Many-target, Many-sensor Ship Tracking and Classification

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Agenda

- Introduction
- Motivation
- Background
- Methods
- Experiments and Results
- Shortcomings of Tracking Metrics
- Conclusion

Introduction

- Key elements of our work:
  - Many-target tracking
  - Many-sensor tracking
  - Ship tracking
  - Ship classification
  - Unknown number of targets
- **We created a tracker that achieves high track purity and high classification accuracy on several datasets.**

Motivation

- Surveil ships in strategically important regions

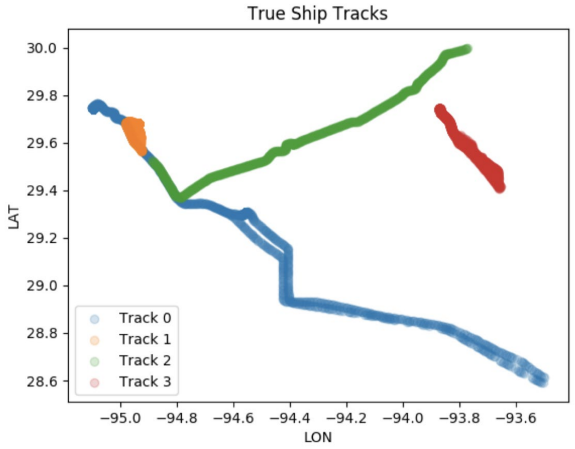
DRAPER

Background

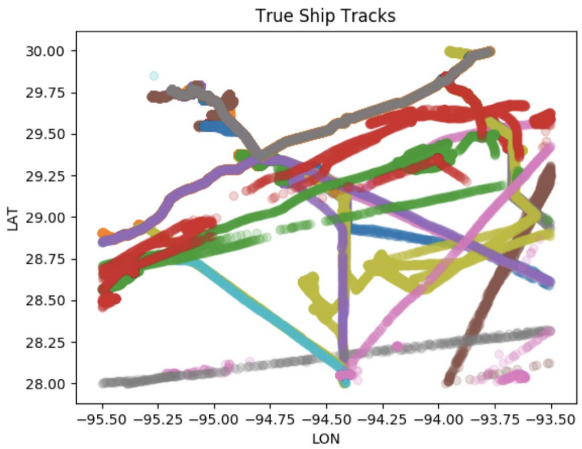
- Multitarget tracking:
  - Global Nearest Neighbors (GNN)
  - Multiple Hypothesis Testing (MHT)
  - Metrics: track purity, disagreement accuracy
- Neural networks:
  - Feed-forward
  - Metric: classification accuracy

Methods: Dataset

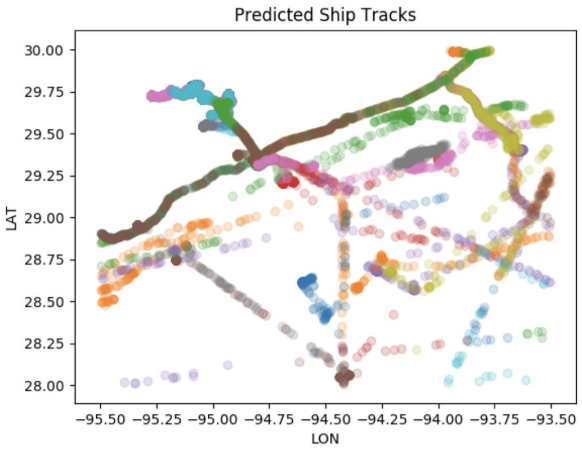
- AIS data
  - Observation: (timestamp, LON, LAT)
  - 90% decimation
  - Houston, Boston, Miami, Anchorage, Los Angeles
  - **Number of sensors: dozens**
  - **Number of targets: dozens**



(a) True tracks: 25,000 observations.



(b) True tracks: 250,000 observations.



(c) Predicted tracks: 250,000 observations, 90% decimation.

Methods: Tracking Algorithm

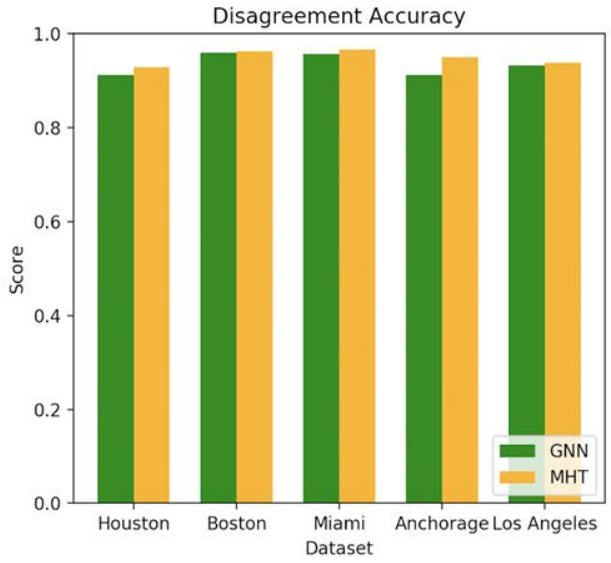
1. Sort observations by timestamp
2. For each observation x:
   a. If x is far from the last observations of all tracks, start new track
   b. Else, apply GNN or MHT based on last observations of all tracks
   c. Remove all inactive tracks

