Laser-Based Feature Extraction and Pattern Recognition in Intersection Management Systems

Gustavo Velasco-Hernández

Pattern Recognition, 2014

Main Objective

- To develop a feature extraction and pattern recognition laser-based module for an intersection management system

Sub-objectives

- Review of laser-based feature extraction and pattern recognition in ITS and IMS

Sub-objectives

- Review of laser-based feature extraction and pattern recognition in ITS and IMS
- Evaluate pros and cons of the reviewed methods

Sub-objectives

- Review of laser-based feature extraction and pattern recognition in ITS and IMS
- Evaluate pros and cons of the reviewed methods
- Implement at least one method

Sub-objectives

- Review of laser-based feature extraction and pattern recognition in ITS and IMS
- Evaluate pros and cons of the reviewed methods
- Implement at least one method
- Evaluate implemented module and compare it with similar developments

Conditions

- The information source will be a dataset.

Conditions

- The information source will be a dataset.
- Just one laser.

Applications, Methods and Techniques

Project	POSSi	Ko-PER
Applications	Recognition, Classification and Tracking of Vehicles and Pedestrians	
Methods and Techniques	- Clustering - KL Transform - Markov Chains - Kalman Filtering - AdaBoost	- DBSCAN - Multi-object Bayes Filter - Sequential Monte Carlo Methods - Dempster-Shafer Theory - Multiple-Model Probability Hypothesis Density Filter (in Gaussian Mixture representation)

