IDC HERZLIYA

Photo Sequencing

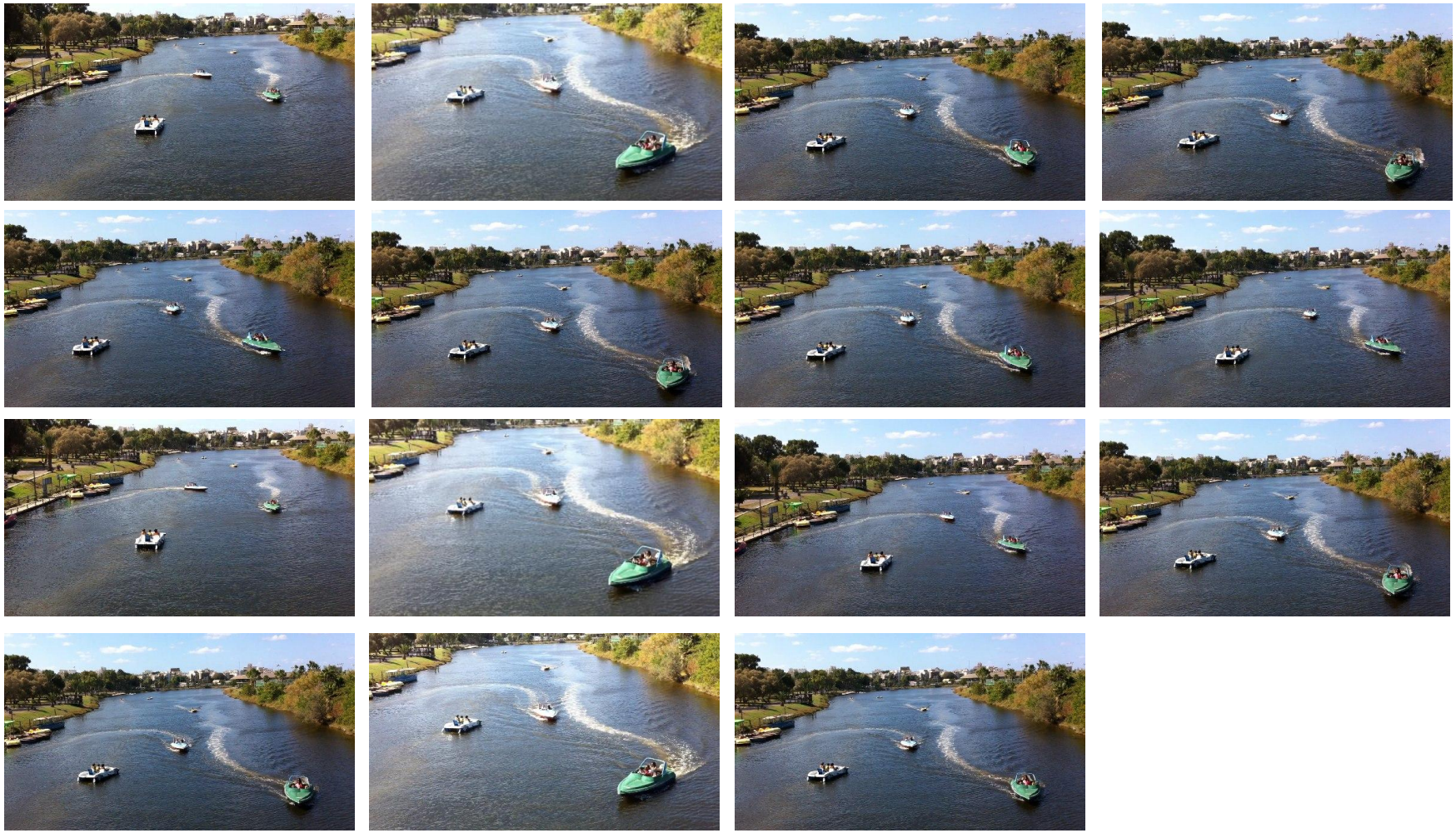
Tali Basha Yael Moses Shai Avidan

ECCV2012

Tel Aviv

The Input

N images taken from different locations at different time steps



Random Order

Our Result

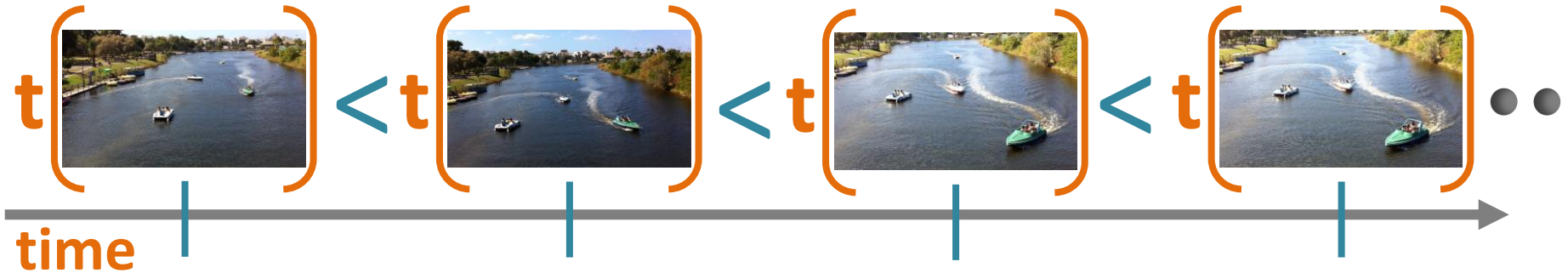
But Who Cares?

- Capturing the highlights of a dynamic event
- Analyzing/Visualizing the dynamic content using still images

Photo Sequencing

Problem definition:

Given *N* still images, determine their temporal order:



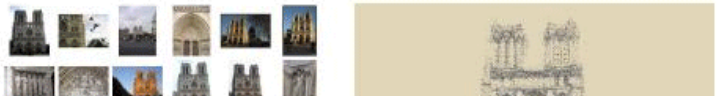
N! possible permutations…

$15! \sim 10^{12}$

Photo Sequencing is Not …

Video Synchronization

Photo Tourism



Static

4D City Reconstruction

years

Inferring Temporal Order of Images From 3D Structure,
Schindler at al., CVPR 2007

Assumptions

Short time interval

Two images taken roughly from the same position

Static & Dynamic Features

Detect features & match to the reference

Static Features

Epipolar Geometry

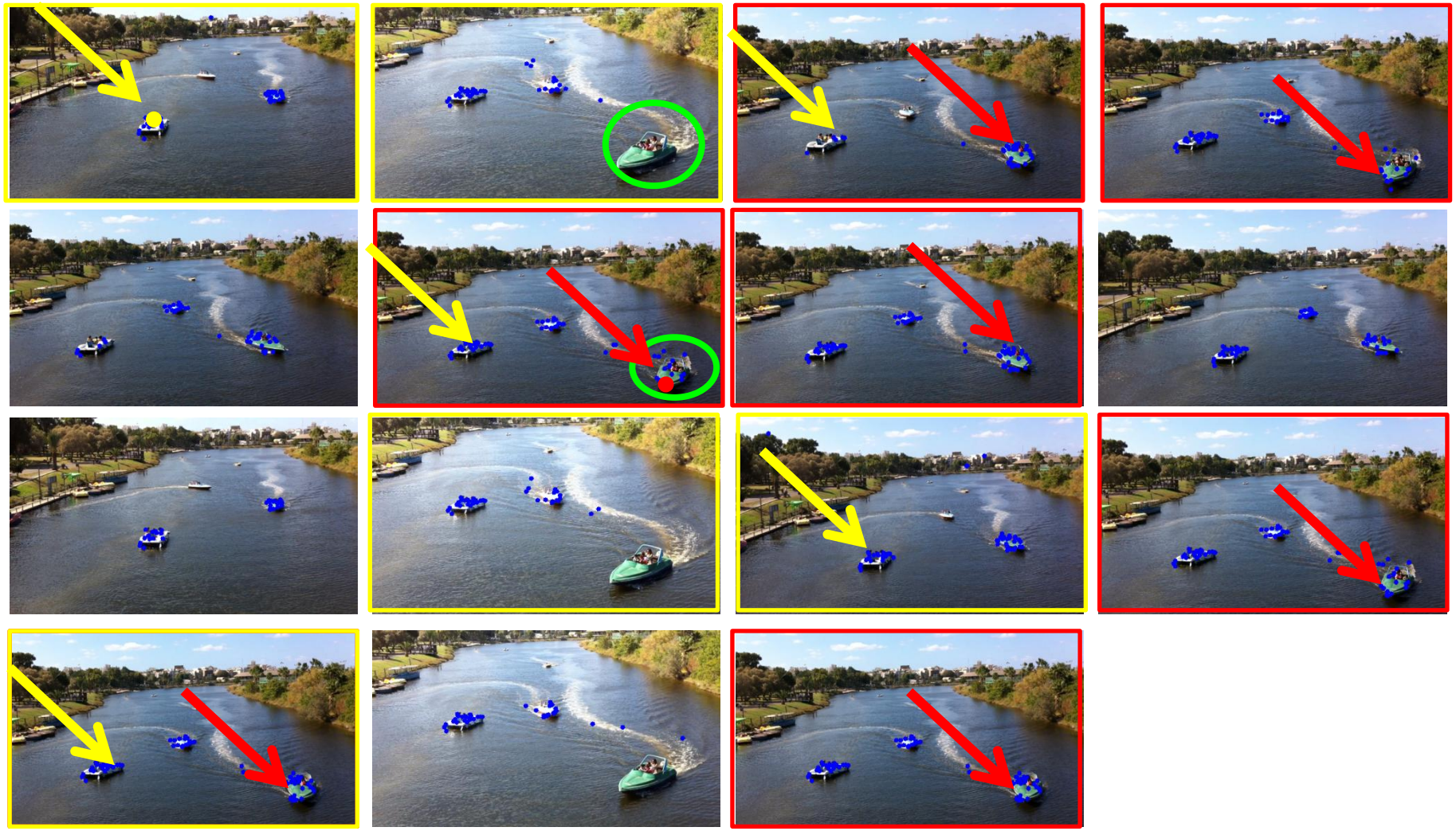
Fundamental matrices w.r.t. the reference image

