VISIÓN ELECTRÓNICA VOL. 18 NO. 1 (2024) • JANUARY-JUNE • P.P. 72-80 • ISSN 1909-9746 • ISSN-E 2248-4728 • BOGOTÁ (COLOMBIA)

UNIVERSIDAD DISTRITAL FRANCISCO JOSÉ DE CALDAS

Visión Electrónica

https://revistas.udistrital.edu.co/index.php/visele

VISIÓN ELECTRÓNICA

A RESEARCH VISION

Prototype of a Rover as a learning outcome

Prototipo de un Rover como resultado de aprendizaje

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INFORMACIÓN DEL ARTÍCULO

Historia del artículo:
Enviado: 10/12/2023
Recibido: 21/12/2023
Aceptado: 23/02/2024

Keywords:
Learning outcomes
Technology
Electronics
Rover
Education

Palabras clave:
Resultados de aprendizaje
Tecnología
Electrónica
Rover
Educación

ABSTRACT

The petty officer's school "CT. Andrés M. Diaz" is aimed at continuous improvement processes through factors, characteristics, and high-quality references, which are reflected in the institution and its academic programs. The objective is to contribute to the understanding of the concepts and regulations associated with Learning Results, as an essential aspect to assess the progress that students make in their training process at the institution. This is how the school focuses its training programs on teaching Learning Results, which is why, from Aeronautical Electronics Technology, they are aligned with the objective of the institution, and from its different subjects it is possible to focus the training process on the perspective of Learning Outcomes. For this reason, this technology focused on the curricula, where a process of structure and coherent alignment between the different contents was promoted. Taking this process into account, an evaluation methodology was used, in the subjects of Electronics III and Microcontrollers, to carry out the investigation of the design of a Rover, with the help of the contents of these subjects, which served as support to carry out the different systems of this prototype, thus achieving the objective of the investigation and generating the Learning Result of the subjects involved. In the development of the prototype, the classroom of seven students was divided into three groups, two of two students and one of three respectively. The group of three students oversaw the design and structure of the Rover, the other two groups, one for the control system and the next for the part of a weather station that was incorporated into the Rover. In the final development of the prototype, the different knowledge of electronics and microcontrollers is reinforced, thus demonstrating the learning outcome proposed at the beginning of the subjects.

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Citar este artículo como: R. M. Molano-Pulido, O. F. Reina-Muñoz, C. C. Serna-Franco, "Prototype of a Rover as a learning outcome", Visión electrónica, vol. 18, no. 1, pp. 72-80, january-june 2024, https://doi.org/10.14483/22484728.22770

RESUMEN

La Escuela de Suboficiales "CT. Andrés M. Diaz", está encaminada a los procesos de mejoramiento continuo por medio de factores, características y referentes de alta calidad, que se reflejan en la institución y en sus programas académicos. El objetivo es contribuir a la comprensión de los conceptos y normativas asociados a los Resultados de Aprendizaje, como aspecto esencial para valorar los avances que los alumnos alcanzan en su proceso formativo. La escuela enfoca sus programas formativos en la enseñanza de los Resultados de Aprendizaje, y desde el programa de Tecnología de Electrónica Aeronáutica se alinean al objetivo de la institución desde sus asignaturas. Teniendo en cuenta este proceso, se utilizó una metodología de evaluación en las asignaturas de Electrónica III y Microcontroladores, para realizar la investigación del diseño de un Rover con ayuda de los contenidos de estas asignaturas, los cuales sirvieron de apoyo para realizar los diferentes sistemas de este prototipo. Para desarrollar el prototipo se dividió el aula en tres grupos, dos de dos alumnos y uno de tres respectivamente. El grupo de tres alumnos se encargó del diseño y estructura del Rover, otro grupo hizo el sistema de control y el otro la parte de una estación meteorológica que se incorporó al Rover. En el desarrollo final del prototipo se refuerzan los diferentes conocimientos de electrónica y microcontroladores. El resultado de aprendizaje del prototipo concuerda con lo planteado en el inicio de las asignaturas.

