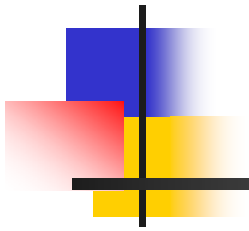
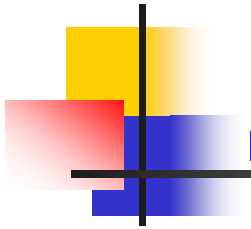


Machine Vision

Lecture 10

Recognition of Motions.

Motion Tracking

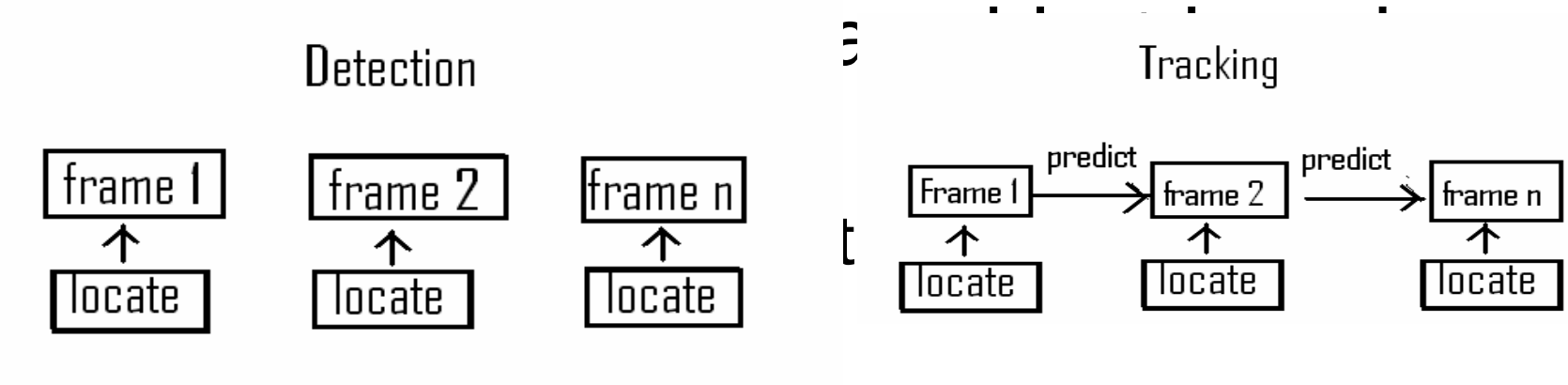


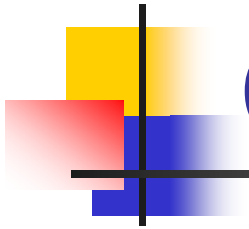
Introduction

- Finding changes in scene
  - Fast changes of image
  - New objects
- Finding how objects have moved in an image sequence
  - Movement in space
  - Movement in image plane
- Camera options
  - Static camera, moving objects
  - Moving camera, moving objects

Tracking vs. Detection

- Detection - locating an object independent of the past information
  - When motion is unpredictable
  - For reacquisition of a lost target