Dynamic Features

Temporal Order

Provide the temporal information

Dynamic Features

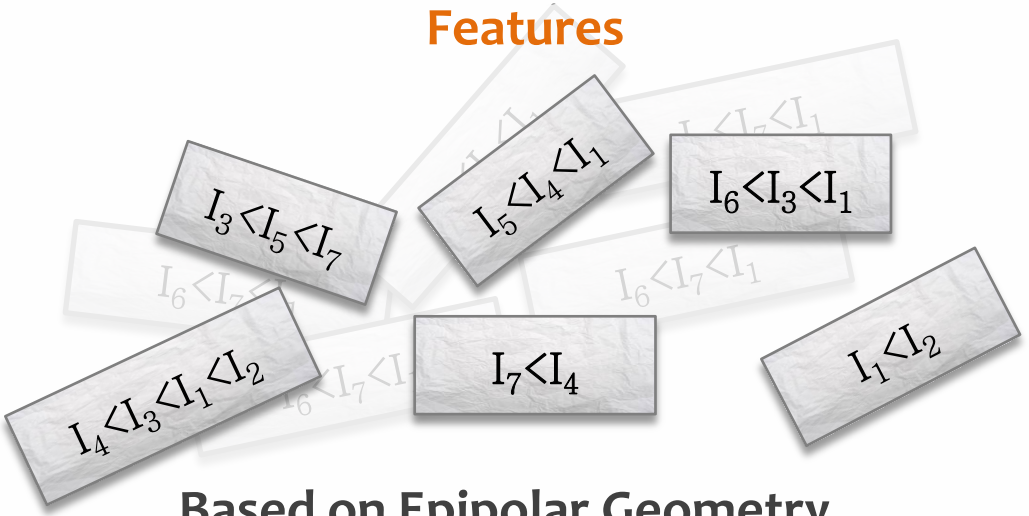


Algorithm Outline

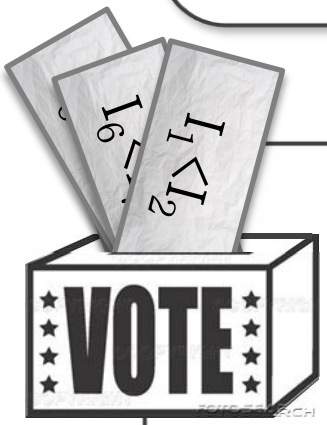
Dynamic Features

Detect & Match w.r.t the reference

Partial Order from a Corresponding Dynamic Features



Based on Epipolar Geometry



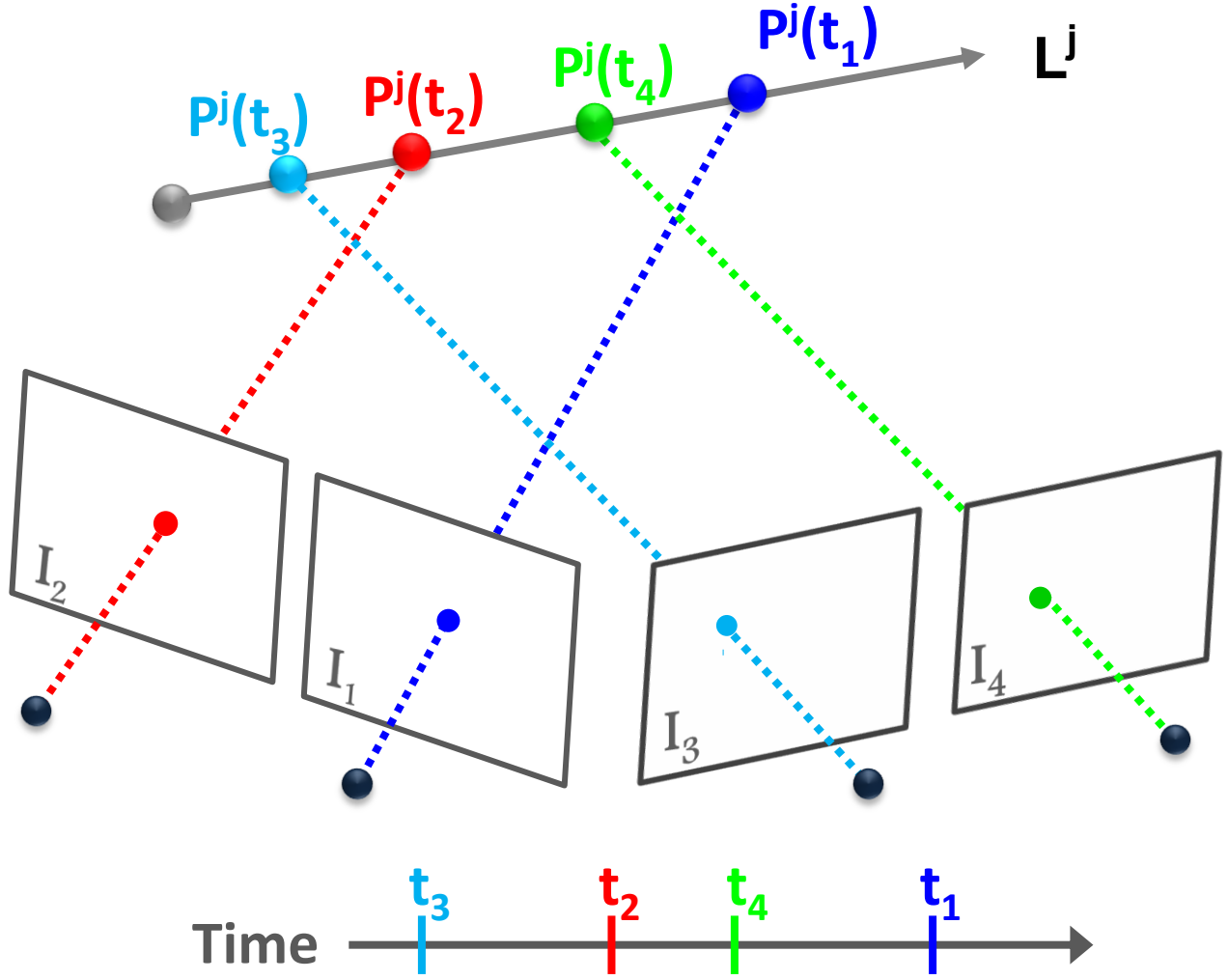
Aggregate Partial Orders

$I_3 < I_5 < I_7 < I_4 < I_1 < I_2$

Rank Aggregation Solution

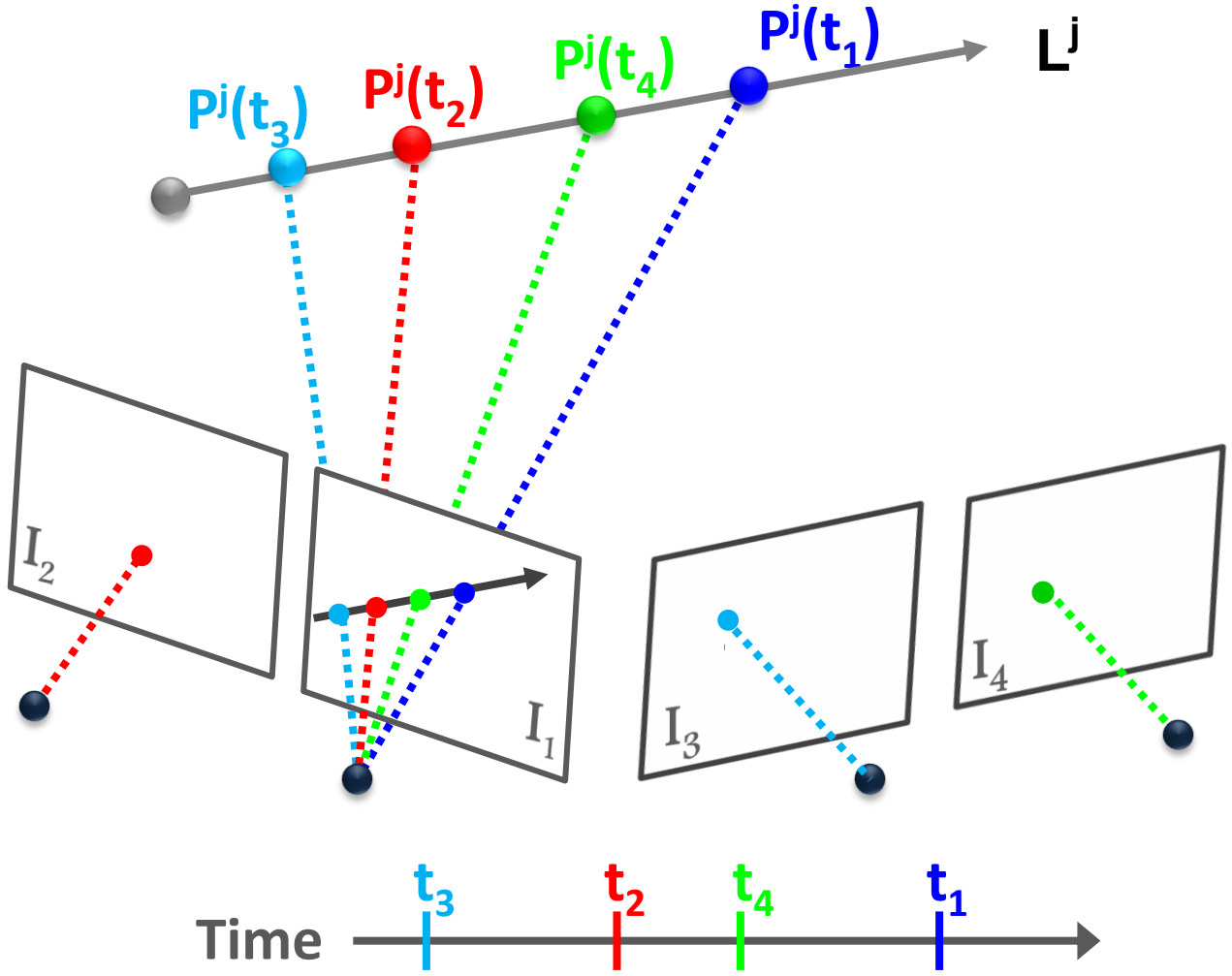
Order from a Single Feature Set

Spatial order in 3D → Temporal order



