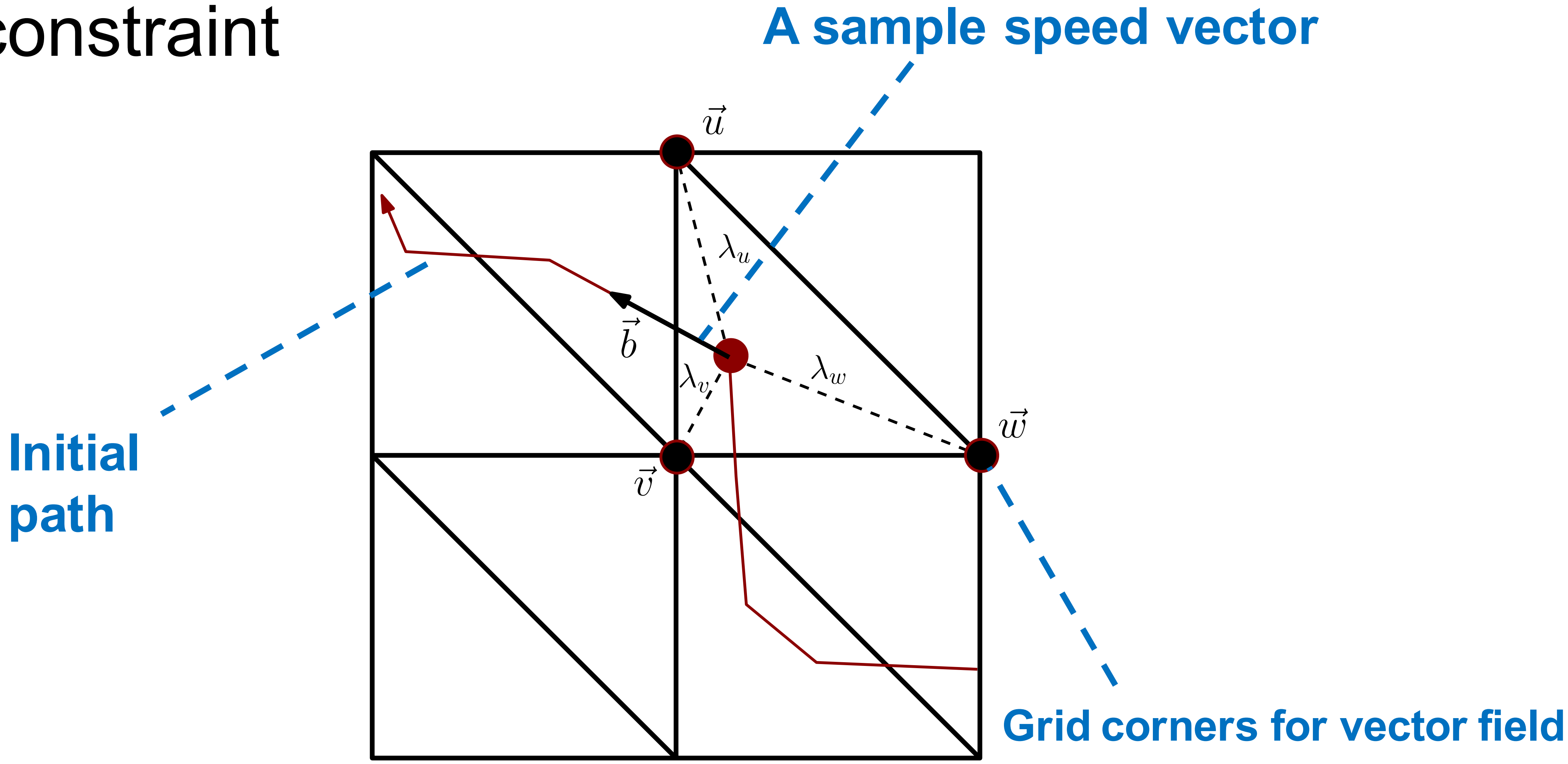
Our Approach – Vector Field Computation

- How to construct a vector field based on an initial path?

- **Core idea**:
  - Overlay an n x n grid over the screen to define the vector field
  - Propose two types of constraints to restrict the vector field
  - Apply the above two steps to each cluster of points

