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

Gustavo Velasco-Hernández

Pattern Recognition, 2014

Context

Master's Research Project: Multisensor Architecture for a Vehicular Intersection Management System

Transportation Systems

Issues in traditional transportation systems

- Congestion
- Traffic rules violation
- Vehicle interaction

Transportation Systems

Issues in traditional transportation systems

- Congestion
- Traffic rules violation
- Vehicle interaction

Intersections are critical places in transportation systems

Intelligent Transportation Systems

Objectives of ITS

- Increase safety
- Increase efficiency
- Reduce costs

Intersection Management Systems

Tasks

- Traffic Monitoring
- Traffic Management
- Warning Advertisement

Intersection Scenario

Pedestrians, Vehicles (Cars, Two-wheeled vehicles, Big vehicles)

Recognition, Classification, Tracking

Incident detection, Intersection Management

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.
- [New!] Just one laser.

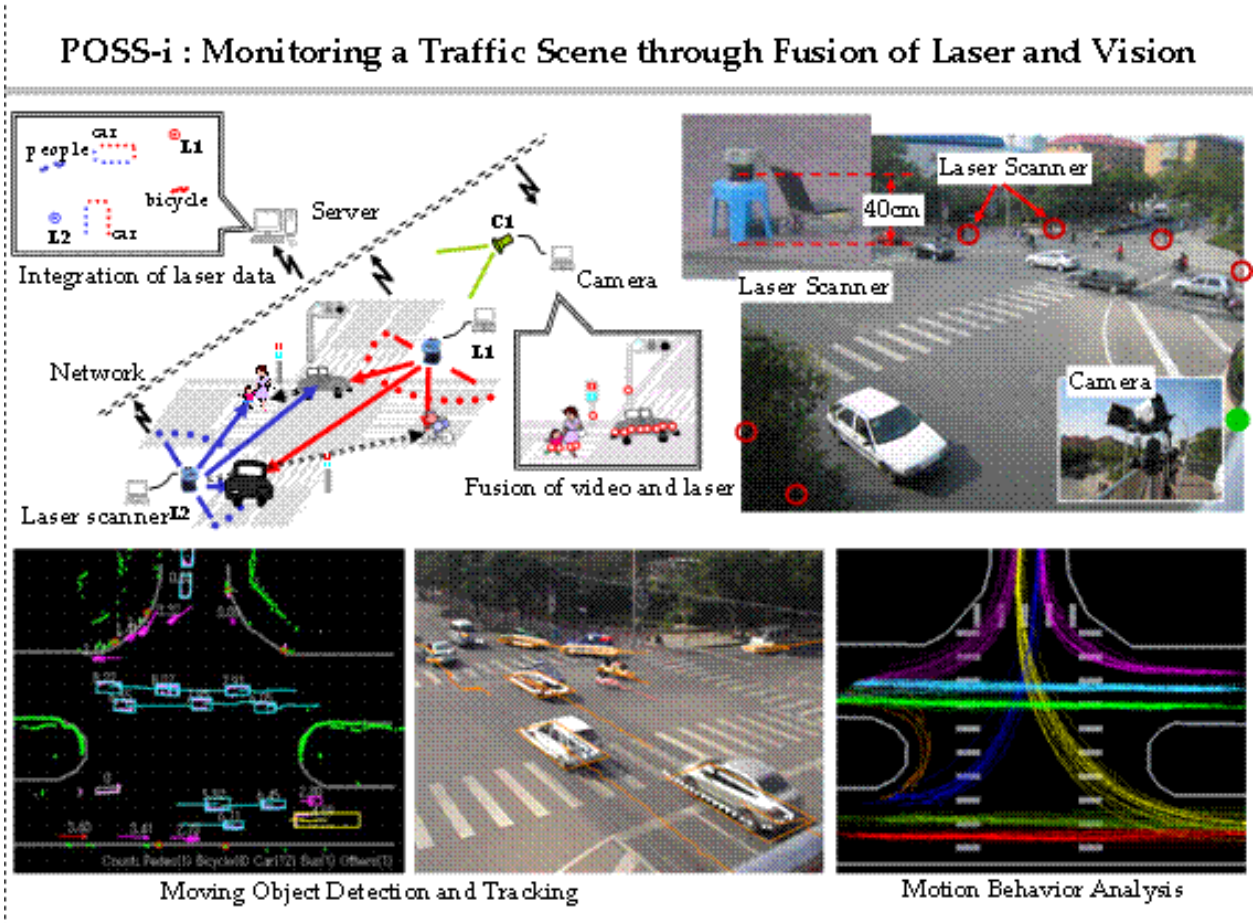
Research Groups

- PKU Omni Smart Sensing (POSS) Research group at Peking University (POSS-i project)
- Institute of Measurement, Control and Microtechnology at Ulm University (Ko-PER program)

PKU Omni Smart Sensing (POSS)

- POSS is leaded by Prof. Huijing Zhao, Ph.D.
- Focus on perception technologies using an intelligent vehicle, a network sensing system or a collaboration of them