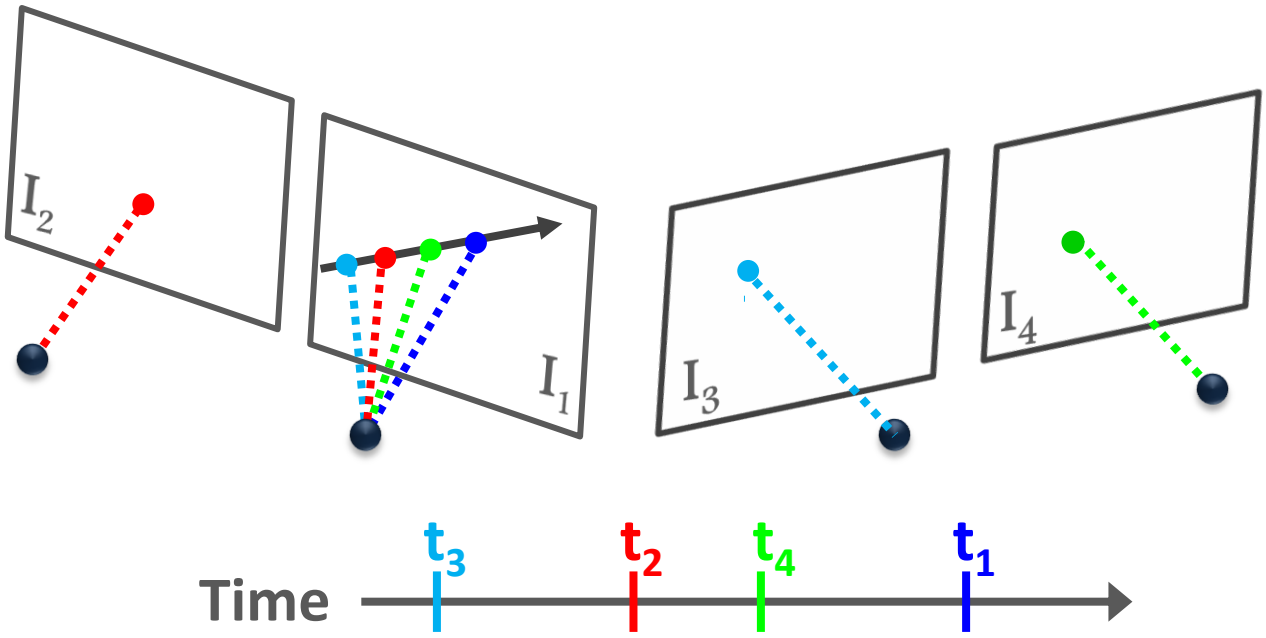
Order from a Single Feature Set

Spatial order in 2D ➔ Temporal order

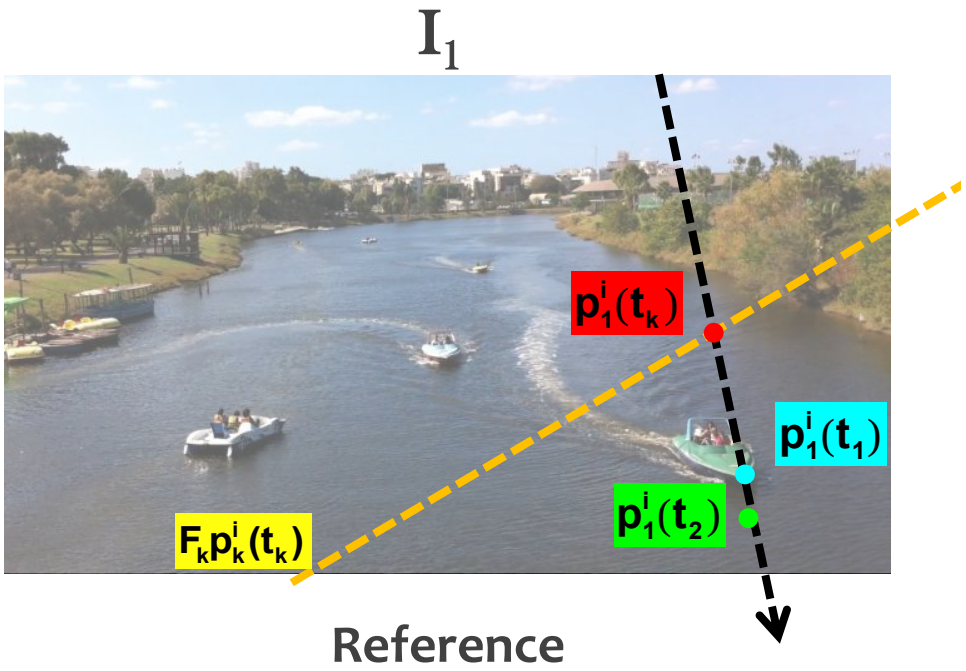


Order from a Single Feature Set

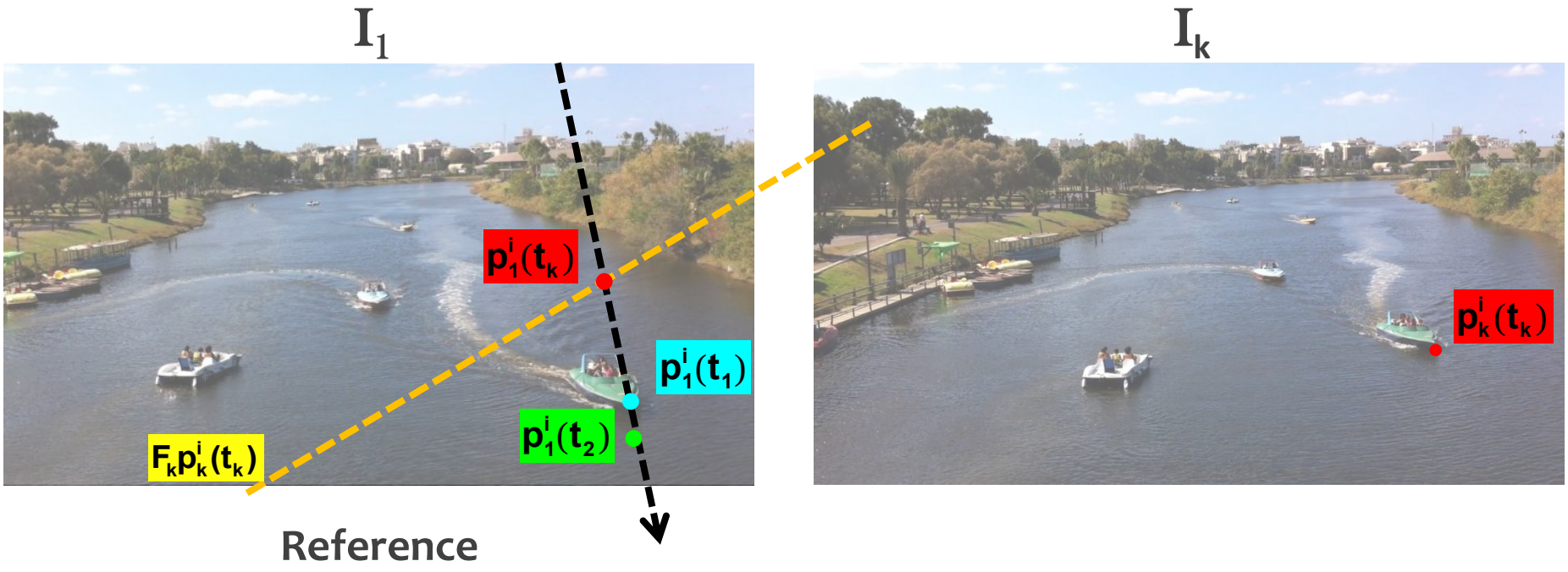
Map all features to the reference image



Mapping to The Reference



Mapping to The Reference



Mapping to The Reference

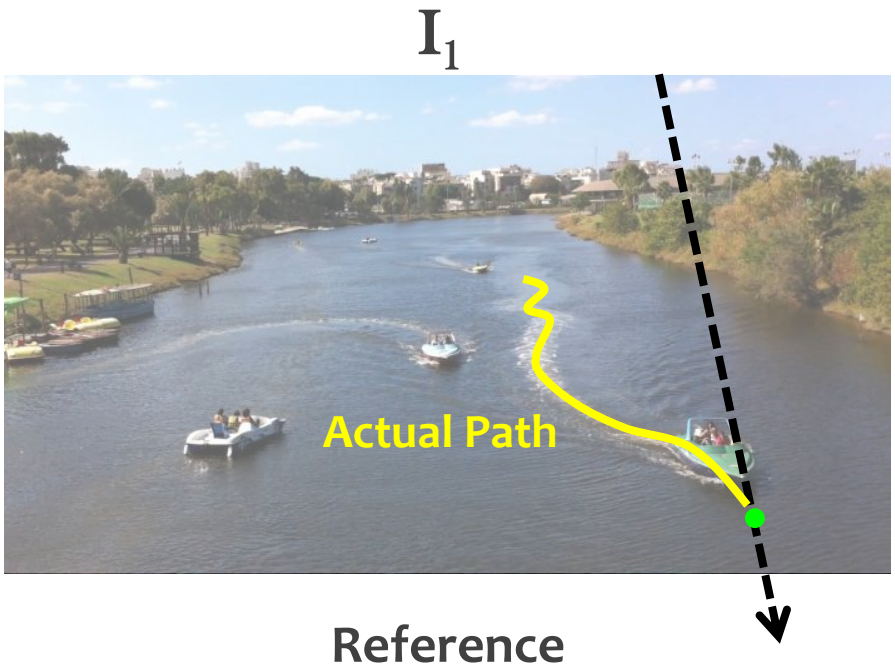
I_1

Reference

I_k

$$I_5 < I_4 < I_3 < I_1 < I_2$$

Mapping to The Reference

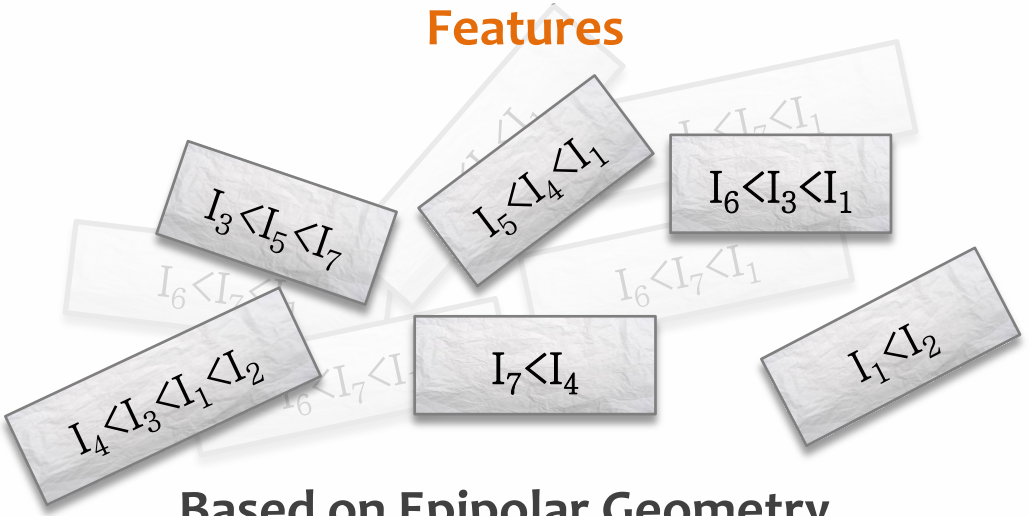


Algorithm Outline

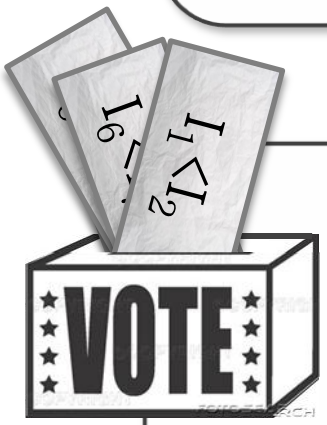