1. Introduction

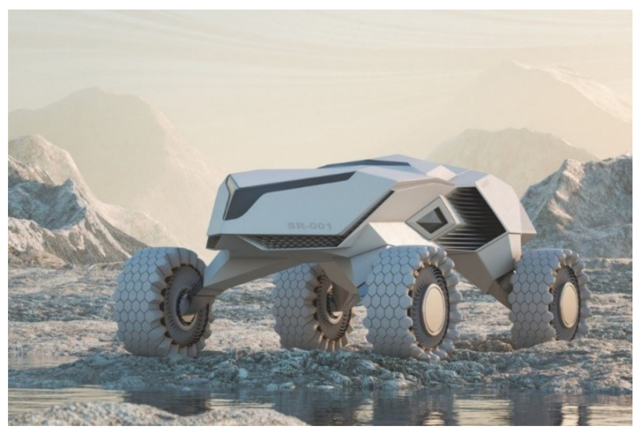
In 2020, the Ministry of Education issued Resolution 021795 on November 19, 2020, which outlines the new guidelines that higher education institutions must follow to obtain their qualified registrations and high-quality accreditation. This is why the Sub-officers School "CT. Andrés M. Diaz" -ESUFA-, has eight technological programs, seven of which have their qualified registrations and are accredited with high quality. This implies that ESUFA must implement strategies and processes to align its programs with the new regulations proposed by Resolution 021795, regarding the evaluation methodology focused on Learning Outcomes -LO-. [1]

In this regard, the Aeronautical Electronics Technology -TEA- aims to align with the LO and, within the curriculum in the fourth semester of the technology, there are the subjects of Electronics III and Microcontrollers, which target the LO and propose that students, at the end of the subjects, create a Rover prototype with 6 thrusters remotely controlled from an App and a mini weather station that measures temperature, humidity, barometric pressure, and GPS variables. These measurements will be sent wirelessly to a PC where the received data will be stored.

Currently, there are countless investigations that use Rover prototypes - ranging from the most basic to those that NASA has already sent to Mars: Sojourner, Spirit and Opportunity, Curiosity, and Perseverance, the latter still in operation. [2]

On the other hand, there are also investigations related to different models of Rovers. Among them, the SR-001 space Rover, figure 1, is a 4x4 type with a suspension system on each wheel, added with four motors that make each wheel independently driven and an interior space for four crew members. [3]

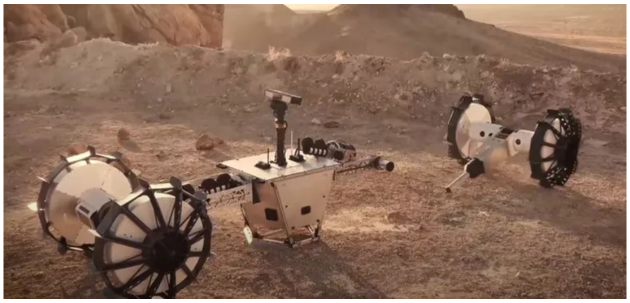
Figure 1. The SR-001 space Rover designed to discover new worlds. [2]



Another development by NASA is a Rover those rappels down slopes on other planets. The DuAxel (Figure 2) consists of two vehicles that join or separate to tackle different terrains. This vehicle consists of a pair of two-wheeled vehicles that can be assembled. To descend steep slopes, it first stops, lowers its chassis, and anchors to the ground before splitting into two.

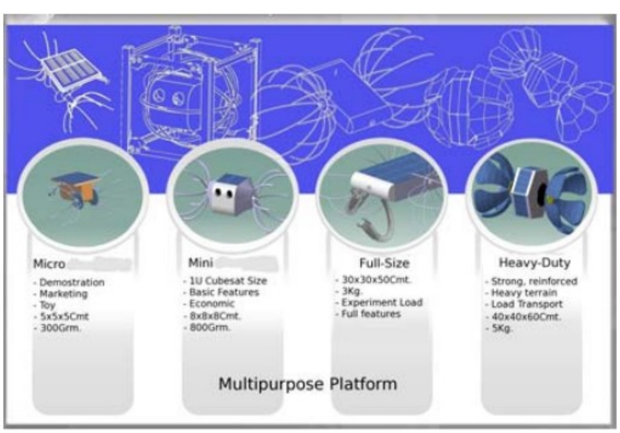
Then, with its rear half firmly anchored to the ground, its front half detaches and rolls away on a single axle. [3]

Figure 2. The DuAxel. [3]



