Coupled Detection and Trajectory Estimation for Multi-Object Tracking

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Motivation

- Multi-object tracking-by-detection
- Improve robustness by coupling object detection and tracking

Contributions

“We propose a novel approach for multi-object tracking that couples detection and trajectory estimation in a combined global optimization framework. At each time instant, our approach tries to find a globally optimal combined solution that provides the best explanation for the current image and all previous frames, while incorporating physical constraints such that no two objects may occupy the same space, nor explain the same image pixels at the same time.”

Object Detection

ISM Recognition [CVPR'05]

- Hypothesis selection
  - Solve a Quadratic Boolean Optimization Problem
  - Constraint each pixel at most belong to a single detection.

Spacetime Trajectory Estimation

Spacetime Event-Cone Following [CVPR'07]

- Trajectory growing
  - Start from each detection (at each time step)
  - Collect detections in event cone
  - Evaluate under trajectory model (EKF)

- Optimization problem
  - No longer submodular

Problem: Asymmetric relationship

- Trajectories rely on continuing detections for support.
- But detections can exist without supporting trajectories (e.g. when a new object enters the scene).

Experimental Results

Spatial Detection Prior from Trajectories

- Hypothesize-and-select paradigm
  - Tracks can adjust according to new evidence
  - The system can automatically recover from mismatches and errors.
  - Just need to make sure correct hypotheses are among the candidates, the model selection framework will (ideally) take care of the rest!

Efficient Implementation

Incremental Computation

- Trajectories can be constructed incrementally
  - Try to extend old trajectories by new evidence.
  - Only grow new trajectories from the last n frames.

- Interaction matrix Σ can be reused
  - Many entries don’t need to be updated.
  - Just need to be weighted with temporal discount.

Multibranch Gradient Ascent

- Boundary breadth-first search for first steps
  - Guaranteed to be at least as good as greedy with constant overhead.
  - Empirically better performance than Taboo search or LP relaxation.

Conclusions

- Proposed framework for non-Markovian multi-object tracking
- Formulation as coupled model selection problem.
- Approach has several interesting properties:
  - Tolerates large-scale background changes.
  - Can track a large number of static and moving objects.
  - Able to recover from errors and temporarily lost tracks.
  - Global optimization resolves trajectory interactions.

New Results

  ⇒ Ask to see the videos!