Our Approach – Vector Field Computation

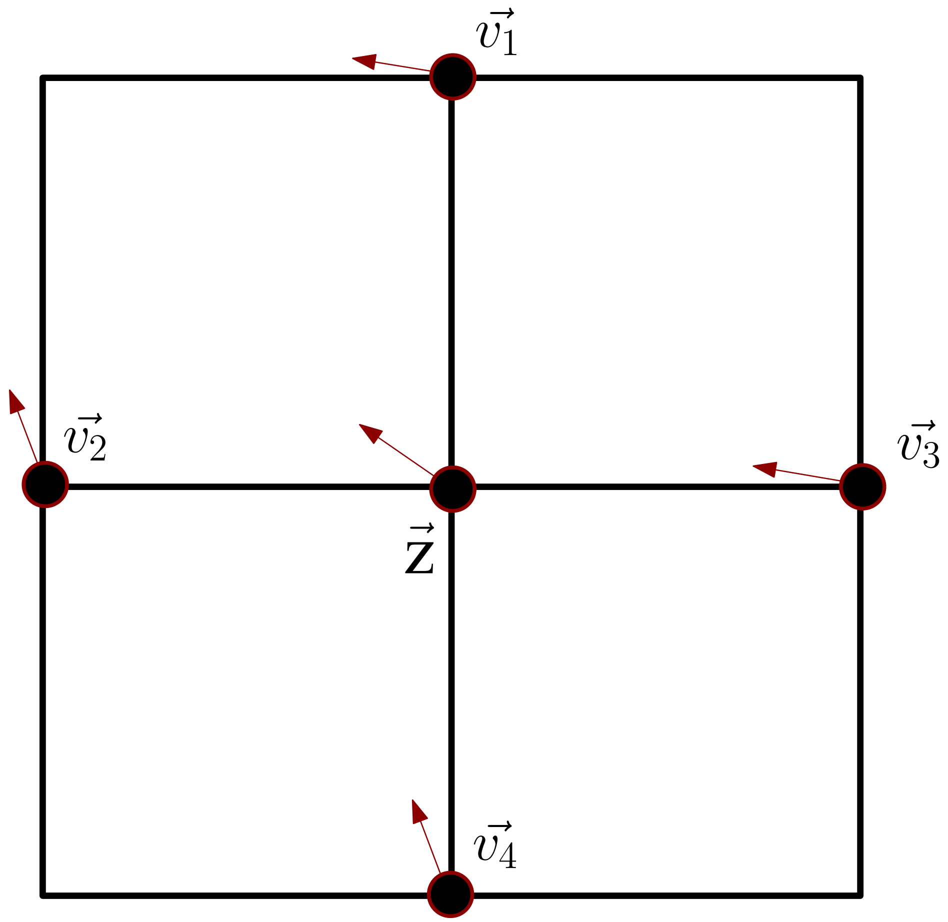
- Path constraint



$$\lambda_u \vec{u} + \lambda_v \vec{v} + \lambda_w \vec{w} = \vec{b}$$
$$\lambda_u + \lambda_v + \lambda_w = 1$$

Our Approach – Vector Field Computation

- Smoothing constraint



$$\vec{z} - \frac{1}{4}\vec{v_1} - \frac{1}{4}\vec{v_2} - \frac{1}{4}\vec{v_3} - \frac{1}{4}\vec{v_4} = 0$$

Our Approach – Vector Field Computation

- By now, we build an over-constrained linear system:

$$A\mathbf{x} = \mathbf{b}$$

$$\downarrow$$

$$\left[\frac{D}{S}\right]\mathbf{x} = \left[\frac{B}{0}\right]$$

Path constraint
($T * n^2$ matrix)

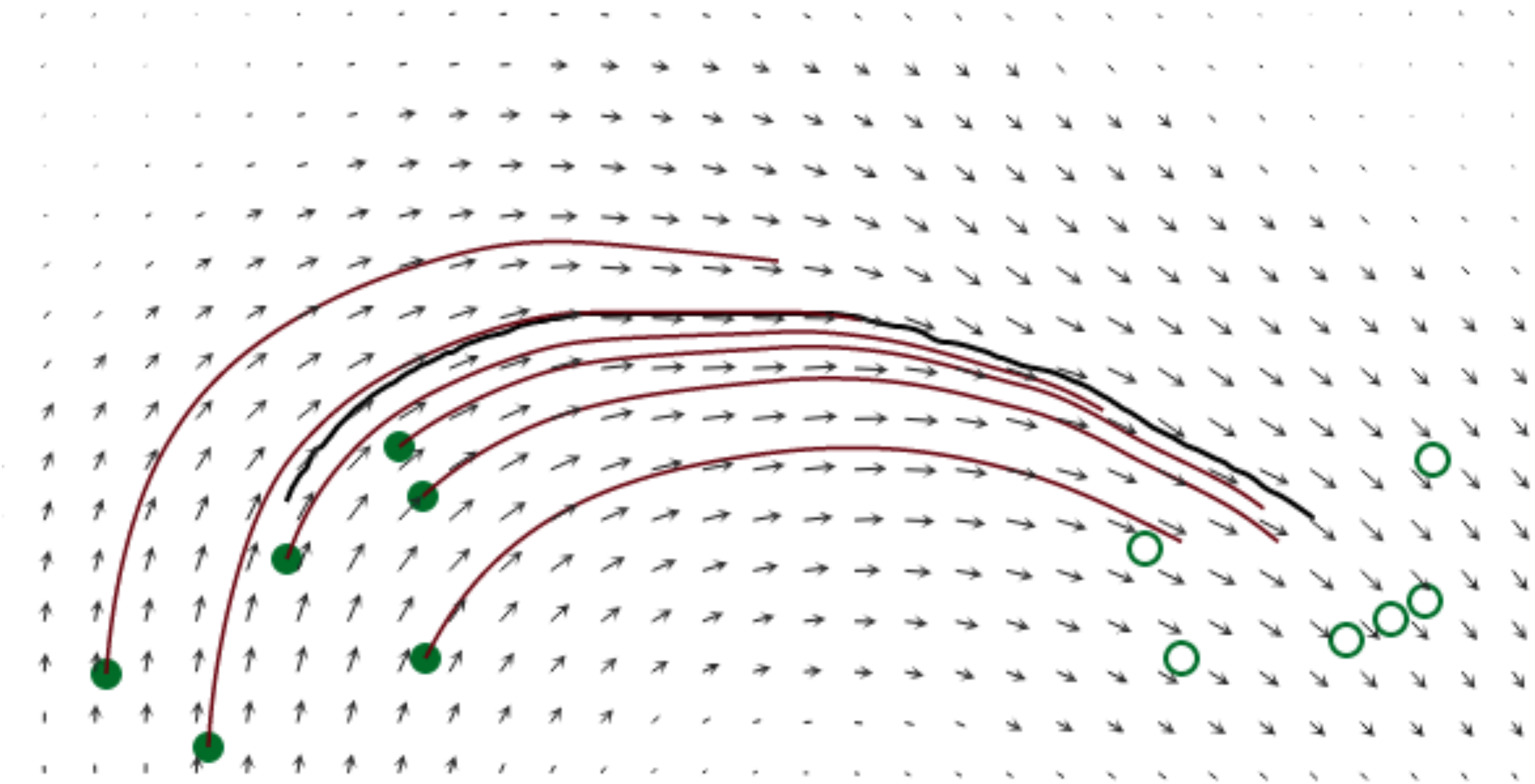
Smooth constraint
($n^2 * n^2$ matrix)

