

Predimap : what are map for intelligent vehicles?

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Predimap project

Vehicle Perception and Reasoning Enhanced
with Digital Maps

Project selected in the 7th call of the ICT-Asia program

PREDIMAP gathers research teams conducting research
on intelligent vehicles and spatial and road map
information.

Predimap project

Collaborative project with 8 partners:

- HEUDIASYC laboratory, **CNRS** and University of Technology of Compiègne, **FRANCE**.
- MATIS laboratory, **IGN**, **FRANCE**
- E-MOTION project-team, **INRIA** Rhône-Alpes, **FRANCE**
- **LIAMA** Sino-French laboratory with CNRS, Beijing
- Key laboratory of Machine Perception (MoE), **Peking University**, Beijing, **CHINA**.
- **Shanghai Jiao Tong** University, **CHINA**.
- Geoinformatics Center, **Asian Institute of Technology**, **THAILAND**
- Center for Spatial Information Science, **University of Tokyo**, **JAPAN**

Predimap project

The originality of this project is to consider together the dual concept for intelligent vehicle applications:

using digital maps for a better perception
and
using perception for mapping.

Outline

1) Map for intelligent vehicles

- Intelligent vehicle and digital map definitions
- Maps at static level
- Maps at dynamic level

2) Case studies

- Navigable space characterization
- Lateral localization
- Integrity domain

3) Conclusion

What are intelligent vehicles?

Vehicles designed to help driving automatically or to monitor a human driver and assist him in driving.

They can warn the driver in case of dangerous situation and/or can provide capabilities of avoiding collisions or mitigate the consequence if there is an inevitable collision.

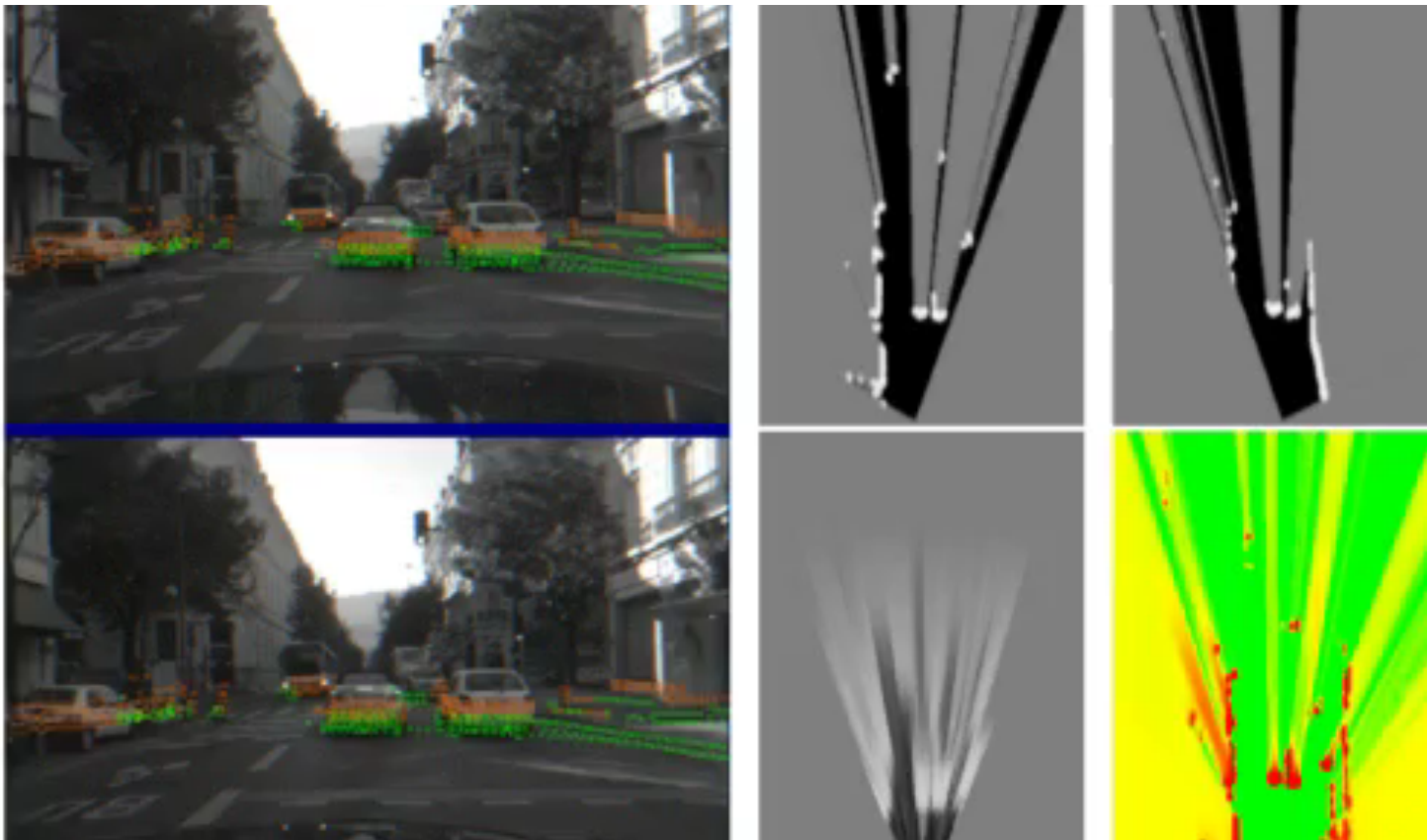
These intelligent vehicle systems should be able to operate in all traffic situations.

