RESEARCH ON DESIGNING AND DEVELOPING AN EXPERIMENTAL MODEL OF A SNOW REMOVAL ROBOT

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ABSTRACT: The age of technology, of development and implementation of modern concepts, has come with numerous benefits, such as the considerable reduction of residential activities of individuals, through numerous contemporary systems, such as: robot vacuum cleaner, smart house, automatic lawn mower. A lack of appropriate research and development of a range of prototypes for snow removal purposes is identified in the current market. In view of the above, it is proposed to initiate a concept on the design and realization of an experimental model of a robot capable of clearing snow. It is envisaged to equip it with a crawler system to avoid possible skidding and to develop a mechanism for snow removal, capable of allowing both raising-lowering and left-right tilting of the blade for clearing.

KEYWORDS: mechanism, snow removal, application, residential use.

1. Introduction

It is proposed to design an experimental model of a snow removal robot for residential use.

The development of the robot aims to increase productivity, mainly due to its autonomy. The correct combination of electrical, mechanical, logic and electronic structural elements results in the finished product, a robotic mechanism capable of successfully removing snow.

The key characteristics, which will be considerations for the development of the proposed theme, are analysed as follows:

- Autonomy:
  - → To function for more hours and have more batteries.
- Resistance:
  - → Hardware structure allowing operation at temperatures of ±5ºC.
- Productivity:
  - → High efficiency of the product during operation through the use of a snow blade and subordinate operated mechanisms (raising-lowering as well as left-right tilting of the blade).
- Obstacle avoidance system
  - → Using an ultrasonic sensor positioned on a servomotor, for better system functionality.

The following softwares were used to carry out the proposed topic:

- Catia V5R21, for the design of the operating mechanisms for raising/lowering the blade as well as its left/right tilting;
- Arduino IDE, for programming the experimental model.

A robot tank kit was purchased, containing the mechanical and electronic elements (1x Arduino UNO R3 CH340, 1x Extension Board V5.0 TB6612, 2x IR Module, 1x Servomotor SG90, 1x Bluetooth Module HC-06, 1x Ultrasonic Sensor HC-SR04, 1x Ultrasonic Sensor Holder HC-SR04, 1x Battery Housing, 1x Remote Control, 1x Chassis, 2x Tracks, 4x Wheels, 2x Motors) [1]. Separately, 3x18650 batteries were purchased. The kit required complete assembly and programming.

2. The current stage

In the Fig. 1, it is presented the snow plow robot, based on the Arduino Uno and controlled by a wireless Play Station 2 controller [2].

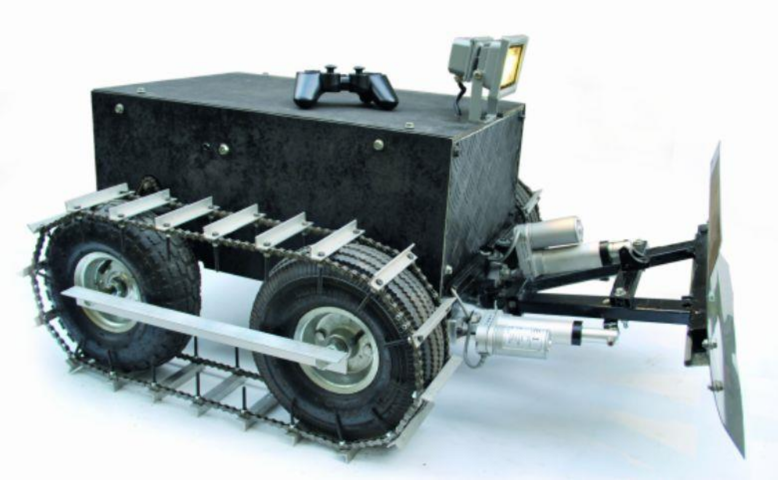

Fig. 1 Snow plow robot

The power supply of the robot is represented by two 7.2 Ah lead gel batteries. The data was loaded via the PS2SHIELD shield. It performs the default receipt and decoding of the order [2].

