A Sensor Platform for Sentient Transportation Research

Jonathan J. Davies, David N. Cottingham, and Brian D. Jones

{jjd27,dnc25,bdj23}@cam.ac.uk

UNIVERSITY OF CAMBRIDGE
Computer Laboratory
Digital Technology Group

At the University of Cambridge Computer Laboratory, we have created a platform for furthering our research into Sentient Transportation, a field which is concerned with computers interpreting and intelligently reacting to sensor data in transportation.

Figure 1: The vehicle

Since 2005, we have been equipping a vehicle with computing equipment that provides a general-purpose platform for integrating communications interfaces and sensors. These sense properties of the vehicle and its environment, to enable the deployment of intra- and extra-vehicular context-aware applications [1].

The vehicle is friendly towards non-technical users, not requiring any specialist knowledge to operate the equipment.

We have used the platform to build up a corpus of sensor data, collecting over seven million data points to date.

Sensor Infrastructure

Sensors have a wide variety of power requirements and data rates. We use three data buses to support a wide range of sensors.

Bus	Characteristics	Sensors
CAN bus	Low data rate; rugged; commonly used in vehicular environments; cheap to interface.	CO_2, temperature, humidity, barometric pressure, inclination, acceleration, orientation.
USB	For interfacing with commodity devices, ad-hoc attachment of personal devices, RS232 devices.	GPS receivers, RFID reader, OBD-II interface.
Ethernet	Supports high data-rate devices; expensive to interface.	Digital video cameras.

The OBD-II interface is supported by all modern vehicles and enables access to data regarding the vehicle's operation, including: engine revs; speed; engine load; air intake temperature; fuel rail pressure; intake manifold pressure; engine coolant temperature.

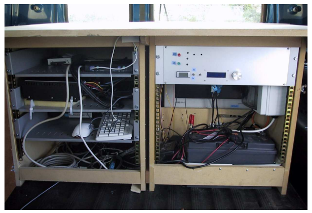

Figure 2: The equipment inside the vehicle

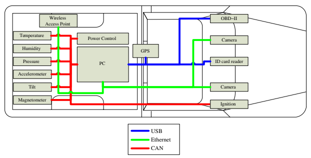

Figure 3: Overview of present sensor infrastructure

Communications

The vehicle supports communication interfaces with infrastructure providing both ubiquitous and more localised coverage. High-speed networks are exploited when encountered. The vehicle supports the following interfaces:

- IEEE 802.11b/g;
- IEEE 802.11a (similar to DSRC/WAVE);
- GPRS/UMTS.

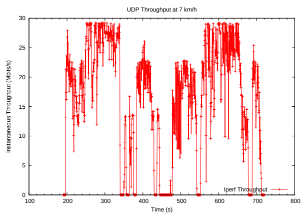

Figure 4: Vehicle-to-roadside throughput

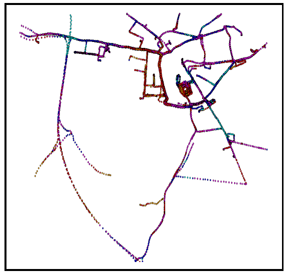

Figure 5: 3G signal strength

We log the coverage experienced and carry out research into handovers. We are also beginning a WiMAX deployment.

Human Interaction

We have two windscreen-mounted 8" LCD touchscreen monitors to enable the driver and passenger to interact with the system. The audio control stalk on the steering column is used as a convenient input device for the driver.

Figure 6: The dashboard with touchscreens for the driver and passenger

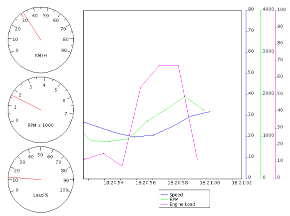

Figure 7: Live graphs of OBD-II data

The carry-space of the van is a development environment, with full-size monitor, keyboard and mouse, to be used by researchers for deployment and debugging.

Power

Vehicles cannot rely on a permanent connection to an external power source. We use our own battery, charged from the vehicle's alternator. Hardware controls when the equipment is switched on, and the computer controls when it is switched off. A failsafe hardware power cut-off protects against draining the auxiliary battery.

Research Topics

We are using the platform to further research into several areas:

Congestion-Aware Traffic Routing. Vehicles upload data about the congestion they have experienced to public access points which can be queried by other vehicles.

Driver Expression Inference. We have recorded videos of the face of the driver, to be used for research into real-time inference of the driver's mood.

Updating Digital Maps. Up-to-date digital road maps can be automatically generated from GPS traces collected from vehicles [2].

Figure 8: GPS traces

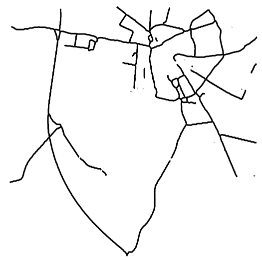

Figure 9: Generated road map

Performance of IEEE 802.11a. We are examining the performance of the technology selected for the WAVE standard for vehicle-to-roadside communication in urban environments.

Wireless Coverage Mapping. We are using the vehicle's GPRS/UMTS data card to map the wireless coverage available in an urban environment.

Atmospheric Chemistry. We use the vehicle's CO_2 sensor to measure atmospheric pollution. This will be used to confirm models produced from government-owned fixed sensor deployments.

Congestion Charging. We have devised a novel scheme for congestion charging which is peer-enforced to provide better privacy for honest drivers than traditional schemes [3]. We intend to use the vehicle to further investigate technologies for congestion charging.

Vehicle-to-Vehicle Communications. We have equipped a second vehicle in a similar manner for use in investigating communication between vehicles at speed in an urban environment.

WiMAX Deployment. We are deploying an IEEE 802.16 network over a large urban area for further evaluation of wireless technologies.

Papers

[1] David N. Cottingham, Jonathan J. Davies, and Brian D. Jones. A research platform for sentient transport. *IEEE Pervasive Computing (Works in Progress)*, 5(4):63–64, Oct–Dec 2006.
[2] Jonathan J. Davies, Alastair R. Beresford, and Andy Hopper. Scalable, distributed, real-time map generation. *IEEE Pervasive Computing*, 5(4):47–54, Oct–Dec 2006.
[3] Robert Harle and Alastair Beresford. Keeping big brother off the road. *IEE Review*, 51(10):34–37, October 2005.

http://www.cl.cam.ac.uk/research/dtg/research/wiki/SentientVehicle