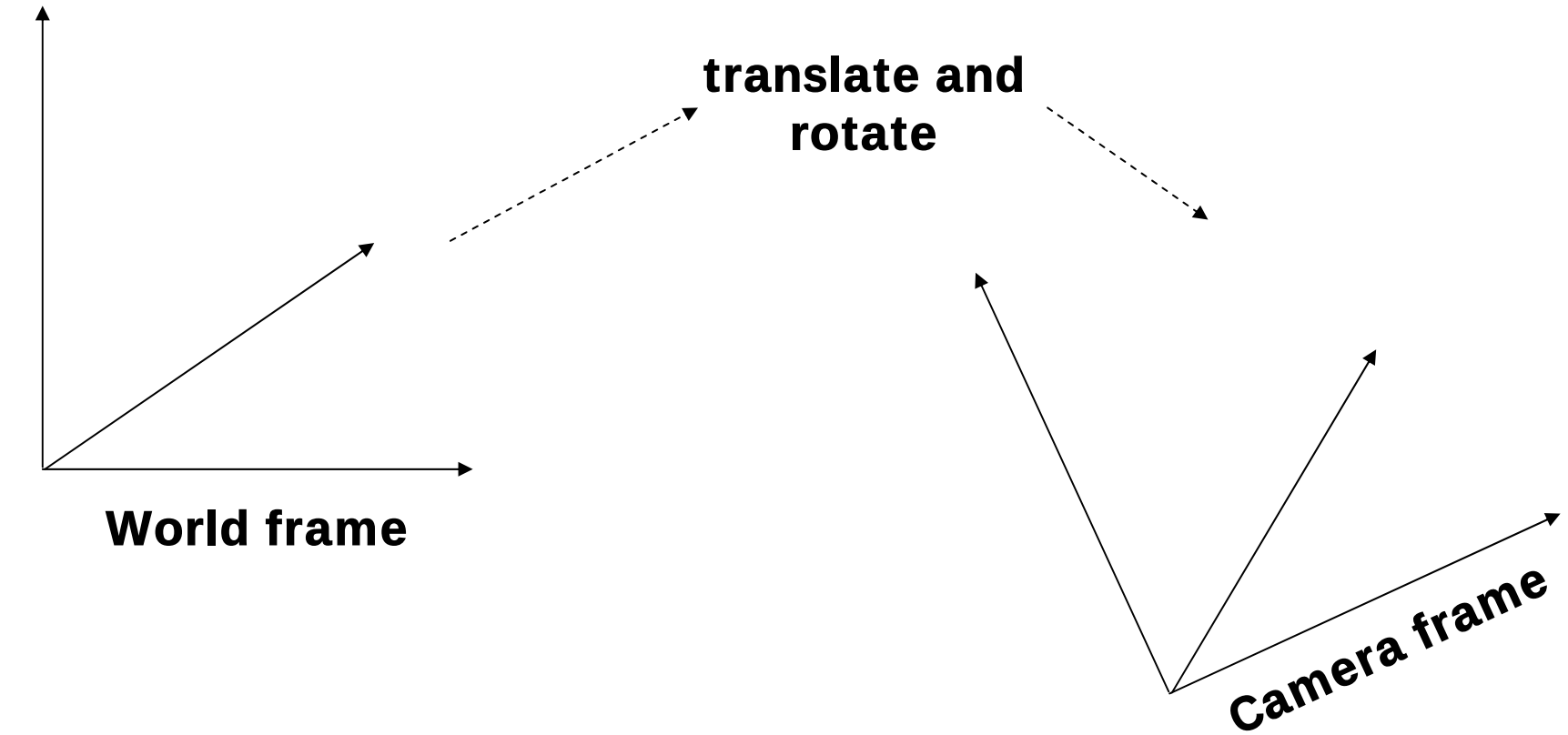




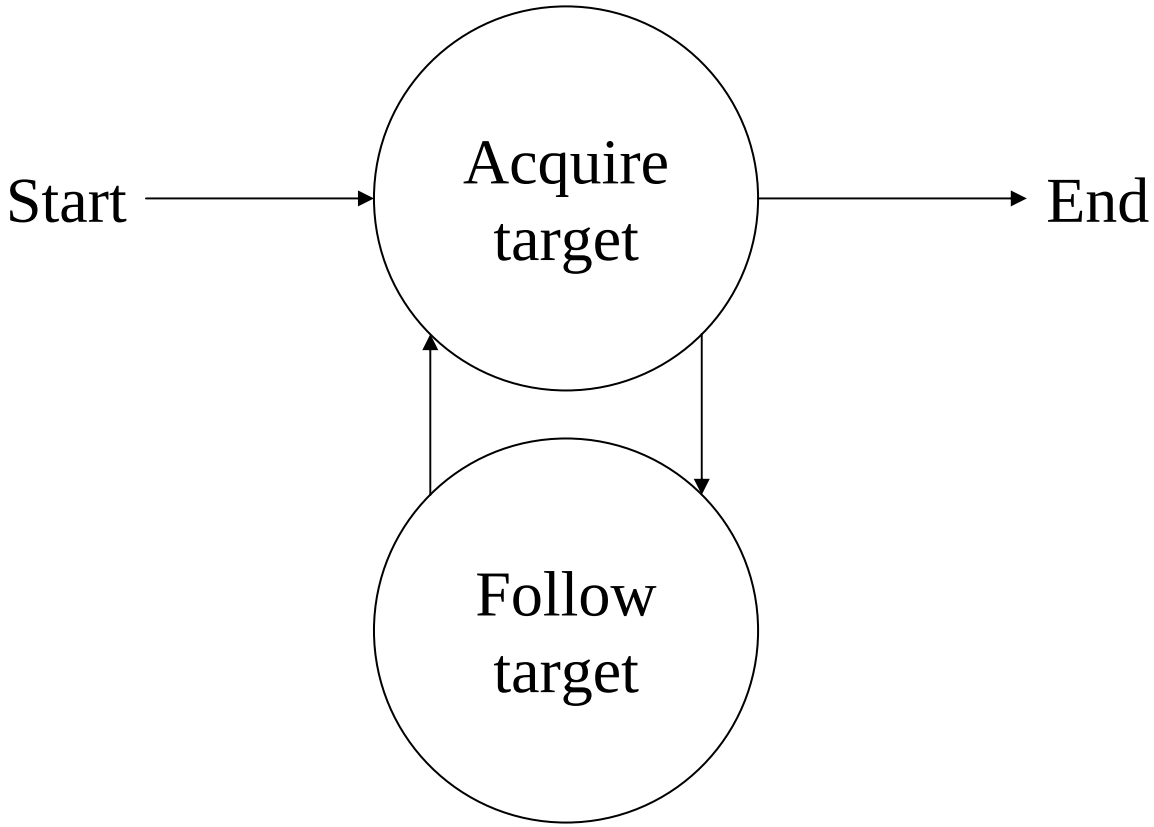
Contents

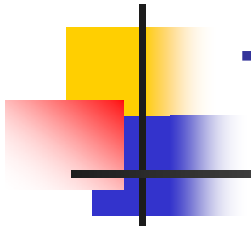
- Acquiring targets
  - Image differencing
  - Moving edge detector
- Following targets
  - Matching
  - Minimum path curvature
  - Model based methods
  - Kalman filtering
  - Condensation
  - Hidden Markov Model

Camera and World Co-ordinates



System architecture



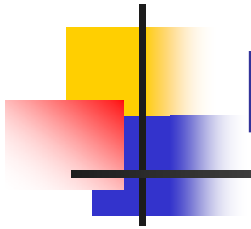


Target acquisition

- Finding a target to follow

- Differencing
- Moving edge detector

Change and Moving Object Detection



- Simplest method of detecting change
- Compute differences between
  - Live and background images
  - Adjacent images in a sequence

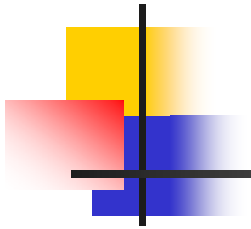
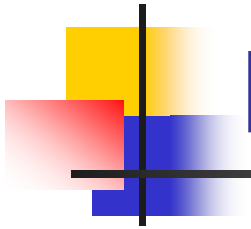


Image Differencing

- Differences due to
  - Moving object overlying static background