The construction of the snowblade is represented by a triangular support structure, on which two linear actuators have been mounted, through which the blade rises and descends and leans left-right [2].

In Fig.2, an autonomous snow removal robot is noted [3].

Fig. 2 Autonomous snow removal robot

The snow plug fulfils the following key features: safety, having implemented a system consisting of three mechanisms for stopping the robot in case of emergency, simultaneous location and navigation on the roads, engine control, mechanics and construction [3].

Another snow plug is shown in Fig. 3, with four engines, which allow the robot to carry a large load, able to autonomously push about 40kg of snow [4].

Fig. 3 Snow removal robot

The robot cumulates the following specifications: its weight is 160kg, dimensions are 1.00x1.5x1.5m, the maximum speed it can reach is 7.2km/h and is equipped with: four batteries sealed with acid lead 2x24V, 16 beam lidar sensor, IMU sensor, three RGB cameras, two Reach M+ RTK GPS modules [4].

3. Assembly of the robot

The robot tank kit was assembled, resulting the finished product as shown in Fig. 4.
The robot has the following characteristics:

- Ultrasonic sensor HC-SR04, used to avoid obstacles. Because the measurement angle of the sensor is 15º, it is positioned on a servomotor, which at the time of detection of an obstacle at a distance less than 20cm, the robot stops, and the servomotor rotates the ultrasound at a angle of 160º, thereby increasing the range of action, for better functionality in circumventing obstacles;Doi senzori IR, cu ajutorul cărora se comandă robotul printr-o telecomandă IR;
- Arduino UNO R3 CH340 for robotic control;
- The V5.0 TB66112 motor drive extension board, provides precise motor control by integrating the driver chip, thus eliminating the traditional L298N wiring and also provides support for various motor types;
- Bluetooth module HC-06, which allows wireless communication between the robot and the phone, via an apk app;
- Three 18650 batteries as a power supply, connected in series, offer a multitude of advantages within the experimental model, as they allow the robot to be used in a variety of environments, not being connected to a fixed power supply;
- Two DC motors to control the movement of the tank;
- Track navigation, providing better traction and stability than wheels on snow. They also have high resistance to wear and damage, and better traction on icy surfaces than wheels, due to the greater area of contact with the surface.

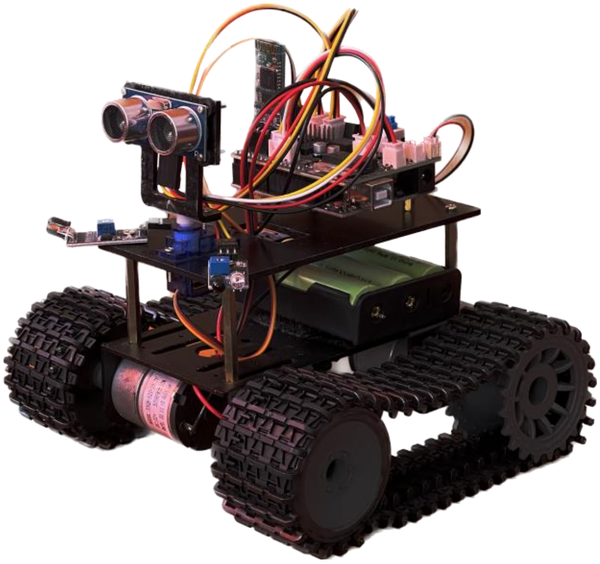

Fig. 4 Robot tank

4. Design of the snow removal mechanism

Initially, it was considered to design a system based on the functionality of linear actuators, but there are no such small dimensions for the experimental model. To solve this situation, a system powered by two servomotors was implemented for the lifting-down and tilt of the blade. One of them controls two arms assembled on the blade, allowing it to rise and descend. The other works through four spherical ball joints, assembled at two heads and mounted both on the servomotor accessory and on a support body, thus rotating the entire mechanism attached to the support.

The snow removal system consists of the following constructive components: a support positioned on the robotic chassis, two servomotor supports, two bearings, four M2 spherical joints with ball, servo arm extension, blade, two arms, two SG90 servomoors, a base support and two ball bears, with dimensions 8x12x3.5mm, being highlighted in Fig. 5 and Fig. 6.