POSS-i

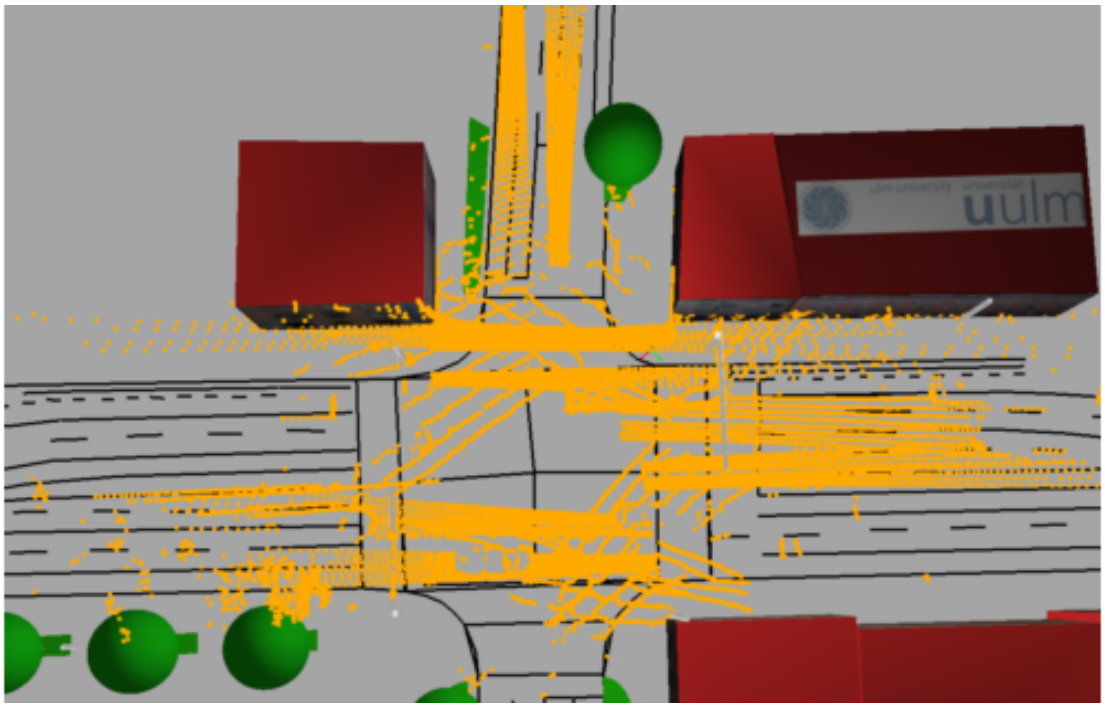


POSS-i project. [Zhao09][Zhao12][Song13b]

Ko-PER

- Ko-PER from Cooperative Perception
- Included in Forschungsinitiative Ko-FAS from Bundesministerium für wirtschaft und Technologie (Germany)
- Cooperative and collaborative sensors system for perception and preventive road safety.
- Daniel Meissen from Ulm University as leader researcher.