  - Moving object overlying another moving object
  - Moving object overlying same moving object
  - Random fluctuation of image data



Background image

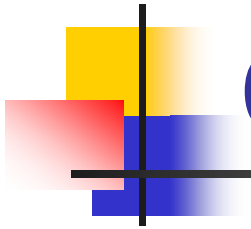
- Detecting true differences required an accurate background
- Lighting changes?
- Camera movement?

Background image updates

- Periodically modify whole background
  - Will include changes in new background
- Systematically incorporate non-changed portions of image into background

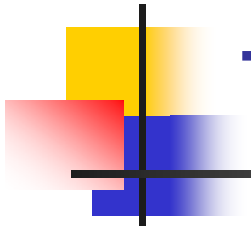
$$if \quad L_{i,t} = background \ then \ B_{i,t} = B_{i,t-1} + L_{i,t}$$

$$else \ B_{i,t} = B_{i,t-1}$$



Critique

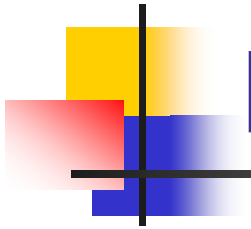
- Can identify changes in the image data
  - But what do the changes mean?
- Need a second layer of processing
  - To recognize changes



Target following

- Observing the positions of an object or objects in a time sequence of images.