Grid corners defining VF
($n^2 * 2$ matrix)

Conjugate gradient method is used to solve this linear system

Our Approach – Point Advection

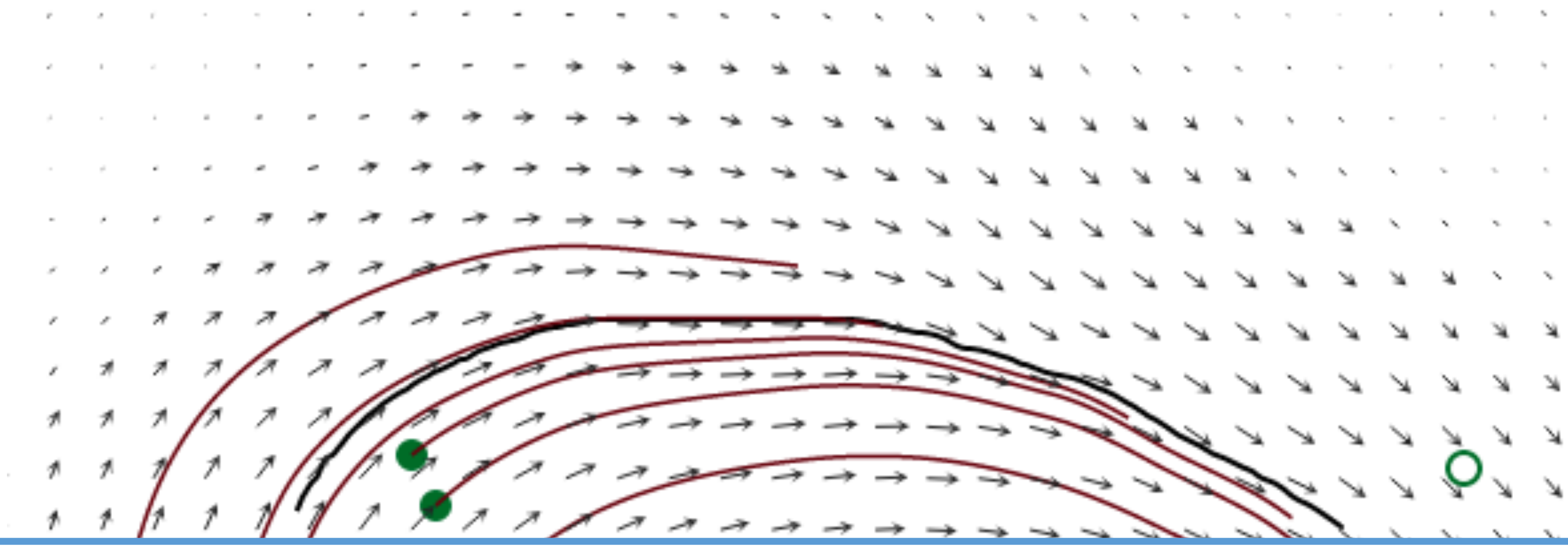
- Given the vector field, we treat the points of each cluster as particles in a flow and advect them



The standard 4^{th}-order Runge-Kutta method

Our Approach – Point Advection

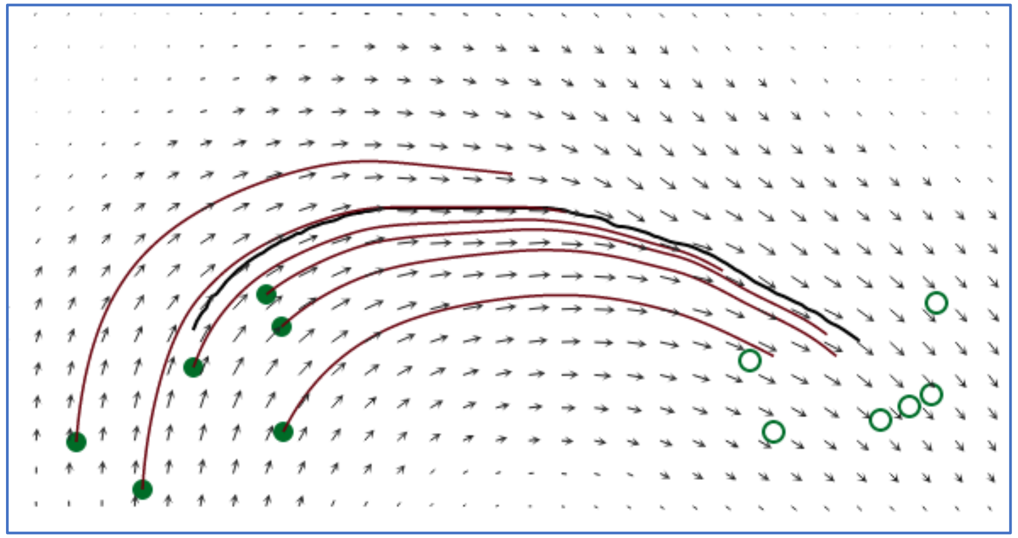
- Given the vector field, we treat the points of the group as particles in a low and advect them