Fig. 5 shows the constructive mechanism of the snowblade, assembled in the Catia V5R21 software.

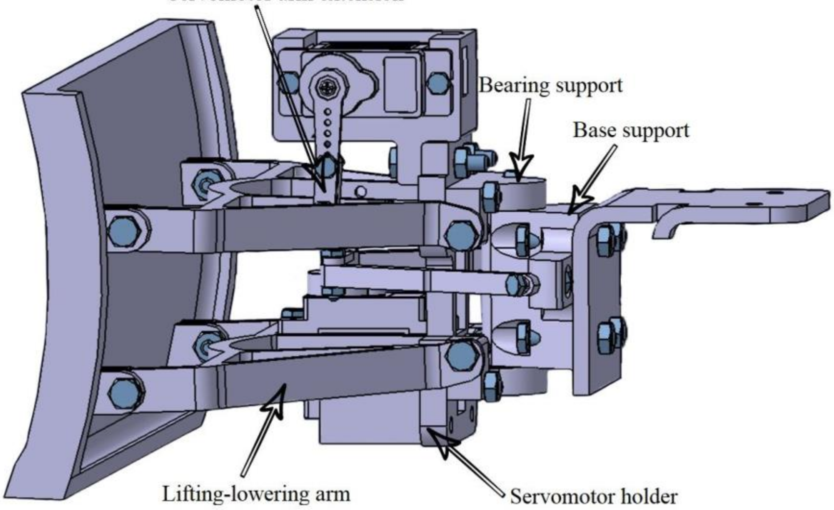

Fig. 5 The mechanism of the snowblade

Fig. 6 highlights a different view of the system, in which the blade is more visible, highlighting its type of construction.

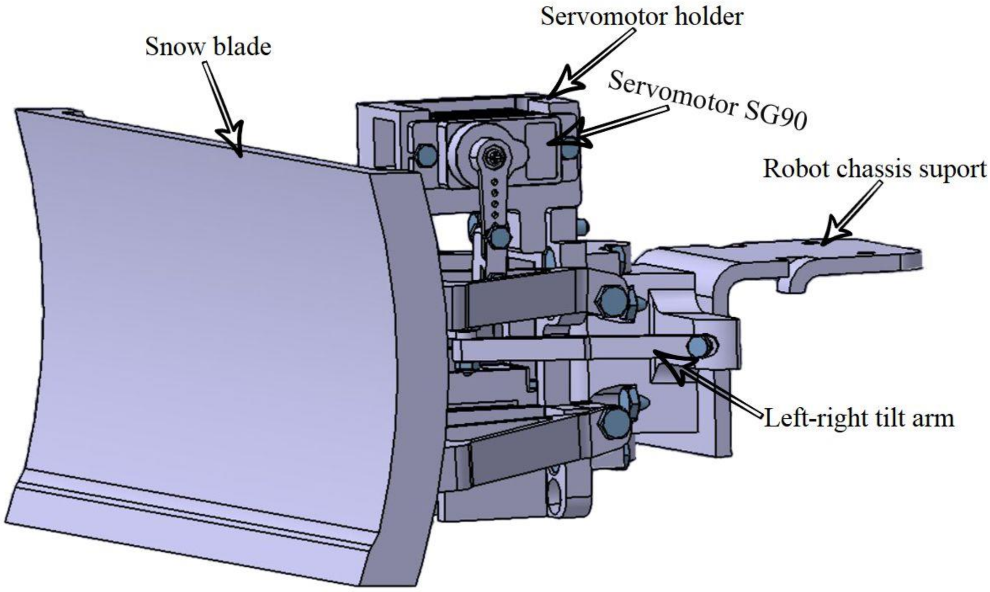

Fig. 6 Snow removal system

5. Programming

In addition to the mechanical and electronic components, the kit contains an apk appplication, available on Android, based on which the programs for the robot were configured. For the programming of the experimental model, the Arduino IDE software is used.

The interface of the application includes the following modules: avoidance of obstacles using the ultrasonic sensor, control of the robot both through the IR remote control, and through a system designed in the application, remotely control. Functions can be seen in Fig. 7.