To solve these tasks, they are equipped with sensors to perceive their surrounding environment and with actuators to act in this environment.

Embedded perception



Example : probabilistic grid with lidar



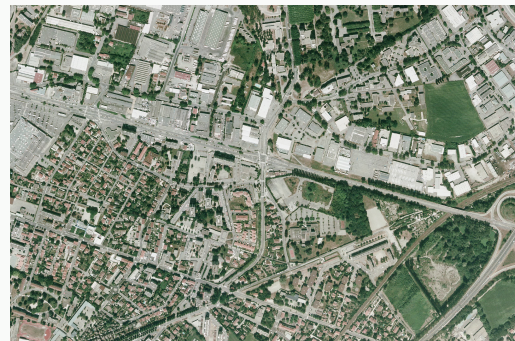
What are digital map?

Digital surface model,
 Road network
 Parcels
 Building footprints
 Addresses

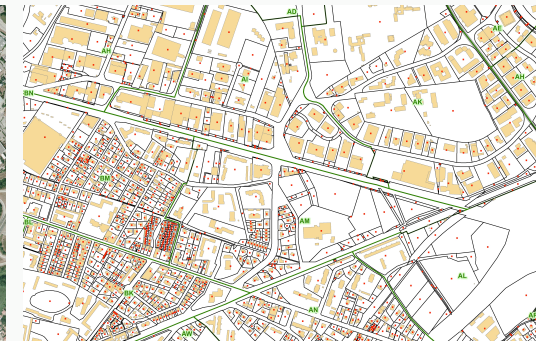
Map for GIS

- large spatial coverage
- low level representations for human navigation / understanding..

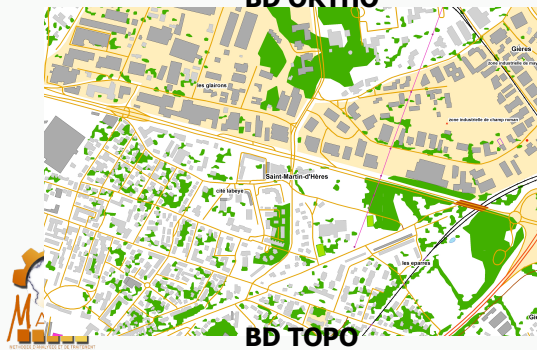
Our metric national mapping infrastructure



