International Journal of Multidisciplinary Engineering in Current Research - IJMEC
Volume 7, Issue 10, October-2022, http://ijmec.com/, ISSN: 2456-4265

ROBOT AUTONOMOUS CAR WITH CRASH PREVENTION SYSTEM

Asif Ali , Sara ,Abdul Rahman, Noureen
LIET

ABSTRACT

Global use of autonomous systems to handle important and nuanced work is increasing. Nonetheless, the importance of its many potential uses cannot be overstated. In this study, we introduce a system that can recognise obstacles and steer a robotic lawnmower around them. The components include a gear DC motor, an Arduino microcontroller, and two sensors (infrared and ultrasonic). The robot's route is monitored by ultrasonic and infrared sensors that feed signals to a microprocessor. When an obstruction is recognised, the microcontroller acts to reroute the robot by activating the motors in a different direction. The system has been evaluated and found to have an accuracy of 85% and a failure probability of 0.15. Finally, an obstacle detection circuit was built using infrared and ultrasonic sensors modules mounted to the front of the robot to emit light and sound waves, respectively, at any obstacle; upon receiving a reflection, a low output is sent to the Arduino microcontroller, which interprets the signal and causes the robot to stop.

Keywords: obstacle avoidance, Arduino, unmanned, infrared, robot.

I. INTRODUCTION

There is a steady daily increase in the scope and sophistication of mobile robot applications. They are finding more widespread applications in the real world, from the military and medicine to space travel and domestic chores [1]. The way humans respond to and perceive an autonomous system is profoundly affected by motion, a crucial feature of mobile robots for obstacle avoidance and route identification. This allows a robot to move about without any help from a human operator. Mobile robots often utilise computer vision and range sensors to identify objects in their environment. When compared to range sensors, the accuracy and cost of computer vision as an obstacle detection technology are far higher. However, most autonomous robots on the market rely on a range sensor to detect danger. The 1980s saw the beginning of the usage of radar, infrared (IR), and ultrasonic sensors in the creation of an obstacle detection system [2]. After extensive testing, however, it was determined that radar technology was the best choice because of its resistance to the effects of weather and other environmental factors. The radar method was also a very practical and reasonably priced technological development. One charge-coupled device (CCD) camera and a spherically shaped curved reflector were described in [3] as a means to achieve ultra-wide angle images. The capabilities of the sensors extend well beyond those of only detecting obstructions. According to [4], an autonomous robot can characterise plants by extracting characteristics from a variety of sensors and then applying the appropriate quantity of fertiliser based on the kind of plant. To help a robot in its hunt for meteorites in Antarctica, [5] installed cameras to assist with navigation and obstacle detection. Dead reckoning for planetary rovers was made easier with the use of stereo vision [6]. [7]

Used ATVs equipped with (five) CCD cameras for reconnaissance and surveillance. The main disadvantage of stereo vision is that it requires sufficient lighting to notice obstacles. As mentioned in [8, 4, 9], this is why cameras are often employed as a backup.

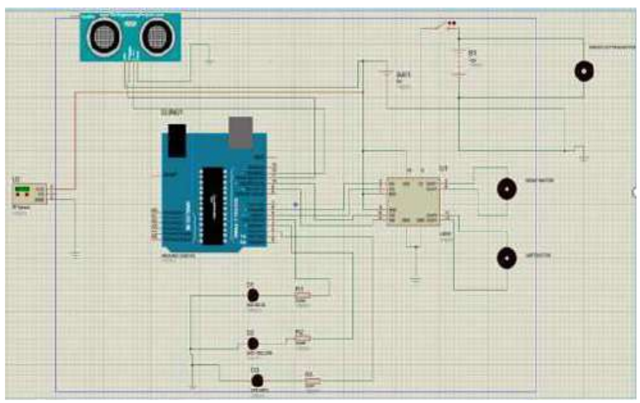
Vehicle localization and navigation in [10, 11, 12, 13, 14] were accomplished with the use of sonar. To help the robot navigate safely around obstacles, [15] programmed a sonar ring to detect and avoid them. One of sonar's biggest drawbacks is that it can't provide enough environmental data for autonomous vehicles with only one sensor.

