Zinguer

Autonomous driving using trajectory planning

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Introduction

The goal of the ROTA project is to build an autonomous vehicle to compete in the Autonomous Driving Competition of the Portuguese Robotics Open and to explore this type of competition as a scientific framework to autonomous driving research. *Zinguer* represents the platform (vehicle plus high-level software) used in the 2010 edition of the Robotics Open.

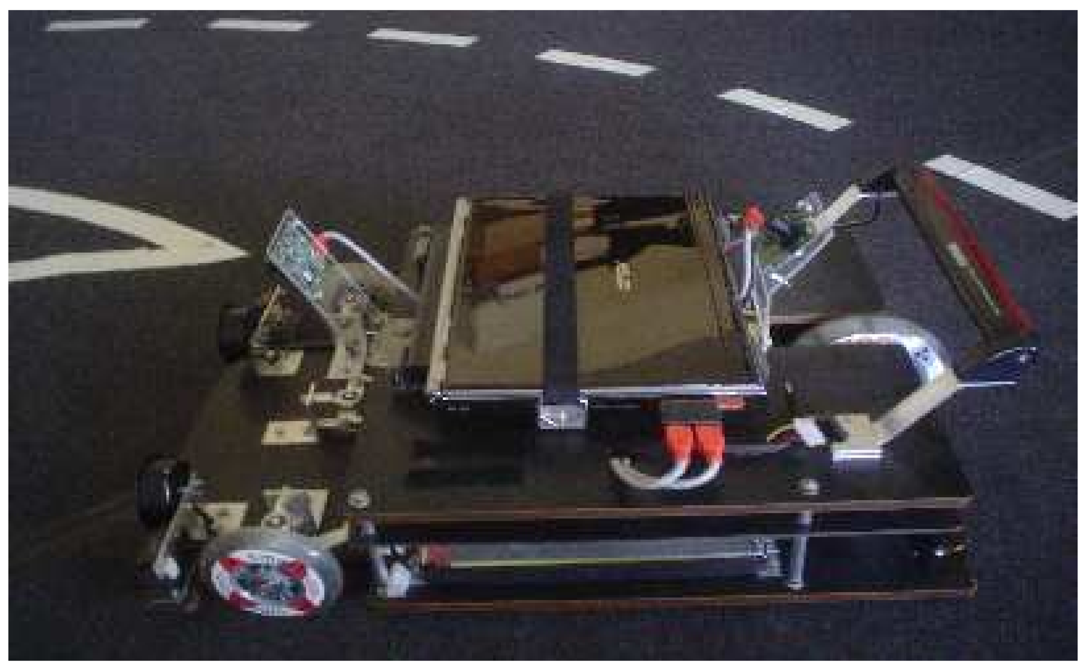

FIGURE 1: The zinguer vehicle.

Robot Platform

Physical infraestructure

The Zinguer robot (Fig. 1) was designed and completely built in-house using home-made mechanical parts and electronic modules. It is built upon a rectangular chassis made of a compact material with phenolic resins (with roughly 550x400mm), which supports one traction motor, the steering system and two batteries. The remaining parts of the robot are placed in three layers above this one. The first layer above the chassis includes all the electronic modules such as the motor controller and I/O interface to other actuators and sensors. The second layer contains the PC (a laptop). Finally on the top of the robot stands the vision system consisting of two standard low cost cameras, one used for navigation purposes and the other to read the traffic panel sign.