BD ORTHO



BD PARCELLAIRE

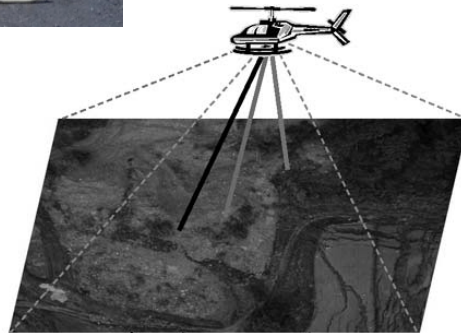


BD TOPO



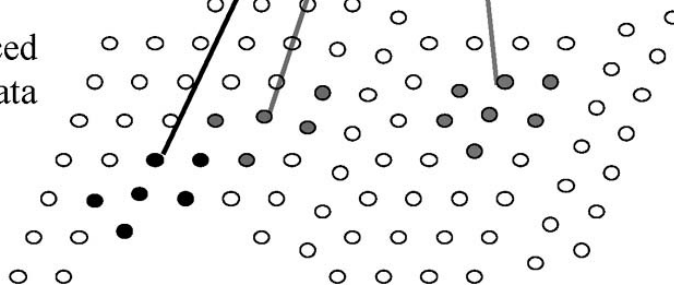
BD ADRESSE

Aerial and ground mobile mapping system



Geo-referenced
CCD image

Geo-referenced
laser range data



Stereopolis



Maps for intelligent vehicles

Nowadays, maps in car navigation systems do not contain enough road details like: lane markers, traffic signs, zebra zones, guild rails and other road facilities.

Map for intelligent vehicles

Map at the street level.

- static part
- dynamic part.

Maps are incomplete and inaccurate

- A map is an abstraction of the (complex) real world
- A map provides prior (with uncertainties) of the real world

Static map generation and updating

Objective

study the solutions to generate and update the various attributes of maps for intelligent vehicles and this at all static description levels

Street Static map

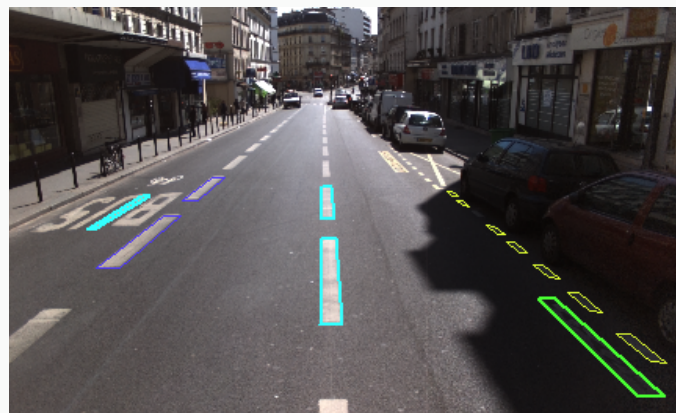
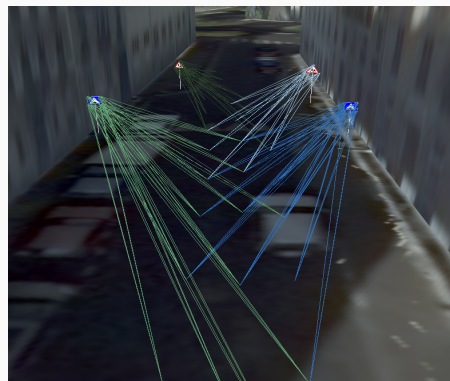
- Road graph (topology and macro-scale geometry)
- Traffic rules
- Land usage, public or private (drivable space, side walk, car park, etc.)
- POIs (lane marking, traffic sign, sign board, crossroad, etc.), landmark for reference ('symbols')
- 3D buildings, vegetation, etc.

Generation of 3D visual landmark databases



From images

[Soheilian et al. 2011a][Soheilian et al. 2011b]



Road Surface POI Detection and Recognition

Surrounding View Cameras



3) Dynamic map generation and updating

Objective :

study possible solutions to generate dynamic components of the maps for intelligent vehicles and at different levels of description

Street map temporal evolution

- Year-change
 - Traffic flow, ex. slow change
- Month-change
 - Traffic flow, ex. season variation
 - Vegetation, ...
- Day-change
 - Traffic flow, ex. weekend vs. workday
 - Space usage (parked car, occupancy, drivable space, ...)
- Hour-change dynamics
 - Traffic flow, ex. School hour, rush hour
 - Space usage (parked car, occupancy, drivable space, ...)

Big Changes in road traffic survey

So far:

Traffic volume, traffic speed and OD survey

- Observation by humans
- Once every five years, for one day



Traffic volume observation by men

Future:

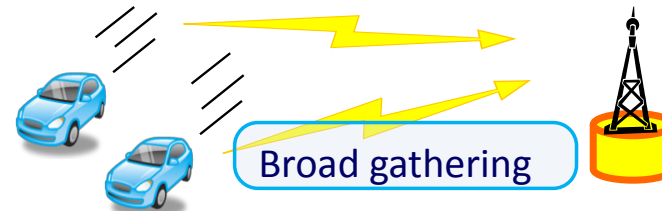
Traffic volume by constant observation

- 365 days, 24 hour observation
- Other sections to be estimated by use of constant observation data.