Dynamic Features

Detect & Match w.r.t the reference

Partial Order from a Corresponding Dynamic Features



Based on Epipolar Geometry

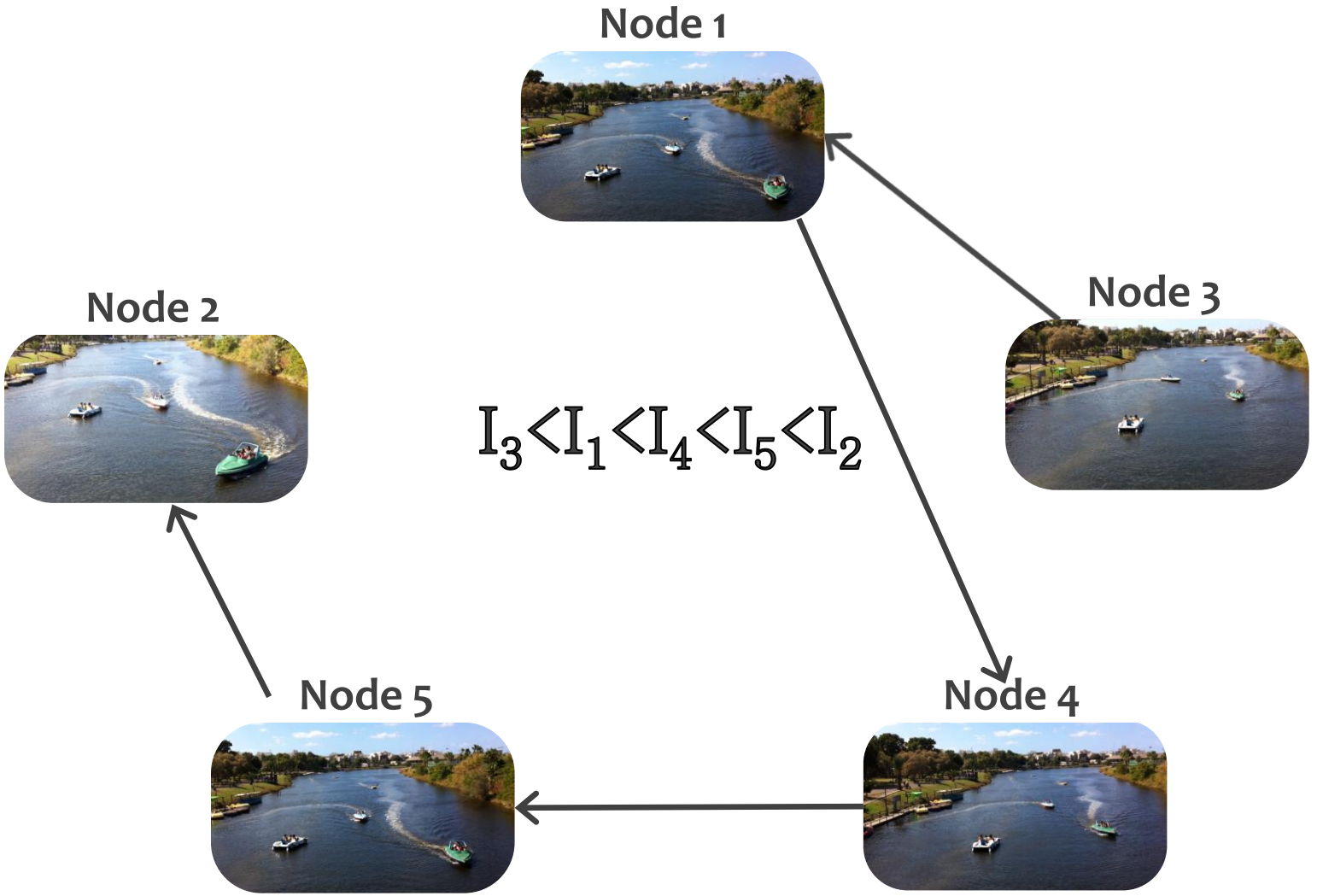


Aggregate Partial Orders

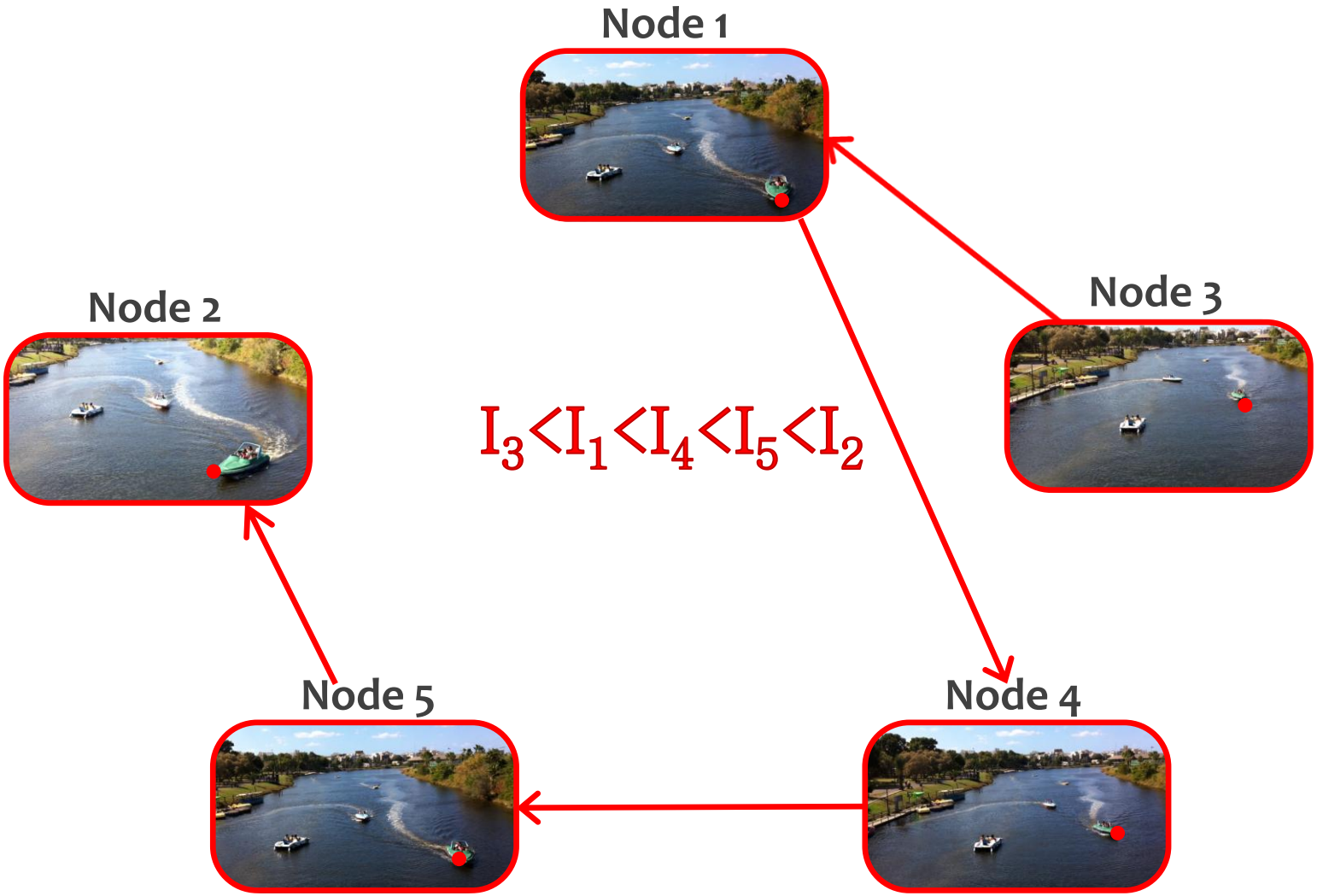
$I_3 < I_5 < I_7 < I_4 < I_1 < I_2$

Rank Aggregation Solution

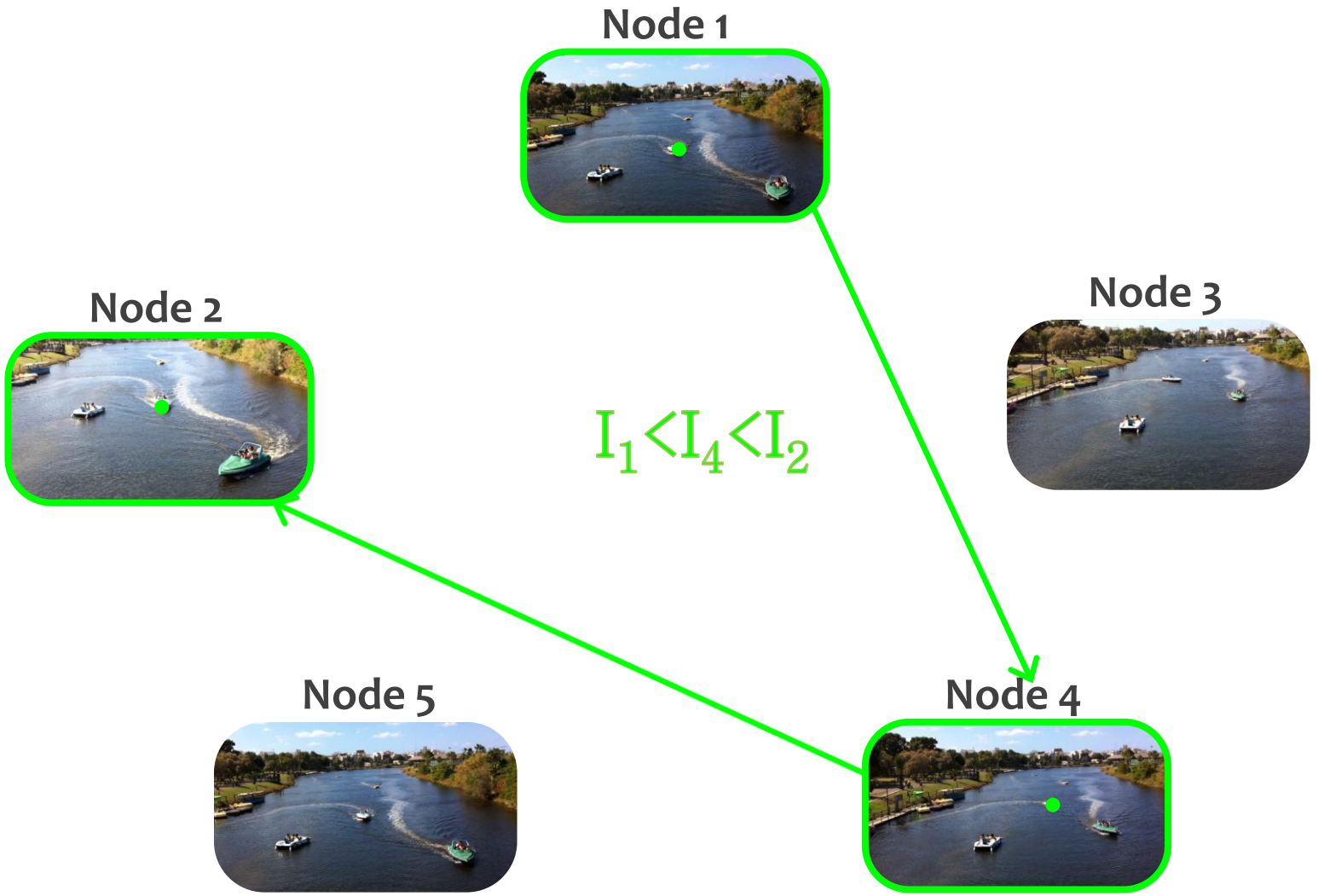
Order Representation



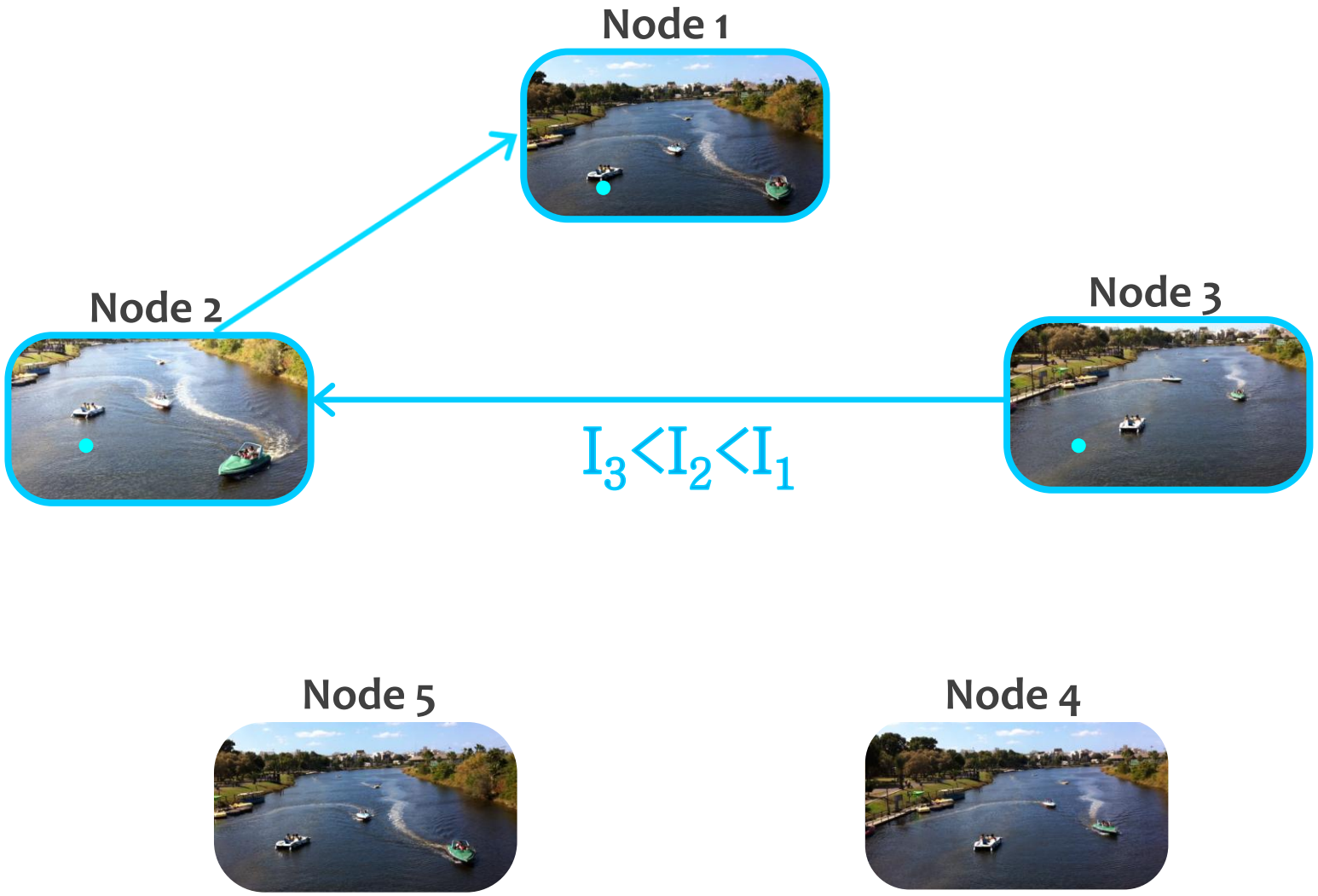
Order Representation



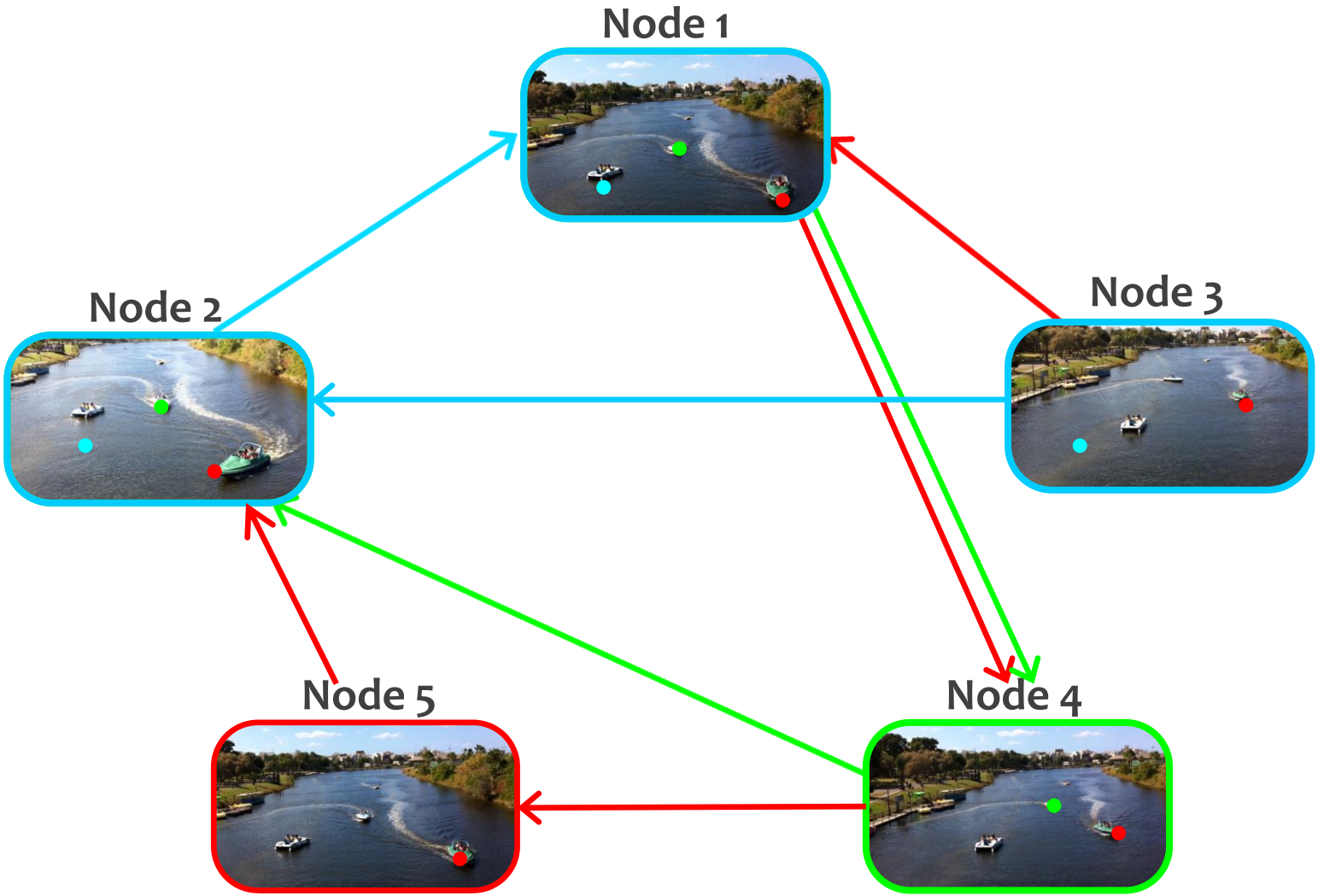
Order Representation



Order Representation

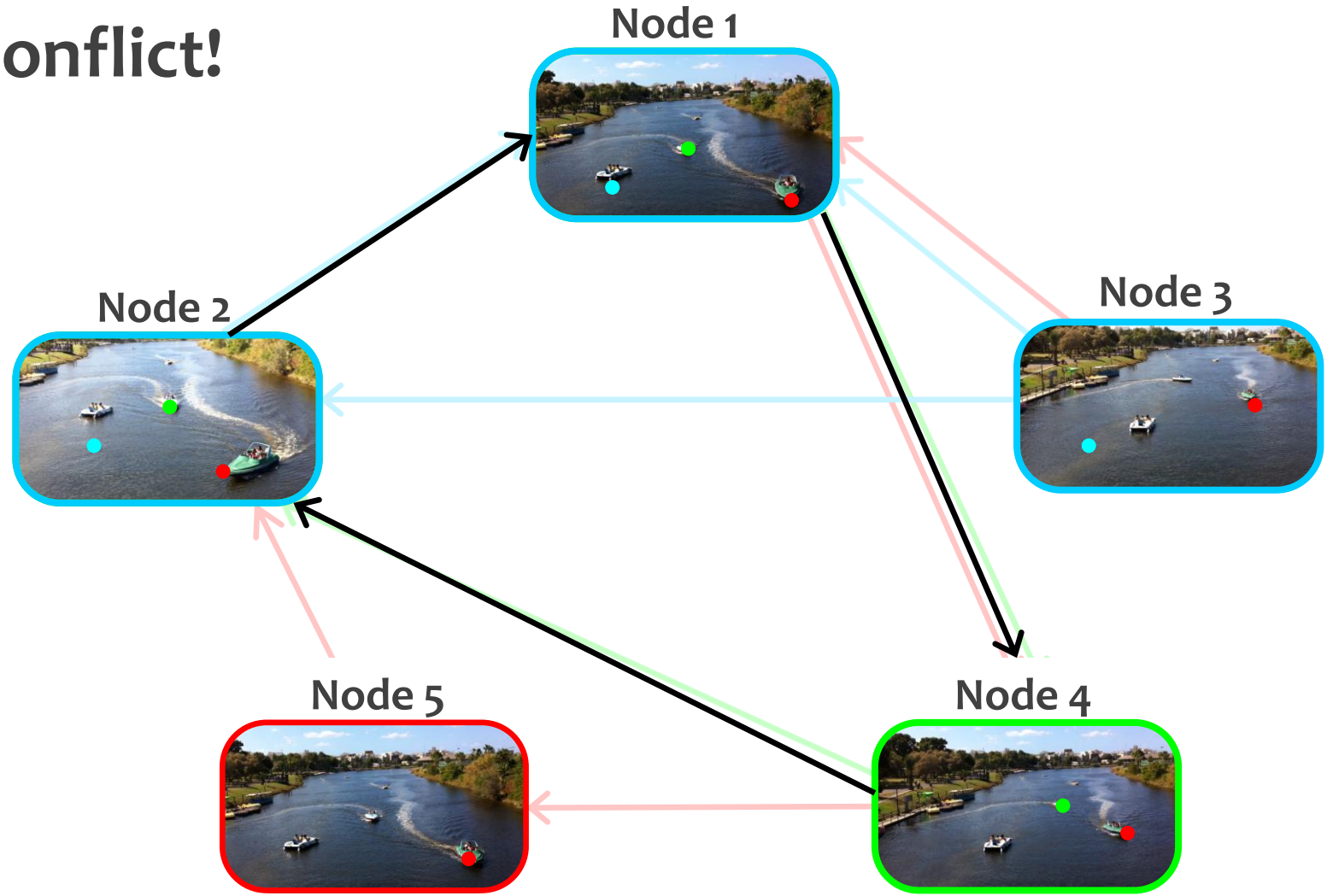


