PROJECT PREDIMAP

VEHICLE PERCEPTION AND REASONING ENHANCED WITH DIGITAL MAPS

MINUTES OF THE SECOND PLENARY MEETING

SAINT-MANDÉ, FRANCE, IGN, JANUARY 29 AND 30, 2013

SUMMARY

MINUTES OF THE MEETING

INTRODUCTION

The objective of the PREDIMAP project is to gather research teams from China, Japan, Thailand and France with complementary skills and expertise to conduct research in the area of advanced perception systems for intelligent vehicles making a large use of digital maps.

This second plenary meeting was an opportunity for patners to present their recent works relative to PREDIMAP actions. These presentations have generated many discussions.

Morover we had pleasure to invit Jack Cao (vice president) and Alex Zhe Xiang (director of Advanced Engineering Center) from Navinfo (Map providers in China) and Alexandre Armand (PhD student) from Renault (French car manufacturer).

The program of presentations is detailed in the section “schedule” and presentations are available on the project web site: https://www.hds.utc.fr/predimap/

EVENTS AND PEOPLE MOBILITY (DEC. 2011-DEC 2012)

- 2 PKU students have visited UTC in December 2011 (Predimap/MPR projects)
- Ph. Bonnifait was a keynote speaker of the Workshop on **Planning, Perception and Navigation for Intelligent Vehicles** organized with IROS 2012. “***Navigable Maps for Intelligent Vehicles Localization and Perception “***
- H. Zhao and four professors from PKU have visited UTC in July 2012 (UTC-PKU workshop)
- H. Zhao has visited UTC in Sept. 2012 (Predimap/MPR/Pretiv project)
- Ch. Laugier has visited PKU/ LIAMA in December 2012 (MPR/Pretiv project)
- 3 PKU students visited INRIA in December 2012
- M. Yang visited PKU in October 2012
- V. Cherfaoui and F. Davoine have visited M. Nagai in Bangkok in November 2012
- V. Cherfaoui and F. Davoine have presented PREDIMAP during the ICT-ASIA Seminar in Bangkok in October 2012

PRESENTATIONS OF RECENT WORKS IN COLLABORATIVE ACTIONS

During the previous meeting we decided to structure our program in four collaborative actions which involve partners in the consortium. Each involved partner is engaged in common work. We present in this section the contributions of each partner in the following actions:

1. Map definition and specification for intelligent vehicles: all partners
2. Static map generation and updating
3. Dynamic map generation and updating

4. Case studies:
    a) Perception and localization
    b) Situation understanding, risk evaluation

MAP DEFINITION AND SPECIFICATION FOR IV:

Considering the various studies on the current use of maps for intelligent vehicles, we made the observation that there is still a real demand in this area and current maps are not well adapted to this purpose. That's why we have oriented this action towards the definition and specification of maps for intelligent vehicles. Given the complexity and variety of scenes that make up the environment of a vehicle and given evolutions at different time scales, we agreed to look the map at the street level. We then defined two main components: the static and dynamic part. The static part consists of several levels corresponding to different uses.

This specification work was then clarified and several levels have been identified for the road description during this second meeting.

Road map definition and specification for intelligent vehicles **(B. Soheilian, N. Paparoditis, M. Brédif, M. Yirci, J. Perret) – IGN**

In this presentation we discussed first, different kind of information that should be provided in road maps in order to make them compatible with intelligent vehicles (IV) needs. Then we proposed a coarse-to-fine multi-level representation road model. Complexity of generation as well as usability of maps for IV increase with the levels:
The first level consists in linear graphs produced classically by mapping agencies in large scale (country coverage). This level is represented by nodes and oriented links. It can be used for coarse path planning for going from point A to point B.
The second level is also a linear graph represented by nodes and directed links, but the links are represented at lane level (vs. section in the previous level) and trajectories are detailed inside the intersections by taking into account traffic rules. This level can potentially be produced from the previous level by taking into account attributes such as number of lanes and traffic rules (if available).
The third level is geometrically similar to the second level, but enriched with traffic rules such as speed limits, prohibitions, reserved lanes etc. This information can be obtained from road mark and traffic signs.
All three levels presented above can represent the road from functionality point of view, but the geometry is not precise. For example the linear links corresponding to lanes do not go exactly over centrelines.
The fourth level is more developed from geometrical point of view. Navigation surfaces are represented by polygons. The advantage is in the possibility of modelling the real geometry of lanes and intersection areas as well as pedestrian areas. This level enables the process of navigation to analyse interactions between pedestrians and vehicles.
We concluded by presenting some standards for road data such as EuroRoads, RoadXML and CityGML.