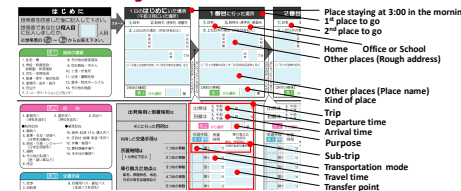


Constant observation by vehicle sensors

Traffic speed by probe car data



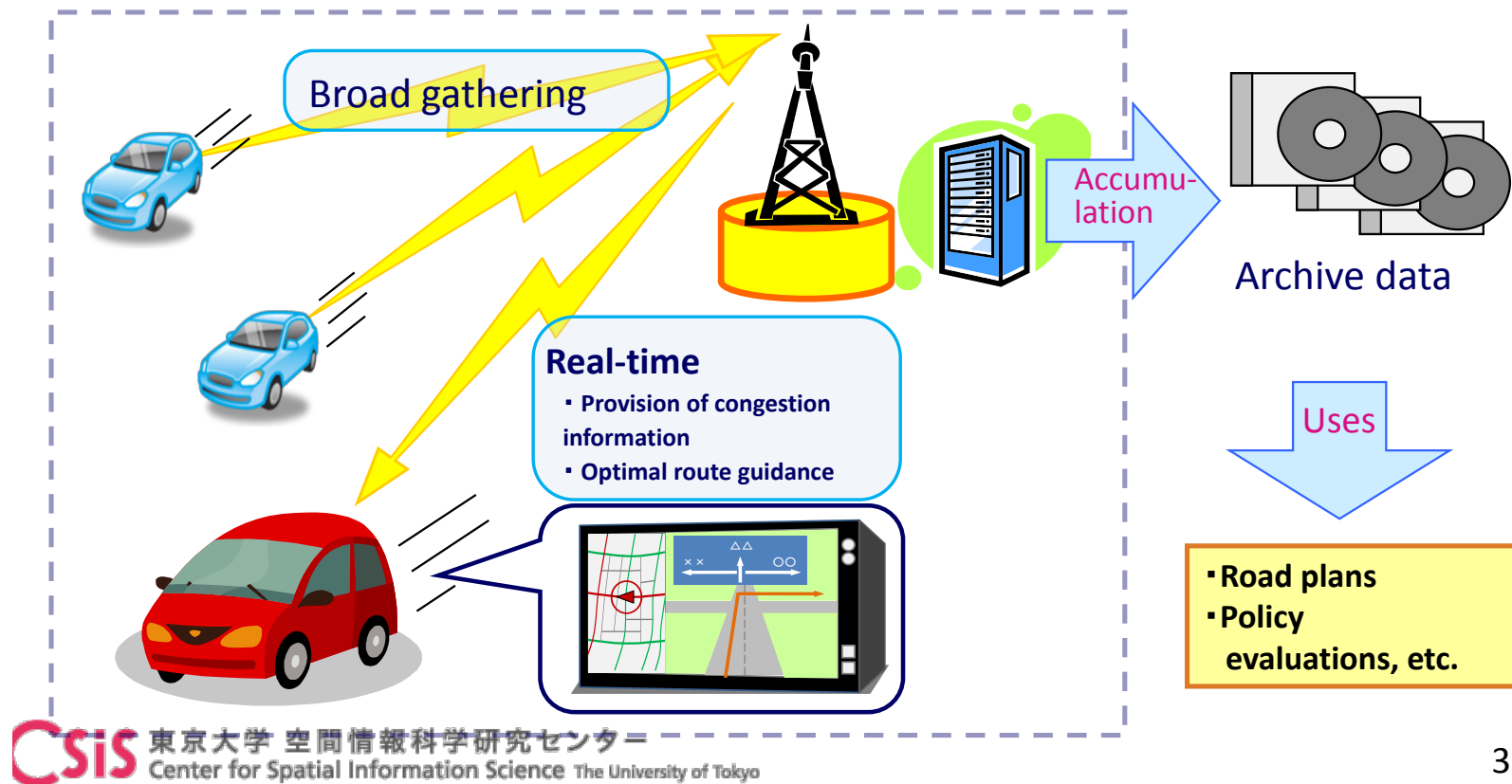
OD survey in road traffic census



- Place staying at 3:00 in the morning
- 1st place to go
- 2nd place to go
- Home Office or School
- Other places (Rough address)
- Other places (Place name)
- Kind of place
- Trip
- Departure time
- Arrival time
- Purpose
- Sub-trip
- Transportation mode
- Travel time
- Transfer point