Order Representation



Order Representation

Conflict!

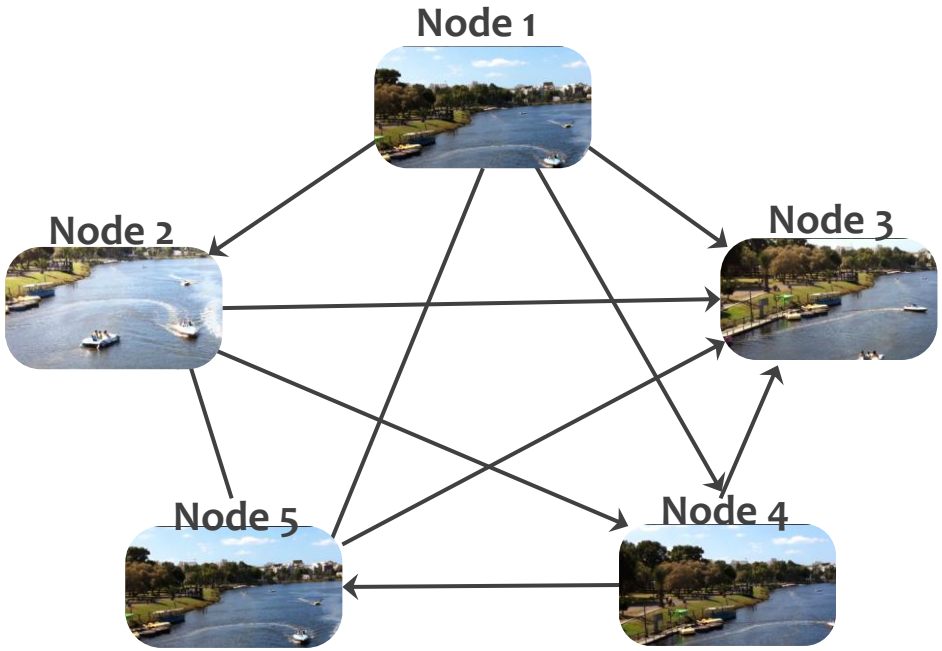


Rank Aggregation

Input: Possibly conflicting partial orders, $\{\sigma_i\}$

Goal: Compute a "consensus" full order , σ:

$$\sigma^* = \underset{\sigma}{\operatorname{argmin}} \sum_{i}^{N_D} K(\sigma, \sigma_i)$$



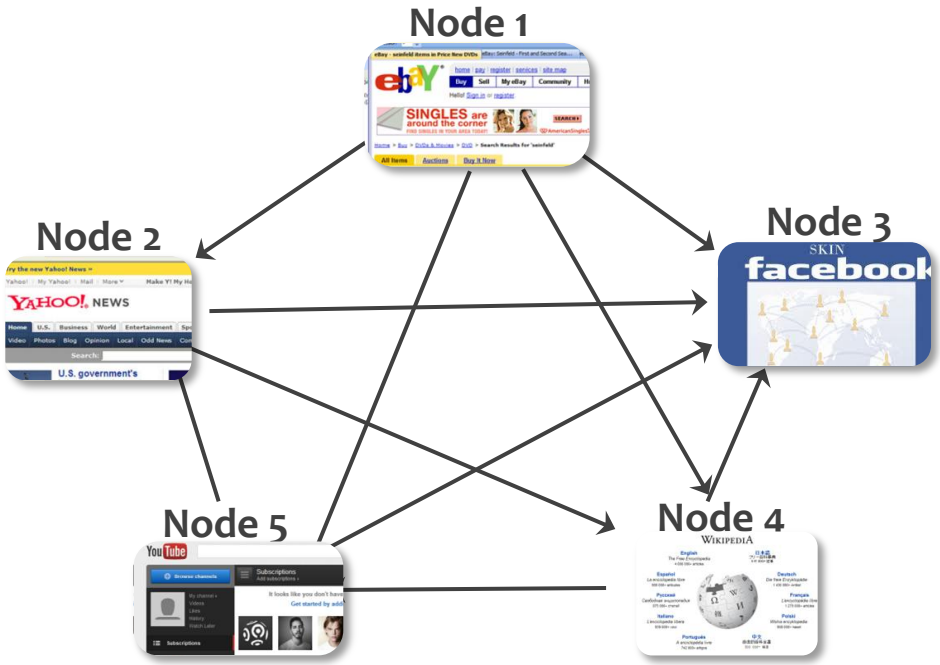
Rank Aggregation

Rank Aggregation Methods for The Web, Dwork et al. 2001

Markov Chain Approximation

$$\sigma^* = \underset{\sigma}{\operatorname{argmin}} \sum_{i}^{N_D} K(\sigma, \sigma_i)$$