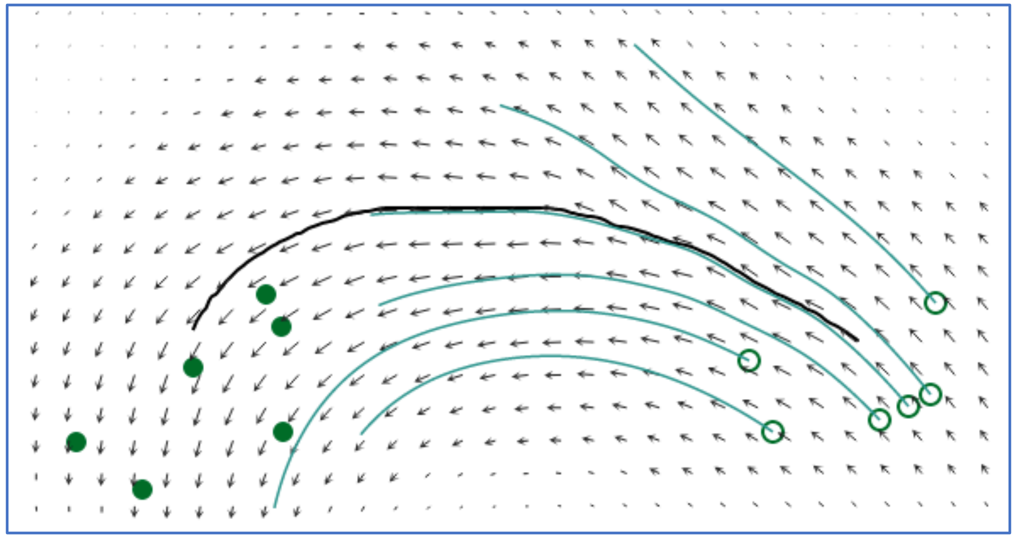
It DOES NOT guarantee each point will definitely reach their end positions!

Our Approach – Point Advection

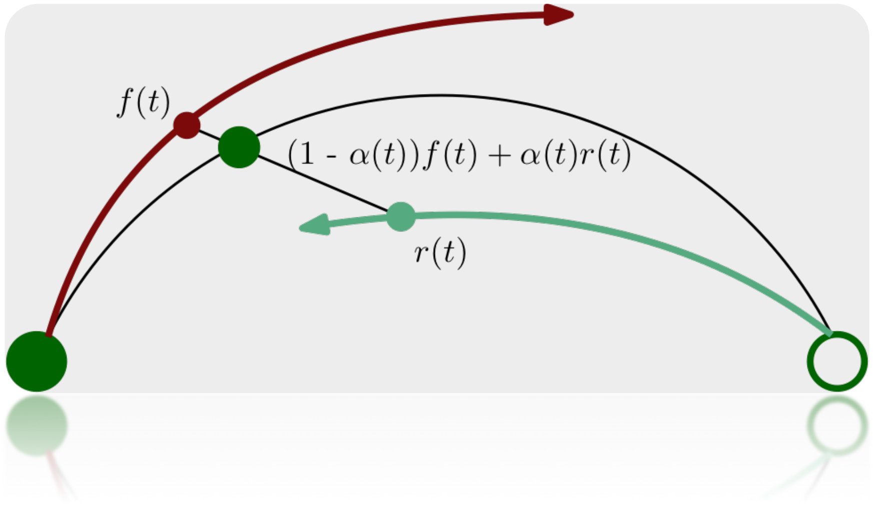
- Interpolation of forward and reverse advection