Travel speed data from probe information

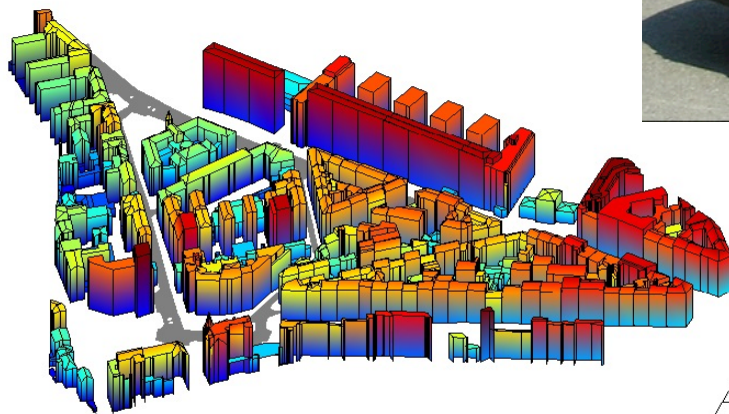
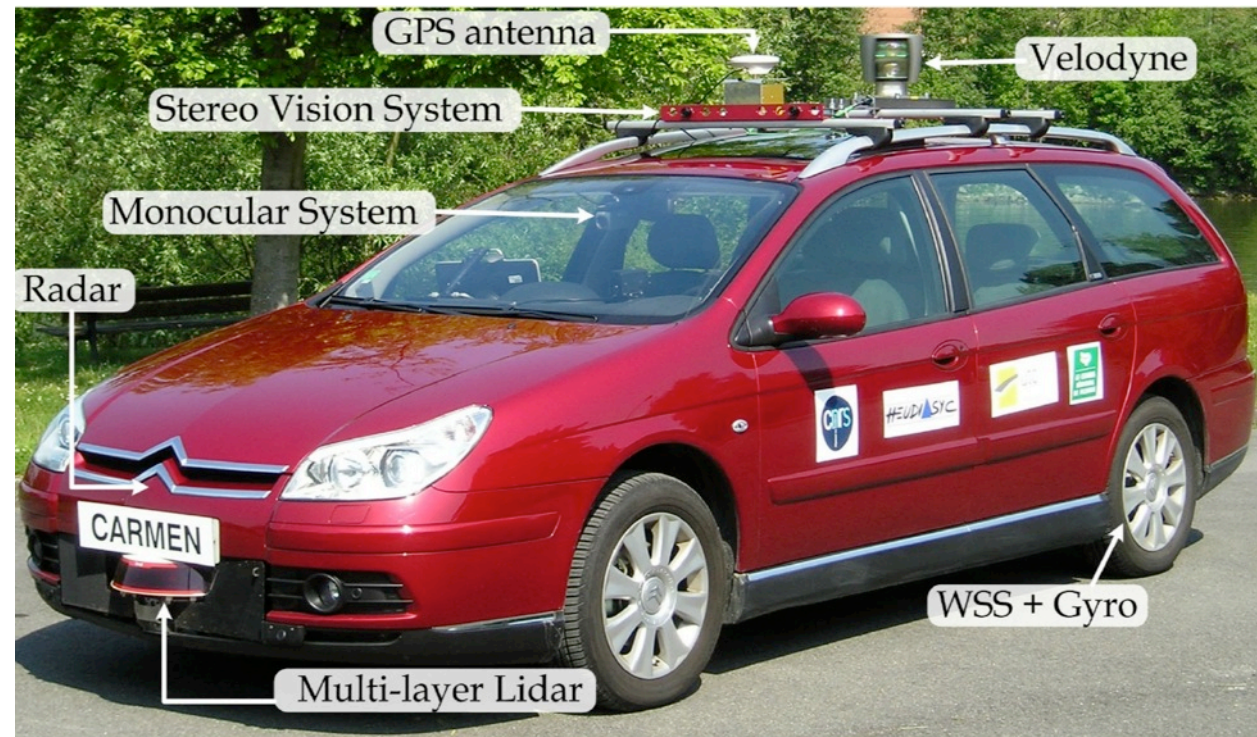
- So far: sampling survey by actual driving in limited scope and time
- Future: collect **probe information of general vehicles** round the clock on arterial roads