Web Applications



Web Rank	Domain
1	google.com
2	youtube.com
3	facebook.com
4	yahoo.com
5	wikipedia.org
6	twitter.com
7	msn.com
8	live.com
9	blogspot.com
10	amazon.com

Markov Chain

$$W(i,j) = Pr\{t(I_i) < t(I_j)\}$$

State 1

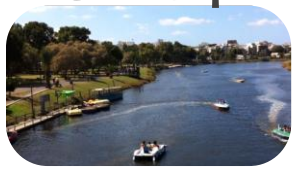
State 2

W(i,j)

State 3

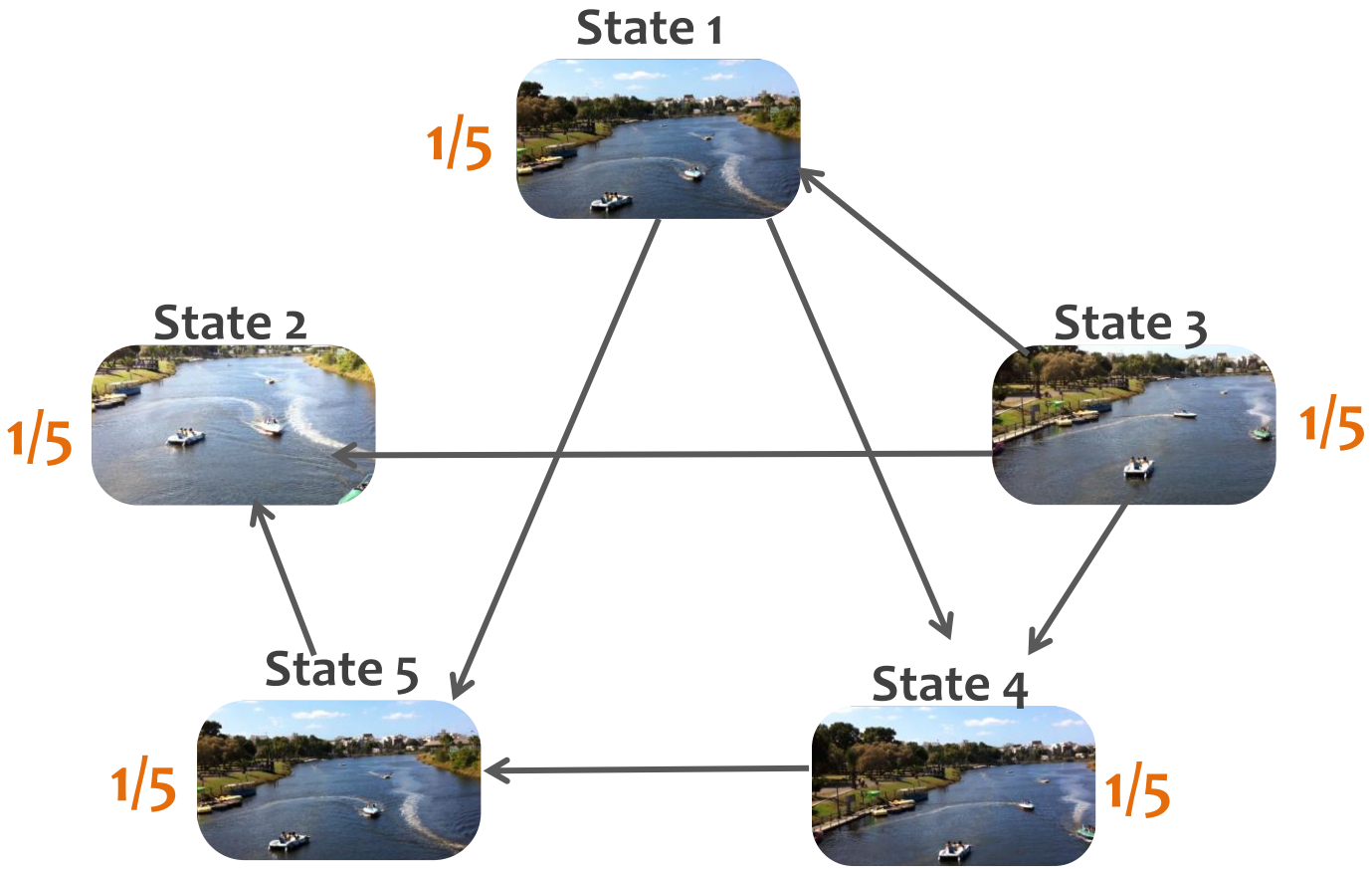
State 5

State 4



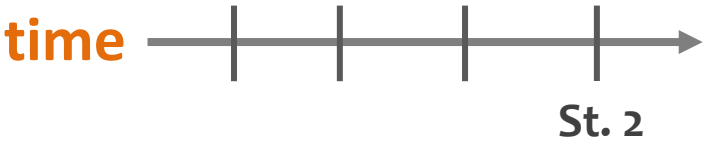
Markov Chain – Initial State

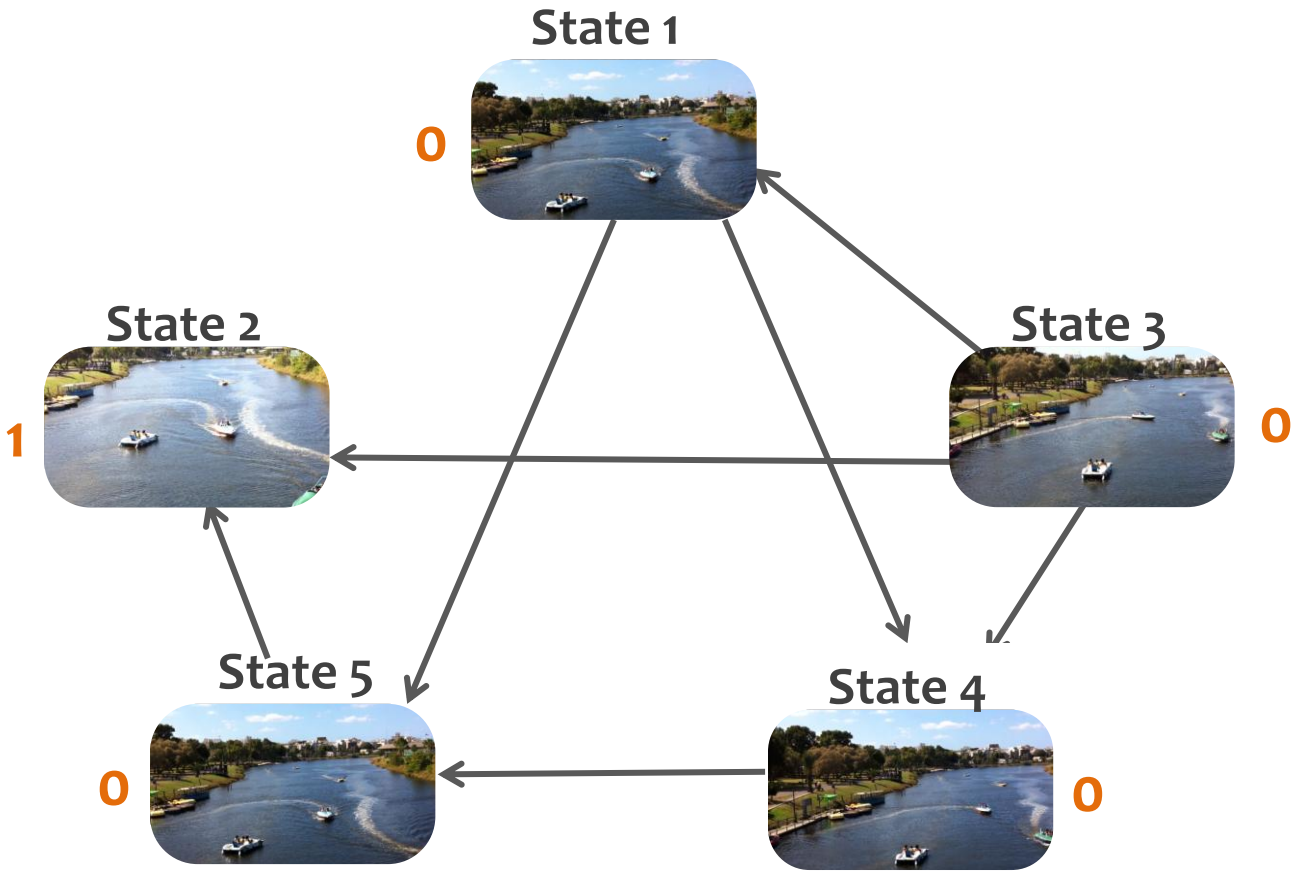
Random walk: start from a uniform distribution