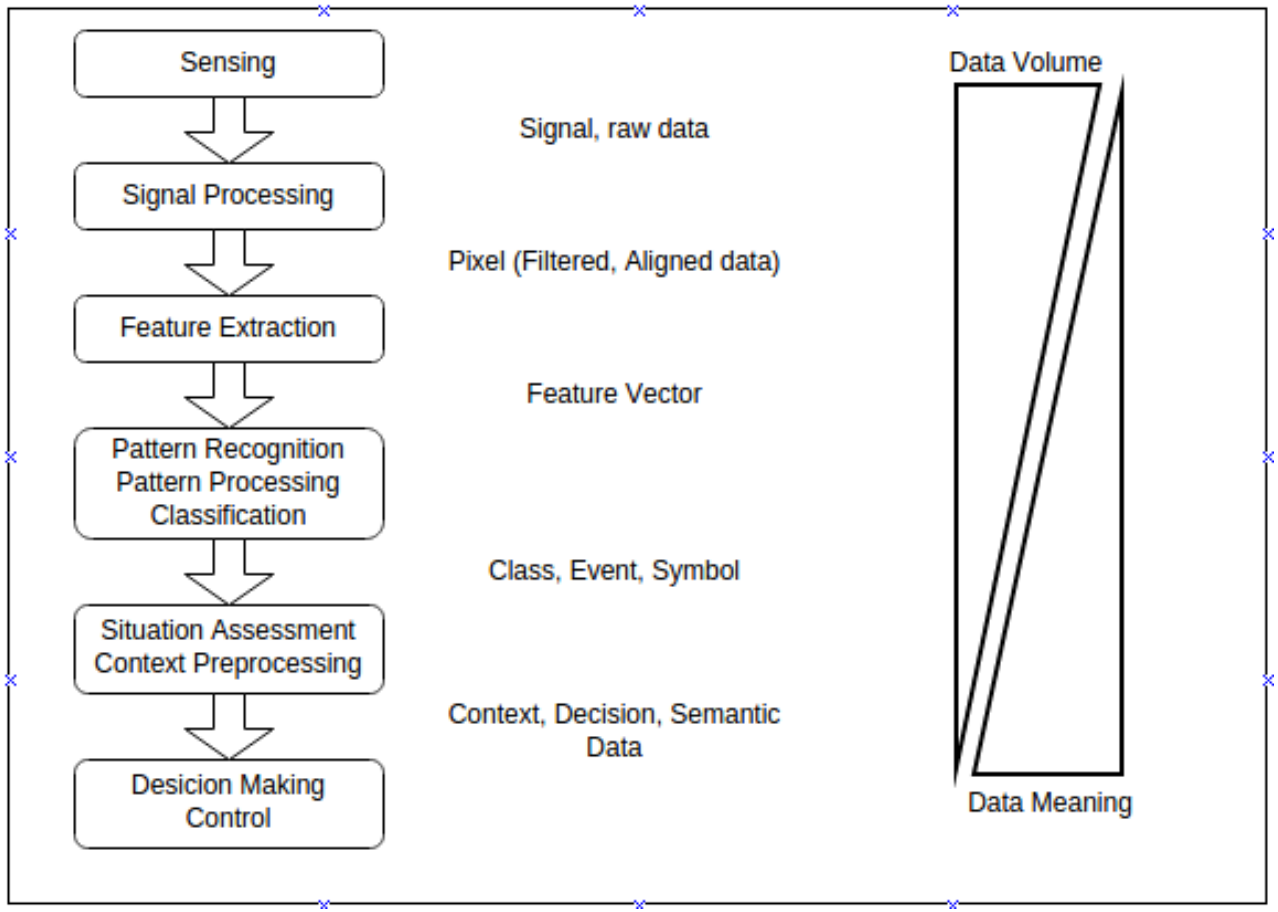
POSSi and PKU projects comparison

Applications, Methods and Techniques

Project	POSSi	Ko-PER
Applications	Recognition, Classification and Tracking of Vehicles and Pedestrians	
Methods and Techniques	- Clustering - KL Transform - Markov Chains - Kalman Filtering - AdaBoost	- DBSCAN - Multi-object Bayes Filter - Sequential Monte Carlo Methods - Dempster-Shafer Theory - Multiple-Model Probability Hypothesis Density Filter (in Gaussian Mixture representation)

