2013 DESIGN REPORT

Sercan Karakaş, Abdul Jamil Aryan,

Utkan Çalışkan, Serkan Solmaz

Contents

1.Introduction

Beehicle is the first vehicle from Istanbul Technical University (ITU), participating in the Intelligent Ground Vehicle Competition. Also it is the first vehicle for this competition representing ITU and Turkey. Our team consists of 5 members who are undergraduate students. Although the materials related with the researches on autonomous vehicles are covered in the scope of a graduate program at ITU, this is the first research which is conducted by a team consisting entirely of undergraduate engineering students, independently. The main goal for this year is to participate in the competition and challenge for basic tasks. We are building a vehicle that is very simplified in terms of mechanical and electronic design in a fairly inexpensive way.

2.Team Organisation

Our team is comprised of 2 Mechanical Engineering undergraduate students, 1 Electronical Engineering undergraduate student, 1 Manufacturing Engineering undergraduate students, as well as Prof. Dr. Mesut Gür, who is the advisor. We divided the team into 4 sub-groups which reflects the interdisciplinary commitment of our team members. Sub-groups include Software Architecture, Mechanics, Management and Electronics. The Software Architecture sub-group is in charge of designing the automated software package from the ground to enable the vehicle function autonomously based on collecting vision data from the surroundings. The Mechanical sub-group takes over the design of the vehicle's chassis and decides on the required materials to be used as well as locating their mounting points on the vehicle. The Management sub-group is responsible for finding and sustaining financial resources as well as for the overall logistics. The Electronics sub-group is tasked with designing and testing of the whole embedded system and ensures about full functionality and integrity of the system hardware to respond timely and which bridges between software architecture and the input-output peripheral units. The Team's captain provides coordination between the sub-groups and engages in communication with and final delivery from sub-groups. Our team's organization is charted below in the figure.

