Connection One

Sensor Fusion for Personnel Detection, Localization, and Tracking

PIs: Prof. Randolph L. Moses

RAs: Mr. Adam Porr

Mentor: Army Research Laboratory

The Ohio State University

Project Description

- The goal is to create and evaluate algorithms to track light vehicles using acoustic DOA and Doppler range rate measurements acquired from a network of sensors.
- Steps of the proposed approach:
  - Create physical and statistical models of tracking problem
  - Evaluate tracking algorithms through analysis and simulations
  - Verify the performance of algorithms through field experiments
- Our constraints/assumptions:
  - One moving target (initially)
  - Multiple stationary sensor nodes with known positions
  - Gaussian measurement noise

Motivation

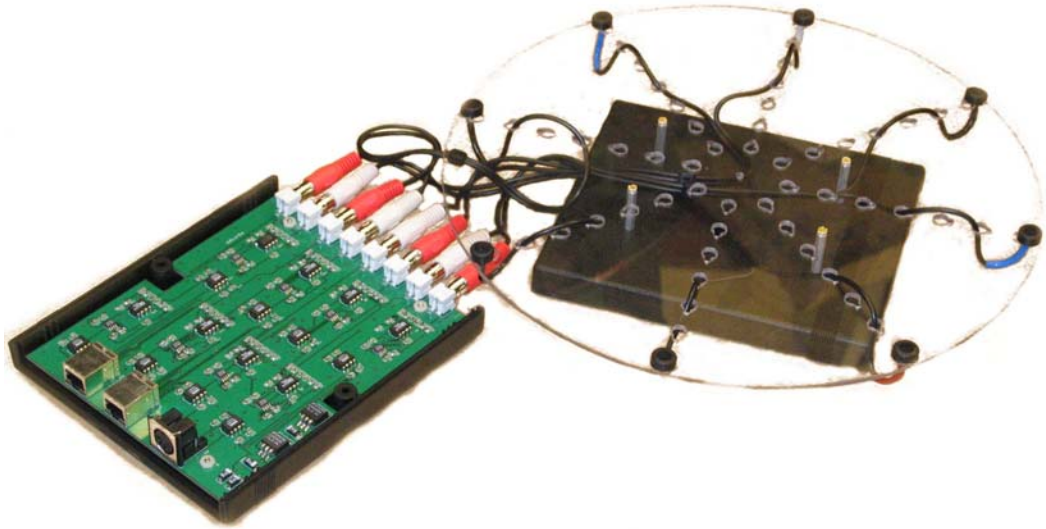
- There's a need for a better way to persistently track light vehicles using a network of spatially distributed sensor nodes.
- The application area is vehicle tracking for such purposes as anti-terrorism, law enforcement, and automated transportation.
- Existing methods are lacking because
  - they are too big
  - they are too expensive
  - they require too much maintenance
  - they use too much energy
  - data transfer requires too much communication bandwidth

Risks and Benefits

- Novel aspects of this project:
  - useful both day and night and in all weather conditions
  - uses inexpensive sensors
  - suitable for sensor nodes with limited processing and storage capabilities
- Risks/challenges in this project:
  - algorithms must be simple, yet effective
  - sensor resolution may limit range
- Potential benefits of this work:
  - evaluation of various data fusion techniques
  - tracking algorithms for use on limited-resource sensor nodes
  - measured acoustic and radar data for use in subsequent research

Accomplishments to Date

- Milestones achieved so far:
  - Physical and statistical problem models created
  - Designed a dual acoustic/radar sensor node prototype
  - Simulations performed using the extended Kalman filter
  - Simulations performed using the particle filter