Projects



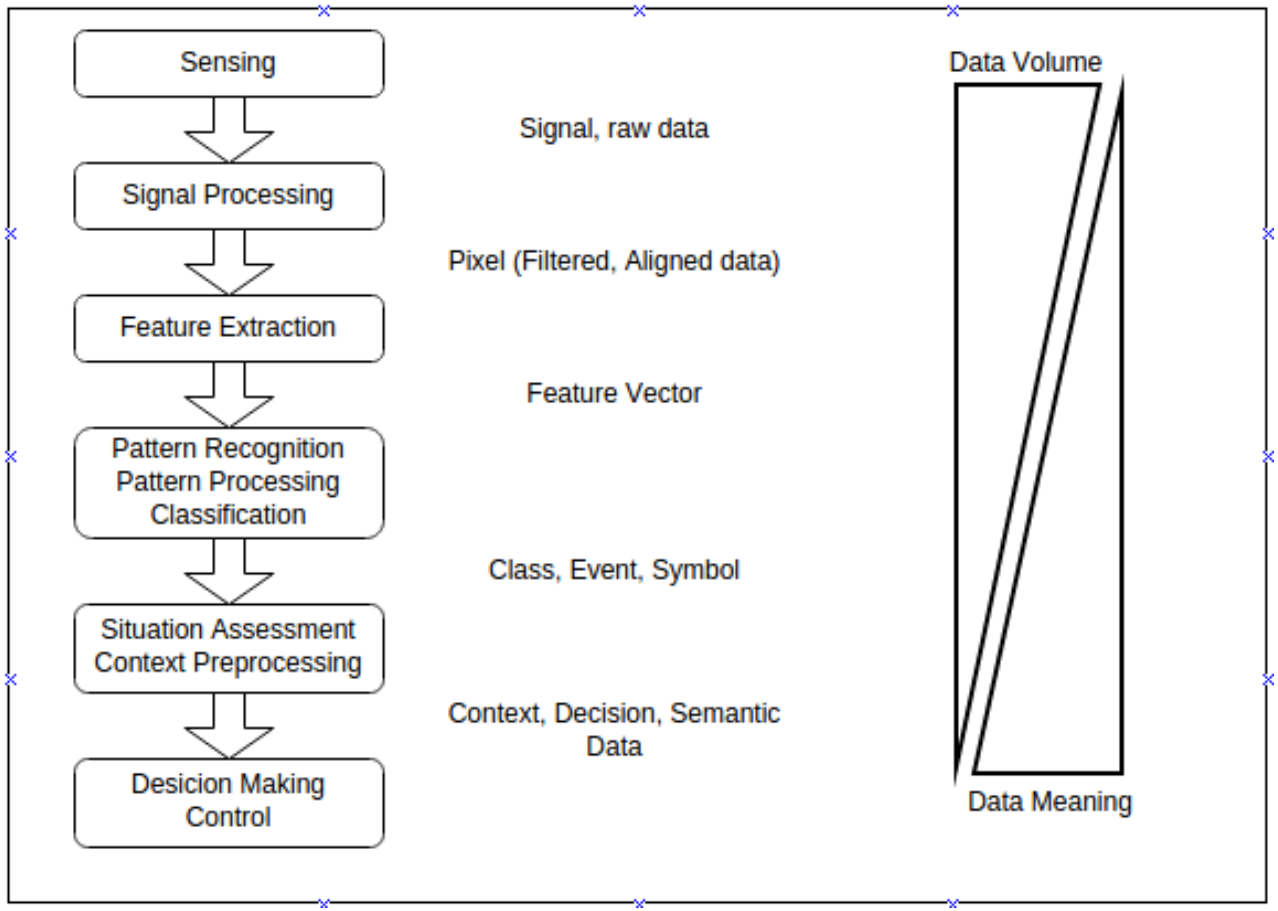
3D-recreated intersection scene with laser beams depicted [Meissner12, 13a, 13b, 13c, 14][Striegel13]

Applications, Methods and Techniques

Project	POSSi	Ko-PER
Applications	Recognition, Classification and Tracking of Vehicles and Pedestrians	
Methods and Techniques	- Clustering - 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)