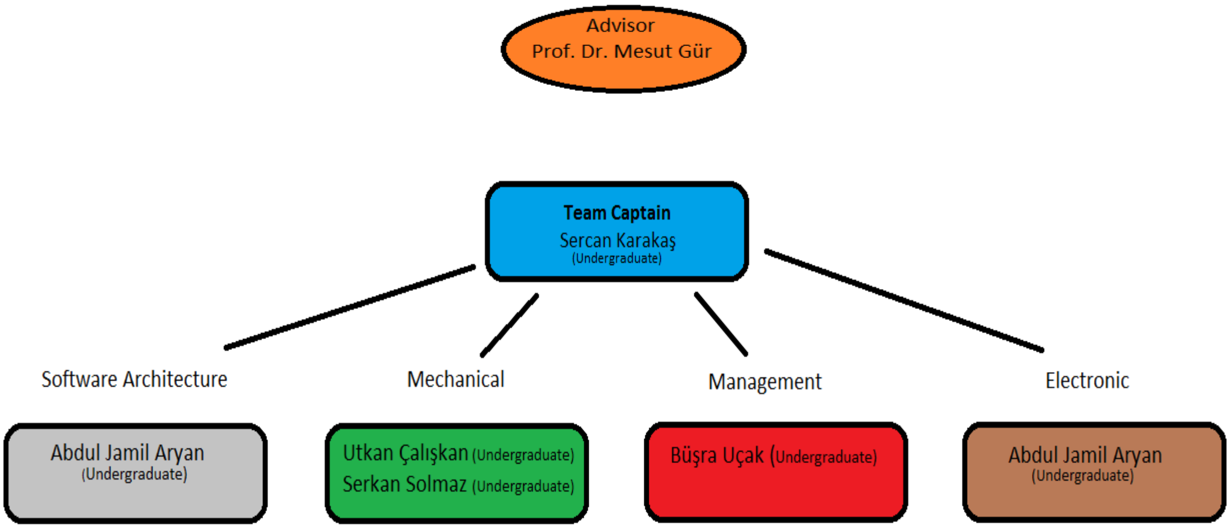


Figure.1 Team Structure

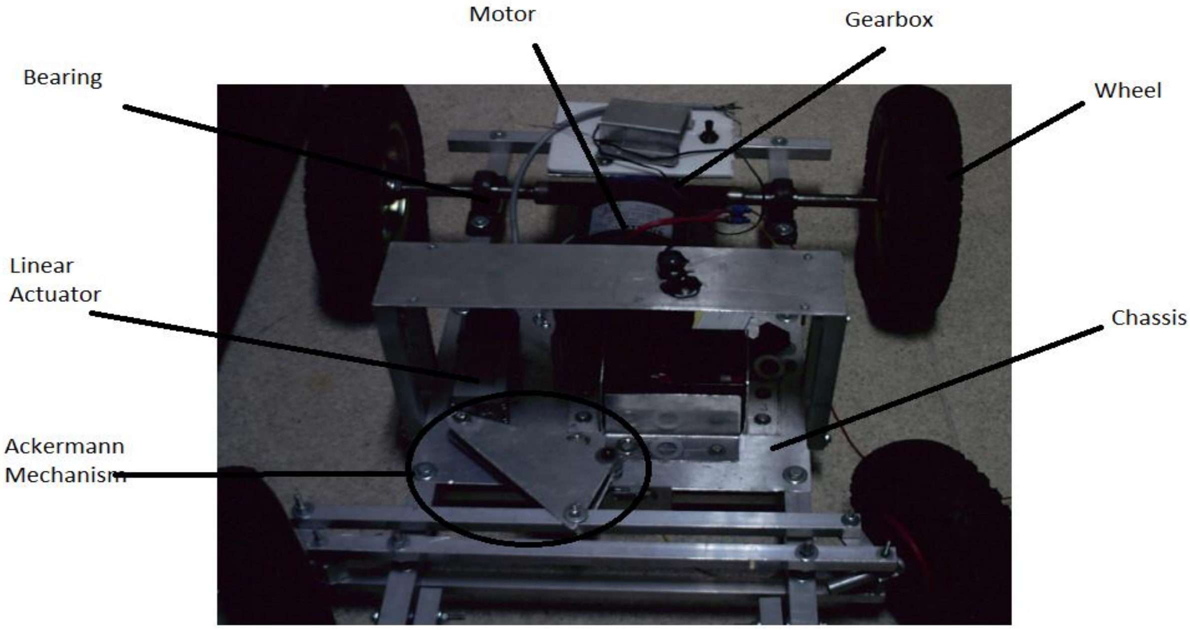
3. Mechanical Design

3.1 Rain proofing

The vehicle can protect its internal units from malfunctioning under a rainy condition. The electronic systems that are under threat from water drops, are gathered and placed in a Nanuk Box and the intermediate cables' conductivity is ensured by the use of watertight couplings. Additionally, the brushed DC motor is protected through a protective brush, and the camera is placed in a rainproof box to be isolated from water drops. The brushes are produced with an inclined design so that any accumulated water will flow down keeping the upper surfaces free of raindrops.

3.2 Mechanical Skeleton

The chassis is made out of a rigid aluminum alloy square tubes which is measured in total as 92mm long by 53mm wide, and the tubes are 1 inch by 1 inch. We mounted aluminum sheets and brackets to implement housings of the chassis.



Construction is provided by bolts and nuts. In order to minimize the inertial momentum of the vehicle, the heavy bodies are placed close to the gravitational center. We intend to make the construction by welding for the next competition. The chassis consists of two wheels that are inter connected to a brushed DC motor and two more wheels at the front provide heading control for the auto-drive as well as the vision angle by mounting the camera on top of the two rotating wheels. The total weight of the vehicle is 28 Kg; however, based on the results obtained from our tests, the DC motor can handle a payload of approximately 60 Kg.

3.3 Drive Train

We consider real-car mechanisms with four wheels, one motor and one gearbox for vehicle's drive train. Rotational control of the vehicle is controlled with Ackermann mechanism which is used in real cars. The rotational movement is achieved through linearly moving the actuator which utilizes a special mechanism to rotate the front wheels in left and right directions. The vehicle moves forward by a brushed DC motor through a high current capable motor controller called 4QHF 2D. A conic gear connected with the DC motor, which provides the forward movement force, enables the vehicle to move with an average speed of 5 mph. Furthermore, the vehicle's drive train allows a maximum 9mph speed, the ability of navigating on grass and driving up a 15 degree inclined surface.

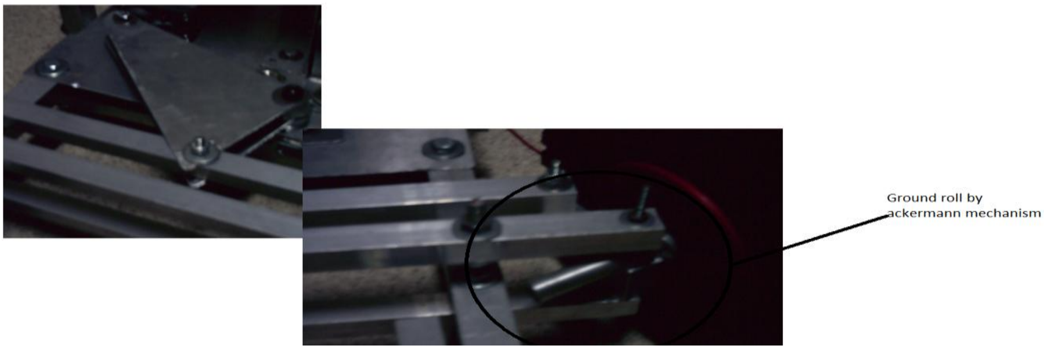
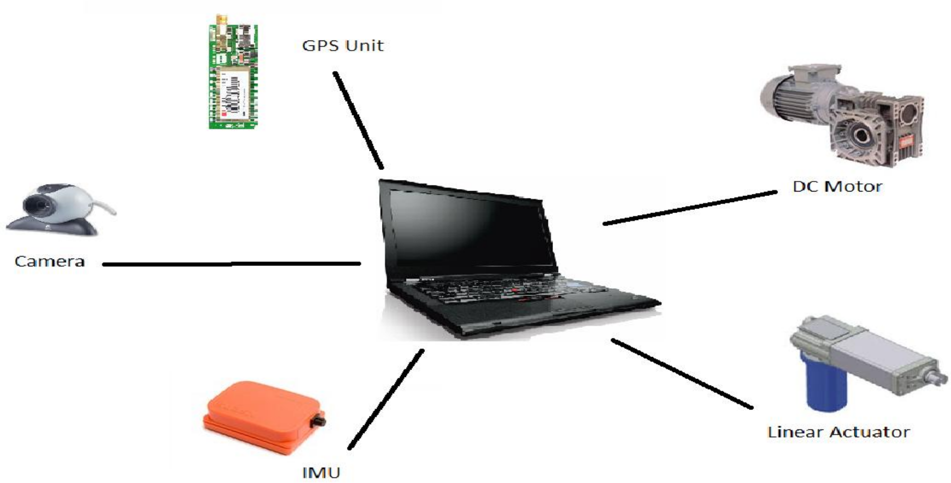