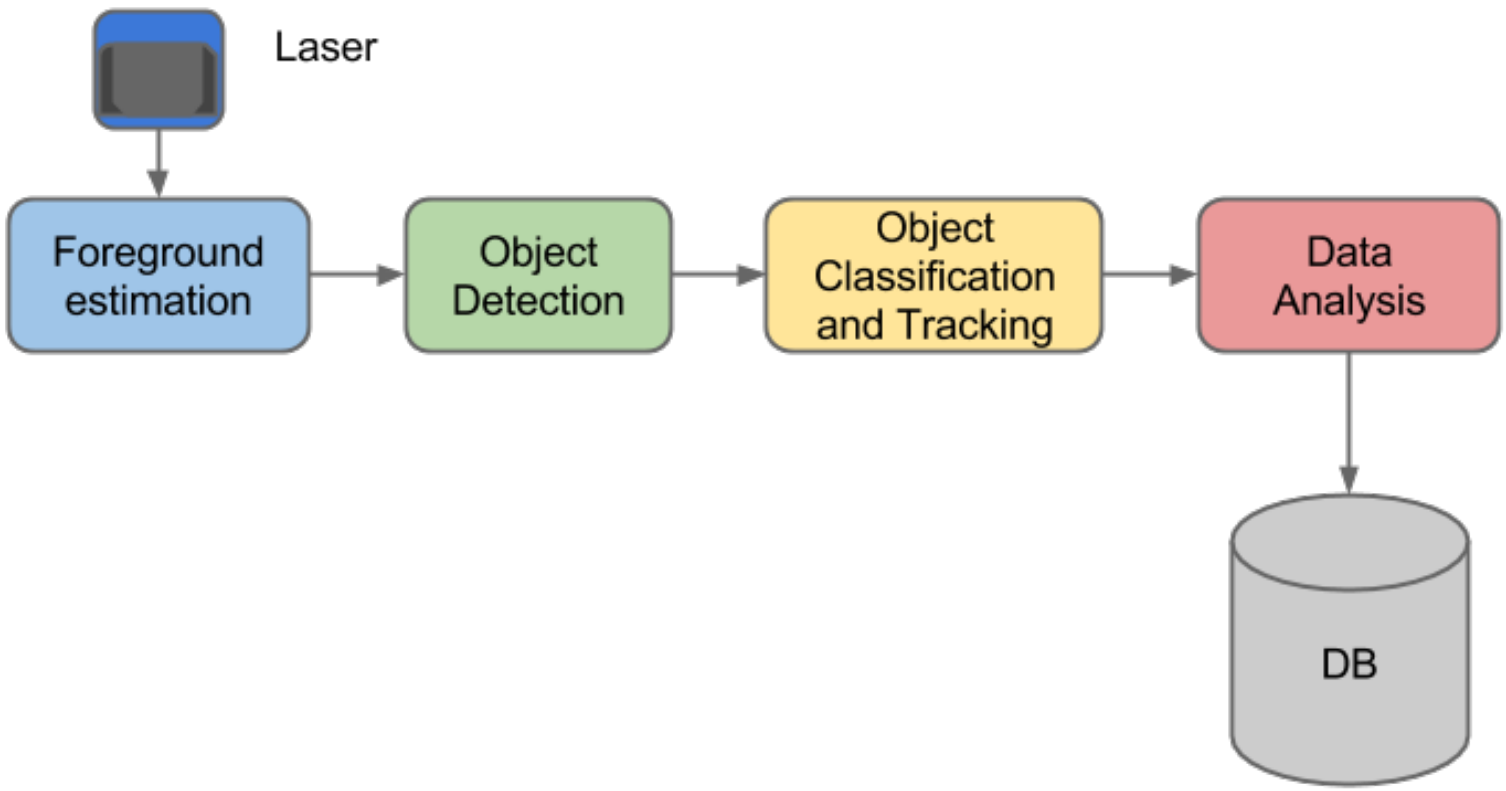
POSSi and PKU projects comparison

Typical System for one source of data

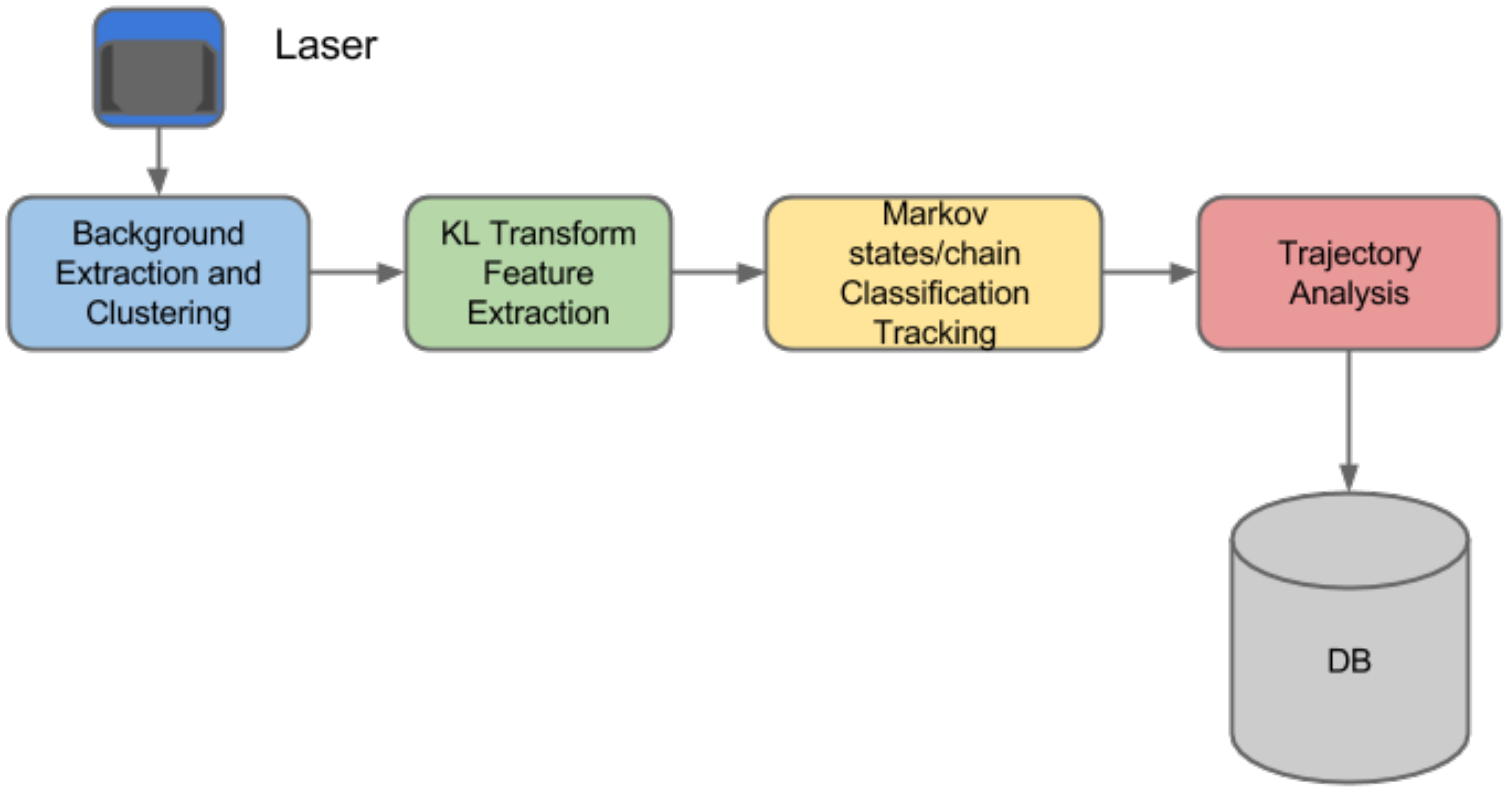


Single source system block diagram

Laser-Based System Block Diagram

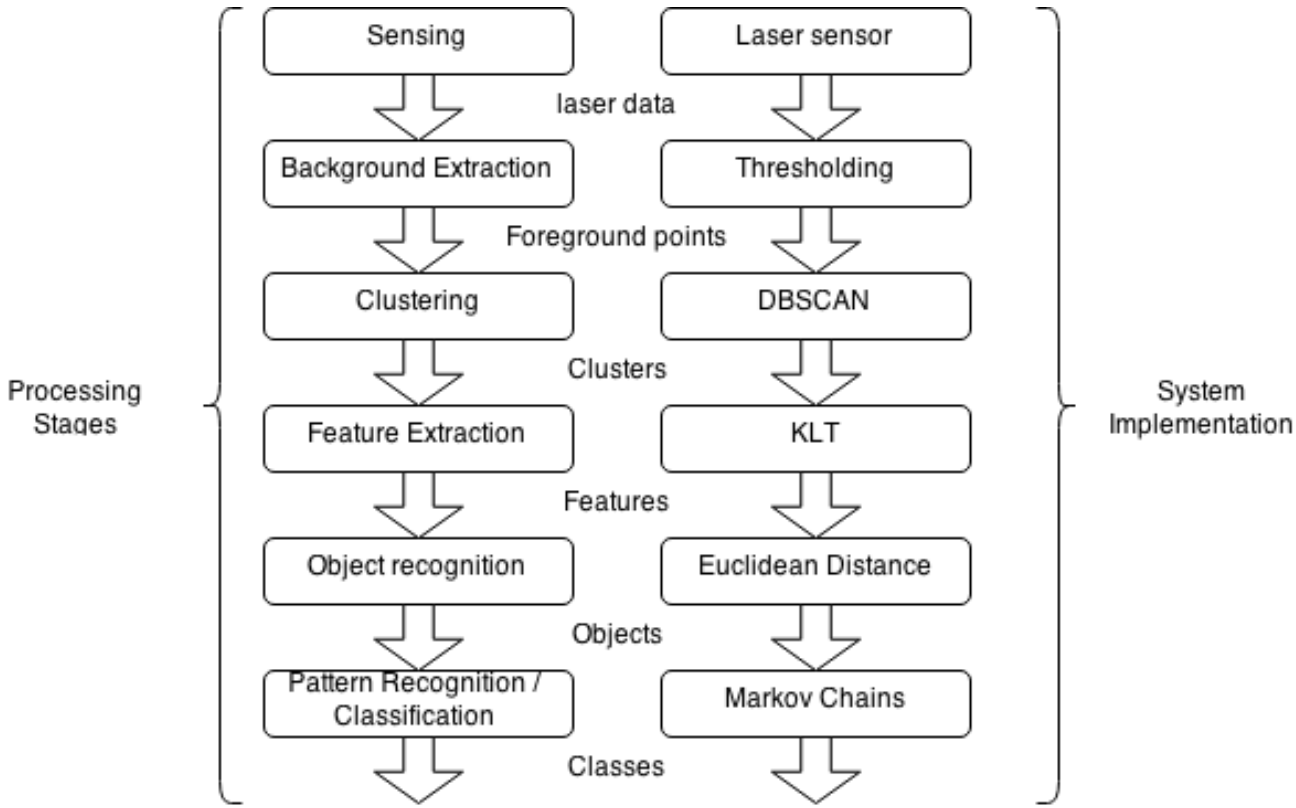


Laser-Based System Block Diagram



Based on [Zhao06]

System Description



Dataset

- Although datasets for both projects are available, POSS-i dataset was choosen.
- It includes laser readings from 6 laser-scanner located in different corners in an intersection.
- The duration of scanning is approximately 10 minutes.

Dataset

Capture of dataset viewer application [Zhao06]

Background Extraction