Markov Chain – Steady State

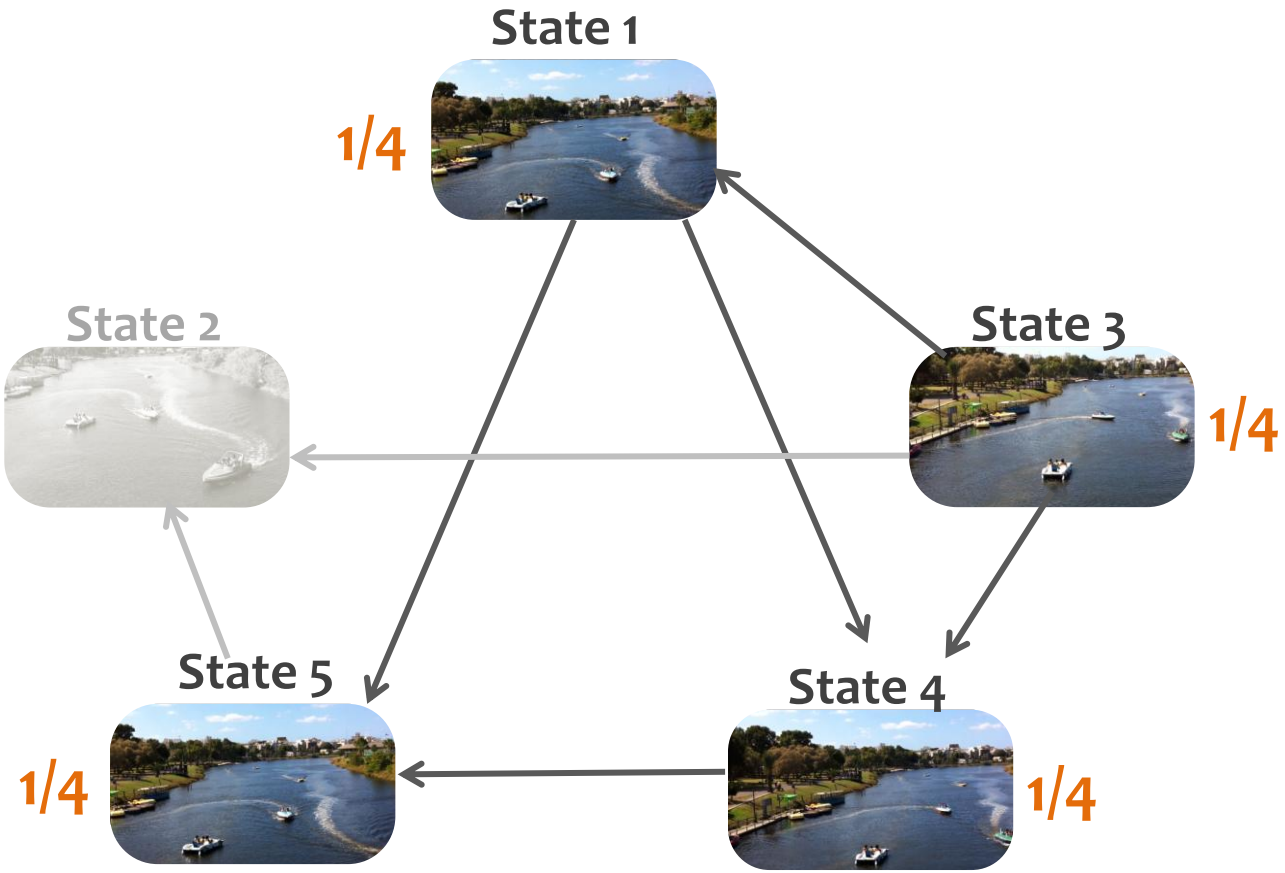
Ends at the sink





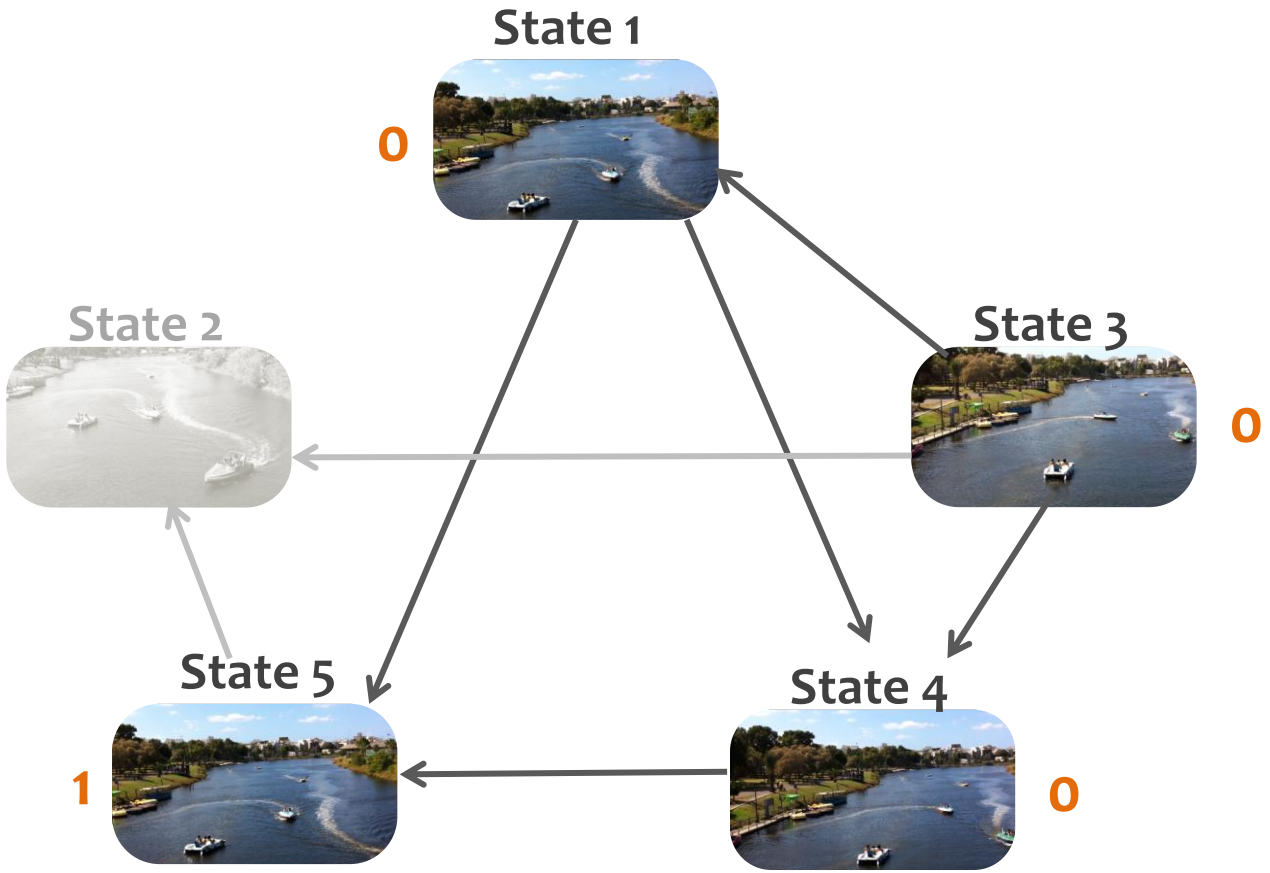
Markov Chain – Initial State

Remove the sink & repeat



Markov Chain – Steady State

Ends at the sink



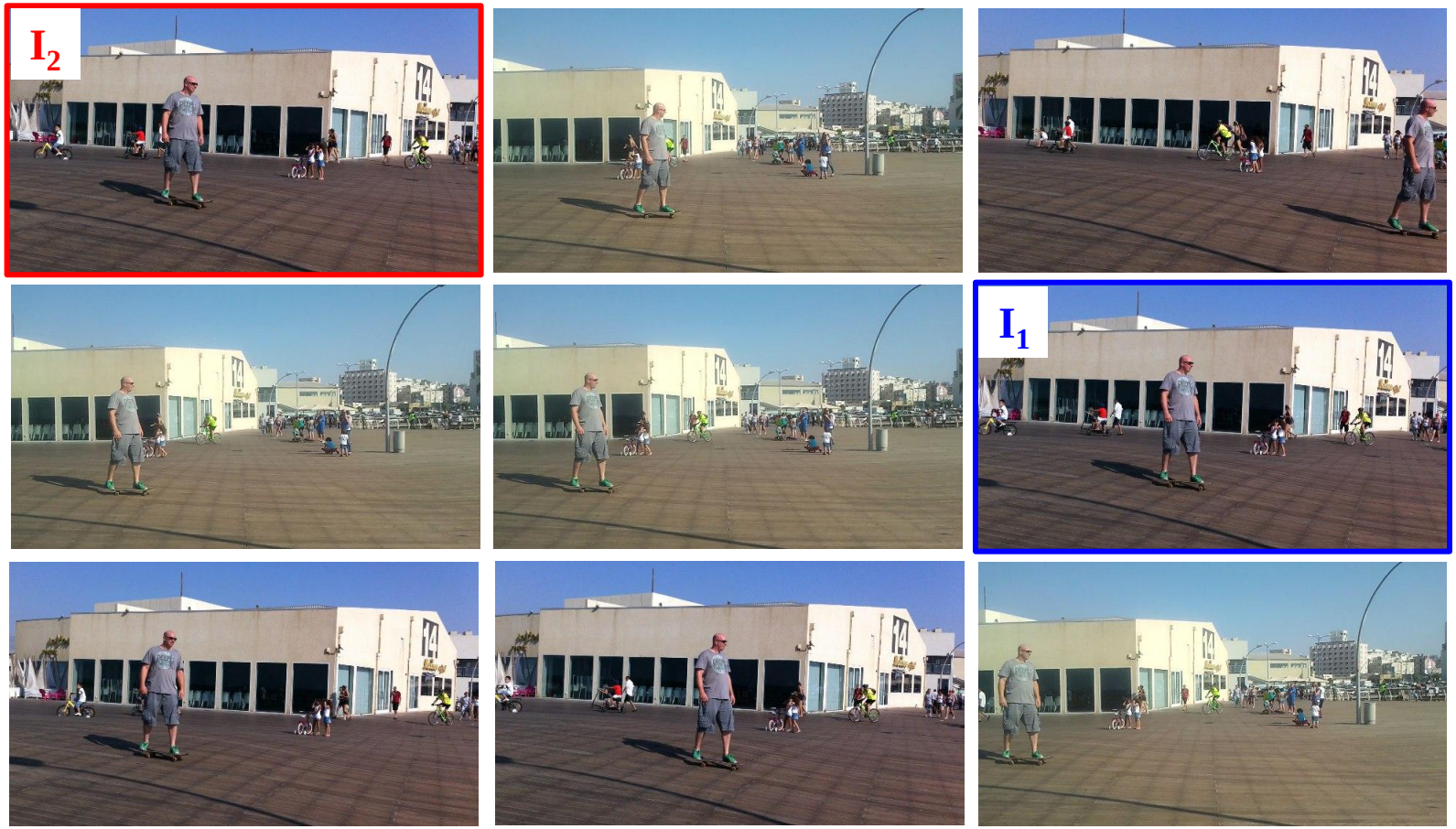
Results

Skateboard - Input

9 still images

Note the different viewpoints and camera parameters

Skateboard - Input



Skateboard - Input

Here are the input images in a random order:

Skateboard - Results

The aligned images ordered by our method

1st Image

The man is skating from left to right

Skateboard - Results

The aligned images ordered by our method

Skateboard - Results

The aligned images ordered by our method

Skateboard - Results

The aligned images ordered by our method

Skateboard - Results

The aligned images ordered by our method

Skateboard - Results

Skateboard - Results

Skateboard - Results

Skateboard - Results

Slide - Input

Slide - Results

The aligned images ordered by our method

Slide - Results

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The aligned images ordered by our method

Slide - Results

The aligned images ordered by our method

Slide - Results

The aligned images ordered by our method

More Results - Beach








More Results - Beach






Beach Results

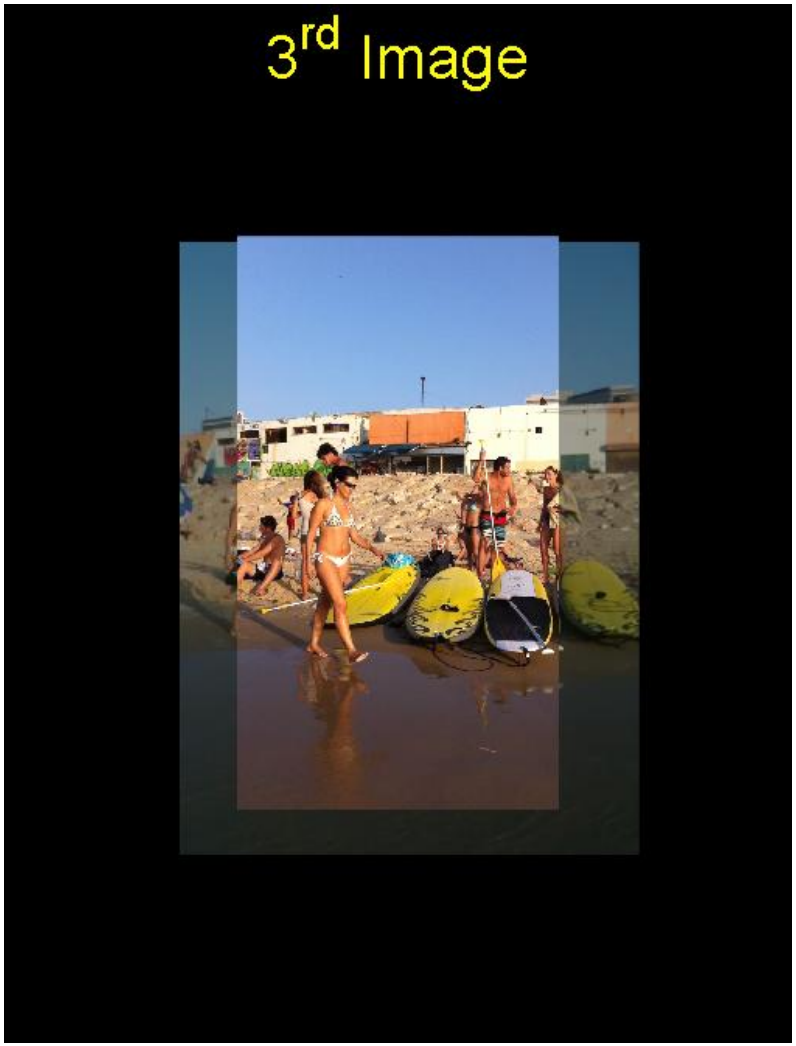
The aligned images ordered by our method