- Object matching
- Minimum path curvature
- Model based methods

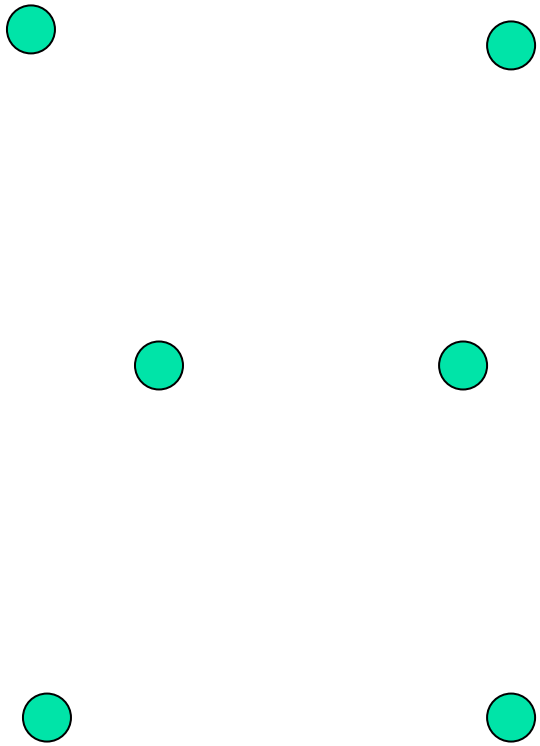


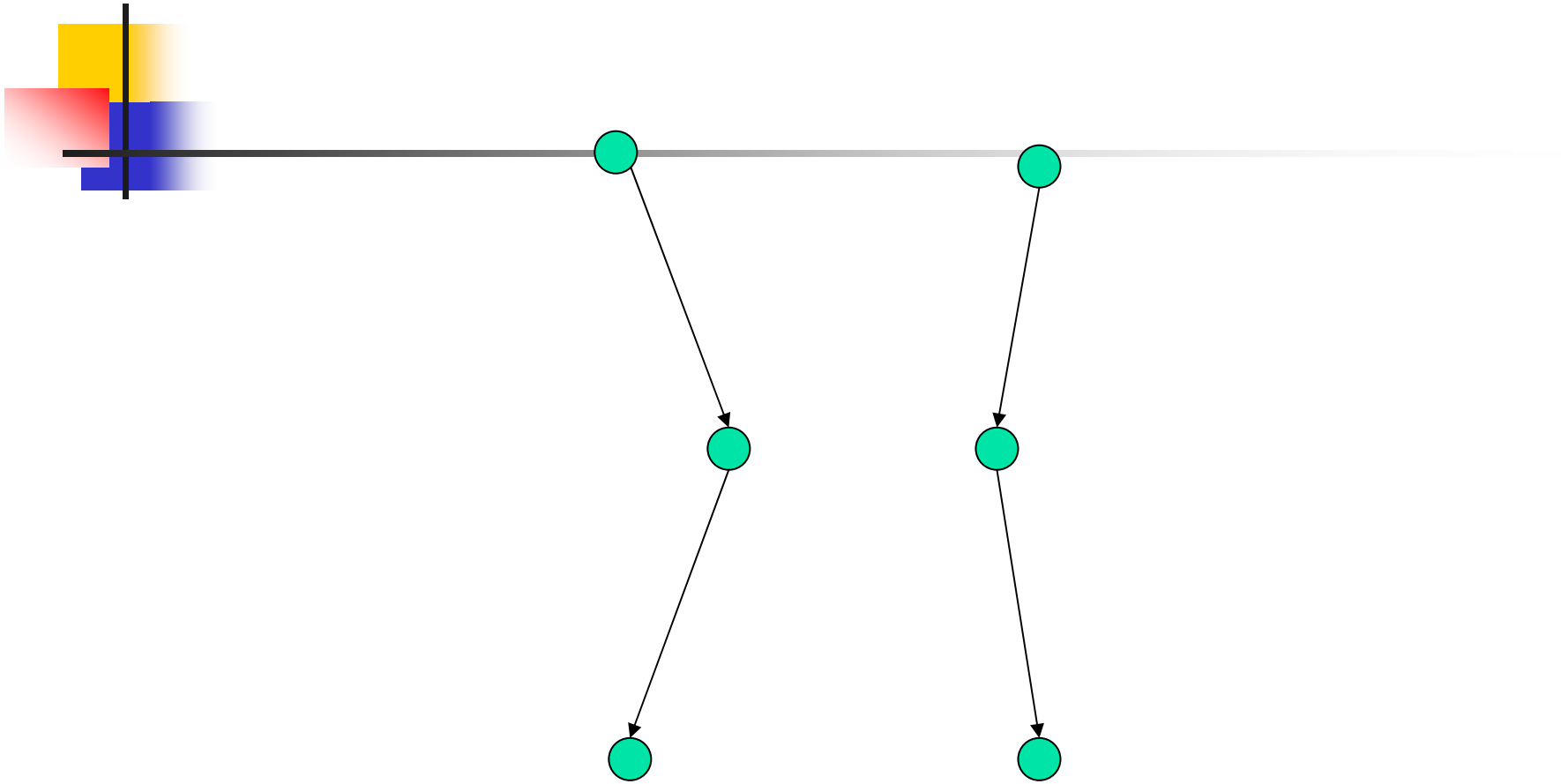