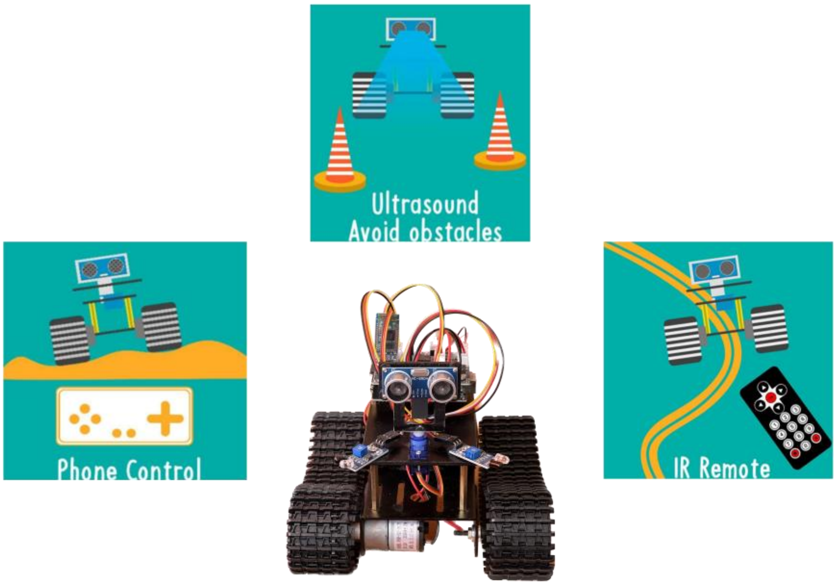

Fig. 7 Apk modules

The logical scheme of operation underlying the implementation of the obstacle avoidance program is shown in Fig. 8.

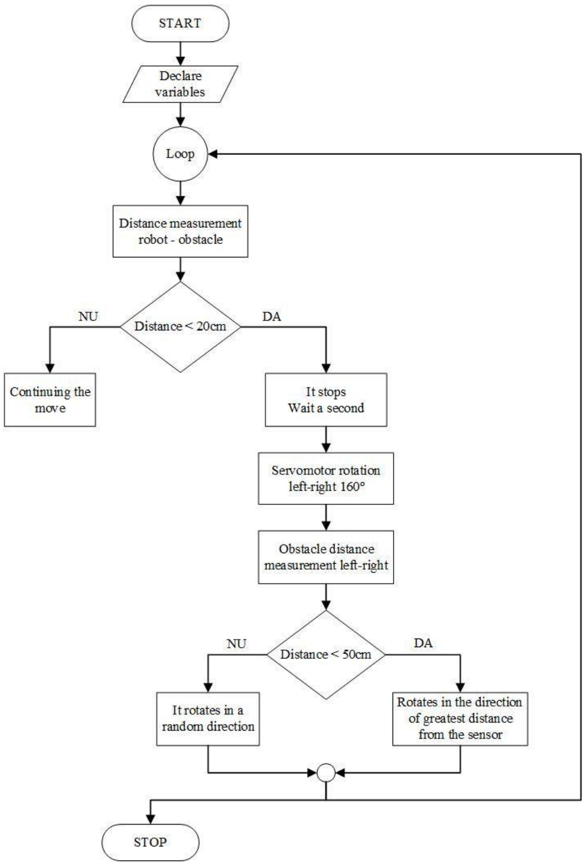

Fig. 8 Logical scheme obstacle avoidance program

6. Conclusions

The original contributions to the experimental model presented are the design of a snow removal mechanism, adapted on a robot capable of obstacle avoidance and remotely controlled by an app, aiming at automating the snow removal process for residential use. Also, by programming the two servomotors assembled on the system, the construction of a mechanism capable of raising-lowering and tilting the snow-clearing blade was achieved, thus increasing the efficiency of the product while performing the work.

As future directions of research, it is intended to develop an algorithm for determining the robot's trajectory using a map learned through sensors and software, and the blade to rotate according to the path of the experimental model.

7. Bibliography

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