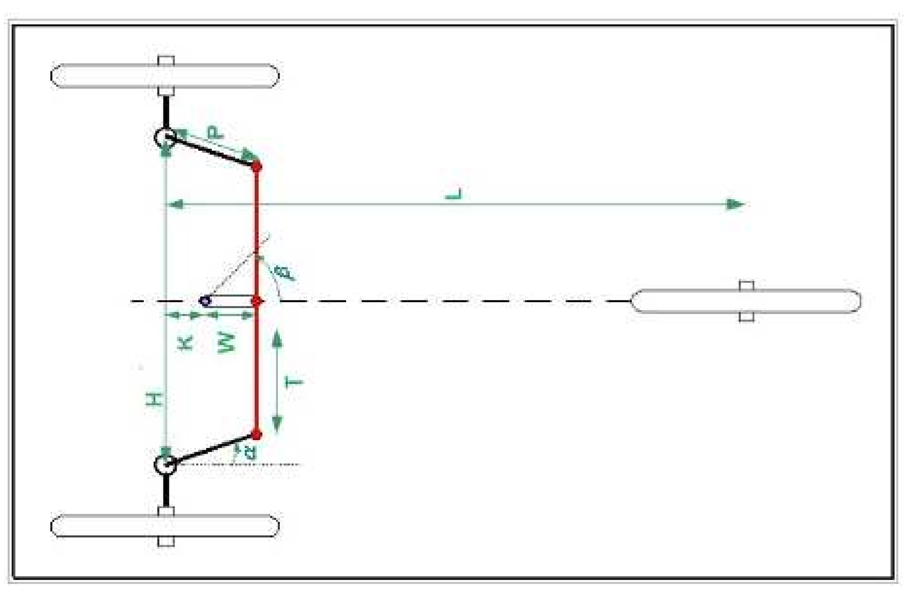

FIGURE 2: The Zinguer steering system.

The traction system adopts a tricycle solution with a single power wheel in the back and two independent steering wheels in the front. This approach greatly simplifies the train solution, since it can be based on a single power DC motor without the need for a mechanical differential solution as would be needed in a conventional two power wheels platform. The steering system, on the other hand is controlled by means of a simple proportional servo-motor with internal position feedback control, allowing a simple and direct action upon the robot curving behaviour.

Low-level sensor/actuating system

The low-level layer has a set of nodes interconnected by means of a CAN network operating at a bit rate of 250Kbps. This network is complemented with the FTT-CAN protocol (Flexible Time-Triggered communication over CAN) for improved real-time performance and composability. A gateway interconnects the CAN network to the PC at the high-level layer either through a serial port or a USB port, operating at 115Kbaud in any case. The low-level sensing/actuation layer executes three main functions: Motion control, I/O interface to other sensors/actuators and System Monitoring

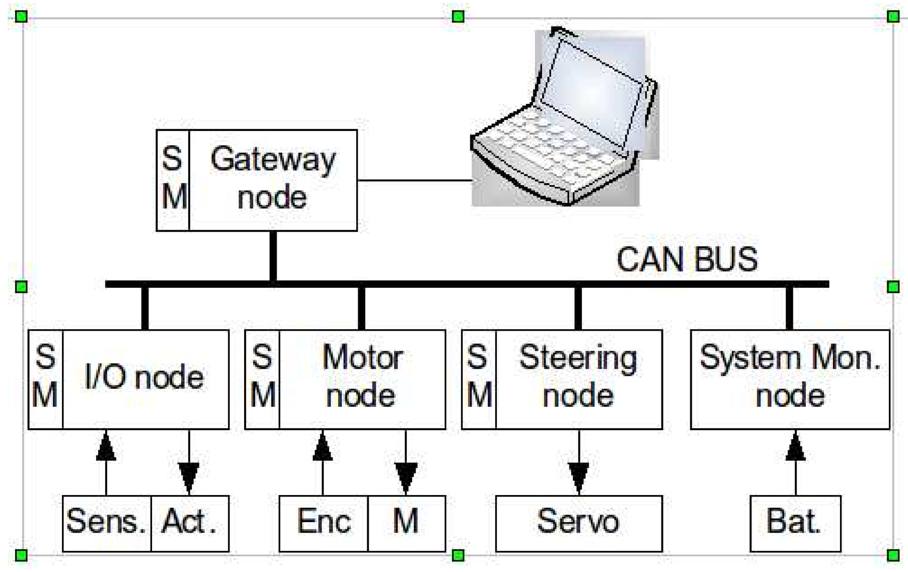

FIGURE 3: The low-level layer.

High-level control

The main processing unit is a laptop that delivers enough raw computing power while offering standard interfaces to connect to the lower layer (USB or serial ports) and the two the cameras (FireWire). The laptop runs the Linux operating system. The high-level coordination layer implements the global control of the robot. It collects data from the two cameras and from the low-level sensing system (e.g. obstacle sensors and odometry information) and sends actuation commands to the motion control. Its software architecture is further explained in the next section.