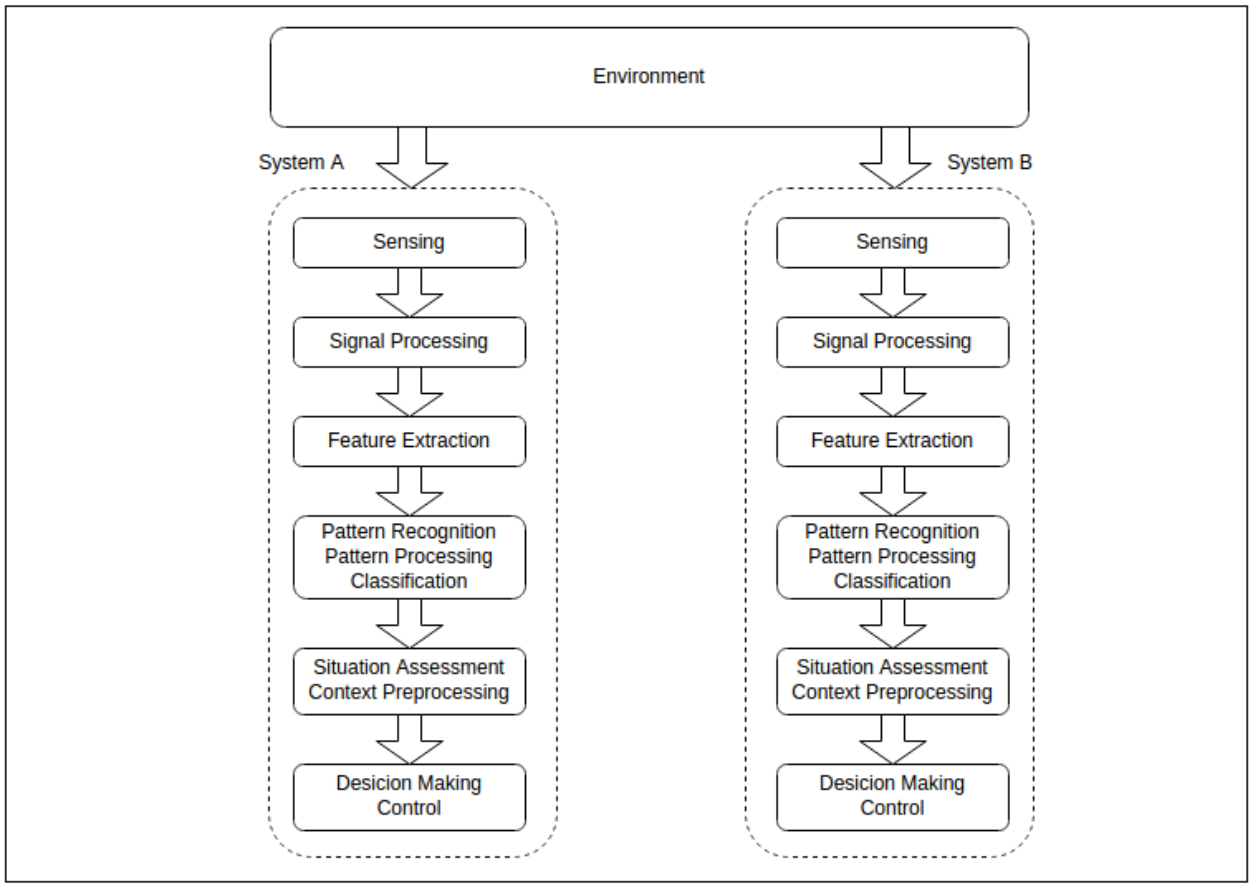
POSSi and PKU projects comparison

Typical System for one source of data



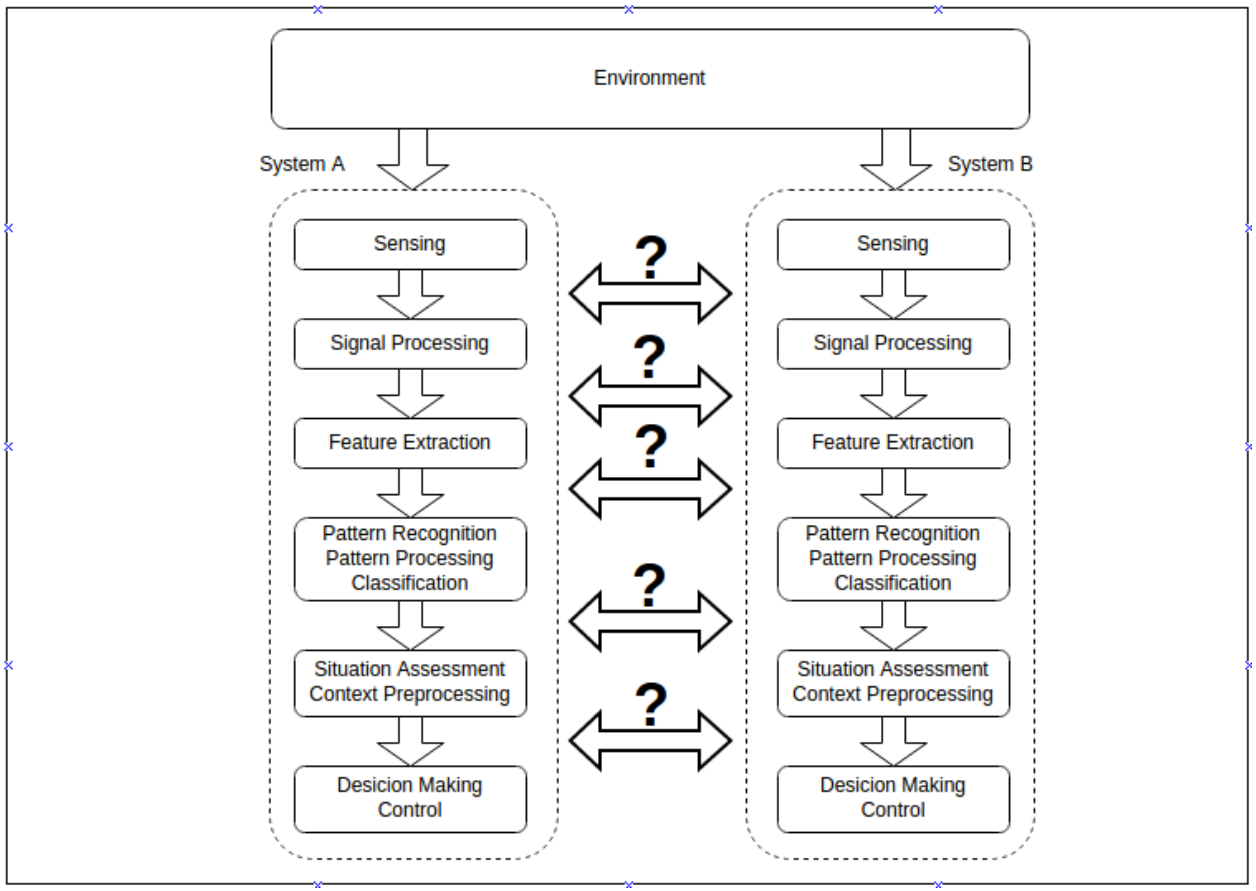
Single source system block diagram

Multisensor Data System