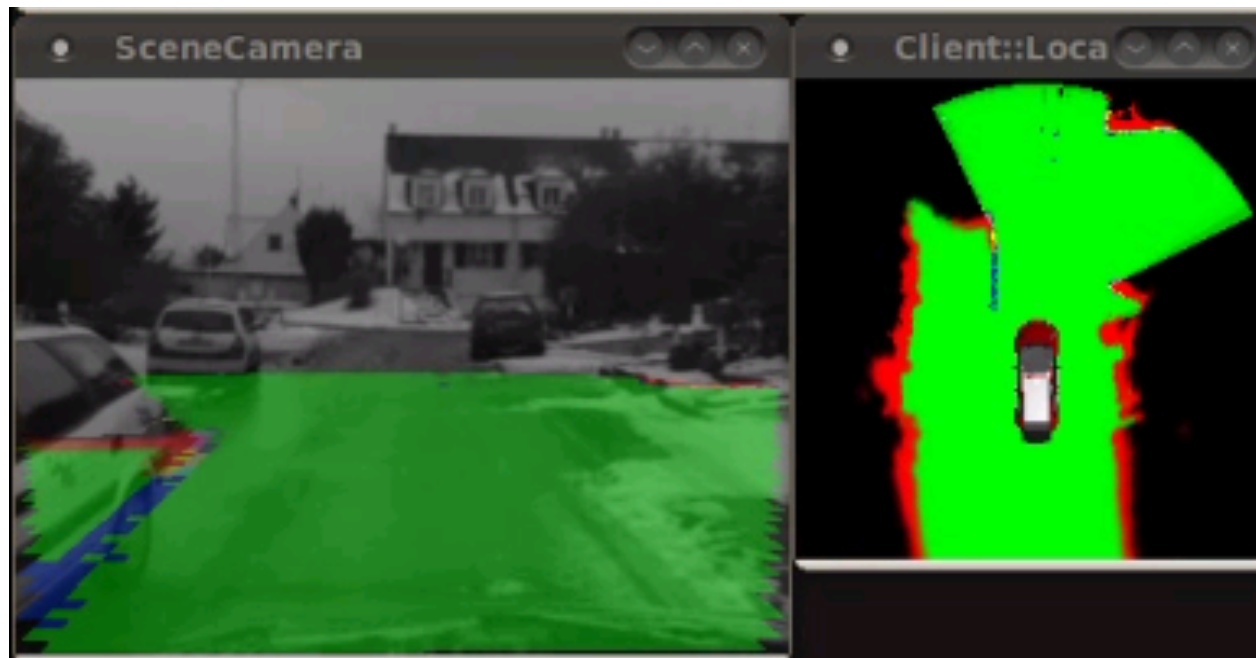
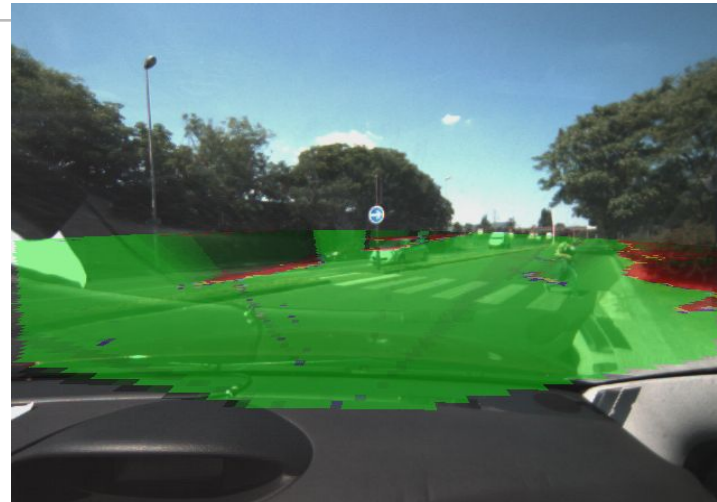


4) Case studies

- Perception and localization,
- Situation understanding, risk evaluation

Navigable space characterization using lidar, GPS and Digital map





Demonstration CityVIP Lot3 : Carte Locale Dynamique

Vue de la Caméra

Carte Locale Dynamique

FPS 13

Carte de la route et des batiments

CamStudio

File Region Options Tools View Help

RenderSoft

CamStudio

OPENSOURCE

Record to AVI

Press the Stop Button to stop recording

dbiteplayer

|> || ○

+ - [Reverse]

