Intelligent Transportation and Telematics

ITTS-Research@UCSD

By

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WITTS 2001:
Workshop on Intelligent Transportation and Telematics Systems

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The UCSD cluster is focusing on researching fundamental issues and technologies underlying the development of novel transportation and telematic systems with applications to:

- Reduce traffic congestion
- Enhance smoother and safer driving
- Improve automobile and occupant safety
- Ensure safe and secure delivery of information to drivers
- Support new types of interactions between vehicles, and develop new forms of e-commerce.
Primary Constituents of ITTS:

- Intelligent roads, bridges, and highways
- Intelligent vehicles, and
- Intelligent stations and services

Investigations and development of novel and powerful means for improved safety, convenience, and experience in the context of these three main constituents are emphasized in the UCSD ITTS research themes.
Research Theme 1:

Distribution and evolution of “intelligence” among infrastructures, vehicles and services:

• Development of intelligent infrastructures (roads, bridges, highways) is primarily pursued by governmental agency.

• Development of intelligent automobiles and gadgets is pursued by commercial industry.

• Development of intelligent stations and services will involve both private and public enterprises.

• These developments are pursued in somewhat independent manner. This gives rise to a range of very important research problems centered on the distribution of the resources and functionalities critical to the effective operation of the overall system are incrementally evolving in the infrastructures and the vehicles.

What kind of overall system performance and functionalities will be achieved in this incrementally evolving scenario?

How to assure a seamless and scalable model for the growth of this complex system?
Research Theme 2:

Dynamic Environmental, Structural, and Vehicular Condition Monitoring using Mobile Webs:

• Embedded sensors and wireless technologies deployed in selected vehicles can provide powerful and dynamic means for monitoring of various environmental, structural (bridges, roads, seismic, etc.) and vehicular conditions.

• At the interface of the intelligent infrastructures-intelligent vehicles-and-intelligent services.

What types of conditions need monitoring?
What kinds of embedded sensors, preprocessing, information pick-up and visualization modules need to be designed?
What should be the deployment configuration of these sensorized vehicles in order to achieve the specified quality of measurements?
Research Theme 3: Driver Distraction and Safety

It is critically important to assure that the use of ITTS technologies do not adversely affect the safety of the driver and others. We will undertake systematic research where development as well as assessment of the new types of telematic devices will be at the core of the investigations.
UCSD Core competencies in ITTS

• Sensing:
  Real-time Video, Location; Audio/speech, multimodal-networks;

• Wireless Communication:
  Security, Low Power, Compression and Coding

• Computing:
  Embedded Systems; Distributed Architectures

• Software:
  Security; Embedded/real-time systems, Databases and Data mining

• Human Interfaces and Cognitive Sciences
  Attention/Distraction Evaluation; Tele-viewing
• Distributed Video Networks
• Video Processing and Compression
• Antenna and Microphone Arrays
• High Precision Localization, GPS
• Televiewing and Visualization
• Semantic Databases and Data Mining
• Wireless Networks and Mobile Base Stations
• Embedded Systems and Smart Cards
• Interfaces and Assessment
• Transportation Structure Health Monitoring

Trivedi
Cosman, Trivedi
B. Rao
Y. Bock
Trivedi, Nadeu
A. Gupta, C. Elkan
R. Rao, R Cruz
S. Dey, A. Kellner
J. Hollan; E. Hutchins
Karbhari, Seible, Trivedi, Vernon
Detection/Verification  |  Response  |  Clearance  |  Recovery

Incident occurred  |  Dispatch travel time  |  Clearance time  |  Getaway time

#1: **DIVA** reduces this delay

#2: **ATON** can further reduce this time through adaptive routing and real time information and control.
**Incident Detection and Management and ATON**

**Remote Agent:** Outdoor Robotar for Tele-existence. Distributed architecture, multiple sensors, 2-way wireless multimedia streaming. Main unit for on-scene incident verification (confirmed detection). Replaces current practice of waiting for CHP vehicle.