Matching

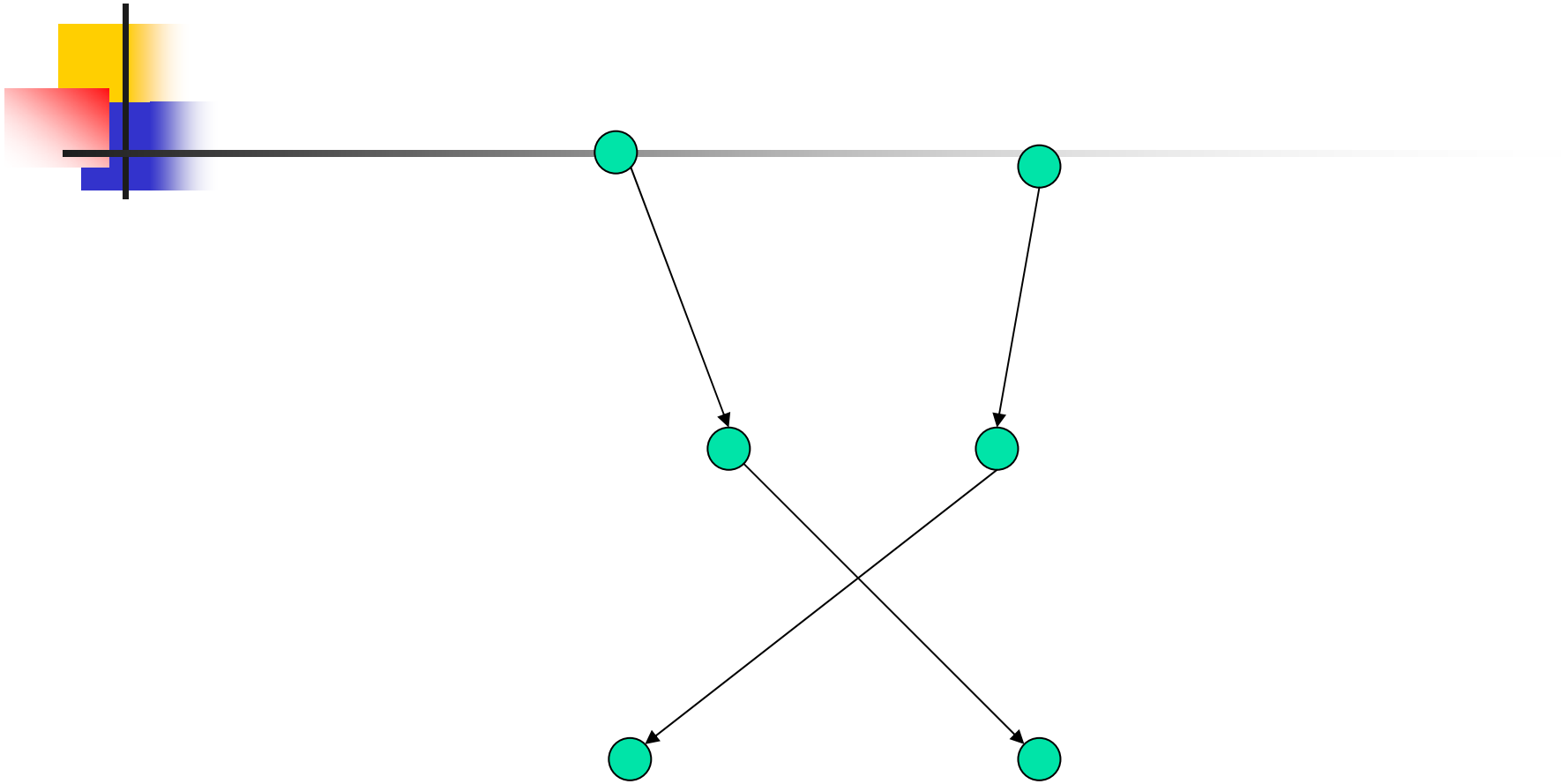
- Locate objects in each image
- Match objects between images

