Club Capra-Herbinator Design Report

Presented to the 8th Robotic Lawnmower Competition

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Introduction

The club was founded in 1996 by a group of students passionate about the world of robotics. Capra is a student science club, which has as main goal the design and implementation of autonomous vehicle.

For almost 4 years now, Herbinator is serving the club with its autonomous skills. We have been using this robot to demonstrated and promoting stability with its hardware architecture. This competition is worldwide and brings together the most prestigious universities in the field of robotics.

Team

Looking at the team's architecture, the team contains 22 actives students separate in 4 major departments who developed their objectives and vision of the robot. Here is the team's architecture and different teams:

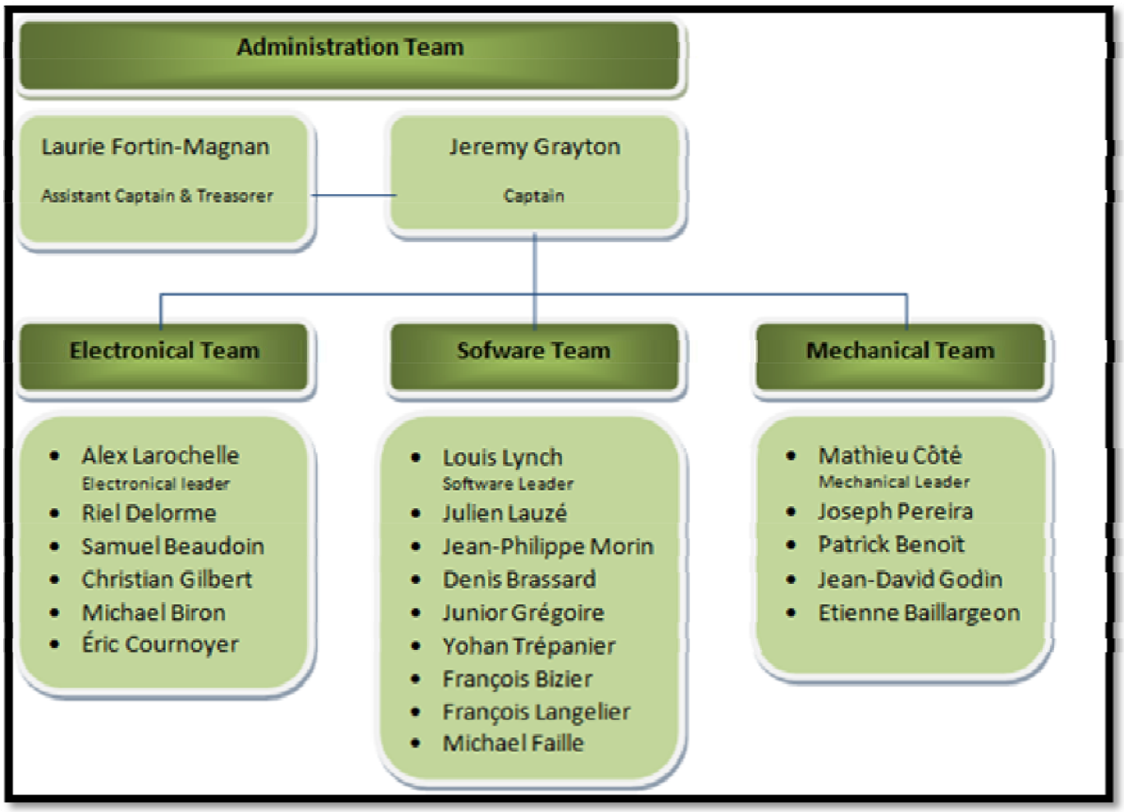

Figure 1: Capra's team architecture

Costs (througout the years)

Component	Sponsor by	Detail cost	Price paid
Batteries	Batterie Experts	$400	$160
Electronics	Labo Circuit	$800	$800
Encoders		$340	$275
Electric motors		$1,400	$100
Grass Trimmer		$80	$80
GPS	NovAtel	$19,000	$4,600
IMU	MicroStrain	$1,500	$0
Camera		$500	$500
Lawn mower		$250	$175
Mechanical		$200	$200
LCD screen		$300	$300
Omnistar service	Omnistar	$2,500	$0
Computer	Kontron	$1,450	$450
Range Finder		$6,500	$2,550
Structure	Palardy	$600	$200
Wheels		$140	$140
Total		$35 960	$10 530

Each year Herbinator has to be optimized, so Capra's team spends money on it. Represented above, is the cost of the robot from year one to today.