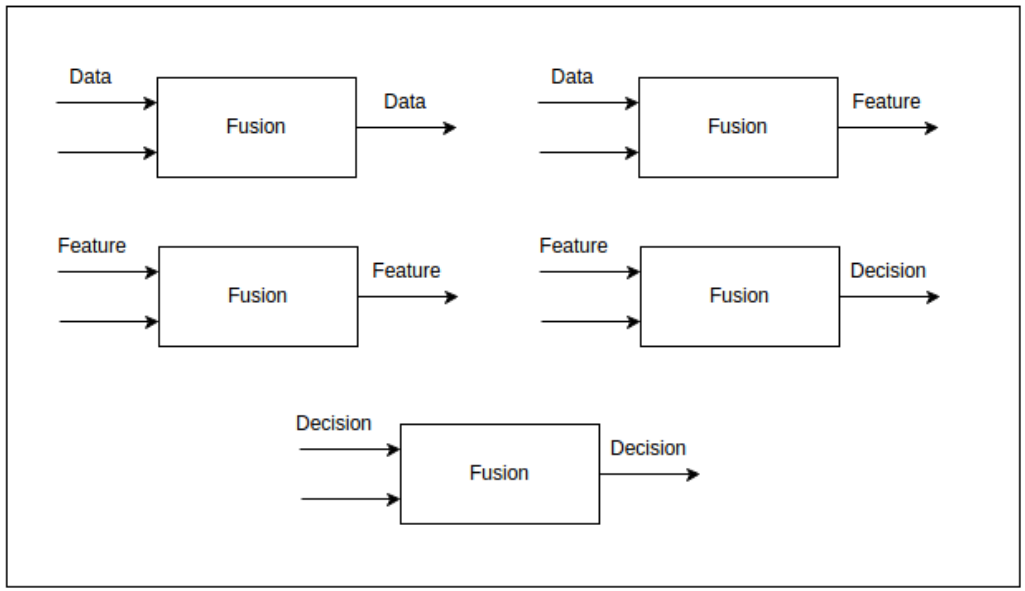
Multisensor system block diagram

How to fuse information?



Multisensor system block diagram

Fusion Levels



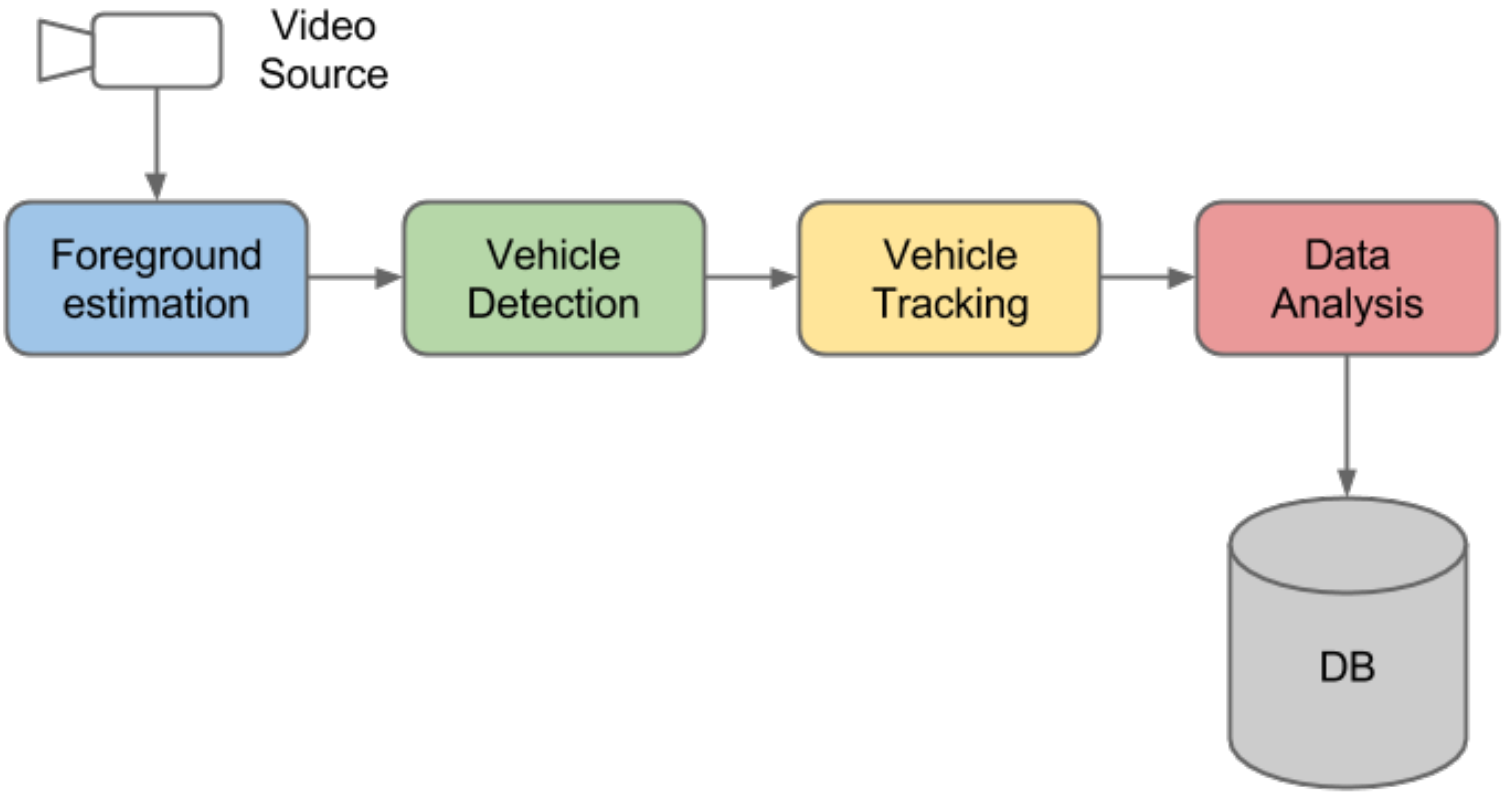
Fusion Levels [Luo11]