- Histogram-based background extraction
- Done for each angle
- When a pick value is detected, tells that an object is detected

Background Extraction

- Histogram-based background extraction
- Done for each angle
- When a pick value is detected, tells that an object is detected
- Dataset already includes a background model for each laser scanner

Clustering

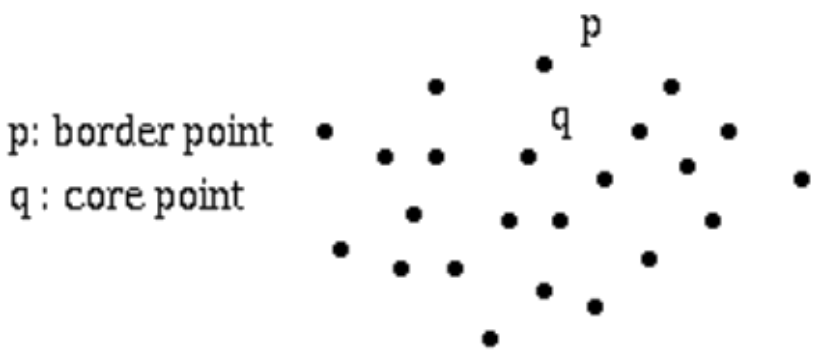
- In [Zhao06] it is not detailed how clustering was done, so DBSCAN is proposed to identify clusters in laser-data points

DBSCAN - Introduction

- Density-Based Spatial Clustering for Applications with Noise
- Proposed by Ester et al in 1996 in KDD conference [Ester96].

DBSCAN - Explanation

- The algorithm needs two parameters: *Eps*(ϵ) and *minPts*
- Also are defined two types of points: Core points and border points
- *p* is a core point if in its *Eps-Neighborhood* are at least *minPts* points.



Types of points [Ester96]

DBSCAN - Algorithm

- DBSCAN starts at an arbitrary point *p*, then evaluate if point's *Eps-Neighnorhood* contains at least *minPts* points
- If *True*, *p* is a core point (Is in a cluster)
  - Assign *clusterId* to p and its neighbour, and neighbours of its neighbours and so on.
  - Increase *clusterId*.
- If *False*, *p* is labelled as Noise
- Continue with an unlabelled point, until all points in dataset are labelled.