Mechanical design

Herbinator is a four-wheel vehicle robot, with two lawn tractor pneumatic motor wheels of 12.5 inches at the front and two free swivel wheels at the back. The chassis is made of welded 1 inch aluminum 6061-T6 square tubing, and the aluminum 6061-T6 shell protect all internal components (electronics, motors and computer. The total weight of the robot is about 225 pounds, and overall the robot is 43 inches long, 30.5 inches wide and 24 inches high without the pole. The pole is almost 4 feet long which contain the computer screen, the GPS antenna, the camera, the IMU and the support for the mouse and keyboard. The cutting diameter of the blade is 20 inches.

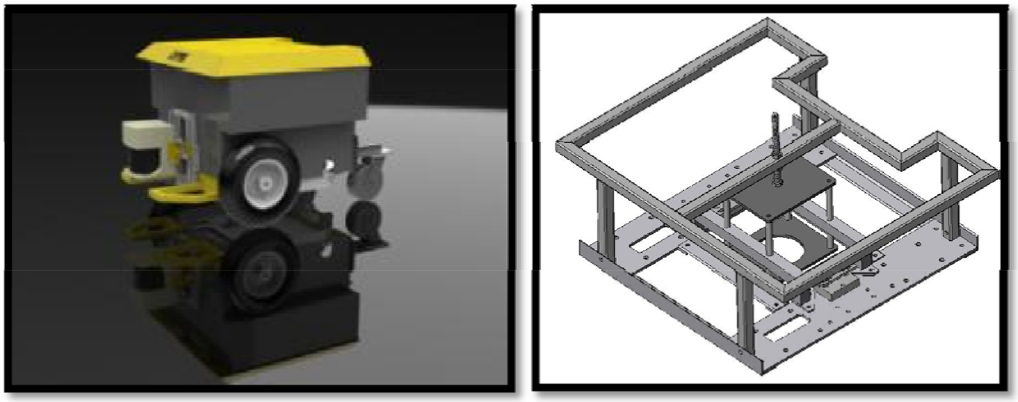

Figure 2: Herbinator frame

Traction Design

The traction system of Herbinator is based on two wheelchair motors with a chain and sprockets design. We use chains instead of belts to eliminate the error of belt slipping and chains are stronger. Those characteristics are important due to the environment in which it operates. Drive shafts and sprocket must be strong to be use with our heavy weight vehicle.

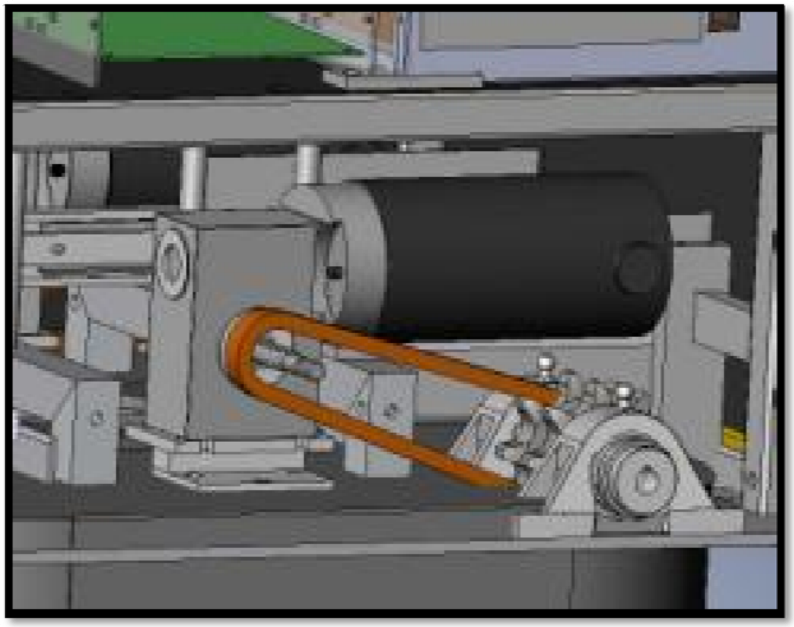

Figure 3: Traction system

Lawn mower

The lawn mower we use is a standard blade of 20 inches under the robot. A protection guard is installed all around the blade to protect everybody of flying particle of grass. The blade is mounted on a motor of 1.5 hp which come from a used lawn mower.

Electronics

The electric team has the task to link the software and the electrical part together. Doing these results in creating a safe system to control the robot based on the commands sent by the artificial intelligence.