STATIC GENERATION AND MAP UPDATING:

The objective of this work is to study the solutions to generate and update the various attributes of maps for intelligent vehicles and this at all static description levels. The following paragraph presents certain issues addressed in this action.

Most geographic databases are generated with the help of aerial and satellite images, which can cover relatively large area, but fail to capture details at the street level because of the limited spatial resolution and point of view. Today, maps in car navigation systems do not contain details such as road marks, road signs or zebra zones which are essential for intelligent vehicles in their task of driving assistance, motion planning and decision making. Mobile mapping systems (MMS) (or Intelligent Vehicle Systems (IVS)) can be considered as complementary tools for mapping, extracting the road details from a different point of view.

Perception for Static Map Generation **(Ming Yang) – SJTU**

Current maps for car navigation systems do not contain details (such as lane markings, road marks, etc.), which are essential for intelligent vehicles in their task of autonomous driving, assistant driving, and cooperative driving. Mobile mapping systems (MMS) can be considered as complementary tools for mapping to aerial and satellite images. For this purpose, two new research platforms are developed in SJTU, MicroIV and CyberTiggo. The former is based on a 1:12 racing car model and the later is based on Cherry's Tiggo passenger car powered by gasoline. Surrounding view vision is new solution for detection and recognition of lane markings, road sign and parking area, and has been integrated on all the research platforms in SJTU including above two new platforms for the generation of lane markings and parking area. In order to reduce the computation cost, the visual selective attention method has been used in the traffic lights and traffic sign detection. Early work on generation of road boundary map using laser radar has also been described. Finally, a two-layer hierarchical topology map has been proposed for the intelligent vehicles with the consideration of traffic rules. Experimental results demonstrated its effectiveness in lane changing and intersection navigation.

UAV mapping and Disaster management with Spatial Information **(Masahiko Nagai) – AIT**

An unmanned aerial vehicle- (UAV-) based monitoring system is developed as an intermediate system between aerial survey and ground survey. All the measurement tools are mounted on the UAV to acquire detailed information from low altitudes which is different from a satellite or a plane. The monitoring is carried out from the sky, but the spatial and temporal resolutions are freely selected near the ground. Several different research approach is introduced for data acquisition, analysis, and sharing.

Road Edge Modeling**. (A. HervieuB. Soheilian, N. Paparoditis) – IGN**

Road edges localization is a key knowledge for automatic road modeling and thus in the autonomous vehicle domain. In this paper, we investigate the case of road border detection using LIDAR data. The aim is to propose a system recognizing curbs and curb ramps as well as reconstructing the missing information in case of occlusions. A prediction/estimation process is here considered, inspired by Kalman filters models. The map of angle deviation to ground normal is considered as a feature set, helping characterizing efficiently curbs while curb ramp and occluded curb are handled within the proposed modeling. Such a method may be used for both road map modeling and driver assistance systems. Road edges are further used to get a model of the road. It is done using a ransac algorithm to fit polynomials on the surface between couples of road edge points (on on the left and one on the right).

Detection and 3D reconstruction of traffic signs **(B. Soheilian, N. Paparoditis, B. Vallet) – IGN**

3D localization of traffic signs is of great interest in large number of navigation applications such as landmark based localization and trajectory planning. We presented an automatic approach to 3D reconstruction of road signs from a set of georeferenced colour images acquired by mobile mapping systems. The method is composed of two main steps called detection and 3D reconstruction. The former consists in detecting, identifying and estimating the silhouette of road signs in every individual image. The latter matches the detected signs within individual images and provides an optimum 3D geometry.

The detection steps starts with blue and red colour segmentation providing regions of interest (ROIs) in which geometric shapes (quadrilateral, triangle and ellipses) are estimated. The best shape is chosen following a compatibility score. This provides road sign candidates in image space. These candidates are evaluated in a validation step by comparing the texture inside the estimated shapes with a complete set of standard road signs. Regarding a similarity score the candidates are either rejected or classified as a particular type (ex. No entry sign).
The reconstruction step gets as input the detected road signs. A matching step finds every 2D road sign corresponding to a same 3D sign trough a hypotheses generation and validation process. Then, geometry of each 3D road sign is estimated trough a multi-view reconstruction involving a priori knowledge about the 3D form of signs. Evaluations revealed that the reconstruction is very precise since it reaches 3 cm of accuracy for position and 4° for orientation of signs.

