NAVIGARE 2010 - GNSS in ITS: the way of co-operation

NEARCTIS: Excellence in co-operative traffic management, role of technologies

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Agenda

• The network of excellence NEARCTIS
  – Context & goal of the project
  – Research programme
  – Resources & associate partners
• Traffic management
  – Traffic control cycle
  – Basics micro-macro variables
• Role of technologies
• Requirements in positioning
• Positioning technologies
• Positioning quality
• Research prospects
NEARCTIS

• NEARCTIS: Excellence in co-operative traffic management
  – A 7th framework programme, Network of excellence, Theme 3, ICT
    • Integrating and strengthening the European Research Area
  – Gathering academic research on traffic management (traffic modelling, traffic control, communication and positioning technologies)

NEARCTIS – Core Partners

• INRETS France, French National Institute for Transport and Safety Research, Scientific Coordinator
• ERT France, Europe Research Transport, Management coordinator
• TUDelft Netherlands, Technical University of Delft
• DLR Germany, Deutsches Zentrum für Luft und Raumfahrt
• University of Southampton, United Kingdom
• UCL United Kingdom, University College London
• Imperial College London, United Kingdom
• EPFL Switzerland, Ecole Polytechnique Fédérale de Lausanne, Labs: LAVOC – TRANSP-OR, TOPO
• Technical University of Crete, Greece
NEARCTIS - Goals

• To create a virtual research institute
  – Integrated research programme
  – Common shared resources
  – Policy and structure for results and dissemination
  – Integration of training capabilities

• To ensure a strong link between the core network and associate partners
  – Academic, stakeholders of traffic, industry

NEARCTIS – Research Programme

• Elaborating a common and consistent research programme
  – Various scientific fields
    • Modelling, optimization and control, and evaluation
    • Communication, positioning and tracking
    • Deployment and implementation issues
  – Various systems implementation field
    • Motorway corridors
    • Dense urban network
    • Global Services: information based on co-operative systems
NEARCTIS – Resources

• Common resources
  – Developing a set of shared resources: databases, software, experimental tracks,…

• Education, Training and dissemination
  – Researchers’ mobility and training
  – PhD grants
  – Workshops, summers schools
  – Web site: http://www.nearctis.org

NEARCTIS – Summer school
  – EPFL, June 2010
  – 40 participants
  – 6 instructors

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<th>Date</th>
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<th>Lecturer</th>
<th>Lecture Title</th>
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<td>Welcome</td>
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<td>Lecture 1</td>
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<td>Traffic state estimation</td>
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<td>Urban traffic control and bus priority</td>
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<td>9:00-16:00</td>
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<td>Towards new research area in co-operative traffic management</td>
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Objectives:
The objectives of this summer school are:
1. To provide an opportunity for young researchers and professionals to acquire knowledge on the basics of road network state estimation, modelling and control and
2. To allow trainees to get insight on possible implications of these basics in their own research and application field.
NEARCTIS – Associate Partners

• Close integration of partners:
  – International academic community
  – Scientific community
  – Professional community: car manufacturers, traffic systems manufacturers, consultants
  – Traffic management authorities and road operators

• Involvement of partners
  – Easy access to information disseminated by the project
  – Participation in networking activities
  – Specific access to resources shared by the network
  – Attend NEARCTIS workshops

• Interested? Please become AP of NEARCTIS

The traffic control cycle

Source: NEARCTIS-COST TU0702 Summer school “Real time road traffic monitoring and control”, June 9-11, EPFL, Lausanne
Acknowledgements: Prof. Hans-Van Lint (TuDelft)
The traffic/transport/transit control cycle

- **Actuators**: Any traffic, transport, transit system
- **Sensors / detectors**: (a) state estimation, (b) state prediction, (c) optimization
- **Goals**: Any consistent set of assumptions / models
- **Control / measures**: All (control application) relevant inputs, boundary conditions & parameters
- **Historical Database**: Data processing / data fusion

**Sources**: NEARCTIS-COST TU0702 Summer school “Real time road traffic monitoring and control”, June 9-11, EPFL, Lausanne

Acknowledgements: Prof. Hans-Van Lint (TuDelft)

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**The basics – micro and macro variables**

- **Density** \( \rho \) is an instantaneous variable

**Equation**: 

\[
\rho = \frac{n}{X} \approx \frac{1}{n} \sum_{i=1}^{n} s_i
\]

**Source**: NEARCTIS-COST TU0702 Summer school “Real time road traffic monitoring and control”, June 9-11, EPFL, Lausanne

Acknowledgements: Prof. Hans-Van Lint (TuDelft)
The basics – micro and macro variables

Time period $T$

Density (veh/m, instantaneous variable)
\[ \rho = \frac{n}{X} \approx \frac{1}{n} \sum h_i \]

Flow (veh/s, local variable)
\[ q = \frac{m}{T} \approx \frac{1}{m} \sum h_i \]

Traffic Management

Edie’s generalized definitions for flow and density:
\[ \rho = \frac{\sum t_i}{TX} \]
\[ q = \frac{\sum d_i}{TX} \]