Clustering

Clustering

Clustering

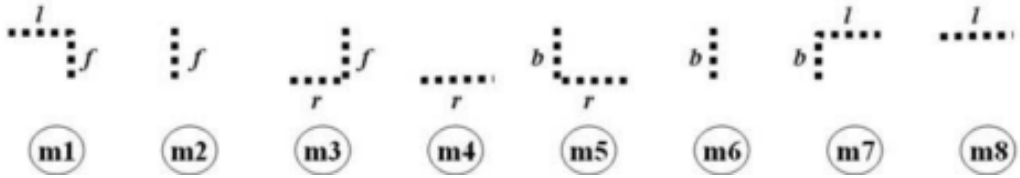

More on clustering in ...
UNSUPERVISED
LEARNING
COMING SOON
2014.11.28

Definitions

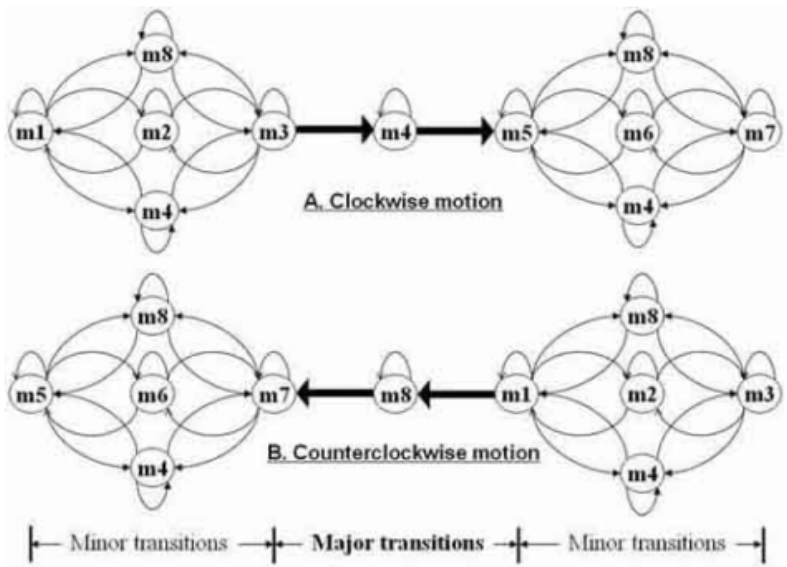
- Classes are proposed based on distribution of points in clusters
- Karhunen-Loeve Transform to detect number of axis

Objects in cross road	Example of laser data					Class definition
	t_1	t_2	t_3	t_4	t_5	
car						2-axis
bicycle						1-axis
pedestrian						0-axis

Markov States



There are 8 patterns that can happen



Possible transitions

Features

- Normal Vectors
- Number of axis
- Axis lengths
- Directional vector, Motion speed
- Markov States

Classification and Tracking

- Classification and tracking stages are under review

Next Steps

- Implement Dataset handler
- Implement Clustering and KL Transform to classify in 0, 1 or 2 axis object
- Get features from objects and obtain trajectory

References

Elmenreich07 Elmenreich, W. **A Review on System Architectures for Sensor Fusion Applications**. *Software Technologies for Embedded and Ubiquitous Systems Lecture Notes in Computer Science Volume 4761 (pp. 547–559)*. 2007.

Esteban12 Esteban, J. et al, **A Review of data fusion models and architectures: towards engineering guidelines**. *Neural Computing and Applications, 14(4),(pp. 273–281)*. 2012.

Ester96 Ester, M. et al. **A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise**. *Proceedings of 2nd International Conference on Knowledge Discovery and Data Mining (KDD-96)*. 1996.