DYNAMIC GENERATION AND MAP UPDATING:

The objective of this action is to study possible solutions to generate dynamic components of the maps for intelligent vehicles and at different levels of description. From a methodological point of view, the approaches are very different depending on the time scale and techniques of data collection (intelligent vehicles, sensors associated with the infrastructure). Observation methods, data fusion, data analysis and machine learning methods will be developed by the in this action. This topic was not discussed at this meeting since parners from CSIS could not go to Paris. Otherwise, many works have been presented in the three other actions.

CASE STUDIES:

a) Perception and localization, Heudiasyc, SJTU, IGN
b) Situation understanding, risk evaluation: E-motion, PKU, Liama

***Lane mapping and localisation*, Zui TAO – Heudiasyc CNRS UTC**

Estimating the position is a primary function for intelligent vehicle navigation. Different solutions exist, most rely on the use of high-end sensors. This approach proposes a solution that exploits vehicle embedded information, features extracted by low-cost perception sensors and an automotive type GPS receiver as well as data stored in vehicle navigation maps. The principle is using the lane detection function of a video camera as a source to provide accurate lateral vehicle position plus orientation with respect to road lane markings. These are first, mobile-mapped by the vehicle itself. It allows for the exploitation of camera-detected features for autonomous localization. The results are then combined with GPS estimates and data from dead-reckoning sensors using two Bayesian recursive estimation methods, namely, Kalman and particle filtering. An analytical observation model of the video camera is proposed to do the mobile-mapping and to implement efficient filter updates.

***Learning from human driving data for risk assessment in lane change,* Yao WEN – PKU.**

Being able to generate a lane change trajectory in a given driving situation is crucial in many driving safety systems, such as collision warning and driving assistant systems. Rather than generating such a trajectory using a mathematical model, this paper develops a lane change trajectory generation approach based on real human driving data stored in a database. In real-time, the system generates parametric trajectories by interpolating k human lane change trajectory instances from the pre-collected database that are similar to the current driving situation. In addition, to build this real lane change database, a human lane change data collection vehicle platform is developed. Extensive experiments have been carried out in urban highway environments to build a significant database with more than 200 lane changes. Real results show that this approach produces lane change trajectories that are quite similar to real ones which makes this strategy a good candidate to produce human-like lane change maneuvers

Information Fusion on Over-segmented Images: An Application for Urban Scene Understanding. **Philippe XU – UTC, LIAMA.**

The large number of tasks one may expect from a driver assistance system leads to consider many object classes in the neighborhood of the so-called intelligent vehicle. In order to get a correct understanding of the driving scene, one has to fuse all sources of information that can be made available. In this work, an original fusion framework working on segments of over-segmented images and based on the theory of belief functions is presented. The problem is posed as an image labeling one. It will first be applied to ground detection using three kinds of sensors. We will show how the fusion framework is flexible enough to include new sensors as well as new classes of objects; it will be shown by adding a sky and a vegetation class afterward. The work is validated on real and publicly available urban driving scene data.

Evidential Grammars, a framework for global scene understanding. **Jean-Baptiste BORDES – *Heudiasyc,* CNRS, LIAMA.**

In the last decade, visual grammars have proved to be an efficient approach to perform image interpretation and recognition. By providing some general knowledge to the system through the grammar rules, they make it possible to learn a model with a relatively small training set. Given a test image, the model is applied under the Bayesian posterior probability to build a parsing tree, which can be used as an interpretation of this image. In this work, an original framework for grammar-based image interpretation using uncertain data is presented. This method takes as input an over-segmented image every segment of which is associated to a belief function providing information one has about its class. We will show how to use the grammar rules to compute a hierarchical decomposition from the scene, to objects, parts and segments while taking into account the spatial relationships. The main contribution of this research is to propose a precise method to propagate the belief functions from the segments to the scene level by modeling the parsing tree as an evidential network. This method is then validated on synthetic data generated using urban driving scene images.

