The Anglet Experiment: A Cybercar on the Beach

Joseph Canou, Damien Sallé, Marc Traonmillin, and Vincent Dupourqué

ROBOSOFT
Technopole d’Izarbel, 64 210 Bidart, France
{joseph.canou, damien.salle, marc.traonmillin, vincent.dupourque}@robosoft.fr

Abstract. This paper presents the "robuCAB", a Cybercar developed by ROBOSOFT, and the results of experimentation in a public and pedestrian area. In a first part, the hardware and software architecture of the vehicle - control, safety and HMI - are presented. The results of experimentation are detailed and the perspectives of evolution (control, safety, HMI) are discussed.

Keywords: Cybercar, control architecture, safety, HMI, experimentation.

Introduction

This article presents the results of an experimentation carried out within a French project called MobiVIP\(^1\) (funded by the French Research Ministry). This experimentation concerns the circulation of a cybercar (robuCAB, developed by Robosoft) in a pedestrian environment. The aim of this experimentation was the validation of the technical and safety aspects of the vehicle. It concerns also the acceptance of the use of a cybercar by the public. This 4 weeks experimentation allowed the transportation of approximately 500 persons.

Robosoft supplies advanced mobile robotics solutions to drastically reduce the cost of services in transport, thanks to its line of mobile robots, its embedded technology of control systems, and its expertise demonstrated in various fields of service robotics since 1985, including research. Robosoft’s core business is the automatic transport of people and goods in traffic-less areas. They have already designed and developed several cybercars:

- Cycab in collaboration with INRIA. Cycab is a cybercar allowing the transportation of 2 persons,
- RobuRide which is an autonomous system dedicated to people transportation. It is used in a historical touristic area (Maginot Line in France),
- RobuCAB, a cybercar allowing the transportation of 4 persons in an automated way.

\(^1\) http://www-sop.inria.fr/mobivip
A cybercar is a vehicle dedicated to people and goods transportation in a fully automated way, as illustrated in figure 1.

![Image](image1.png)

(a) In a technopole environment  (b) Providing service along the beach

**Fig. 1. The robuCAB vehicle**

These future transport modes apply to all the protected sites receiving a high concentration of people having to move on relatively short distances (few kms) in indoor or outdoor environments, as illustrated in figure 2. These vehicles work then either in standalone vehicle or in a fleet of vehicles managed by a supervisor. Among the protected places being able to receive cybercars one can quote:

- Inner city centers
- Industrials or academicals campus
- Public parks
- Airports

![Image](image2.png)

(a) A campus environment  (b) The Anglet experimentation site

**Fig. 2. Illustration of Cybercars in a dedicated area and the experimentation site**

In the future, one can imagine than there will be cybercars able to move at high speed on dedicated zones others than the reduced area than we quoted.
1 RobuBOX overview

All Robosoft's robots are provided with the robuBOX\textsuperscript{2}: a generic and advanced robotics controller software, developed with Microsoft\textsuperscript{®} Robotics Studio and implementing both low level control and high-level mobile robotic functions like path recording and following, obstacle detection, localization and basic navigation... It allows to easily and rapidly generate Service Based Architectures dedicated to service robotics.

The robuBOX main target is to provide researchers, integrators and manufacturers with an off-the-shelf solution to quickly and easily build standalone or fleets of service robots, such as AGV (Automatic Guided Vehicles), scrubbing machines, manipulators, cybercars, and so on. Based on reference designs for both the hardware platforms and control software, and thanks to the robuBOX, it becomes really easy and fast to transform any machine into a professional service robot.

The Robosoft's robuBOX software is really open for researchers through at least three important features:

- it provides existing services and control architectures that can be completely modified: one can develop his own service and integrate it in one of proposed architectures, or he can experiment completely new architectures using existing services as well as third parties services...
- To allow re-use of services and easy integration of new services in existing architectures, Robosoft has proposed definitions for standardized interfaces between robotic components and algorithms. Using these generic contracts, one can really easily develop a new algorithm and still use all the remaining robuBOX functionalities and provided architectures to deploy, test and evaluate it.
- It is not limited to the use of a specific OS, as gateways can be easily implemented to communicate information between services and other micro-controllers or CPUs (potentially running other OS). This can be achieved, among others, through TCP, serial links, webServices or other solutions.

The robuBOX, as it is Service based is really well suited to collaborative developments : once the goals and interfaces of each service have been defined, each user can carry out developments on his own. Once all the services are put back into the robot control system, the hassle of software integration is greatly reduced.

Another very important feature of robuBOX that is the realistic simulation environment: every robot from Robosoft is provided with its realistic model in the simulation (both physical/dynamic properties and graphic properties), as illustrated in the following pictures. The major benefit of the robuBOX simulation and generic interfaces is that the exact same service architecture can be used indifferently on the real robot or in the simulation. This has very strong consequences:

\textsuperscript{2}http://www.robosoft.fr
The users can work on the development of their own services using the simulations: they do not need a real robot in the first phases of a project.