Following the design line, a prototype of a robot with Rocker-Bogie geometry was found in Spain, created in 2022 by Christian Montaleza, Xavier Mayorga, Jimmy Gallegos, and Rogelio León, validated through a degrees of freedom analysis. [5] Additionally, there are various events and contests that challenge the community to participate and present their Rover vehicle designs and models. For instance, in the Google Lunar X PRIZE, the First Design Approach of a Bio-inspired Minimalist Rover was showcased; this research was conducted by Mauricio Ramiro Henríquez Schott from the Austral University of Chile and Matilde Santos from the Complutense University of Madrid (Spain). The project was inspired by the optimization of insect walking to traverse highly irregular terrains; thus, from this model, a prototype was created as a research object. [6]

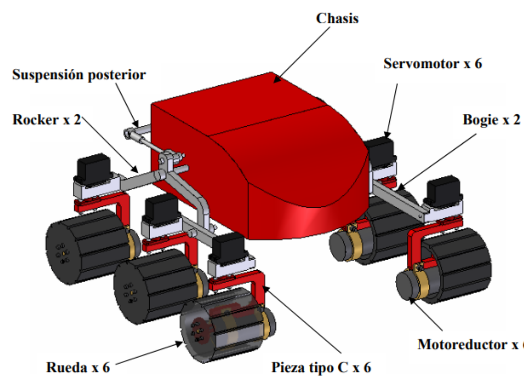
Figure 3. Multipurpose Platform. [4]



Another of the competitions that motivated research based on Rovers was the NASA Human Rover Challenge, where the design of a human-powered vehicle was carried out. This vehicle needed to traverse a surface simulating Martian terrain, capable of folding and occupying a space of 1.5 meters in length, 1.5 meters in width, and 1.5 meters in height. The chassis obtained supports and accommodates two people, and together with the suspension system, it absorbs the reactions generated in the wheels due to the unevenness and obstacles of the terrain. [7]

On the other hand, in Colombia, research related to Rovers has also been conducted. Among them is the one developed by the Universidad de San Buenaventura, focused on the design and construction of an autonomous Rover-type vehicle, expressed as a robot capable of moving on difficult terrains, equipped with 6 wheels, as shown in Figure 4. [8]

Figure 4. 3D Mobile Rover Robot [5].



At the Universidad Autónoma de Bucaramanga, they carried out the design and construction of a scaled prototype of an unmanned Rover-type vehicle for planting, fumigation, and transportation of agricultural products in the rugged terrain of the Berlín Santander region. This project involved the modeling, construction, and control of a 'Rocker Bogie' type vehicle, which operates to assist farmers in the cultivation process. It has three main functions:

transporting crops in uneven terrain, fumigating crops, and planting seeds." [6]

2. Theme Development

2.1. Method

ESUFA is in the process of aligning itself with the new CNA conditions regarding Educational Learning Outcomes (LO) for high-quality accreditation and program accreditation. It is currently in the phase of aligning the curriculum of each program and ensuring that course syllabi are aligned with the Educational Outcomes. Therefore, the Aeronautical Electronics Technology program focuses the curriculum of the subjects on Electronics III and Microcontrollers, applying them to the Educational Outcomes. To achieve this, the development of a Rover has been established, which integrates the knowledge acquired in previous semesters in electronics and microcontrollers.

In conducting this research, various sources of information were reviewed to support the Rover design. Initially, the research focused on theses related to Rover vehicle development and NASA advancements in this field. Information was gathered from scientific articles published on the internet, detailing the tools and stability and strength studies required for the terrain conditions where the designs were tested.

The objective of this project is to create a Rover as part of the Educational Outcomes for the mentioned subjects. The first phase involved designing a medium-sized Rover with a PVC structure, low-power motors, and small wheels, suitable for less demanding terrains. In the second phase, with a clearer understanding of motor, wheel, and structural requirements compared to phase one, a new structure design was developed. This design was based on a simulation of a Rover for irregular terrains, using motors with 17 kg-cm torque, 13 cm wheels, and a structure measuring 1.30 m in length, 60 cm in width, and 50 cm in height

2.2. Materials

In the development of the Rover design, various materials were used for assembling the Rover, including the following:

2.2.1. Structure

PVC Pipe: 1/2-inch PVC pipe was used with different accessories such as 90-degree elbows, half-elbows, and unions (Figure 5). This material was chosen for its ease of handling and simple manipulation, facilitated by readily available accessories.

Polyvinyl Chloride (PVC) Pipes: PVC pipes are commonly used in household installations for transporting cold water, wastewater, rainwater, and ventilation. This material offers five main benefits: ease of use, resistance to internal and external corrosion, a variety of accessories, smooth surface, and low cost. [7]

Figure 5. PVC pieces.

