SINGLE TARGET TRACKING USING VECTOR MAGNETOMETERS

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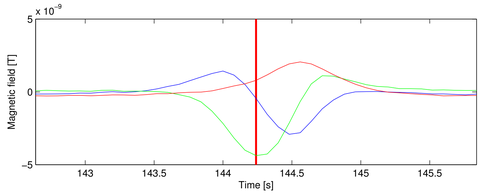
Contribution

Tracking of targets is a primary concern in automated traffic surveillance systems. We explore the usage of three-axis magnetometers in this field.

Background



Vehicles induce a magnetic field partly due to the permanently magnetized material (hard iron) in the vehicle and partly due to the deflection of the earth magnetic field (soft iron). This induced magnetic field can be measured with a stationary magnetometer. The signal depends on the position, velocity and the magnetic signature of the target.

Sensor Model

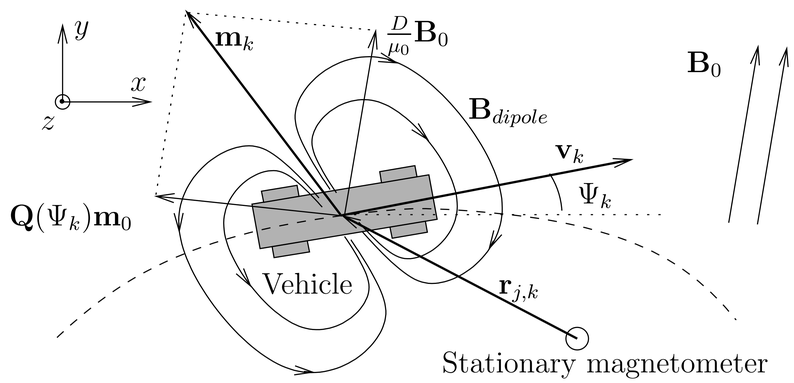
A vehicle can approximately be seen as a moving magnetic dipole. A magnetic dipole is specified by a vector $\mathbf{m}_k$, and affects the magnetometer signal with the three-dimensional vector

$$\mathbf{h}_j(\mathbf{x}_k) = \mathbf{B}_0 + \frac{\mu_0}{4\pi}\frac{3(\mathbf{r}_{j,k}\cdot\mathbf{m}_k)\mathbf{r}_{j,k} - \|\mathbf{r}_{j,k}\|^2\mathbf{m}_k}{\|\mathbf{r}_{j,k}\|^5},$$

where $\mathbf{r}_{j,k} = \mathbf{r}_k - \boldsymbol{\theta}_j$ is the position of the target relative to sensor j positioned at $\{\boldsymbol{\theta}_j\}_{j=1}^{J}$.

The magnetic dipole moment consists of hard and soft iron contributions $\mathbf{m}_k = \mathbf{m}_k^{\text{hard}} + \mathbf{m}^{\text{soft}}$ where

$$\mathbf{m}_k^{\text{hard}} = \mathbf{Q}(\Psi_k)\mathbf{m}_0 \qquad \text{and} \qquad \mathbf{m}^{\text{soft}} = \frac{D}{\mu_0}\mathbf{B}_0.$$

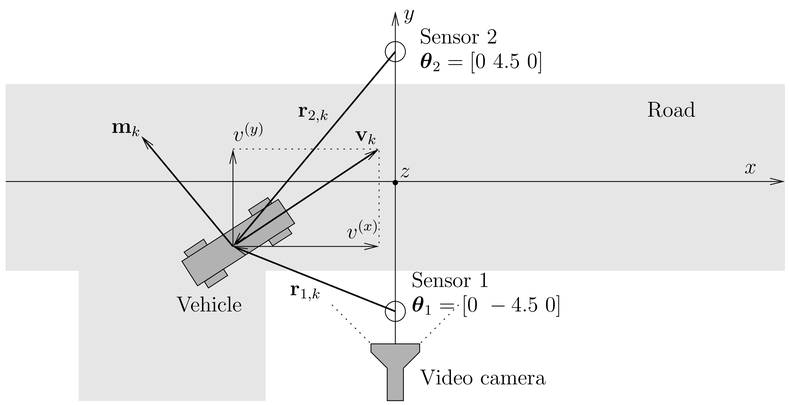


State Estimation

The state estimation problem is solved using Extended Kalman Filter (EKF). Multiple EKFs have been initialized, each assuming that the vehicle is coming from one of the N different heading directions in a N-way intersection.

Target Tracking Experiments

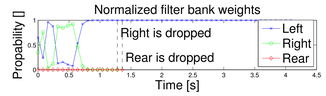
Real data has been collected with two magnetometers, which have been placed at a 3-way intersection.

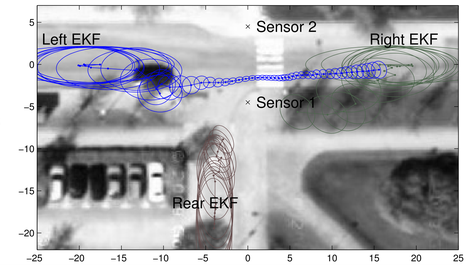


Since we in this work have short observation intervals, a constant velocity motion model is assumed for the vehicle.

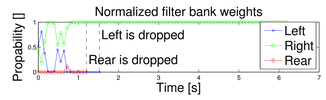
Table 1: The trajectories according to the three different EKFs in three different scenarios. The ellipses represent a 90% confidence interval.

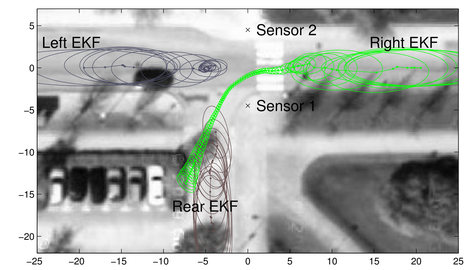
The vehicle is coming from the left heading right.



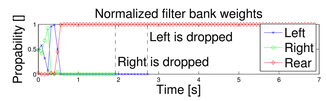


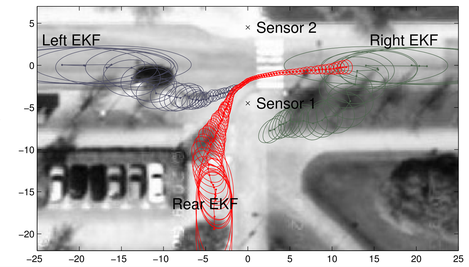
The vehicle is coming from the right turning left.





The vehicle is coming from the rear turning right.





Conclusion

It has been found that a moving metallic target can be modeled as a magnetic dipole. Results from real data with two magnetometers indicate excellent tracking of target position.

Future Work

Extended target models and Multi target tracking