Fusion Algorithms

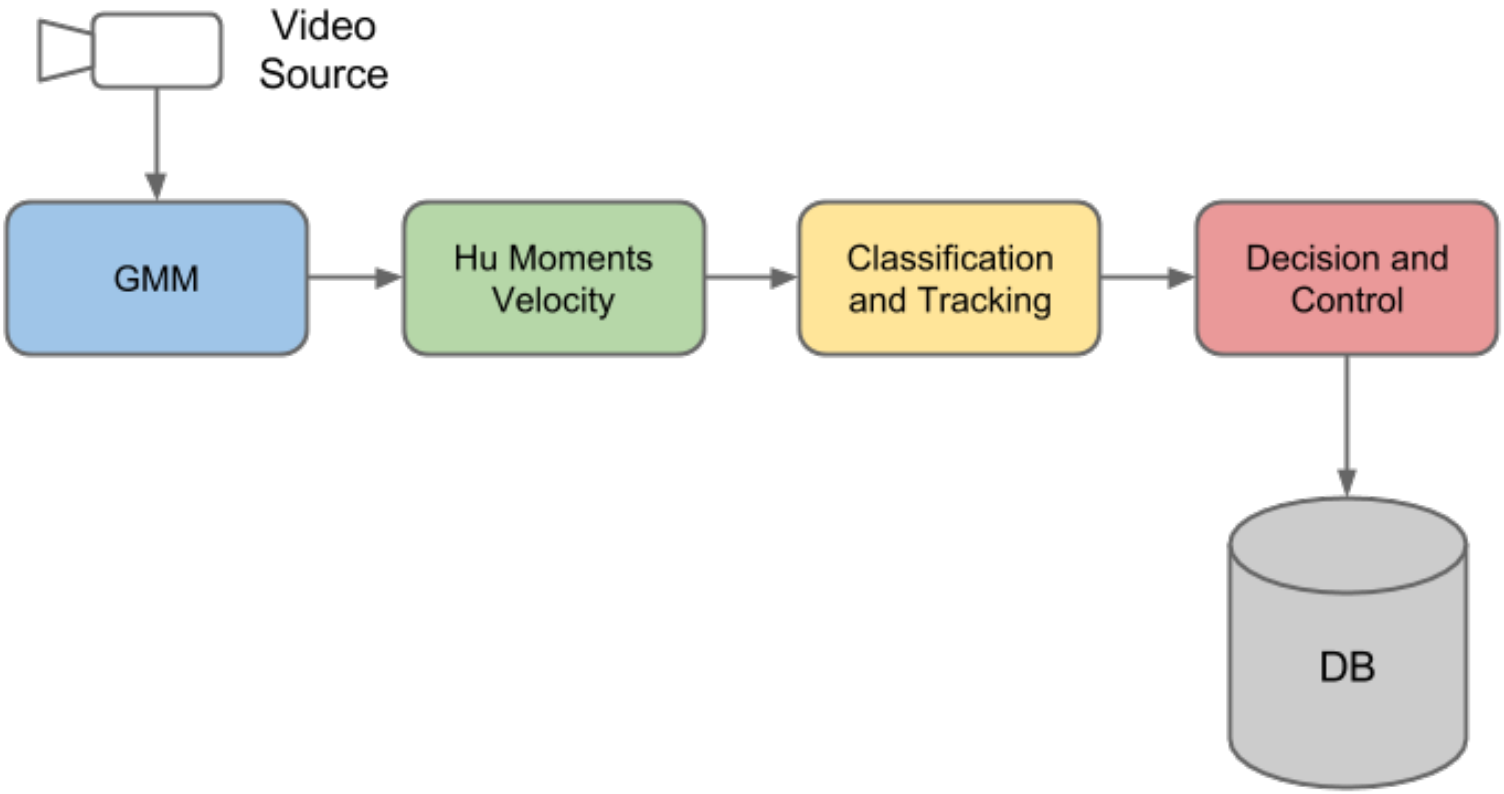
Low level fusion		Medium level fusion	High level fusion
Estimation methods		Classification methods	Inference methods
Recursive: • Kalman filter • Extended Kalman filter Non-recursive: • Weighted average • Least squares	Covariance-based: • Cross covariance • Covariance intersection • Covariance union	• Parametric templates • Cluster analysis • K-means clustering • Learning vector quantization • Kohonen feature map • Artificial neural network • Support vector machines	• Bayesian inference • Particle filters • Dempster-Shafer theory • Expert system • Fuzzy logic