Source: http://www.advantaca.com

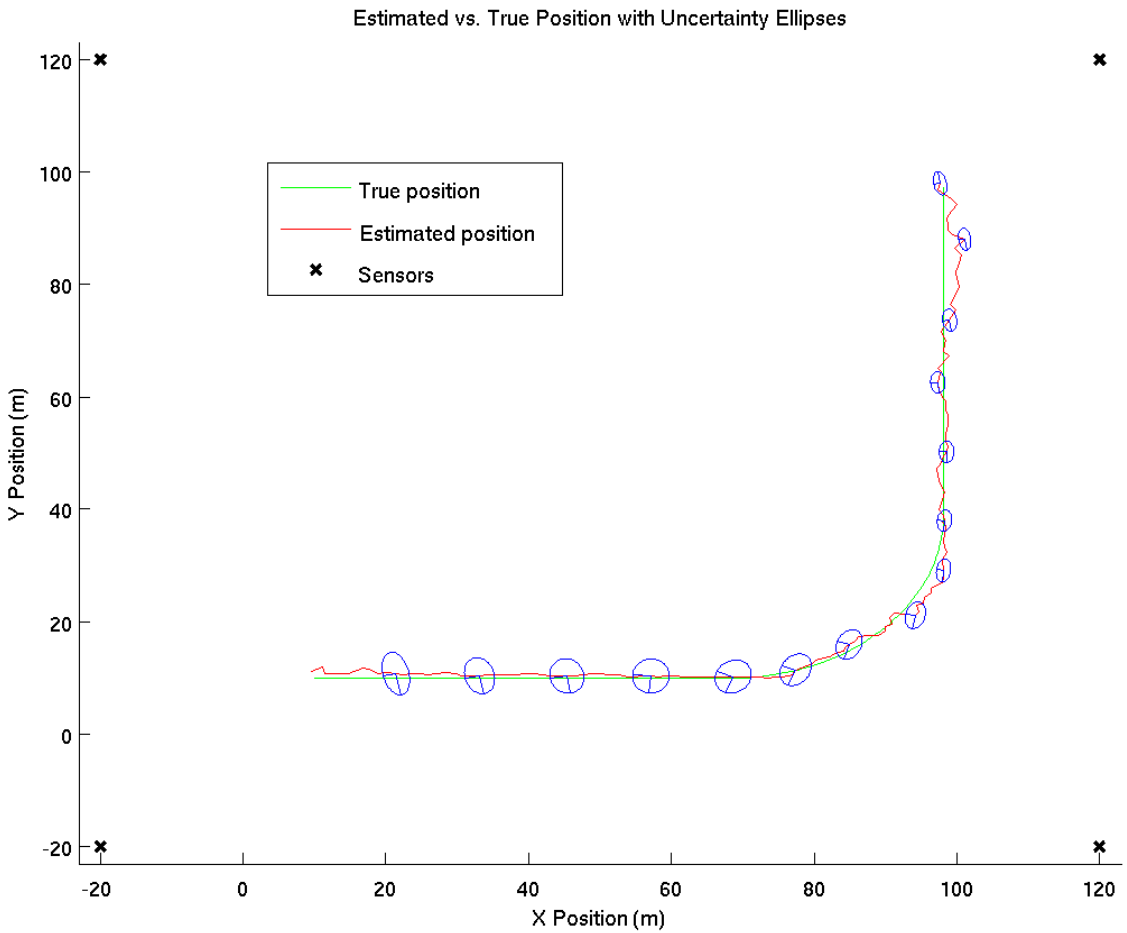
Technical

State transition model : $\vec{\phi}[k+1] = A\vec{\phi}[k] + \vec{w}$

$$\begin{bmatrix} x[k+1] \\ y[k+1] \\ \dot{x}[k+1] \\ \dot{y}[k+1] \end{bmatrix} = \begin{bmatrix} 1 & 0 & T & 0 \\ 0 & 1 & 0 & T \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x[k] \\ y[k] \\ \dot{x}[k] \\ \dot{y}[k] \end{bmatrix} + \begin{bmatrix} w_x \\ w_y \\ w_{\dot{x}} \\ w_{\dot{y}} \end{bmatrix}$$

Observation model : $\vec{z}[k] = h(\vec{\phi}[k], \vec{v})$

Technical



Doppler Only

$$MSE = \begin{bmatrix} 6.2447 \\ 2.0034 \\ 0.9333 \\ 1.2833 \end{bmatrix}$$

Acoustic Only

$$MSE = \begin{bmatrix} 1.4819 \\ 2.8728 \\ 6.9806 \\ 8.2023 \end{bmatrix}$$

Doppler/ Acoustic

$$MSE = \begin{bmatrix} 0.7588 \\ 0.8684 \\ 0.7435 \\ 1.2399 \end{bmatrix}$$

What Remains?

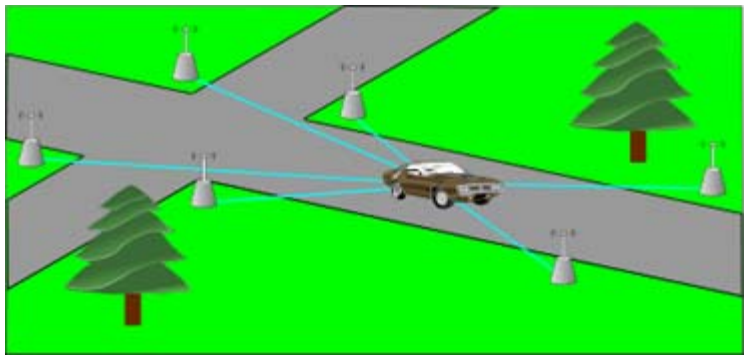
- Compare performance of data fusion techniques
- Evaluate the benefit of using both acoustic DOA and Doppler range rate measurements
- Collect acoustic and radar data through field experiments
- Verify algorithm performance using collected data

Timetable and Deliverables

Item Description	Delivery Timetable
Complete simulations and evaluate algorithms	March 2007
Implement sensor nodes and collect field data	June 2007
Analyze field data and improve algorithms	August 2007

PROJECT OBJECTIVES

Track light vehicles using acoustic DOA and Doppler range rate measurements acquired from a network of sensors



TECHNICAL APPROACH

- Compare data fusion techniques through analysis and simulation
- Evaluate the benefit of using both acoustic DOA and Doppler range rate measurements
- Verify the performance of the algorithms through field experiments

ACCOMPLISHMENTS

- Physical and statistical problem models created
- Simulations performed using the extended Kalman filter
- Simulations performed using the particle filter

FUTURE TASKS

- Compare performance of fusion techniques
- Evaluate the benefit of using both acoustic DOA and Doppler range rate measurements
- Verify algorithm performance through field experiments