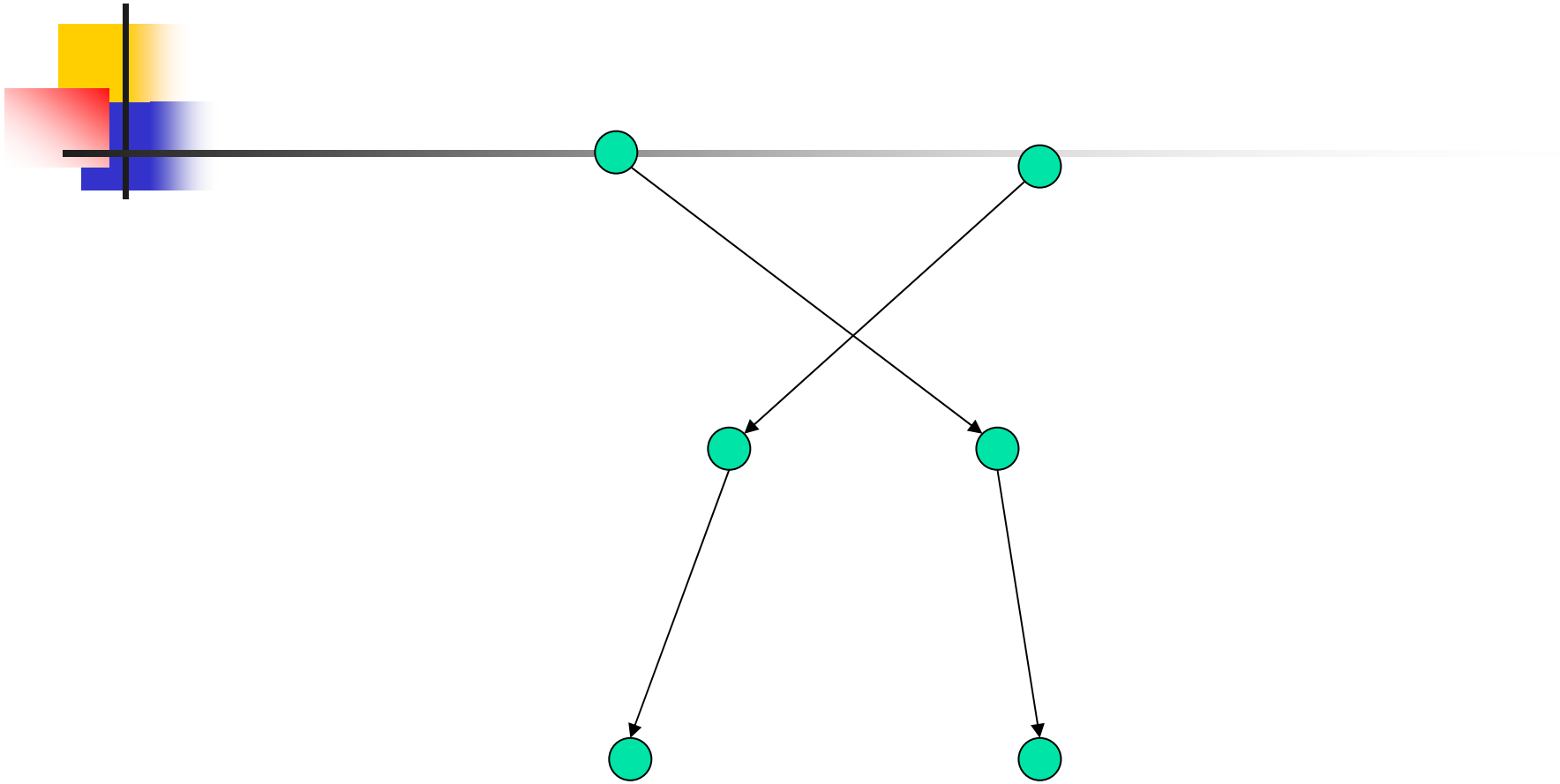
Minimum path curvature

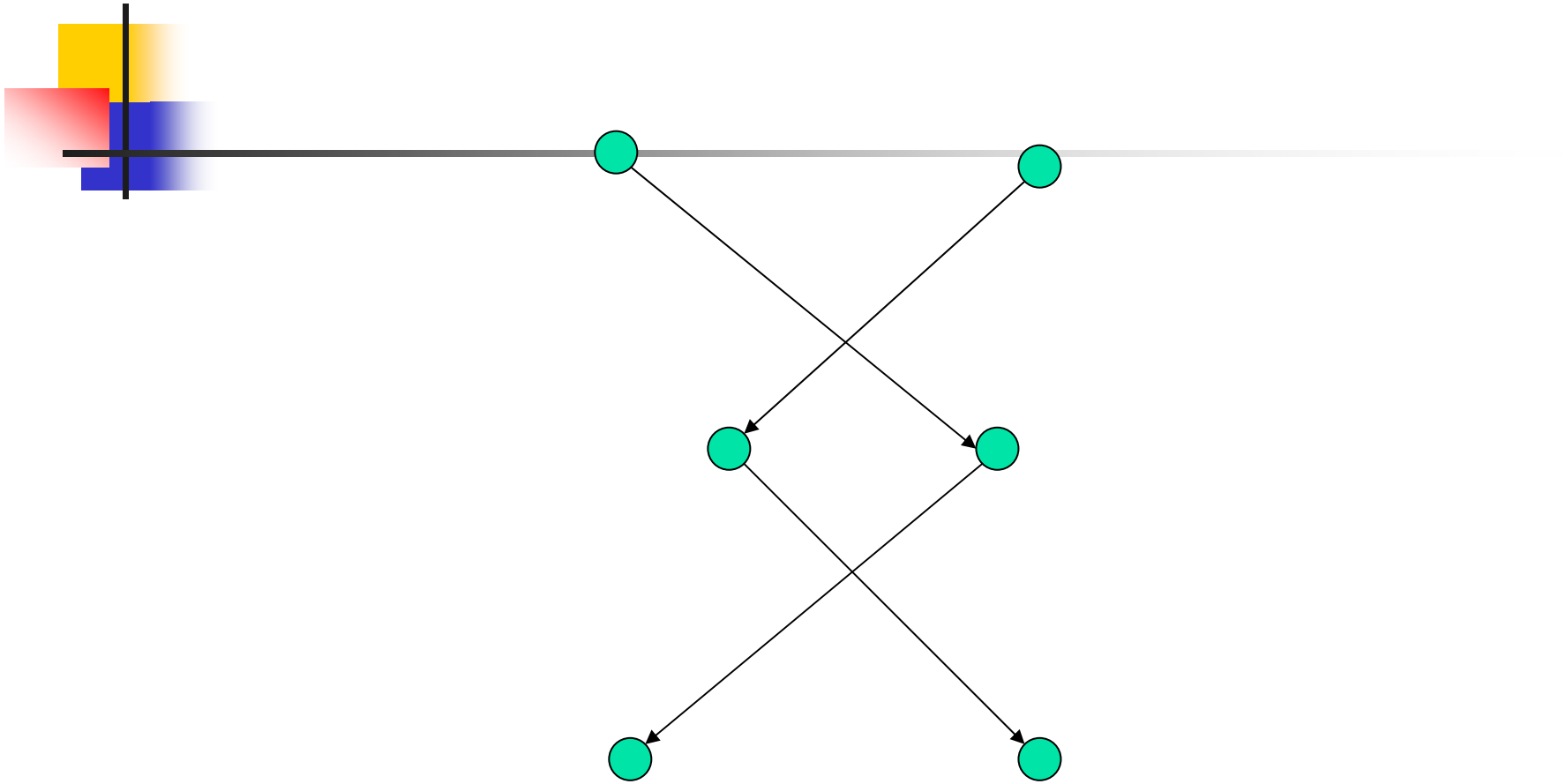
- Observations of two objects in three images

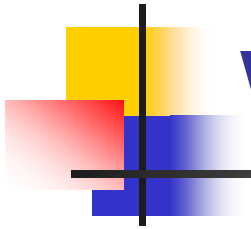












Which is “best” solution?