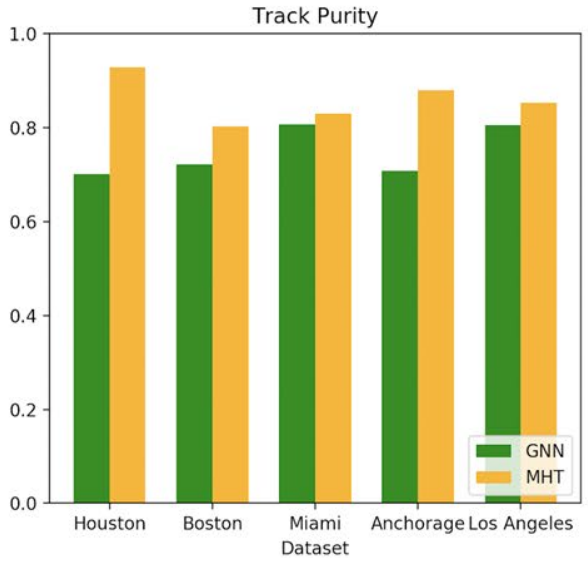
Methods: Classification Algorithm

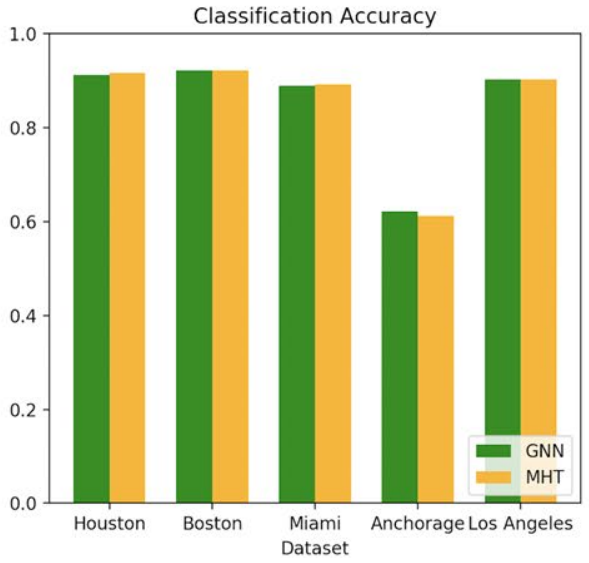
1. Run tracking algorithm
2. For each observation x:
   a. Using tracks found, calculate additional features for x (velocity, turn rate, etc.)
   b. Run feature vector for x through neural network
   c. Neural network outputs ship type

Experiments and Results

- Disagreement accuracy: not useful
- Track purity: very good
- Classification accuracy: very good, but Anchorage?

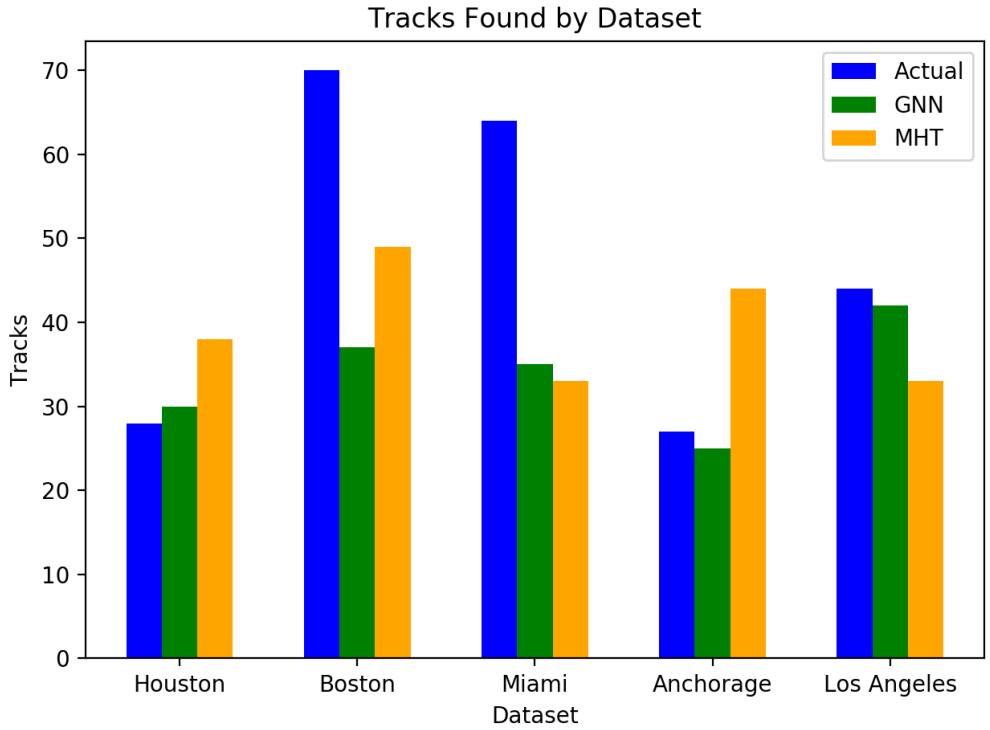






Experiments and Results

- Tracks found not consistent with tracks present
- 2-approximation



Shortcomings of Tracking Metrics: Disagreement

- Problem: always too high with many-targets
- **Recommendation: do not use**

Shortcomings of Tracking Metrics: Track Purity

- Problem: when number of targets is unknown *a priori*, even bad tracking algorithms can score highly
- **Recommendation: force 2-approximation (or better)**

Conclusion

- Many-target, many-sensor tracker
  - High track purity
  - High classification accuracy
- MHT is more accurate than GNN, but slower
- Contributions:
  - Tracking and deep learning
  - Many-target, many-sensor
  - Real-world data
  - Tracking metrics

Acknowledgement

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