**Locally Active Little Agent:** A team of small, flexible robots which work under the supervision of RA. Lower bit rate links, selected sensors, task-specific design. Team capability is very attractive.

**KMET:** Automatic discovery of available services. Advanced communication links, may also carry CMS (Changeable Message Sign).

**Roadside Active Network Adaptor:** A controller for adaptive control for ramp metering and intersection control.

**DIVA:** Distributed Interactive Video Arrays
Autonomous Transportation Agents for On-Scene Networked Incident Management

**Research Objective** Realization of an integrated traffic-incident detection, monitoring, and recovery system to reduce congestion on the highways.

**System Architecture**
- C.H.P.
- Caltrans
- CVRR
- KMET
- Remote Agent (RA)
- LALIA
- Local Active Little Inexpensive Agents

**Distributed Multisensor Networks**
- Omniview camera
- Rectilinear camera
- Infrared camera
- Range camera
- Microphone
- Ctr for Processing & communication

**Anatomy of an Incident**
- Step 1: Incident Detection reporting by an ODVS network.
- Step 2: KMET dispatches Remote Agent (RA).
- Step 3: RA arrive at the site, verify incident and divert traffic.
- Step 4: Team of little agents (LALIA) dismounted from RA and forms a safe zone in a coordinated way.
- Step 5: Assistance offered by a RA using a tele-existence.

**Research Objective** Realization of an integrated traffic-incident detection, monitoring, and recovery system to reduce congestion on the highways.

**Realization of an integrated traffic-incident detection, monitoring, and recovery system to reduce congestion on the highways.**
Autonomous Transportation Agents for On-Scene Networked Incident Management
Mobile Media and Telematics Infrastructure Research

- High-speed pan/tilt/zoom rectilinear cameras at multiple lamp posts
- Omnidirectional Cameras
- Provides a continuous 360° view of the area surrounding the pole
- Wired directly back to the lab using fiber optics
- Capability of sixteen high-bandwidth bidirectional Video streams accessible over internet
- Televiewing algorithms for digital pan/tilt/zoom

Televiewing Video
Mobile Media and Telematics Research Infrastructure

- Base Node
- Control Node
  - SERF
- Wireless Test Zone
- Immersive Environment
  - Movie

CAL-(IT)$^2$
Application to Kinematic Positioning: Vehicle Tracking

This display shows the trajectory of a van moving in an urban environment computed by GPS. Comparison with high-end inertial navigation system verifies that the precision of GPS is at the 1 cm level.

Y. Bock, Courtesy of Geodetics, Inc.
Adaptive Wireless Data Communication (Sujit Dey)

Will enable content-rich wireless information technology in heterogeneous networks
Will facilitate Wireless Networked Transportation Systems
Distributed Cognition and
Human-Computer Interaction Lab

- Explore Distributed Cognition as Theoretical Basis for HCI
  - Ethnography and Experimental Work
  - Design & Evaluate Prototypes
- Research Projects
  - NSF KDI (Hollan, Hutchins, Kirsh)
    - designing digital work materials for collaborative environments
  - NASA Pilot Expertise (Hutchins)
    - development of expertise and understandings of automation and instrumentation
  - Intel, Sun, (Darpa) Pad++ and STkPad (Hollan)
    - multiscale interface software and information visualization
  - NSF ITR Image-Based Information Access and Activity History Visualization (Hollan)
  - Vision-Based Interfaces (Hollan)
  - Eye Movement Studies (Hollan)
  - CAL-IT² Projects
  - ...

http://hci.ucsd.edu
Data Analysis: Tracking

• Associating cars between image frames allows tracking of vehicles through the scene, and calculation of higher level data, such as:
  • Vehicle Velocity
  • Vehicle Behavior (lane-changing, merging)
  • Abnormal conditions (stalled vehicles, vehicles moving in wrong direction)
Utilizing the ODVS, a program has been devised to count the number of cars crossing a roadbed. Using network tomology, vehicle behaviour monitoring is possible.
Research Objectives

- Detection, representation, storage, and query of semantic events.
- Representation, storage, and query of spatio-temporal composition of traffic behavior.
- Traffic behavior analysis using semantic databases.