Beach Results

The aligned images ordered by our method

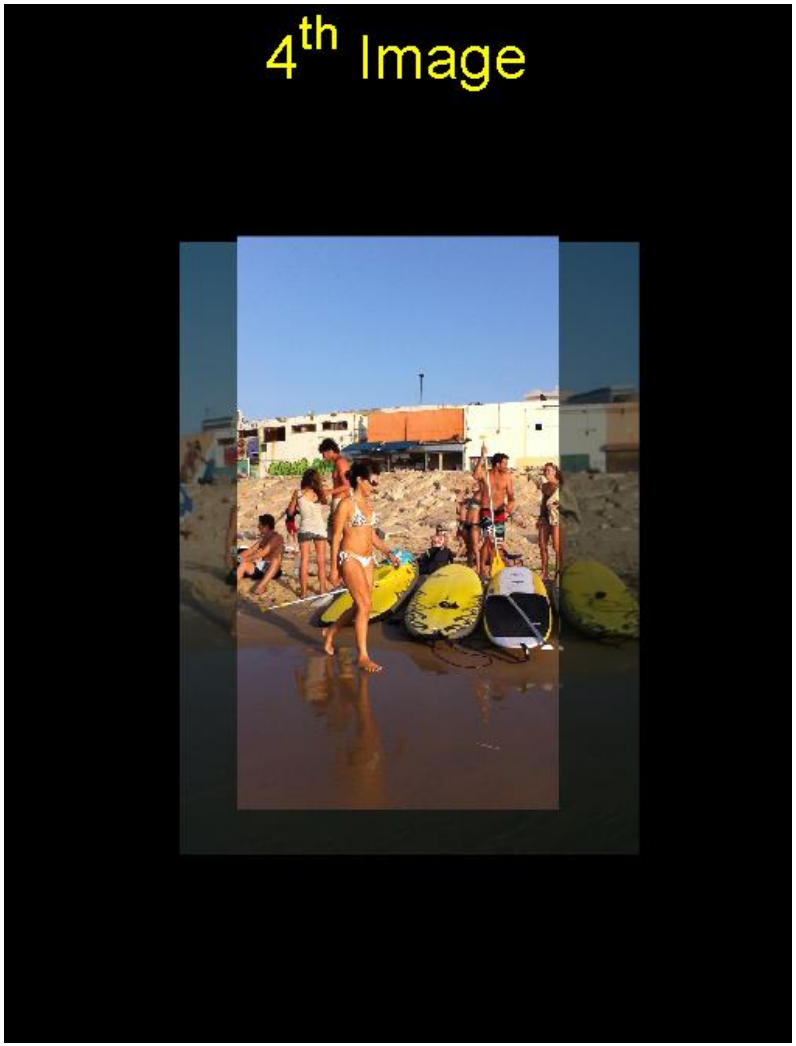
Beach Results

The aligned images ordered by our method



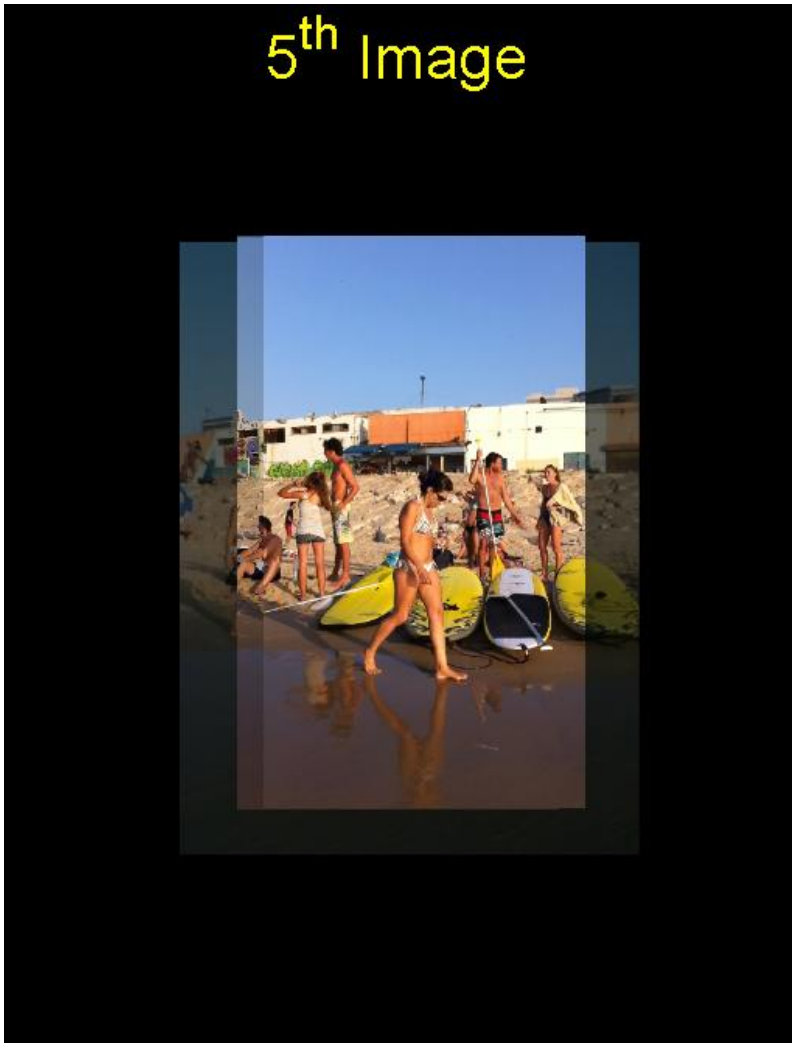
Beach Results

The aligned images ordered by our method



Beach Results

The aligned images ordered by our method



Beach Results

The aligned images ordered by our method

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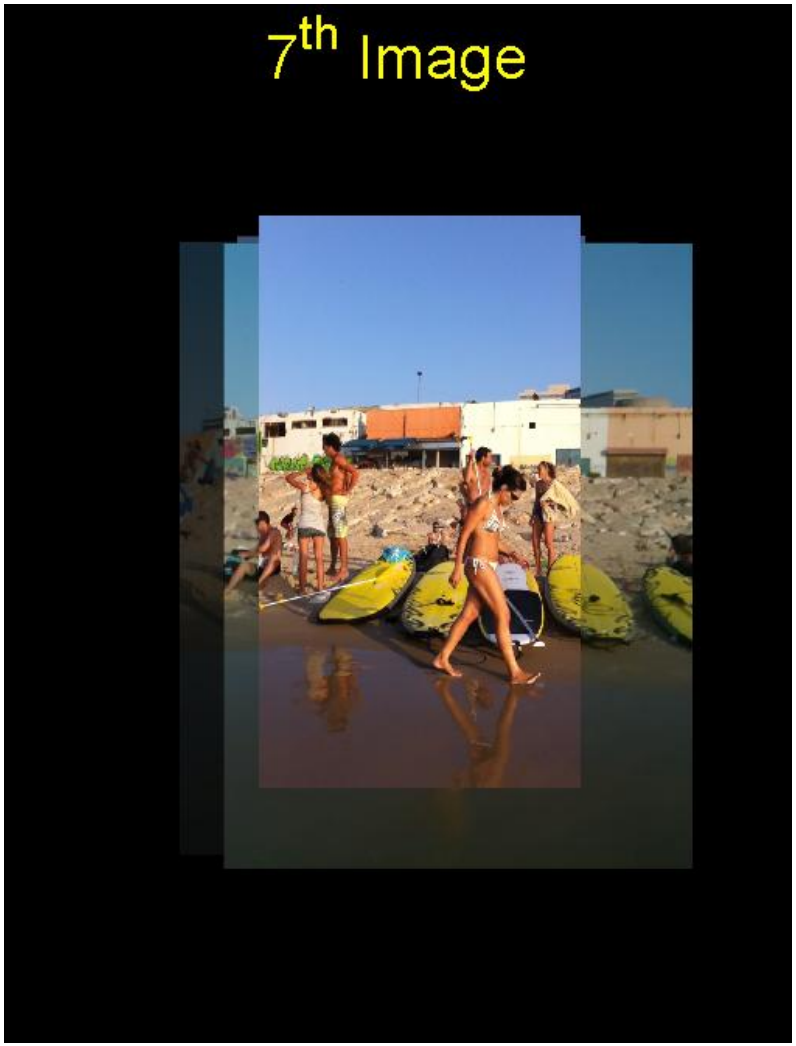
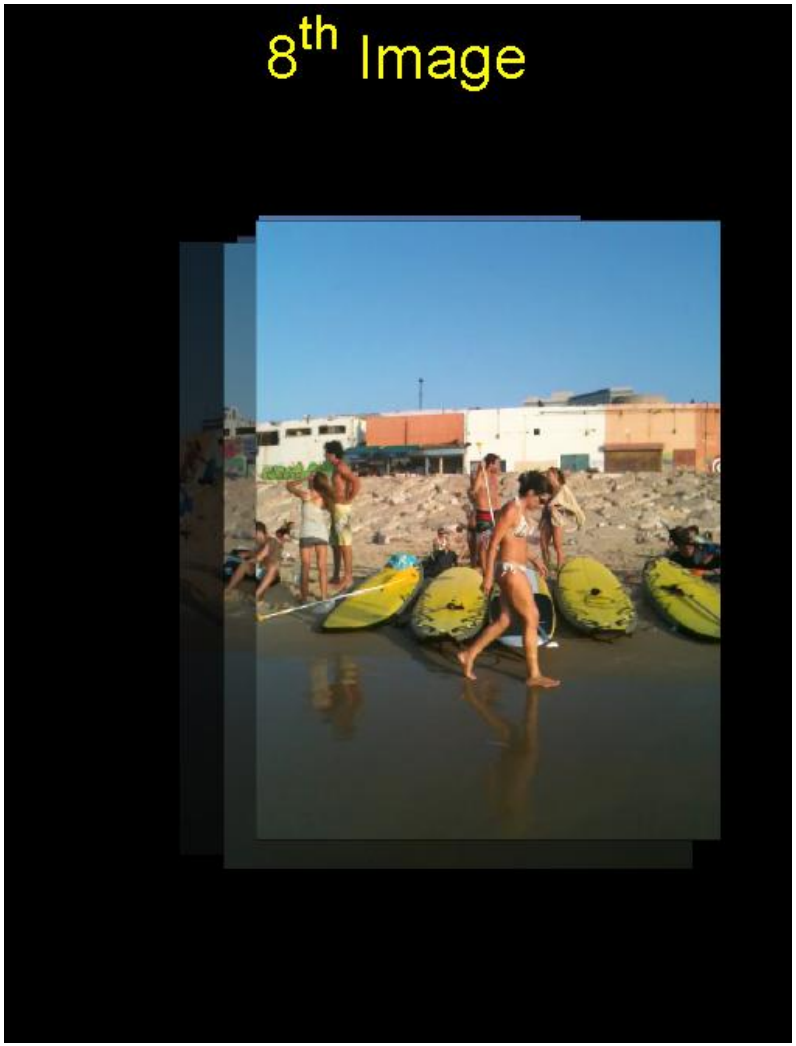


Beach Results

The aligned images ordered by our method



Conclusions & Future Work

- Photo Sequencing – Geometry based solution
- Rank Aggregation

Short Term Future work:

- Matching
- Relaxing the assumptions
- Scalability

Long Term Future work:

- Can still images replace monocular videos ?