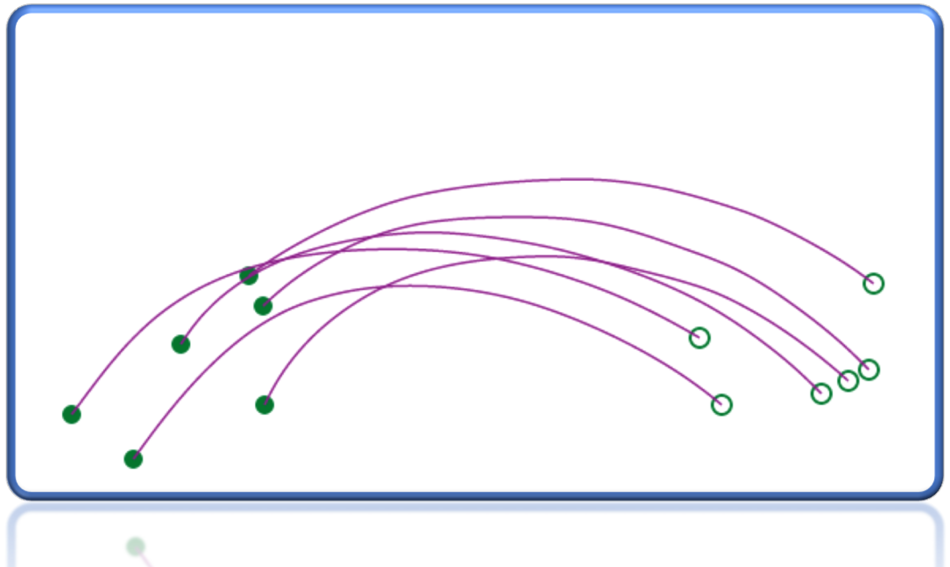


Forward Advection



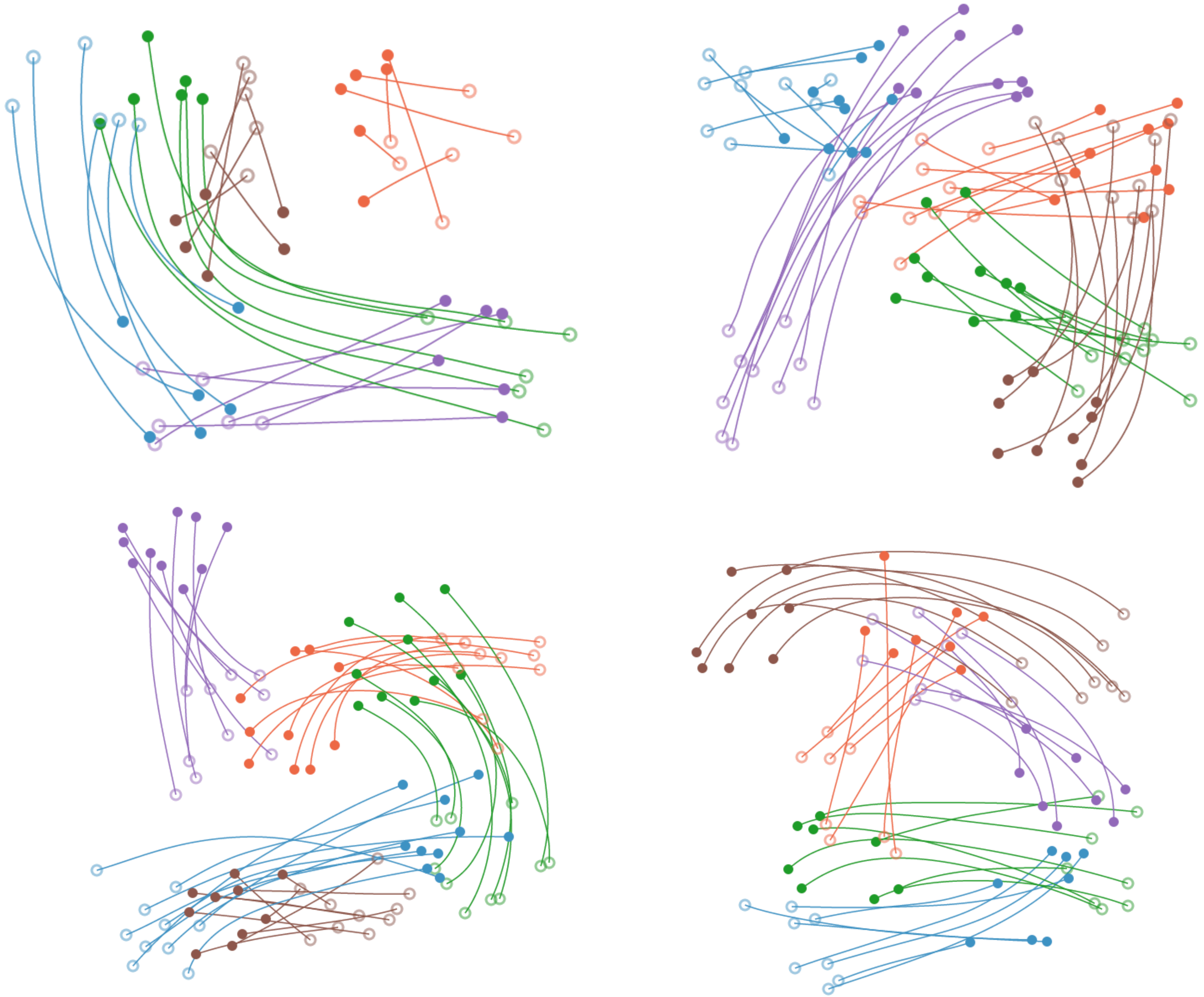
Reverse Advection



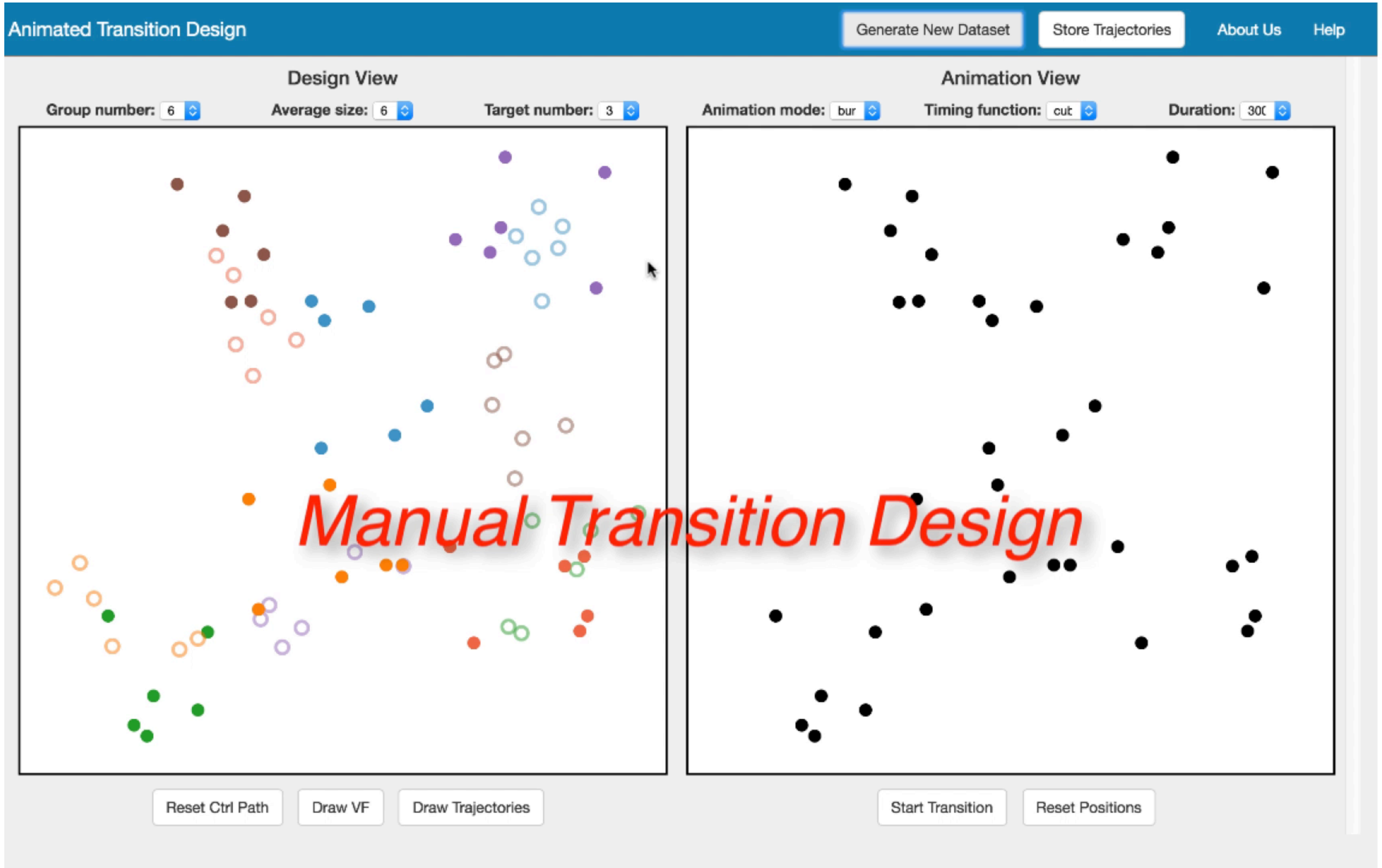


Final Trajectories

Trajectory Examples



Demo



Animated Transition Design
Generate New Dataset
Store Trajectories
About Us
Help
Design View
Group number: 6
Average size: 6
Target number: 3
Animation View
Animation mode: bur
Timing function: cut
Duration: 30(
Manual Transition Design
Reset Ctrl Path
Draw VF
Draw Trajectories
Start Transition
Reset Positions

Evaluation

Evaluation – Qualitative User Interview

- Purpose: evaluate the usability of manual transition design

- Ask 4 participants to do manual sketching for animated transition design and collect their feedback

- *Major feedback*

  - Participants enjoy the flexibility of designing transitions by themselves

  - More point clusters bring more difficulty for manual sketching

[3] Fan Du, Nan Cao, Jian Zhao and Yu-ru Lin . "Trajectory bundling for animated transitions." *CHI*, 2015.