Embedded perception using map, **Julien Moras and Marek Kurdej – *Heudiasyc, CNRS UTC.***

This presentation proposes a perception scheme in the field of intelligent vehicles. The method exploits prior map knowledge and makes use of evidential grids constructed from the sensor data. Evidential grids are based on the occupancy grids and the formalism of the Dempster--Shafer theory. Prior knowledge is obtained from a geographic map which is considered as an additional source of information and combined with a grid representing sensor data. Since the vehicle environment is dynamic, stationary and mobile objects have to be distinguished. In order to achieve this objective, the evidential conflict information is used for mobile cell detection. As well, an accumulator is introduced and used as a factor for mass function specialisation in order to detect static cells. Different pieces of information become obsolete at different rates. To take this fact into account, contextual discounting is employed to control the cell remanence. Experiments carried out real-world data recorded in urban conditions illustrate the benefits of the presented approach.

Bayesian perception and risk assessment, **Mathias Perrollaz *Heudiasyc* – Emotion Inria.**

Inria has presented recent advances related to Bayesian perception and risk assessment. Particularly, the following aspects have been exposed:
- ROS middleware: in 2012, Inria has modified the software architecture of its experimental vehicle. Now the platform is fully operational using the ROS middleware. We have presented the improvements due to this modification, as well as the early results obtained.

- Occupancy grid computation from multiple layers of laser scans: The approach classically used for computing occupancy grids from lidar data shows great performances with single-layer laser scanners. When considering multiple layers of scan, the method can fail, due to conflicting information between the layers. We have presented an approach for fusing such information, which can overcome the problem, by computing confidence values in each cell of each layer of scan.
- Occupancy grid from stereovision: We have presented an original method for computing occupancy grid from stereovision, which includes a notion of geometrical visibility. The method proposes to perform all the computation in the disparity space associated to the stereoscopic sensor. This approach allows a better management of the uncertainty, a highly parallel implementation on GPU, and a better robustness toward matching errors.
- Lane change prediction: We have presented a method for prediction of lane changes of the ego-vehicle, on highway. The method relies only on visual data: a particle filter-based lane tracker is used to estimate the relative position and orientation of the car, with respect to the lane. Then this data is provided to a multi-class SVM for classifying the maneuver (the SVM was previously trained from data of real lane changes). The output of the SVM is finally filtered using a Bayesian filter in order to obtain a smooth prediction. The first experimentations showed prediction capabilities up to 3 seconds in advance, with an average prediction horizon of 1 second.
- Motion detection: In order to properly detect and track moving objects, it is necessary to distinguish between the static and dynamic parts of the environment. Inria has presented two approaches for solving this problem. The first approach relies on counting how many times a cell of a global map is seen as free or occupied. The second approach showed improved results, by implemented a simplified SLAM (Simultaneous Localization and Mapping) strategy.
- Vehicle detection: Inria has presented a new approach for detection and recognition of vehicles, from visual data. The approach extends the existing "part-based approach", by combining intensity and depth features in a probabilistic framework. Experiments showed a significant improvement of the performances.
- Risk at intersection: Inria has presented an approach for prediction of dangerous situations at intersections. The approach relies on the comparison between the expected behavior of a driver (including traffic rules) and its actual intention. A dynamic Bayesian Network is used to estimate the intention and expectation probabilities.

DISCUSSIONS

Dr Alex Zhe Ziang has presented Navinfo activities and R&D projects. Navinfo is

- Engaged in R&D of professional China navigable map since 1997, company established in Dec, 2002, more than 2,500 employees.
- Leading Service Provider in China, in fields of navigable map, dynamic traffic information and automotive integrated information
- China’s largest and world’s fourth-largest navigable maps provider;

Their current projects are:

- Data collect for ADAS: signboard recognition for navigation, lane and mark detection for navigation, privacy data protection
- Navigable map definition for intelligent vehicle especially for the 2013 China Autonomous Vehicles Competition,
- Data collection for detecting change of traffic rules, road shape speed limitation, etc.
- Streetview service.

A long discussion takes place at the end of the meeting on the different levels of detail of map in the scheme proposed by IGN and SJTU. The partners agreed that IV maps should be composed at least with level 3 and 4 and tools to switch from one level to another.

Another discussion concerned the GIS and database formats. The problems faced by IV partners relates to the poor knowledge of data formats and the need for tools to easily manipulate these data (access, modification, deletion etc…). GIS and database specialists could help us in this domain.

1. Next Meeting and workshop organization

The budget is limited, so we decide to organize one other meeting at the end the project. The final meeting will take place in Japan during the IEEE IROS conference. Yoshihide Sekimoto agreed to participate in the organization in Tokyo.