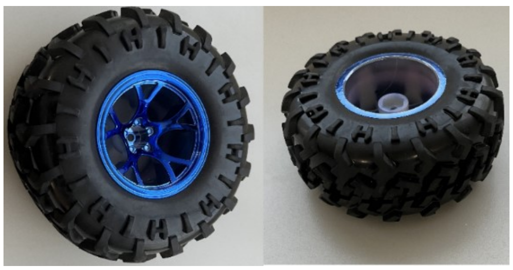
Source: own.

2.2.1. Rover Traction

In the first phase, 65 mm wheels and DC gearmotors with 1 kg/cm torque were used. However, in the second phase, larger diameter wheels suitable for irregular terrains were used, along with gearmotors with higher torque compared to those in the first phase.

2.2.1.1. 130mm Wheel: These wheels are ideal for the Faulhaber 2342L012CR gearmotor and are designed to fit DC motors with a gearbox and rectangular shaft (Figure 6).

Figure 6. 130 mm wheels.



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2.2.1.1. Faulhaber 234L012CR Gearmotors: These gearmotors feature a digital encoder and provide a torque of 17.54 kg-cm, making them particularly suitable for university projects in Robotics and Mechatronics (Figure 7). [8]

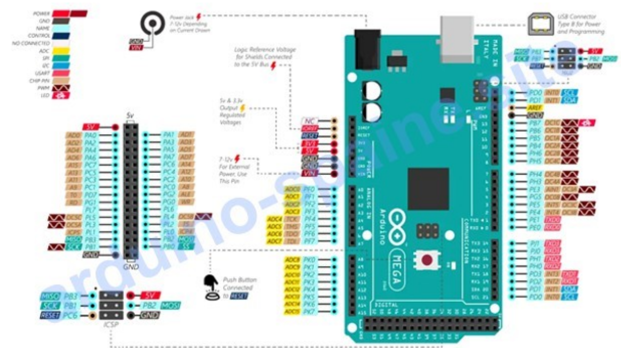
Figure 7. Motor Faulhaber 2342L012CR [9].

2.2.2. Rover Control For this system

An Arduino Mega 2560 development board was used along with 4 L298N driver boards. Communication was facilitated by the HC05 Bluetooth module, and the entire system was powered by a 12-volt, 9-ampere battery. An Android app was also used for control via Bluetooth.

2.2.2.1. Arduino Mega 2560 Board: This is an open-source development board featuring an Atmega 2560 microcontroller. The board includes input and output (I/O) pins, both analog and digital (Figure 8). [10]

Figure 8. Arduino Mega (pinout) [11].



2.2.2.2. L298N Module: It has two H-Bridge channels, allowing it to control two DC motors or one stepper motor, managing both direction and speed. The module consists of an L298N driver, protection diodes, and a 5V voltage regulator (78M05), as shown in Figure 9.

Figure 9. L298N Module [12].

2.2.2.3. HC05 Bluetooth Module: This Bluetooth module enables wireless communication between the PC and our project, operating seamlessly like a serial port (Figure 10). [13]

Figure 10. HC05 Bluetooth Module [13].

2.2.2.4. 12V Battery: These are deep cycle stationary batteries used in solar power systems that, unlike conventional batteries, allow slow and deep charging and discharging cycles (Figure 11). [14]

Figure 11. 12V 9A battery [15].

2.3. Construction of the System With the materials already established and selected, the construction of the Rover began.

2.3.1. Structure Design Taking

As an example the video 'Development of a Rover Vehicle with Rocker-Bogie Suspension for Agricultural Inspection' from the Universidad Politécnica de Pachuca, Master in Mechatronics 2016, a hand-drawn sketch of the Rover's potential structure was created.

Figure 12. Rover-Bogie vehícle [16].

Having the sketch with measurements for each piece already established, the PVC pipe was cut, and the necessary accessories were prepared for assembling the structure at each end (Figure 13).

Figure 13. Cortes de las diferentes piezas de PVC.

Source: own.

After cutting the pieces, assembly of the end parts was carried out, followed by the assembly of the Rover's structure (Figure 14).

Figure 14. Side pieces already assembled.

Source: own.

With all pieces assembled, the installation of the motors and wheels onto the Rover was carried out to complete the assembly of the entire structure (Figure 15).