Evaluation – Metric Evaluation

- Metrics
  - *Occlusion*
  - *Dispersion*
  - *Deformation*

- *Datasets*
  - 50 synthetic transitions
  - 20 real transitions

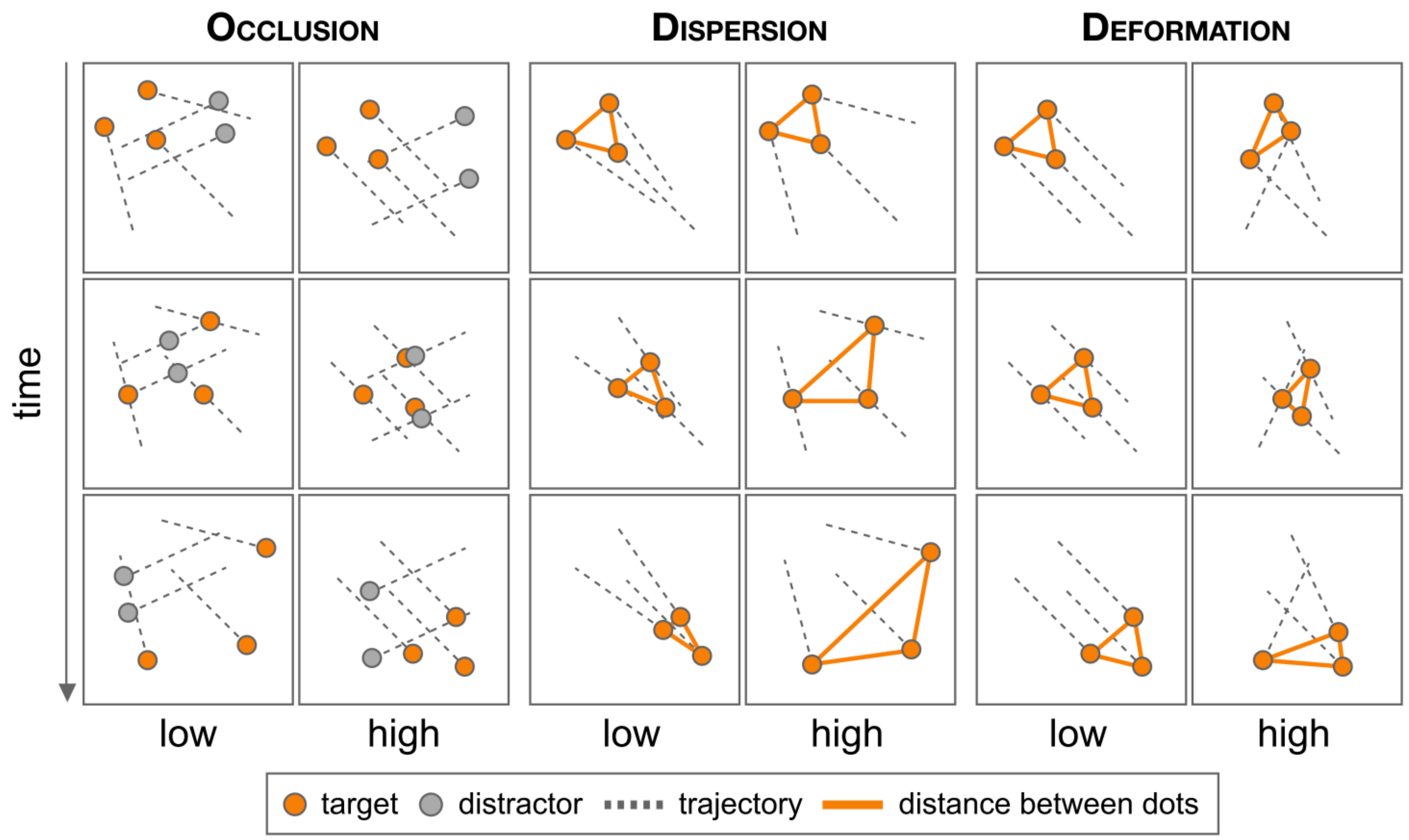


Illustration figure from Reference [3]

[3] Fan Du, Nan Cao, Jian Zhao and Yu-ru Lin . "Trajectory bundling for animated transitions." *CHI*, 2015.

Evaluation – Metric Evaluation

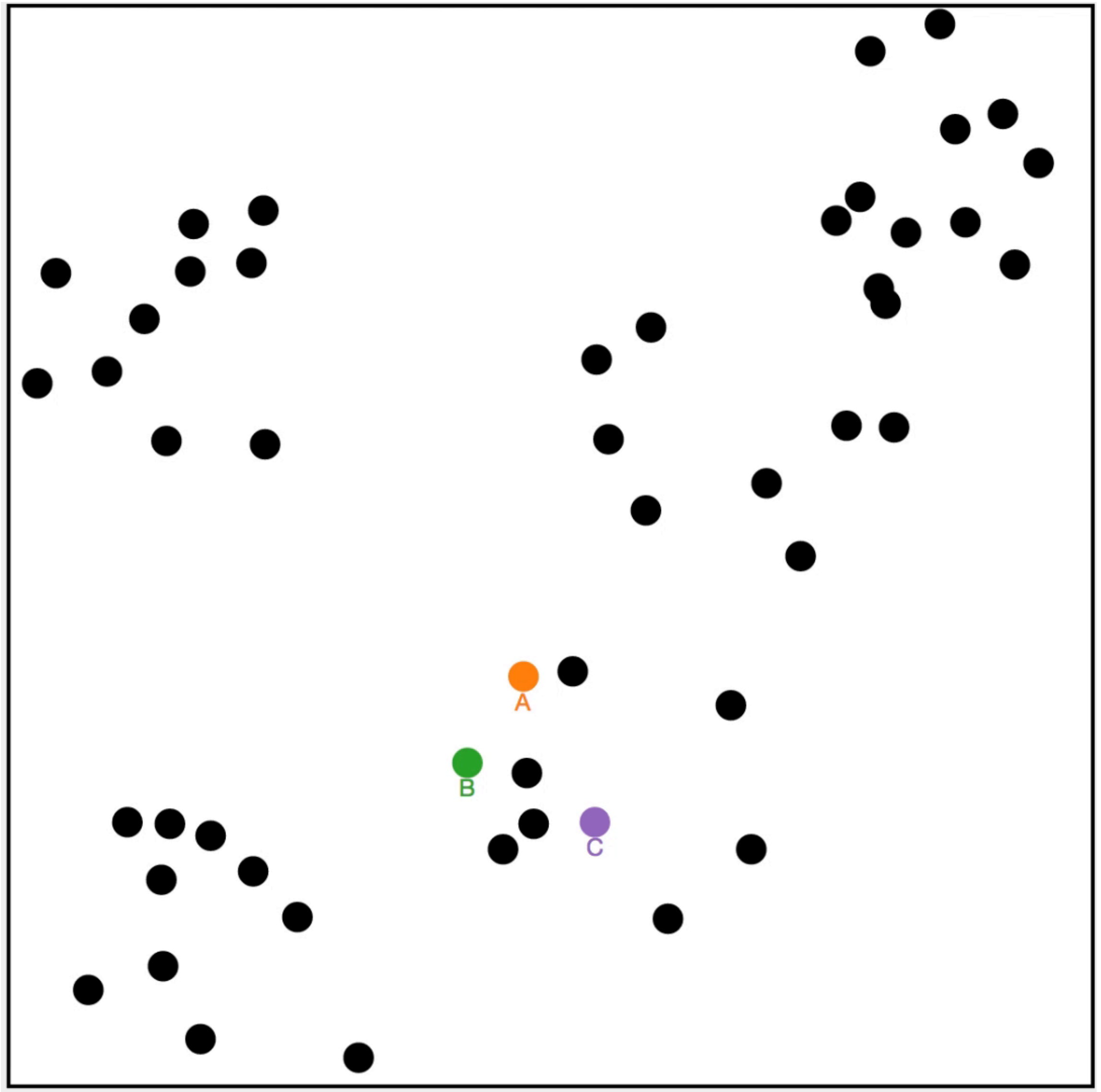
- Results

  - Our approach strikes a good balance in **reducing crowding** and **deformation** in animated transitions

    - *Compared with linear transition: lower outer occlusion*
    - *Compared with trajectory bundling: lower deformation*
    - *For more details, pls refer to our paper*

Evaluation – Formal User Study

- Tasks: ask 24 participants to track 2 or 3 targets in transitions of high outer occlusion