Playing State - speed : 1

Min time 1316006902147221

Max time 1316007442828183

Current time 191.516 - 1316007093663126

Windows taskbar: Démarrer, Invite de com..., C:\WINDOWS..., NovAtel CDU, Explorateur, E:\CityVip\pac..., pacuscityvip..., CamStudio, Demonstratio..., DemoCityVipP..., dbiteplayer, 08:06

Intelligent Vehicles navigation

meso-scale maps are needed + exteroceptive sensing



Method: Mobile Map then navigate

Use an accurate localizer during a learning stage and log sensor data

In post-process:

Localize every detected lane

Build a map of the lane-markings

Points decimation (Douglas-Peucker)

Lines fitting (Least Squares)

Store this information in the navigable map

While navigating

- Use the camera to correct the pose estimate

Map-match the camera measurements

Use a dynamic state observer

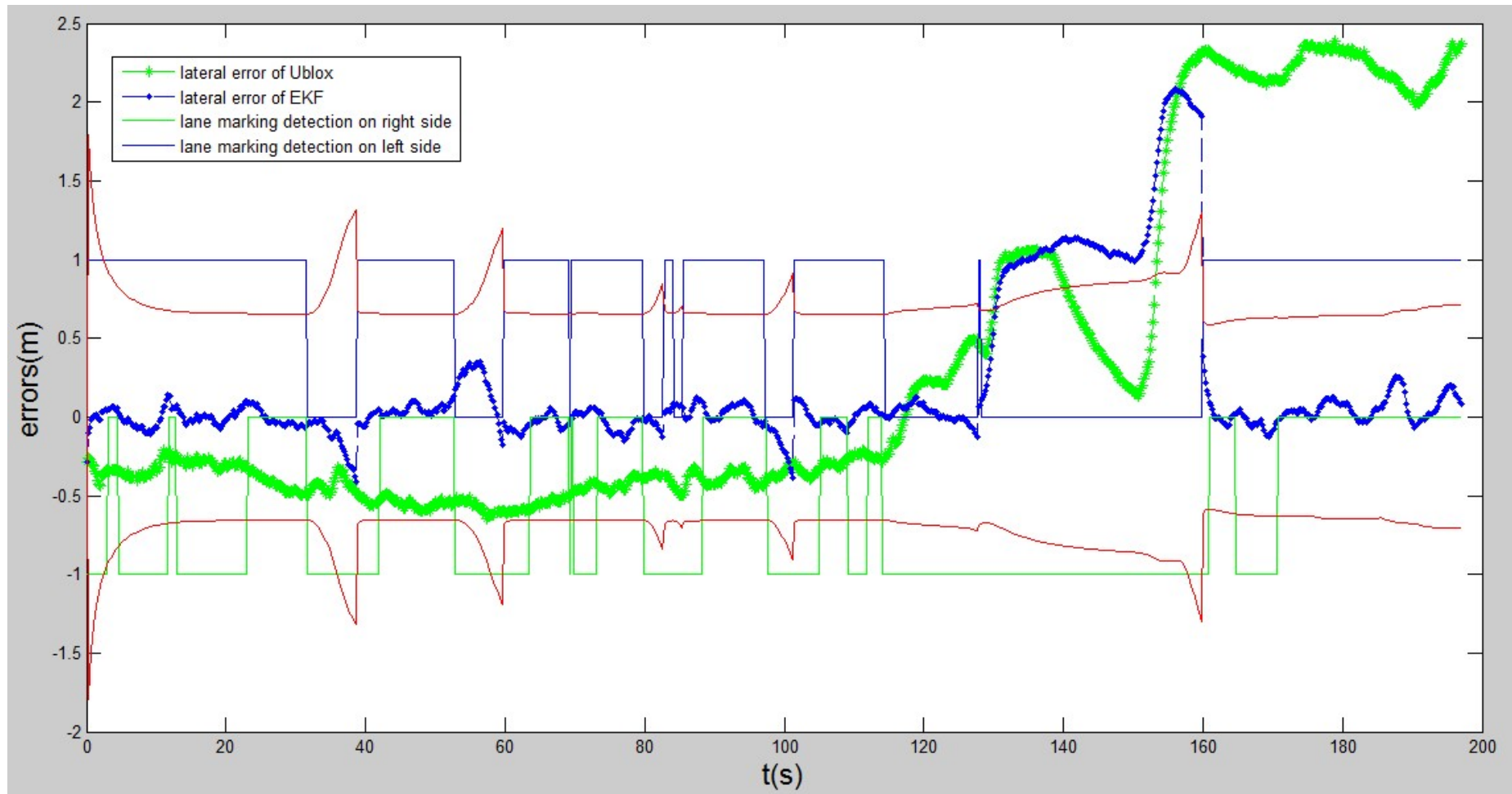
Vector map only



Lane marking (zoom in)