Christian Laugier proposes to contact the other organizers of the Workshop on **Planning, Perception and Navigation for Intelligent Vehicles (**P. Martinet**,** U. Nunes, C. Stiller, A. Broggi). The idea is to propose a session focusing on the topic "Maps for Intelligent Vehicles"**.** This workshop is organized with IROS 2013.

Several other events could be considered as opportunities to organize a meeting or a workshop:

Intelligent Vehicle and Robotic conferences

- IV 2013 (Australia)
- ITSC 2013 (Netherlands)
- ICRA 2013 (Germany)
- IROS 2013 (Tokyo)
- Chinese Future Vehicle Challenge 2013 (Beijing China)

Mapping and Geographics data conferences

- Int. Symposium on Mobile Mapping Technology 2013 (Taiwan)

Other events

- ICT-Asia Regional Conference (Asia)
- Meeting of the PRETIV project (partners : PKU, UTC, LIAMA, INRIA)
- Meeting of the MPR project (partners : PKU, UTC, LIAMA)
- …

2. Project website

A website hosted at the UTC is dedicated to the project. Its address is https://www.hds.utc.fr/predimap

PROJECT BUGDET

The budget of 28000€ (the requested amount was 40000€) is given for two years and for researchers and students mobility, meeting and workshop. The budget allocation is the following:

- 2011 : 4000 € from CNRS
- 2012 : 14000 € from MAEE + CNRS
- 2013 : 10000 € from MAEE

Budget (Predimap) of the first meeting in Compiegne 5000 €, + 4000 € given by Heudiasyc and MPR-LIAMA

Budget of ICT-Asia Seminar, fall 2012, Bangkok 3500 €

Budget (Predimap) of the 2d meeting in Saint Mandé 6200 €, + 1200 € by MPR-LIAMA

The budget for this second meeting:

3600 € **PREDIMAP** (air flight 3persons + train tickets)

~ 1000 € **PREDIMAP** (hotel)

~ 1600 € **PREDIMAP** (restaurants)

~ 1200 € LIAMA (project MPR) (airline tickets 1 person)

Budget for last year: 14000 €: 10 K€ for Tokyo meeting 4 K€ for other purposes like student mobility.

ANNUAL AND MID TERM REPORT

One annual report must be delivered for CNRS the next days. The organization of the report (in french) will be done by V. Cherfaoui and F. Davoine soon and will be available on the website.

We will provide an interim report to the MAEE including a technical and financial report for the first year, as well as a financial and technical implementation plan for the second year. The final activity report is to be transmitted to the MAEE during the fall 2013.

LIST OF PARTICIPANTS (PREDIMAP PROJECT)

PREDIMAP partners	
Matis IGN (France) :	Nicolas PAPARODITIS
	Bahman SOHEILIAN
	Alexandre HERVIEU
Heudiasyc UTC (France)	Véronique CHERFAOUI
	Philippe BONNIFAIT
	Julien MORAS
	Marek KURDEJ
	Zui TAO
GC, AIT (Thailand)	Masahiko NAGAI
LIAMA and PKU (China)	Franck DAVOINE
	Wen YAO
	Philippe XU
	Jean-Baptiste BORDES
SJTU (China)	Ming YANG
E-motion INRIA (France)	Christian LAUGIER
	Mathias PERROLLAZ
	Dizan VASQUEZ
Invited people	**(funded by themselves)**
NAVINFO (China)	Zhe XIANG
	Xiaohang CAO
RENAULT (France)	Alexandre ARMAND
Excused	
CSIS Univ. Tokyo(Japan)	Yoshihide SEKIMOTO
PKU (China)	Huijing ZHAO
PSA (France)	Jean-François BOISSOU
RENAULT (France)	Javier IBANEZ-GUZMAN

2 DAY WORKSHOP, PRELIMINARY PROGRAM

IGN, Institut National Géographique
Room Arago
4 Avenue Pasteur, 94160 Saint-Mande
Metro : Saint Mandé (line 1) or RER A : Vincennes

DAY 1, JANUARY 29TH, 2013: PRESENTATIONS

09:30 Welcome (V. Cherfaoui, F. Davoine)

10:00 Presentations of on-going activities and research **in relation with PREDIMAP** topics

- 10:00–11:15 IGN, Matis, FRANCE (N. Paparoditis, B. Soheilian)
- 11:15–12:15 AIT - Geoinformatics Center, THAILAND (M. Nagai)