Evaluation – Formal User Study

- Tasks: ask 24 participants to track 2 or 3 targets in transitions of high outer occlusion

- Experiment setting:

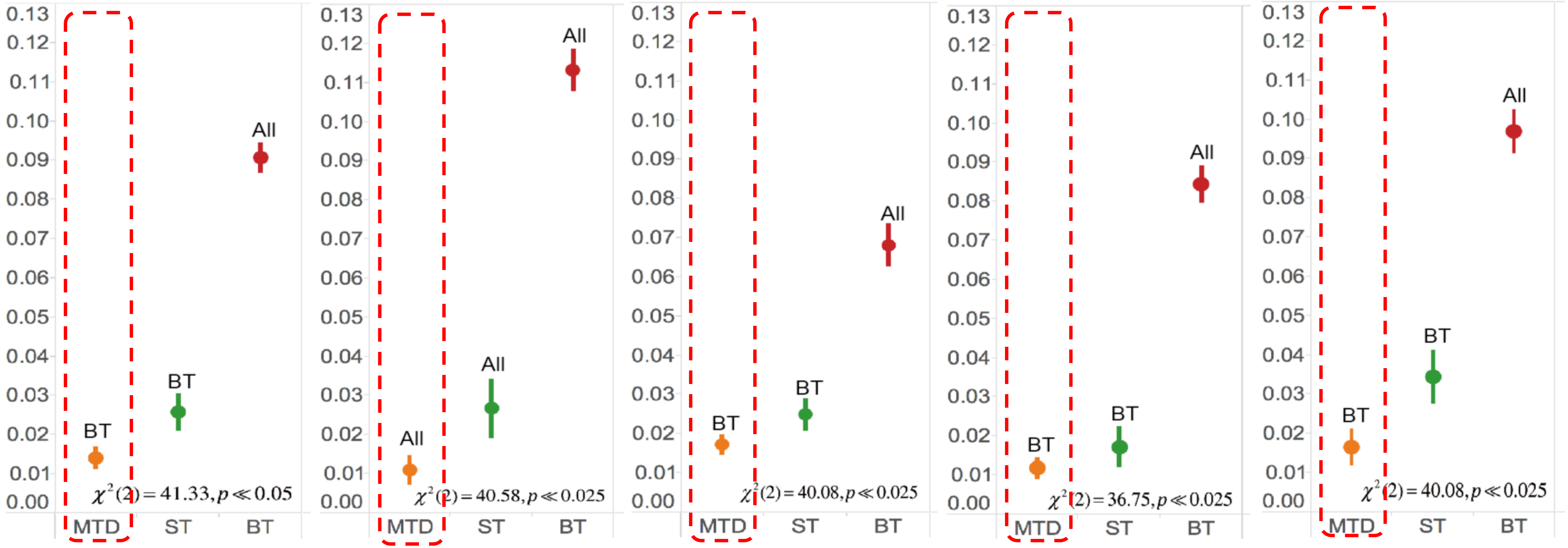
  - 3 techniques (ours, linear transition, trajectory bundling.)

  - 2 target number (high: 3, low: 2)

  - 2 group size (10 pts/group, 5 groups; 5 pts/group, 10 groups)

Evaluation – Formal User Study

- Results - accuracy
  - *Our approach has better accuracy (or less error)*



(a) Overall **(b)** Five groups **(c)** Ten groups **(d)** Two targets **(e)** Three targets

Distance between the entered and correct points

Summary and Discussion

- The proposed animated transition approach using vector field design:
  - Strike a good balance in lowering occlusion and deformation
  - Enhance coordinated motion and avoid crowding
  - Improve tracking accuracy in transitions of high occlusion

- Limitations
  - Scalability issues
  - Very curved trajectory may influence tracking accuracy

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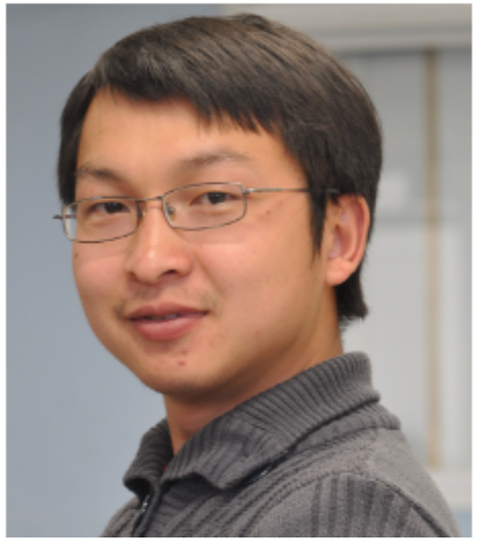


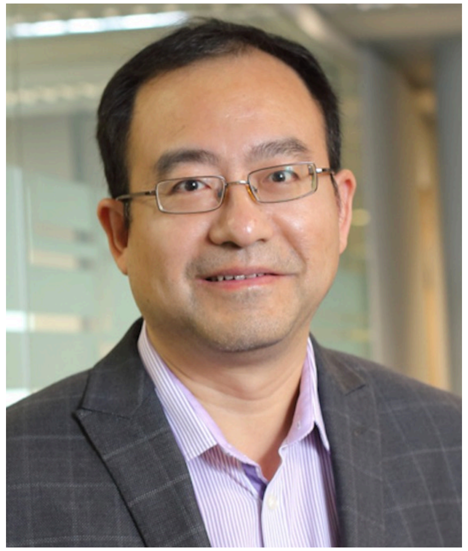

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http://home.cse.ust.hk/~ywangct/proj/vf_animation.html