MC IMPULSE SUMMER SCHOOL

OCTOBER 11-13, 2010

LINKÖPING UNIVERSITY

MONDAY OCTOBER 11
Internal presentations

Glashuset, House B, Entrance B25

Get together day for ESR and ER.

Presentations of individuals and projects.

See separate programme.

TUESDAY OCTOBER 12
Tutorials

Glashuset, House B, Entrance B25.
Session 1:

09:00-12:00	**Bayesian Tracking and Data Fusion** Martin Ulmke
10:00-10:20	Break for coffee
12:00-13:00	LUNCH

Session 2:

13:00-15:00	**Particle Filter Theory and Practice** Fredrik Gustafsson
15:00-15:15	Coffee
15:15-16:30	**Sequential Monte Carlo Methods for Localization** Ludmila Mihaylova
17:00-	Dinner and visit at the recently reopened aircraft museum

WEDNESDAY OCTOBER 13
Joint McImpulse and CADICS Workshop

Bus leaves from First Hotel 07:50 to Norrköping.
The bus makes a stop at the University at 08:00.

Session 1 in K1

09:00-09:10	**Welcome and Introduction** Fredrik Gustafsson
09:10-10:00	**Target Tracking without Tears** Neil Gordon
10:00-10:20	Coffee

Session 2 in K3

10:20-11:10	**Distributed Particle Filtering and Incident Detection for Traffic Network** Rene Boel
11:10-11:35	**Particle Filtering for Vehicle Positioning** Rickard Karlsson
11:35-12:00	**Statistical Sensor Fusion Meets Vision** Gustaf Hendeby
12:00-13:00	LUNCH at Visualiseringscenter

Session 3 in the Dome

13:00-14:00	Panel discussion on future challenges in particle filtering
14:15-15:15	Dome presentation
15:15-15:30	Coffee
15:30-16:00	**Sensor Fusion: from Navigation to Collision Avoidance** Fredrik Gustafsson
16:00-16:30	**UAV Research at LiU** Patrick Doherty
16:30-17:00	**Visualization Research at LiU** Anders Ynnerman
17:30	Bus leaves to Linköping

ABSTRACTS

Neil Gordon, DSTO, Australia

Target tracking without tears

Target tracking is a vital element of surveillance systems, whose role is to determine the number, position and movement of targets. The fundamental building block of a tracking system is a filter for recursive target state estimation from new sensor data arriving sequentially in time. The apparent simplicity of Bayes' theorem as the key computational mechanism to solve this problem hides the difficulties of implementing a solution to any but the simplest of problems. The elegance of the Kalman filter comes at the cost of pretending to live in a linear Gaussian world. Once forced to accept the reality of the nonlinear, non-Gaussian world you quickly realise the limitations and frustrations of the Kalman framework. In the late 80s sophisticated Monte Carlo techniques emerged which, coupled with the vast increase in available computational power, led to a powerful new Bayesian toolkit. Out of this grew the particle filter based approach to dynamic estimation and target tracking problems.

In this talk I will describe the surveillance problem and discuss some of the difficulties encountered in automatic target tracking. I will review the historical development and current status of particle filtering and its relevance to target tracking. We will then consider in detail several applications where conventional (Kalman based) methods appear inappropriate (unreliable or inaccurate) and where we instead need the potential benefits of particle filters.

René Boel, SYSTeMS Research group, Ghent University

Distributed Particle filtering and incident detection for traffic network

This talk will introduce several simple, stochastic, models for road traffic (both freeway traffic and urban traffic). Each of these models gives rise to simple distributed simulation tools for the dynamic behavior of road traffic. On-line measurements of the traffic (sensors detecting the passage times of vehicles at some locations in the network) are available, and can be used as input for a particle filter.

This talk will explain how the simulators can be used in order to define the state update step in a particle filter. Models of the sensors on the other hand define the Bayesian measurement update steps in the particle filter. Experiments have shown that simulator and particle fitler tools are sufficiently fast to obtain estimates of the current traffic state (density and speed of vehicles at different location along the freeway, or queue sizes behind traffic lights). This talk will also explain how this particle filter can be decomposed in small interacting, local particle filters thanks to the distributed nature of the traffic model, and the locality of the measurements.

Finally the talk will discuss how these particle filters can be used for incident detection (changes in road capacity due e.g. to accidents), and how the results of particle filtering can be used for traffic control (on-ramp metering or switching of traffic lights).

Rickard Karlsson, Nira Dynamics AB

Particle Filtering for Vehicle Positioning

Nira Dynamics is specialized in sensor fusion and signal processing applications and algorithms for the automotive industry. The main product is TPI, which is an indirect Tire Pressure Monitoring System (TPMS). It uses sensor fusion and advanced signal processing algorithms for real-time tire pressure monitoring. In addition to this, a prototype system for GPS-free navigation has been developed. The Map Aided Positioning (MAP) system uses information from the vehicle's CAN-bus (wheel speed and yaw rate) together with vectorized road-maps to deduce the vehicle's position.

This Particle Filter (PF) based navigation system is fully compliant with TPI data logging, and can be used separately in real-time or for off-line evaluation.

For sufficiently varied road-maps the performance is similar to that of a normal GPS. For everyday usage a combination between GPS and MAP is the most promising, where GPS performance degradation due to multi-path and signal failure due to obstacles can be mitigated.

The system has also been tested using an IMU (Inertial Measurement Unit) as a complement or in combination with wheel speed signals. Map aided positioning can also be used for deflation estimation or wheel radius estimation, where an efficient Rao-Blackwellized PF (RBPF) implementation enables real-time performance.

ABSTRACTS

Gustaf Hendeby, DFKI, Kaiserslautern University

Statistical Sensor Fusion Meets Vision

The Augmented Vision department at German Research Center for Artificial Intelligence (DFKI) is a young research group already having many interesting projects, ranging from object detection and reconstruction to tracking of objects and ego-motion using both vision information and inertial measurement units (IMUs). Which of the standard statistical sensor fusion and particle filtering ideas can be brought to this setting? And how can it be done?

This talk does not attempt to answer these questions, instead it will show what type of applications the Augmented Vision group works with, not limited to current particle filter applications, but also including examples where particle filtering techniques could be useful.
These projects will then be used to exemplify the potential of particle filtering methods, and draw parallels to the more theoretical work I did while still being a PhD student in Linköping.

Panel discussion

The panel members will first make short statements of their favorite topics and wish lists for the future research, and then an open discussion follows

Patrick Doherty, Prof in Computer Science,Linköping University

UAV research at LiU

Unmanned aerial vehicles (UAV) are very well suited to solve a wide range of surveillance missions in both safety and security applications. The presentation gives an overview of the past 15 years development of AUV systems, including navigation and tracking algorithms as well as high level algorithms from the artificial intelligence area. Many successful demonstrators will be surveyed.

Fredrik Gustafsson, Prof in Sensor Informatics, Linköping University

Sensor Fusion: from navigation to collision avoidance

The presentation gives a tour on selected projects in the sensor fusion group and uses application examples to illustrate the development of the research field in general in areas relating to navigation, tracking, mapping and path planning.

Anders Ynnerman, Prof in Technical Visualization, Linköping University

Visualization research at LiU

Many real world systems for tracking, mapping and surveillance generate enormous data sets. Scientific visualization is aimed at making humans understand what information is contained in data. The presentation overviews many exciting areas, from human body to universe mapping, where visualization has been successful, utilizing the technical features of the dome.