12:15 Lunch time

14:00 Presentations (continued)

- 14:00–15:00 NavInfo (Zhe XIANG, Xiaohang CAO), CHINA
- 15:00–16:00 Key Lab of Machine Perception - PKU, LIAMA, CHINA (F. Davoine, Wen YAO, Ph. Xu, J.-B. Bordes)
- 16:00–17:00 Inria - Emotion, FRANCE (Ch. Laugier, M. Perrollaz)

17:00 **Stereopolis visit** - IGN mobile mapping system for generating georeferenced image databases

19:30 Dinner

DAY 2 JANUARY 30TH, 2013: PRESENTATIONS + DISCUSSIONS + PREDIMAP 2013

9:00 -12:30

- 09:00–10:00 Heudiasyc, CNRS, UTC, FRANCE (J. Moras, M. Kurdej, Z. Tao),
- 10:00–11:00 Shanghai Jiaotong University - CHINA (Ming YANG)
- 11:00–12-30 **discussions: perception for mapping and map updating**

12:30 Lunch time

- 14:00–15:30 **discussions: maps for perception/localization /risk assesment**
- 15:30–16:30 **PREDIMAP 2013**: Actions, people mobility, deliverables, next meeting.

PHOTOS OF THE EVENT

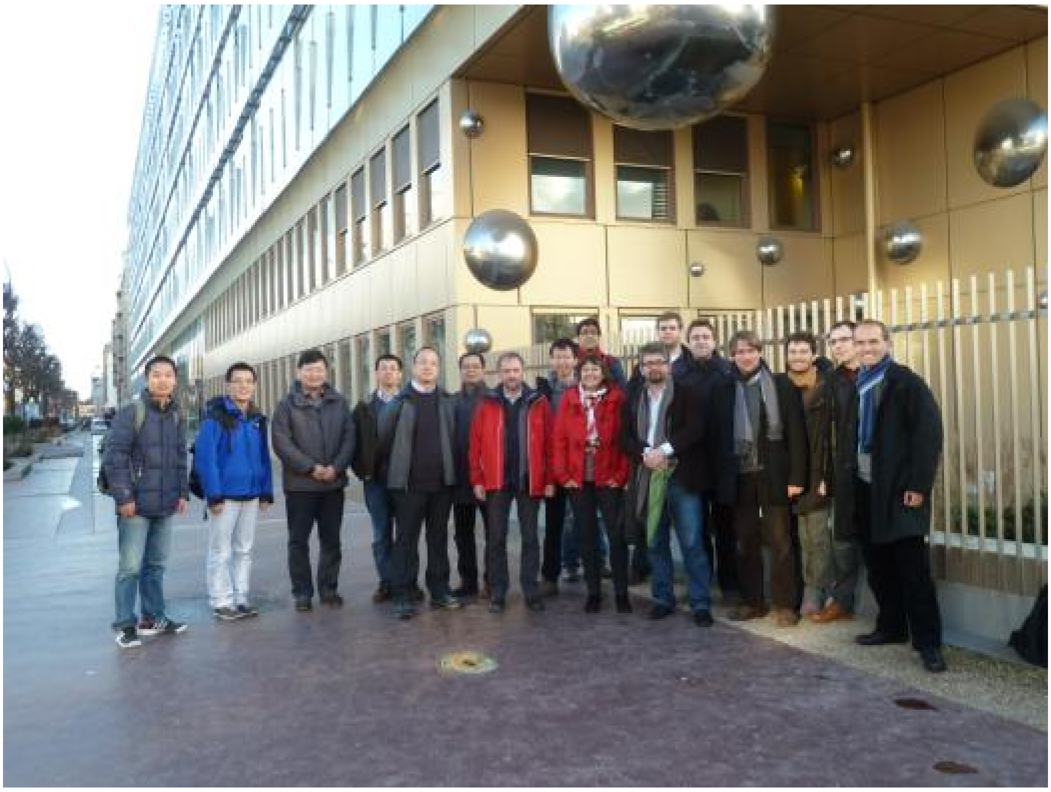

Figure 1. PREDIMAP meeting, participants, IGN Saint Mandé 2013.

Figure 2. PREDIMAP meeting IGN Saint Mandé 2013, Stereopolis demo.

Figure 3. PREDIMAP meeting IGN Saint Mandé 2013, dinner.