Spatiotemporal variables

Source: NEARCTIS-COST TU0702 Summer school "Real time road traffic monitoring and control", June 9-11, EPFL, Lausanne
Acknowledgements: Prof. Hans-Van Lint (TuDelft)
The basics – micro and macro variables

Time period $T$

Density (veh/m, instantaneous variable)

$$k = \frac{n}{X} \approx \frac{1}{n} \sum_i d_i$$

Flow (veh/s, local variable)

$$q = \frac{m}{T} \approx \frac{1}{m} \sum_i h_i$$

Density (veh/m, instantaneous variable)

$$\rho = \frac{\sum_i u_i}{A}$$

Flow (veh/s, local variable)

$$q = \frac{\sum_i d_i}{A}$$

Edie’s generalized definitions for flow and density

spatiotemporal variables

Source: NEARCTIS-COST TU0702 Summer school "Real time road traffic monitoring and control", June 9-11, EPFL, Lausanne

Acknowledgements: Prof. Hans-Van Lint (TuDelft)

Real Traffic Data

Source: [LAWOC]
Traffic Management

• Techniques used for measuring the traffic variables
  – Fixed
    • Loop detectors, IR
    • Optical sensors, camera
  – Mobile
    • Floating car data
    • Floating phone data
    • Remote sensing, aerial

Role of Technologies

• The improvement of transport efficiency will be based on new traffic and travel information services
• Co-operative systems will play a key role in this context
• V2V – Vehicle to vehicle; V2I: Vehicle to Infrastructure
Role of Technologies

• Communication and positioning systems are basic components of co-operative systems
• The ongoing development of GNSS and the new short range communication systems lead to new possibilities for traffic management
• Innovative traffic management systems require development of specific positioning and communication systems

What are the requirements in positioning?

Why do we need positioning systems?

Requirements in Positioning

• Grouping of ITS services according issues of safety or liability
  – Safety-of-life: applications considered as safety critical, or having any safety implication
  – Liability-critical: applications presenting any commercial or legal relationship between the service provider and the users
  – Non safety-of-life; non liability-critical: application not presenting any commercial, legal or safety implication
Requirements in Positioning

• **Specific requirements**
  – **Accuracy**: measure of the difference between the estimated position of a vehicle and its true position
    • Which road, which lane, where in the lane?
  – **Integrity**: measure of the trust that can be placed in the correctness of the information supplied by the positioning system
  – **Continuity**: capability of the system to perform without unscheduled interruptions during the intended operation
  – **Availability**: percentage of the time that the positioning service is usable and is delivering the required accuracy, continuity and integrity

• **Available**: True error < Protection level < Alert Limit
• **Not available**: True error < Protection level > Alert Limit
• **Integrity Risk**: True error > Protection Level

AL: Alert Limit
Positioning Technologies

- Fundamental parameters used in positioning
- From fixed location to dynamic measurements
  « Linking the measuring device (e.g. GPS) to the vehicle »
  - Set of « particles » distributed in the road network
  - Capability to provide instantaneous parameters

Parameter

- **Absolute position**
  - Tech.: GNSS, combination with other sensors
  - Perf.: availability (e.g. tunnels, urban canyon)
  - Role: tracking, locate the vehicle on the map

- **Relative position**
  - Tech.: beacons, radio-based systems
  - Perf.: limited to specific location (e.g. gantry)
  - Role: relevant in V2V & V2I architecture
Positioning Technologies

Parameter

- **Time**
  - Tech.: GNSS provide an accurate time scale
  - Perf.: availability (e.g. tunnels)
  - Role: key parameter for real time applications

- **Speed**
  - Tech.: speed sensors or GNSS based sensors
  - Perf.: continuity
  - Role: traffic state estimation, safety, enforcement

- **Acceleration**
  - Tech.: onboard inertial sensors
  - Perf.: continuity
  - Role: ADAS application, crash recorder

- **Travelled distance**
  - Tech.: wheel sensors, GNSS based systems
  - Perf.: availability
  - Role: management systems (e.g. fleet)
Positioning Quality - Example

- Field test: 18 km, travelled time: 40 min
- Comparison: GPS “low cost” – High end GPS/INS
  Ref.: Project ENAC, Master students: Paola Cavadia, Amir Sohrab Sahaleh

Positioning Quality - Example

- Horizontal error: GPS “low cost” vs reference trajectory
Positioning Quality - Example

- Position accuracy: influenced by the environment, variable in time and space

- GPS code “low cost”
  \( \sigma: +/\ - 5 \pm 8 \text{ m} \)

- GPS/INS high end
  \( \sigma: +/\ - 0.2 \text{ m} \)

Positioning Quality - Example

- Position accuracy: bias, systematic error

Stop of the vehicle
Positioning Quality - Example

- Continuity of the positioning signal

Research prospects

NEARCTIS has identified some interesting researched areas on the integration of emerging technologies in traffic management.
Research prospects

- **Reliable positioning** and tracking in dense traffic areas
- **Secure vehicles positioning** for traffic management
- Enhanced and **multi-scale positioning**, combination between global (GNSS) and local positioning (sensors)
- **Accurate distance identification** between vehicles for traffic safety
- **Self-calibration and synchronisation** of image-based positioning and tracking systems