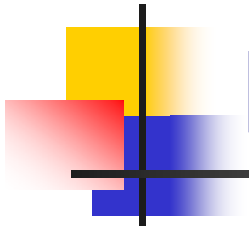
- One with overall straightest paths

For each solution

  For each path

    Compute total curvature

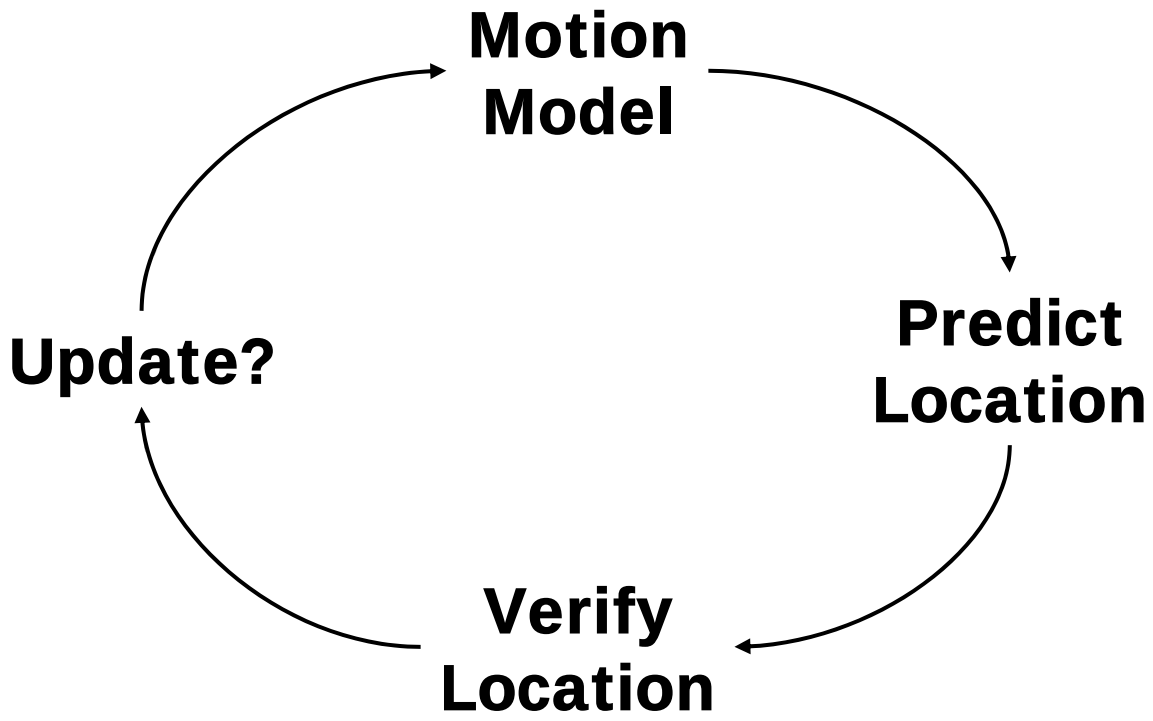
  Sum



Model based tracking

- Mathematical model of objects' motions:
  - position, velocity (speed, direction), acceleration
- Can predict objects' positions

System overview

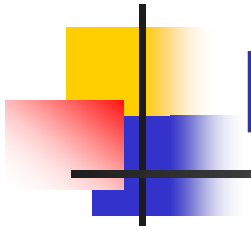


Simple Motion Model

- Newton's laws

$$s(t) = s_0 + ut + \frac{1}{2}at^2$$

  - s = position
  - u = velocity
  - a = acceleration
    - all vector quantities
    - measured in image co-ordinates



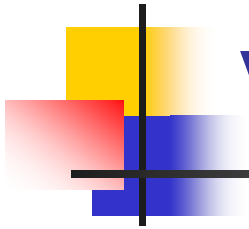
Prediction

- Can predict position at time t knowing
  - Position
  - Velocity
  - Acceleration
- At t=0

Uncertainty

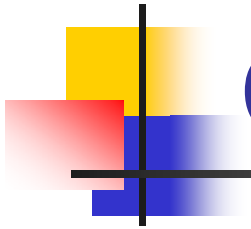
- If some error in a - Δa or u - Δu
- Then error in predicted position - Δs

$$\Delta s(t) = s_0 + \Delta u t + \frac{1}{2}\Delta a\, t^2$$



Verification

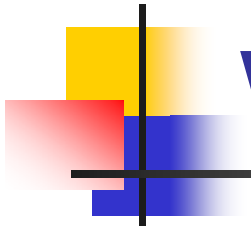
- Is the object at the predicted location?
  - Matching
    - How to decide if object is found
  - Search area
    - Where to look for object



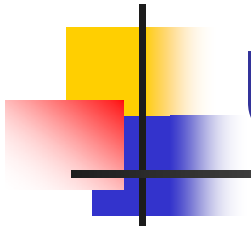
Object Matching

- Compare
  - A small bitmap derived from the object vs.
  - Small regions of the image
- Matching?
  - Measure differences

Search Area: Why? and Where?

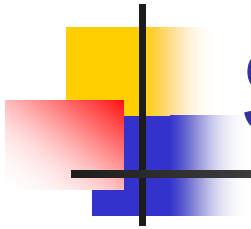


- Uncertainty in knowledge of model parameters
  - Limited accuracy of measurement
  - Values might change between measurements
- Define an area in which object could be
  - Centred on predicted location, $s \pm \Delta s$



Update the Model?

- Is the object at the predicted location?
- Yes
  - No change to model
- No
  - Model needs updating
  - Kalman filter is a solution



Summary

- Target acquisition
  - Image differencing
  - Background model
- Target following
  - Matching
  - Minimum path curvature
  - Model based methods