Goldhammer12 Goldhammer, M. et al, **Cooperative multi sensor network for traffic safety applications at intersections**. *2012 15th International IEEE Conference on Intelligent Transportation Systems (pp. 1178–1183)*. 2012.

References

Khaleghi11 Khaleghi, B. et al, **Multisensor data fusion: A review of the state-of-the-art**. *Information Fusion, 14(1) (pp. 28–44)*. 2011.

Luo02 Luo, R. C. **Multisensor fusion and integration: approaches, applications, and future research directions**. *IEEE Sensors Journal, 2(2), 107–119*. 2002

Luo11 Luo, R. C. et al. **Multisensor Fusion and Integration: Theories, Applications, and its Perspectives**. *IEEE Sensors Journal, 11(12), 3122–3138*. 2011.

Meissner10 Meissner, D. and Dietmayer, K. **Simulation and calibration of infrastructure based laser scanner networks at intersections**.*2010 IEEE Intelligent Vehicles Symposium, 670–675*. 2010.

References

Meissner12 Meissner, D., Reuter, S., and Dietmayer, K. **Real-time detection and tracking of pedestrians at intersections using a network of laserscanners**. *2012 IEEE Intelligent Vehicles Symposium, 630–635*. 2012.

Meissner13a Meissner, D., Reuter, S., and Dietmayer, K. **Road user tracking at intersections using a multiple-model PHD filter**. *2013 IEEE Intelligent Vehicles Symposium (IV), (Iv), 377–382*. 2013.

Meissner13b Meissner, D. et al. **Road User Tracking Using a Dempster-Shafer Based Classifying Multiple-Model PHD Filter**. *Information Fusion (FUSION), 2013 16th International Conference on (Vol. 32, pp. 1236–1242)* 2013.

Meissner13c Meissner, D., Reuter, S., and Dietmayer, K. **Combining the 2D and 3D world: a new approach for point cloud based object detection**. *IET Intelligent Signal Processing Conference 2013 (ISP 2013) (pp. 4.1–4.1)*. 2013.

References

Meissner14 Meissner, D. et al. **Intersection-Based Road User Tracking Using a Classifying Multiple-Model PHD Filter**. *IEEE Intelligent Transportation Systems Magazine, 6(April 2014), 21–33*.2014.

Song08 Song, X. et al. **Bayesian fusion of laser and vision for multiple People Detection and tracking**. *2008 SICE Annual Conference, 3014–3019*. 2008.

Song13a Song, X. et al. **Laser-based tracking of multiple interacting pedestrians via on-line learning**. *Neurocomputing, 115, 92–105*. 2013.

Song13b Song,X. et al. **An Online System for Multiple Interacting Targets Tracking: Fusion of Laser and Vision, Tracking and Learning**. *ACM Transactions on Intelligent Systems and Technology*. 2013.

References

Strigel13 Strigel, E., Meissner, D., and Dietmayer, K. **Vehicle detection and tracking at intersections by fusing multiple camera views**. *2013 IEEE Intelligent Vehicles Symposium (IV) (pp. 882–887)*. 2013.

Zhao06 Zhao, H., and Shibasaki, R. **Joint tracking and classification of moving objects at intersection using a single-row laser range scanner**. *In Proceedings of the IEEE Intelligent Transportation Systems Conference (pp. 287–294)*. 2006.

Zhao08 Zhao, H. et al. **Monitoring an intersection using a network of laser scanners**. *Proceedings of the11th International IEEE Conference on Intelligent Transportation Systems (pp. 428–433)*. 2008.

Zhao09 Zhao, H., Cui, J., and Zha, H. **Sensing an Intersection Using a Network of Laser Scanners and Video Cameras**. *IEEE Intelligent Transportation Systems Magazine, 31–37*. 2009.

Zhao12 Zhao, H. et al. **Detection and Tracking of Moving Objects at Intersections Using a Network of Laser Scanners**. *IEEE Transactions on Intelligent Transportation Systems, 13(2), 1–16*.