Multiple Object Tracking and Identification

Lecture 21

EE 493/593
Wireless Sensor Networks

Outline

- Overview
- Multiple Object Tracking
- Multiple Object Identification
- Gating
- Data Object Association
- Example (miniProject 7)
Overview

- Multiple Object Tracking
  - Track multiple targets at the same time
- Multiple Object Identification:
  - Identify multiple targets at the same time
- Key Challenge
  - Interference between different target signals
  - Artifacts (ghost)
- Solutions
  - Data to Object Association
  - Gating
  - Orthogonal Class Subspaces

Multiple Object Tracking

Functional Elements of a Recursive Basic Multi-Target Tracking System
**MOT Procedure**

- Detection and localization algorithms do the necessary sensor data processing to form the observations.
- Observations are gated with current tracks first; Then more refined data association algorithms are used for final assignments.
- Observations not assigned to existing tracks initiate new tentative tracks; A tentative track becomes a confirmed track on satisfying some quality test; Low quality tracks, as determined by the update history, are deleted.
- Kalman filter (or other least-squares methods) may be used to predict the track state at future times; The prediction covariance matrix is used to make the gates for next data association recursion.

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**Gating**

- **Gating**: The process of specifying a region for predicting the next localizer output.
- Helps in eliminating false localizations.
- More sophisticated data association algorithms may be used on the gated localizations.
- Different types of gates can be used depending upon data characteristics and physical constraints. E.g., circular, elliptical & V gates.
- The size of the gate is calculated at each recursion from the prediction covariance matrix.
- Tracks which share localizations with each other are grouped together into “clusters.”
- Data association algorithms are run on these clusters.
Data Object Association

- Nearest Neighbor
- Joint Probability
- Multiple Hypothesis

Track Maintenance

- Tracks are maintained for their quality at each iteration
  - Tracks which receive new localizations after gating are updated for predicting track locations (e.g. using a Kalman filter)
  - Tracks which do not receive new localizations are declared miss-detected and hence penalized. Tracks which suffer a certain number of miss-detections are deleted.
- New tracks, called tentative tracks, are created from unpaired new localizations. Tentative tracks get confirmed after few successive updates.
Multiple Target Classification

- Key challenge: interference between different target signals
- A solution: orthogonal class subspaces
- Define mixture correlation matrix:
  \[ C = E[xx^H] = \sum_{i=1}^{M} P(\omega_i)E[x,x_i^H] \]
  - There exists a matrix \( B \) such that \( B^HCB = I \)
- Transform feature vectors: \( g = B^Hx \)
- Transformed class correlation matrices
  \[ C_j = P(\omega_j)E[g_jg_j^H] = A_j\Lambda_jA_j^H \] (eigen-decomposition)

Orthogonal Projection Classifiers

- Then \( C_j = I - \tilde{C}_j = I - \sum_{i\neq j} C_i \)
- \( C_j \) and \( \tilde{C}_j \) share the same eigenfunctions and
  \[ \Lambda_j = I - \tilde{\Lambda}_j \iff \lambda_{j_k} = 1 - \tilde{\lambda}_{j_k} \]
- Projection classifier for class \( j \)
  \[ P_j = \sum_{k=1}^{n} a_{j_k}a_{j_k}^H \]