Classification of Fusion Algorithms [Luo11]

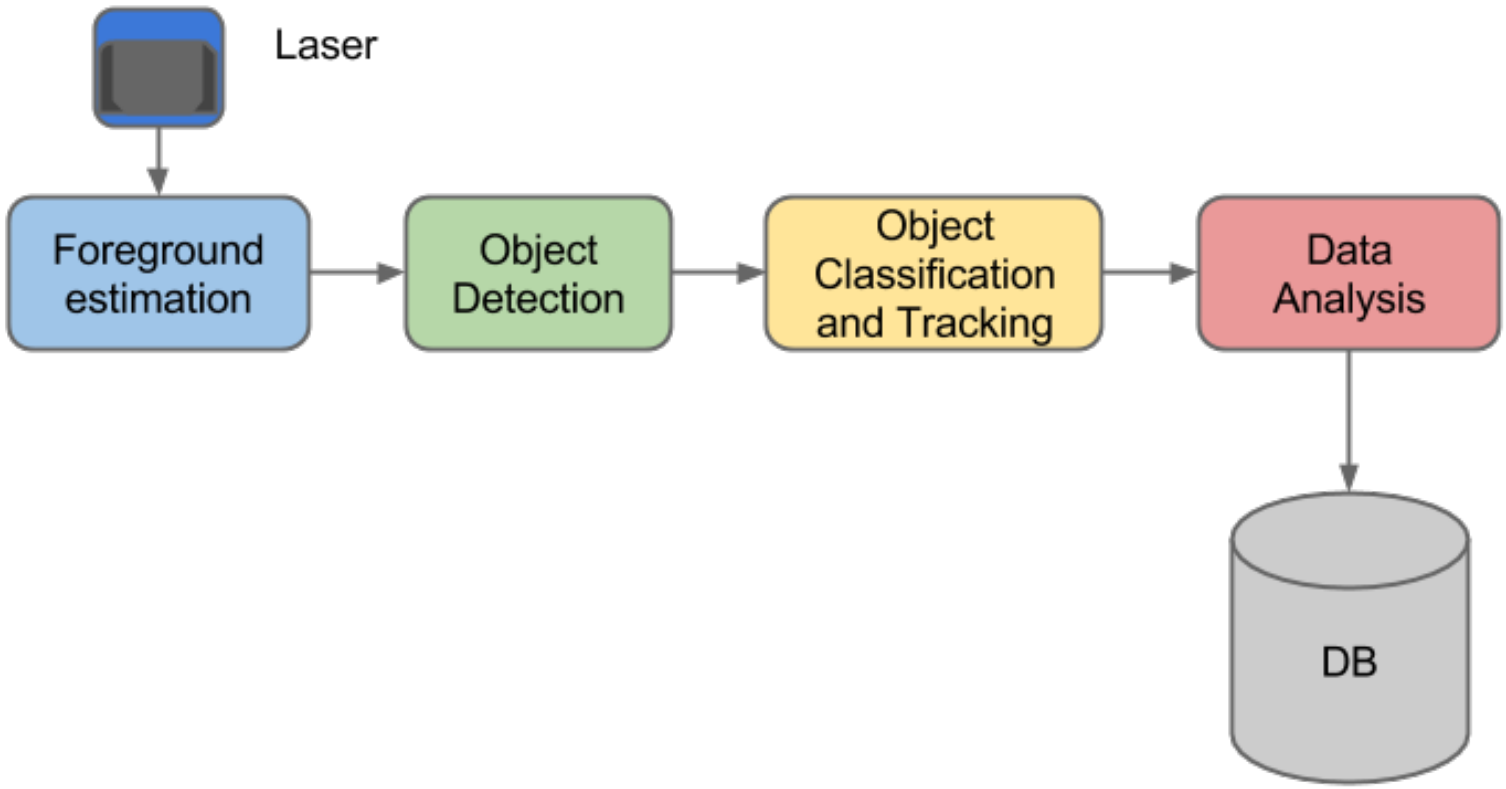
Video-Based System Block Diagram



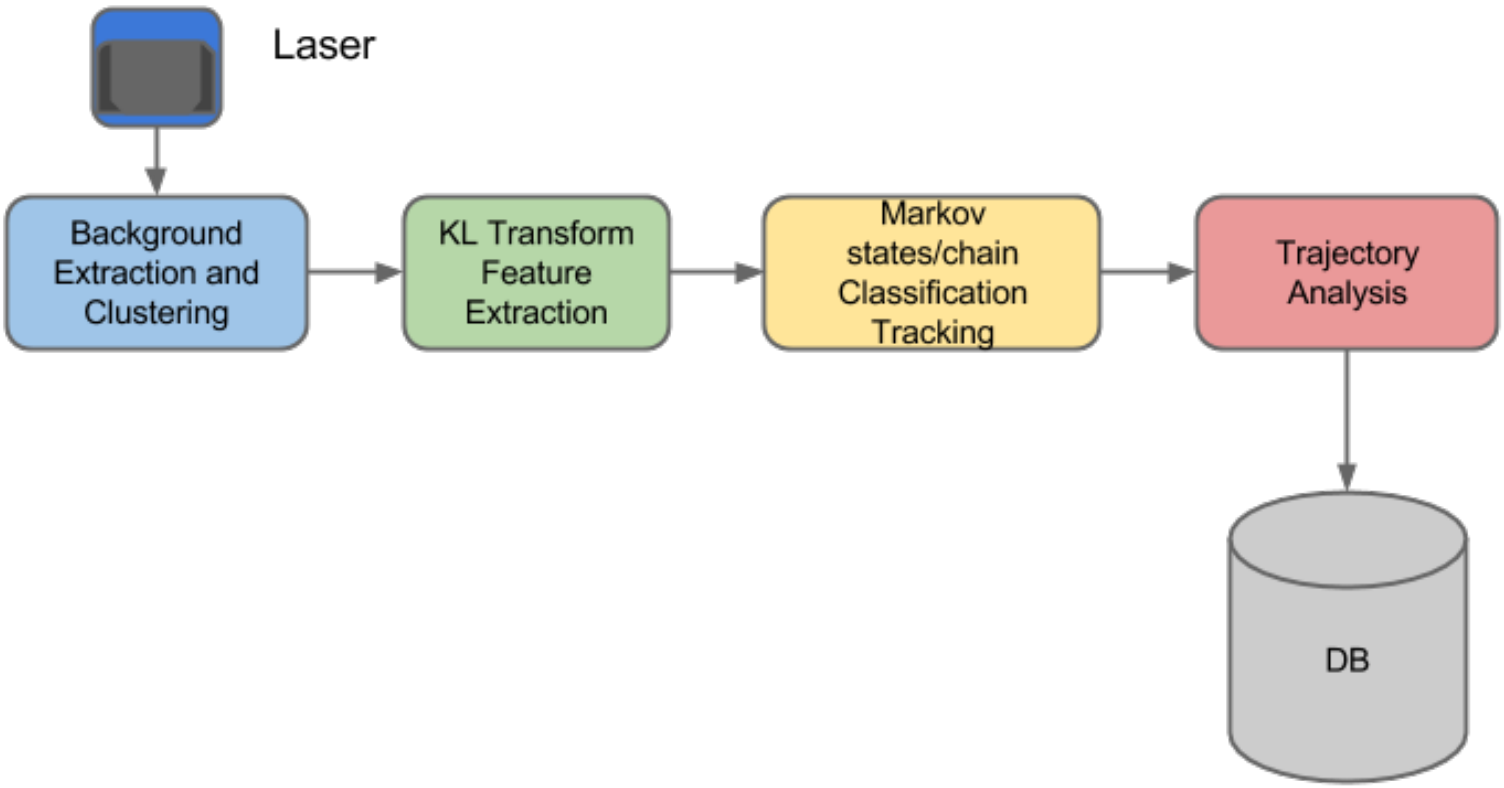
Video-Based System Block Diagram



Laser-Based System Block Diagram



Laser-Based System Block Diagram



Based on [Zhao06]

Background Extraction

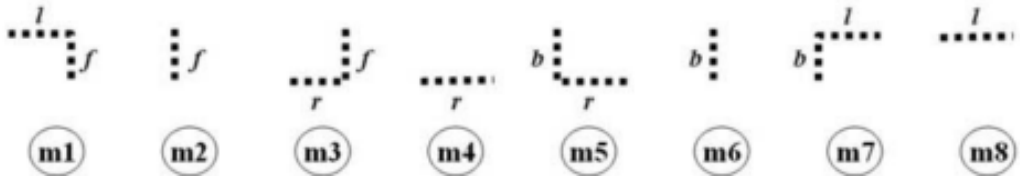
- Histogram-based background extraction
- Done for each angle
- When a pick value is detected, tells that an object is detected

Classification

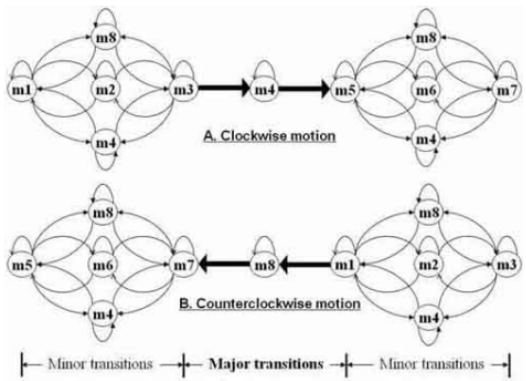
- Classes are proposed based on distribution of points in clusters
- Karhunen-Loeve Transform to detect number of axis

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

Dataset

Capture of application [Zhao06]

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

Clustering

Clustering

Clustering


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

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.

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.

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

References

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.

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.

References

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.

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.

References

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.

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.

References

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*. 2012.