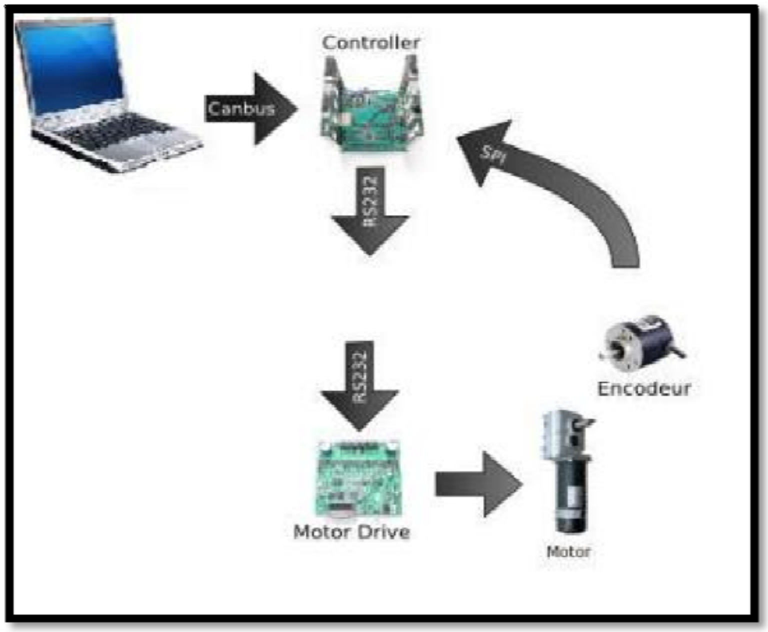

Figure 4: Communication with the controller board

The controller board, powered by a CAN-capable Atmel AVR microcontroller, interacts with many of the robot's peripherals. Here is an overview of those communications:

The controller and the computer communicate with each others with an Ixxat USB-to-CAN Compact interface, allowing the AI to send commands to the controller. Finally, the appropriate commands are sent to the drive, a RoboteQ AX1500, via a RS-232 connection.

Devices

Due to a malfunction with the old lawnmower motor, we swapped it for a new one. The blade's diameter is still 21 inches and the blade is still adjustable to desired height. The lawnmower motor is a 1/3 hp consuming 10 amps and the speed of the robot is 4m/s.

The computer is the heart of the vehicle. The computer assumes the link between each component. It also allows the robot to have intelligence. In the past years, the team was using an embedded pc, but this year, the team decided to change for a laptop. This allows the same functionalities than the embedded pc and because the laptop has it's own energy source, it allows the vehicle a greater autonomy.

Two 24 volts ⅓ Hp motor allow the robot to move. That kind of motor is often used on wheelchair. The 1/3 hp motors are controlled with a 2X50Amps channel roboteq AX2550 motor controller. The controller receives the signs of the micro-controller.

The encoders are used to have a feedback of the speed of our robot. It also allows us to know the distance travelled. The encoder had 360 counts per turn to acquire the rotation feedback of our wheels.

The SICK LMS 291 laser scanner is used to detect obstacles in a 180 degrees radium in front of the robot. The data collected by the laser scanner is sent to the computer for analysis.

The OEMV-3 GPS receiver coupled with a GPS-532-C L1/L2 aircraft antenna are used to receive a GPS signal to pinpoint the location of the robot. For the GPS, our subscription with the Omnistar differential GPS service allows us to have an error of less than 10 cm. This system is also a lot more reliable than the CDGPS (Canadian Differential GPS service)

The Microstrain 3DM-GX1 inertial measurement unit allow us to correct a position error due to a lost of grip on the grass. The inertial measurement unit detects a change in the field.

The controller board, powered by a CAN-capable Atmel AVR microcontroller, interacts with the encoders, the motor controller, the lawn mower and the computer. The communication between the computer and the controller is the can protocol.

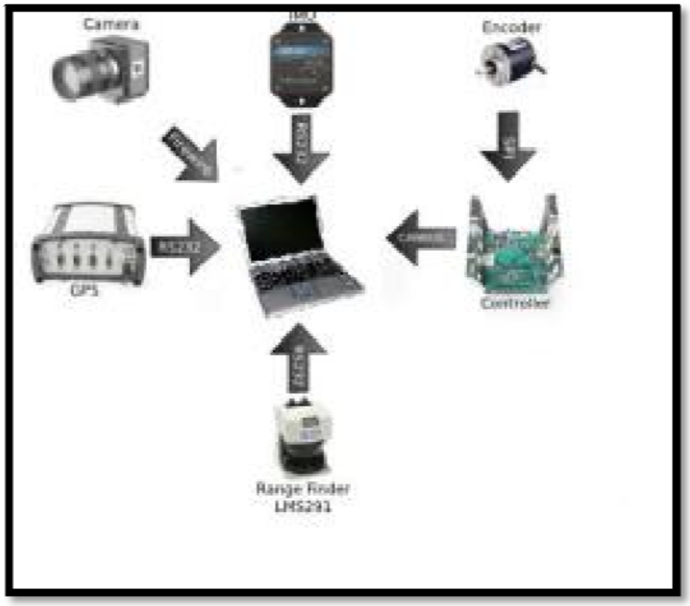

Figure 5: Communication between the sensors and the computer

There are two parts in the electrical system, each one connected to a battery pack: the electronic section (computer, sensors and controller) and the motors section (motors and drive). This allows us to change the motor battery without having to shut down the computer and protect the computer from the power surge caused by the battery. Each battery is made of two 12V batteries connected in series to get a 24V battery pack. The electronic section is powered by a 24v Battery pack through a homemade power supply. Our homemade power supply is compact because it was made to fulfill our particular needs. We are using a very easy color code for the wiring. This code allow anyone to work on the robot with a minimal risk