There is a drastic gain in time and development effort for the prototyping and implementation of robotic control architectures, as they can be optimized while the robots are being built.

Experimental testing is faster while still as efficient as when using real robots since the control architecture remains exactly the same between the simulation and the real robot.

The robuBOX, as it is Service based is really well suited to collaborative developments: once the goals/and interfaces of each service have been defined in early phases of a project, each partner can carry out developments on his own. Once all the services are put back into the robot control system, the hassle of software integration is greatly reduced.

2 Description of The Anglet Experiment

The experimentation carried out within a French funded project called MobiVIP concerns the circulation of a cybercar (RobuCAB, developed by Robosoft) in a pedestrian environment. The aim of this experimentation was the validation of the technical and safety aspects of the vehicle. It concerns also the acceptance of the use of a cybercar by public in an open environment for a long period.

The objectives of this experimentation were as follows:

- Validation of the vehicle behavior in a crowd
- Validation of user acceptance
- Get feedback about user interface and possible vehicle improvements
- Feedback about safety issues

Description of the frame of experimentation:

- Duration : 4 weeks
- Path is a 700m loop with 4 possible stops
- The width of the path followed by the vehicle is 3m wide
- Localization made with a DGPS and odometry

The whole trajectory followed by the vehicle is composed by several sections. The sub-trajectories are learned using a joystick (teach by showing process). During this teach by showing process the characteristic points of the path are obtained from the DGPS system. The user defines then a scenario from the network of pre-learned sub-trajectories.

The figure 3 illustrates a teach by showing process.

The figure 4 is a screenshot of the HMI available to the user of the robuCAB. On a touch screen he can choose the starting and ending point of his course and visualize the result on a real picture of the site.
3 Autonomous navigation of the RobuCAB

This navigation system is divided in 2 parts (see figure 5):

- Localization: the information is coming from DGPS and Wheels sensors. They are combined to obtain reliable position/orientation information.
- Control law: current position from localization is compared to the reference trajectory. This comparison allow us to generate the speed and steering control of the vehicle allowing the trajectory following.

The aim of the localization system is to perform the low acquisition rate of the DGPS and some lack in the data. Each time a valid DGPS data is received the wheel sensors position estimation is reevaluated based on the DGPS information.

The robust CAB navigation is made using a control which combines orientation error and lateral error with respect to a reference trajectory (see figure 6).
The control law implemented on the vehicle is as follows:

\[
SteeringAngle = D \times K_{pp} \times ErrorSteer \times K_e \times \frac{180}{\Pi} + OffsetSteer
\]

In this control law the parameters are:

- \( D \): lateral error (orthogonal projection on the followed line)
- \( ErrorSteer \): steering error
- \( OffsetSteer \): mechanical offset
- \( K_{pp} \): proportional gain on lateral error
- \( K_e \): proportional gain on steering error

During the experimentation out of scope of Anglet demonstration, the vehicle is able to follow a trajectory up to 18km/h. For safety reasons (a lot of pedestrian on the demonstration site, elderly people...) the vehicle speed was limited to 11km/h. This speed was customizable by the user between 1, 2 and 3m/s.
4 Safety

During the displacement of the vehicle, the pedestrian protection is made autonomously using US sensors and a laser range finder.

![Diagram of safety zone](image)

**Fig. 7. Safety zone**

The pedestrian protection is made through a division of the space in front of the vehicle. Each zone is attached to a risk value, this value being dependant on the presence of an obstacle. The speed of the vehicle is managed directly by these risk zones and their values. When an obstacle is detected in front of the vehicle (see figure 7), a sound is emitted by the robuCAB to inform the person who could be there.

The vehicle is also equipped with emergency stop button located inside and outside the vehicle. In order to allow the passenger of the vehicle to adapt the vehicle speed to its desires, the HMI offers the possibility to limit the maximum speed of the vehicle.

5 Conclusion

During the 4 weeks of the experimentation, approximately 500 persons used the robuCAB without any major incident. The only encountered problem was material problem: DGPS failure, brake/motor failure and tyres. The comportment of the vehicle was conform to the implemented control law. However, the sensors used for the safety of the vehicle while navigating in crowd do not allow “intelligent” obstacle avoidance. In some case we have been confronted to a static obstacle (like a bicycle parked on the vehicle trajectory) and the vehicle just stops. If we want to improve the behavior of the vehicle in such a case we need more information from sensors. One of the most important information could come from a video system, allowing a more “intelligent” interpretation of the
situation. We had also the opportunity to discuss with a person from a French institute working on certification of such a system. From this discussion we obtained information concerning the improvement we could make to our vehicle for utilization in a taxi-like mode, like an automated door closing or a vocal warning instead of a "simple" sound warning. From a general point of view the user acceptance was good. People would like to have such a type of taxi-like transportation system. They were very interested in the ecological aspect of the vehicle and also in the possibility to share a vehicle for short courses, like in inner city.