Results of Tailgate and Exit Queries.

Spatial Structure of A Highway Segment
In a camera cluster, when an incident occurs, the monitor can choose the “best” camera view and control its PTZ.. and even choose to “follow” the car responsible of the incident!!
The DIAMOND architecture exhibits great flexibility. Using the interface the user can create new event-action tuples.

<table>
<thead>
<tr>
<th>EVENT</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>stopped car in a given area (like emergency lane)</td>
<td>Zoom in (Secondary camera 1)</td>
</tr>
<tr>
<td>stopped car in a given area (like emergency lane)</td>
<td>Zoom in on the license plate (Secondary camera 2)</td>
</tr>
<tr>
<td>incident detected</td>
<td>Take a close of the injuries (Secondary camera 2)</td>
</tr>
<tr>
<td>incident detected (injuries)</td>
<td>Take video from all the perspectives possible (Robot omnidirectional 1) – drive toward the incident site</td>
</tr>
</tbody>
</table>

Event Driven Servoing
VCAT: Visual Context Capture and Televiewing

Context Aware Spaces
indoor, outdoor or mobile

Televiewing, Interfaces and Virtual Environments

Context Capture
- sensor network design
- person recognition
- pose, gesture, affect analysis
- activity recognition
- environment context recognition

Multimodal Reasoning and Distributed Architectures
Fusion of information from multiple sensing modalities: visual, audio and others

Compression, Transmission, Mobility and Connectivity Models

Research Challenges:
- Visual context capture and compression
- Multimodal sensor fusion
- Distributed system Architectures
- Wireless connectivity and networking
- Context-sensitive reasoning
- Databases and multimodal search engines
VCAT Testbed

Omnidirectional cameras

Rectilinear cameras

Stereo system

Thermal cameras
Multimodal imaging modules and computational platform

- 6 1GHz Dual Processor PC’s with Matrox Meteor II framegrabbers
- Synchronous capture using optotrigger input
- 1 thermal camera
- 8 rectilinear cameras with lenses 2.8-12mm
- 3 real-time trinocular stereo systems
- 4 omnidirectional cameras

PRETAL

Computer Vision and Robotics Research Laboratory
Visual context capture using omnidirectional camera

Please see the movie at: http://cvrr.ucsd.edu/VOW/Movies/data/Highway1.wmv
Interactive, multi-client, simultaneous, customized Televiewing

Original Video

Server Side → Client Side

MJPEG Compression Server → Fiber / Internet Connection → MJPEG Decompression Software

Received Video

Televiewing Video

Projection onto image plane

Perspective view pan-tilt-zoom
“smart airbag” system

Scene sensing
- Single perspective
- Thermal camera
- Stereo system
- Multicamera system

Feature selection and analysis
- Region occupancy analysis
- Simplified body model
- Detailed body model

Posture categories
- Must not deploy
- Depowered deploy
- Must deploy
Enhanced Cellular Telephony Systems using Sensor Arrays

Microphone Array

Camera Array
Dynamic Multi-application Smart Cards

• Current applications can be extended, future applications added dynamically, all without breaking systems already in the field.

• Development covers four issues:
  – Smart card operating system that permits secure multiple applications.
  – System infrastructure that supports dynamic downloading of applets to cards.
  – Security, particularly between the card and the infrastructure.
  – Interface of the smart card infrastructure with legacy information infrastructures.
FRP composite bridge to be built over I5

Need for continuous monitoring and inspection

Optical sensors and use of pattern recognition would provide cost-efficient means of health monitoring

UCSD
Caltrans
FHWA
WITTS 2001 (Real) Organizers

Thanks!