The robot has two safety devices. One is a simply emergency stop button that cuts power everywhere in the robot. The second one is a remote emergency stop. This one does the same thing has the first one, but we don't need to be near the robot.

Software strategies

First we generate an itinerary for the robot to cover most of the field. Then its follow the path to the next “checkpoint” we assigned it.

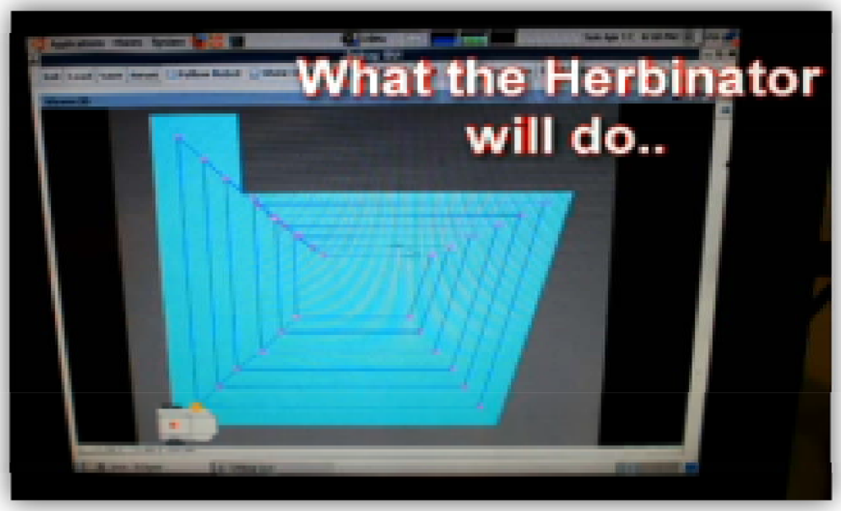

Figure 6: Snapshot from the qualification video – Demonstration of Herbi’s path

Environment Mapping

Using this mapping we find a possible path from our current position to the next checkpoint using an AI star algorithm. Using this technique allow the robot to keep going in the desired direction even if a straight path is obfuscated.

The robot also has a memory map that is implemented using a grid. The grid resolution is configurable and offers some commodity. This grid is responsible to mark a cell has: visited, out of reach, out of bound or obstacle. With these region and states it eases the computation of heuristic for the AI algorithm.

Evaluating Position

To evaluate our position we rely on GPS position. This position is not perfectly accurate and stable. To ensure more stability to the robot position we use relative position as our real time solution. Encoders give a good idea of the progression made even if the wheels slip. With its counterpart, the GPS, its can appear like if we just jumped out of the field. We try to avoid considering these “jumps” for real time decision making.

Orienting Displacements

Locating our robot using GPS positions does not provide information about the orientation of the robot. We use an IMU (Inertial Measurement Unit) to know what the orientation for the robot from north. Using this static referential ensure we can navigate in the right direction. We can also use this device to know if we are moving in a straight line or not. If we derive from our targeted orientation the system will detect a shift in direction and straighten the robot.

Vision Obstacles Detection

The range finder gives a frame every inch even at maximum speed. This awake is essential for responsiveness when we are talking about dodging moving obstacles.

Relying on this solution for obstacle detection might work fine but sometimes we had trouble detecting bright dark reflecting surfaces or very low obstacle since grass is long enough sometimes. The flower bed for example has exactly these characteristics.

Using a high camera to avoid non grass looking pattern may help to detect more reliably this particular obstacle. The down side of this method is that treating the image can take up to 100 ms and this delay means we have one frame every few inches.

Conclusion

Team Capra is proud to participate in this multidisciplinary project and all members always try to surpass themselves. The students worked for at least 200 hours this year on Herbinator trying to resolve problems and to optimize its performance. Combining over 4 fields of engineering in the project is a challenge of its own. The administration of the team is one of a kind, based on some volunteer work. As for the different departments (mechanical, electrical and software), they combine their expertise towards one goal: an autonomous lawnmower. The results are there, and we are looking forward on bringing Herbinator on the field!