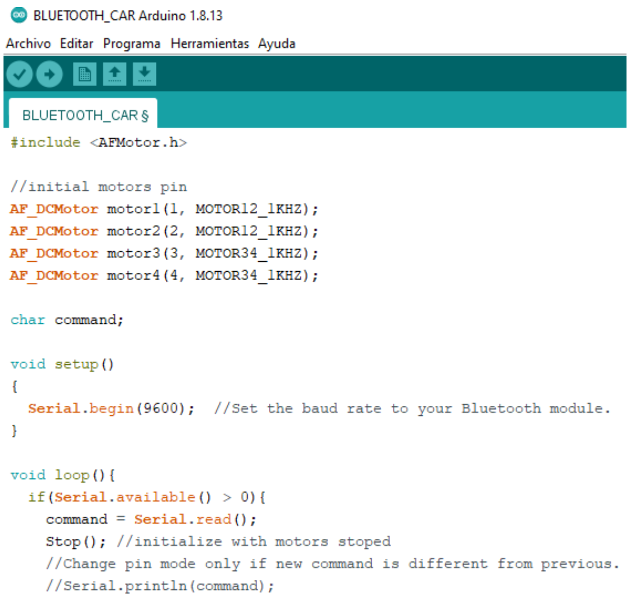
Figure 15. Rover vehicle.

Source: own.

2.3.2. Rover Control Design

For controlling the Rover, the Arduino Mega 2560 board was used along with the L298N module and the HC05 Bluetooth module, which facilitated the connection between the Rover and the cell phone using the app. First, a program was created to control the 6 motors with the L298N modules, which provide the necessary current for the operation of the motors used.

Figure 16. Arduino program.



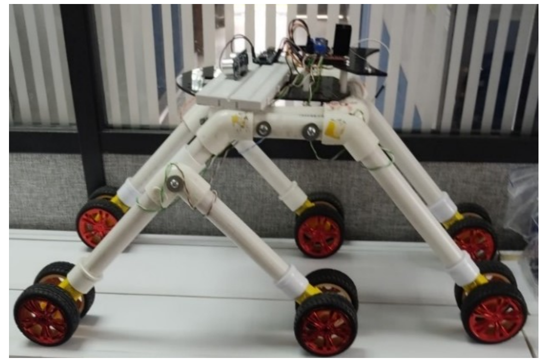
Source: own.

With the programming completed and operational, the Rover vehicle underwent respective testing, and the Learning Outcomes for Electronics III and Microcontrollers were achieved.

4. Results

In the design and construction of the Rover, various changes were made to the structure, motors, wheels, and driver modules. In the first phase, a medium-sized Rover was built with small gearmotors producing 1 kg-cm torque and 65 mm wheels. However, this vehicle had the disadvantage of not being suitable for irregular terrains, only flat and stable surfaces (Figure 17).

Figure 17. Rover Vehicle First Phase.



Source: own.

In the second phase, research was conducted on structures from various theses on Rover vehicles, as well as on the theory of gearmotors and their appropriate torque for irregular terrains. This included determining the correct size and grip needed for the wheels. During the assembly process of the structure, some issues were encountered, such as instability in the end parts tending to open up. This was resolved by adding three braces that provided more stability to the structure (Figure 18).

Figure 18. Rover vehicle Second Phase.

Source: own.

Another result was the implementation of an application for the Rover, which included a small weather station. Initially, it used a Neo 6M GPS to determine the vehicle's position, measured temperature and humidity with the AHT10 sensor, CO_2 levels with the MQ-7 sensor, and barometric pressure with the BM-P280 sensor. These measurements were transmitted via the NRF24L01 module to a PC designated for data acquisition and storage.

5. Conclusions

Currently, higher education institutions align themselves with learning outcomes, and ESUFA, an accredited institution, is working to ensure that its 8 programs focus their curricula and syllabus on the objectives set by the CNA regarding Educational Outcomes. From the teaching staff, efforts are being made to establish various activities or projects for students to demonstrate their learning outcomes throughout their educational journey.

In the process of developing the Rover prototype, the knowledge acquired in electronics and microcontrollers is demonstrated through the implementation of the various systems constituting this project.

Developing this prototype required understanding research on Rover vehicles. Combining the experiences gained from the first phase, it can be concluded that with knowledge and experience, a more efficient and robust prototype was achieved.

In conclusion, developing this prototype necessitated prior knowledge of Rover vehicles, which was acquired through experience in the first phase of development. Therefore, greater experience in the field enables the creation of more efficient and robust models in the future.

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