Software architecture

The software running in the laptop follows the architecture depicted in fig. 4. It is composed of a central shared data memory (the `RtDB`) and several processes running around. The `RtDB` is used to store information items that are shared between two or more processes. It was inherited from the CAMBADA project. It follows a description of the roles of the several processes:

- The `CarBase Comm` process guarantees that actuating orders put in the `RtDB` are sent to the low-level layer and that sensor data received from the low-level are stored in the `RtDB`.
- The `Road Vision` process aquire information from the road camera. This includes delimiting lines, obstacle and road maintenance cones localization.
- The `Sign Vision` process adquire information from the sign camera. This includes traffic light sign and vertical sign identification.
- The `Agent` process implements data fusion and trajectory planning and computes the actuating orders to be sent to the low-level layer.
- Finally, the `logger` and `viewer` processes are used to log and display the information items stored in the `RtDB`.

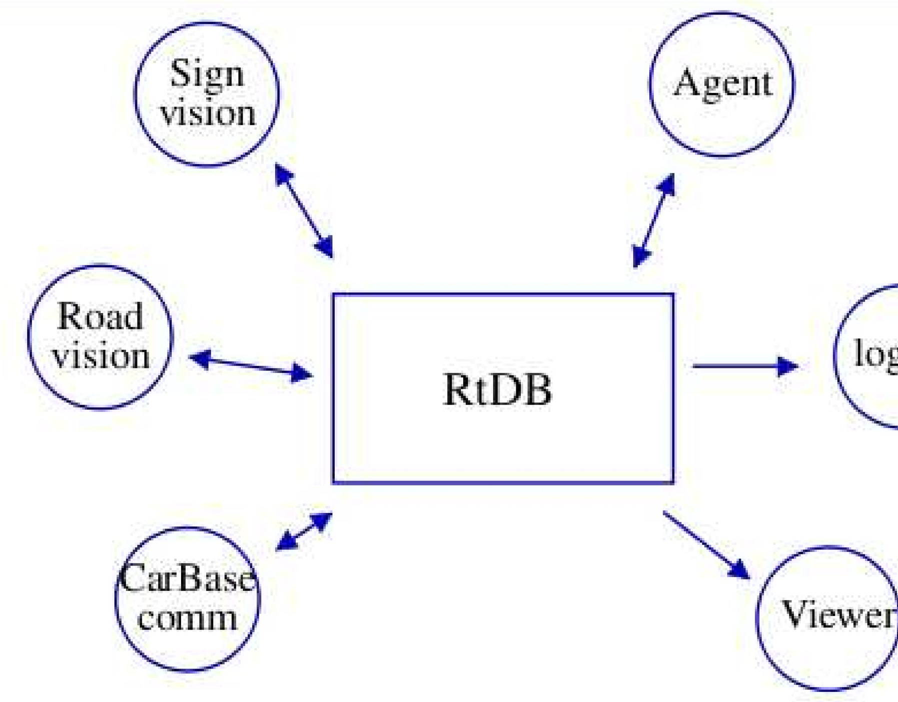

FIGURE 4: Overview of the high-level software.

All processes run in a cycle based approach, with a synchronization point at the beginning of the cycle. Thus, different ways of synchronization among the several processes can be implemented, being, in the current software version, followed a sequential approach. The `Road Vision` process defines the beginning of the global cycle, based on the grabbing of the road camera. It follows in order the `Sign Vision`, `Agent`, sending thread of `CarBase Comm`, `logger` and `viewer`.

Scientific challenges

- Object recognition
- Robot localization
- Trajectory planning
- Data fusion
- Track representation

Competition results

- 3rd place in the FNR 2006
- 2nd place in the FNR 2007
- 4th place in the FNR 2008
- 4th place in the FNR 2009

Recent publications

- José Luís Azevedo, Artur Pereira, Bernardo Cunha and Luís Almeida; *ROTA: a Robot for the Autonomous Driving Competition*; Encontro Científico do Robótica 2007. Paderne, Portugal, 2007.