Figure3. Ackermann Mechanism

4. Electronics & Software System

The electronic components used in IGV Beehicle consist of an array of sensors, an electronic interface card and a set of actuators. All of these sets are controlled by an automated Laptop which functions as the brain and the auto-pilot, mounted as an independent unit on IGV Beehicle.



This is an i-7 quad core PC which can handle the vision, path planning and navigation. The array of sensor suite consists of an HD camera, a GPS, and an IMU which are all directly connected to the main PC through USB cables. The HD camera is the main sensor on the vehicle which accomplishes gathering of visual data and distance measurement. The IMU helps in sustaining feedback for the heading on plain surfaces and tilt on surfaces with inclinations. The set of actuators consist of a brushed DC motor with a high current handling capacity, providing the force of motion and a linear actuator for controlling the heading. There is an Arduino card associated with interconnections which is used as the electronic interface card for controlling the actuators through ready to use motor controllers. The vehicle provides two sources of powering the peripherals which are two 12-Volts accumulator batteries in series, and the battery that comes as built-in along with the main PC laptop.

List of Electronic equipments used in Beehicle

Equipment	Specifications	Description
Lenovo Laptop	Intel Core i7 2.2GHz , 6GB Ram 750GB Hard disk	
Logitech HD Camera	LOGITECH C920 BLACK FULLHD WEBCAM	
Xsens IMU	9-DOF Inertial Measurement Unit providing Euler Orientations	
Click Board GPS sensor		
Arduino Uno	16 MHz AVR Microcontroller	
Linear Actuator	Mecvel branded	
Femsan Brushed DC Motor	FEMSAN 24-Volts, 21 A Brushed	
Batteries	Two 12 Volt, Orion branded batteries	

By keeping the electronics details as simple as possible, the team has had the chance to keep focused at the overall functionality of the vehicle, ensuring to take part in the competition in a very short time. Another aspect is based on the fact that by using open source hardware and software alternatives, it is easy to present a fully functional autonomous vehicle without going deep into some physical circuitry, instead one can spend more time and effort on challenges and designing high-level algorithms for performing tasks.

The collection of software packages used in the vehicle are all based on an open source style and through the help of manuals accompanied along with those packages. As a bundle, these packages are compiled to run on top of an embedded Operating system which solely serves the purpose of hosting the core software package. The core software package is designed from the ground in C++ programming language using the nowadays popular and favorite cross-platform IDE called Qt Framework.

The main purpose behind such a selection was based on the fact that open source software/hardware is the future of rapidly growing robotics sector. Another factor that pushed the cause even further was the emergence of Open-CV Library package. As the vehicle's autonomous functionality depends on visual data gathering from the environment, Open-CV proved to be the most powerful and suitable choice for such a system mainly involved with embedded calculations which provides real-time response based on the robustness of its underlying hardware.

The ability to embed pieces of Open-CV code snippets inside a core application which deals with lots of ports and resource management, not only provides a compact system but also reflects the unique real-time functionality that remains without a rival so far. Due to the time constraints for this year, the Beehicle team will continue to utilize the same analogy and will further makes use of such an integrated software code snippets to develop a more sophisticated FSM-behavioral-machine. Currently, the vehicle has the ability to track a lane of two white lines in an outdoor environment and recognize the color of objects in the surrounding. Since a Laser Range Finder is not installed on the system, the object recognition capability will be the main tool to avoid obstacle collision.

The mix of software packages that are used in the vehicle makes it easy to convert the vehicle into ROV by doing some small scale manipulations in the code and a set of GUI interfaces can be easily incorporated into the system which can function as a control panel for driving.

5. Conclusion:

The team has successfully built an Autonomous Ground Vehicle which moves on terrain based on visual data from its surrounds. The vehicle can reach a speed of 5mph on average, and it is designed in a less than one month period and in a very cheap way. All the components and pieces are maintained from within the national borders. This vehicle can serve as a reference for any future academic research on the field.