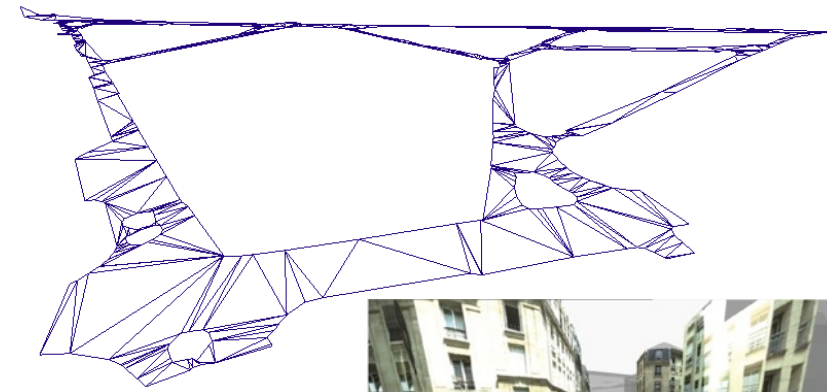
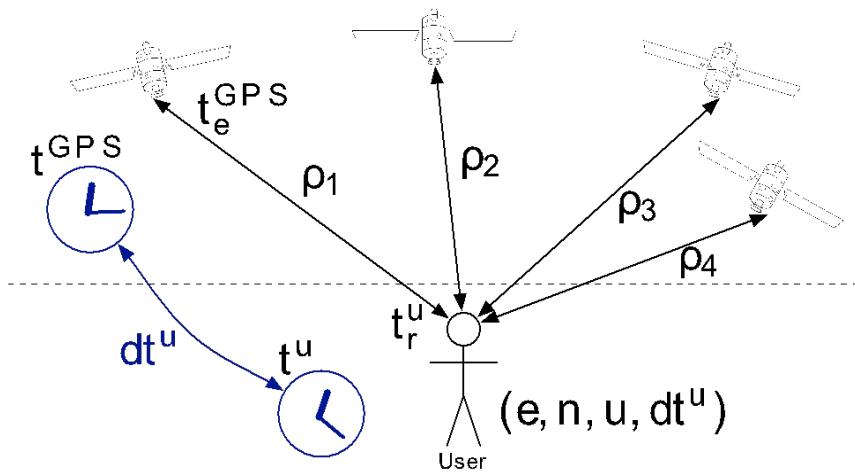
Experimental results



Lateral error

Integrity for localization

Pseudo range + 3D facet of navigable space



IGN
INSTITUT NATIONAL
DE L'INFORMATION
GEOGRAPHIQUE
ET FORESTIERE



3D facets of the drivable space :
Photogrammetry from aerial photographs
Precision of vertices
5 cm planar / 20 cm altitude

C/N0 threshold: 25 dBHz

Middle ECEF XYZ : mid(x)=4202155.2 mid(y)=166765.8 mid(z)=4779301.3

Radius ECEF XYZ : rad(x)=37.67 rad(y)=82.67 rad(z)=35.53


[+4.0 m; -4.0 m] PR error

1 outlier(s) tolerated



HeuDiaSyC [vincent.drevelle@hds.utc.fr] – 6 sat. used / tracking 6 sat.

Time : 0:4:57.78 >> 10s >>



```

time elapsed in $!UI0: 594 ms
inliers counts: [0]13526 [1]13538 [2]12750 [3]13056 [4]12004 [5]13544
No outliers found
    
```

Conclusion

Two days 1st PREDIMAP workshop (UTC- Compiègne) was very fruitful.

- Definition of map for intelligent vehicle
- Several discussions already took place regarding the use of maps available in each country.

In France, public research or higher education may use maps of the IGN Bati3D (layer RGE). In contrast, Chinese partners can not access an equivalent. The maps available via the Internet are much less accurate and there is no possibility of purchasing ones.

Next workshop will be held in Paris-Saint Mandé at IGN in January 2013
NavInfo (map provider in China) will join us