As shown in [16, 17, 18, 19], several sonar sensor rings are often linked together to achieve maximum performance. The process of putting this into practise is often time-consuming and costly. Despite its drawbacks, sonar is still an effective backup method for detecting obstacles. In addition, [20] demonstrates how an autonomous ground vehicle may employ a combination of a camera and a laser scanner to navigate around obstacles. As [21] explains, a local route for an autonomous ground vehicle may be created using a machine called a support vehicle machine (SVM). Moreover, [22] has reported their work on an unmanned ground vehicle system for remote-controlled surveillance. Unmanned ground vehicle dependability and failure testing was conducted in [23]. The utilisation of industrial robots across American businesses was analysed in [24, 25]. Finally, [26] demonstrates how an ultrasonic sensor may be used by an obstacle-avoidance robot vehicle to clear a way for movement.

The goal of this research was to create and assess the effectiveness of a simple, low-cost autonomous system for avoiding obstacles employing two (2) sets of dissimilar sensors.

II. METHODOLOGY

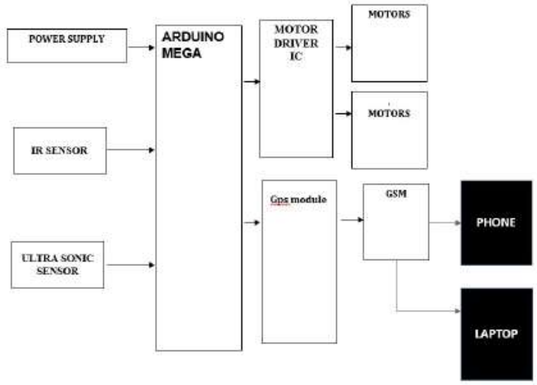
Within this part, the compositions of the hardware components and software implementations that were used during the process of designing and building the project were detailed. The system's chassis and casing, both of which were fabricated, are another topic of discussion.



a. Hardware design

Power supply unit, IR led/receiver sensor pair, ultrasonic sensor, Arduino microcontroller, geared DC motors; these are the main components of the system. The ATmega328 is the basis of the Arduino Uno microcontroller board. It has a USB port, a power jack, an ICSP header, a reset button, and 14 digital I/O pins (6 of which may be utilised as PWM outputs). It also has a 16 MHz ceramic resonator. Because of its low price and low power consumption, this is a popular option. In order to enhance the sensitivity and dependability of current systems, two distinct sensor technologies—ultrasonic and infrared—were used.

For detecting purposes, an infrared sensor employs the tried-and-true method of using the reflected light from the



obstacle's presence.

Figure-1. Block diagram of the system.

The HC-SR04 is an ultrasonic device whose main purpose is to periodically transmit a "ping" signal and listen for a response. The microcontroller module was powered by a 9V battery, while the infrared and ultrasonic sensors were powered by a 12V source that was controlled to 5V. Proteus8.5 was used to create the circuit seen in Figure-2.

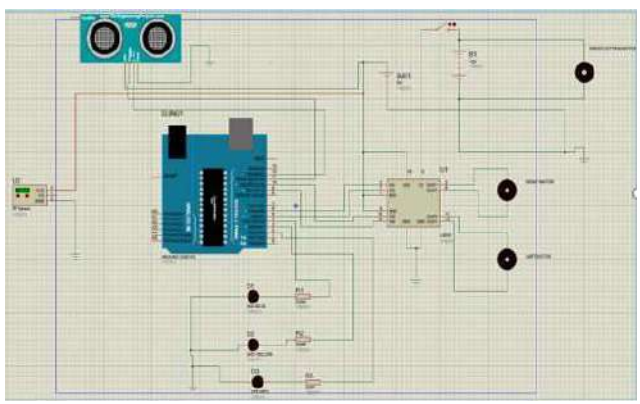


Figure-2. Schematic diagram of the system in Proteus.

b. Software implementation

Arduino was used to implement the system in C++. Figure 3 depicts the robot's flowchart at the beginning of sensor initialization, which occurs at the same time as the motor is activated to propel the robot forward. Using a frequency of 37 KHz, the ultrasonic sends out a signal and listens for a reverberating echo. When the system has an estimated ahead-of-time supplied by:

$$D = \frac{t_{IN} \times V}{2} \quad (1)$$

where

D Distance between the sensor and the detected object.

t_{IN} Time Between transmitted and received reflected wave.

ISSN: 2456-4265

DOI: https://doi-ds.org/doilink/01.2023-81262776

Ultrasonic wave propagation speed in air at normal speed 344m/s.

If the distance ahead is less than 40 m, the controller instructs the motor to make a 90-degree turn and go forward, as shown in Figure-3. Once the ultrasonic section is clear, the infrared sensor will transmit its signal; if it, too, identifies an impediment, the automobile will reverse, turn to the right, and go on ahead, as illustrated in Figure 4.

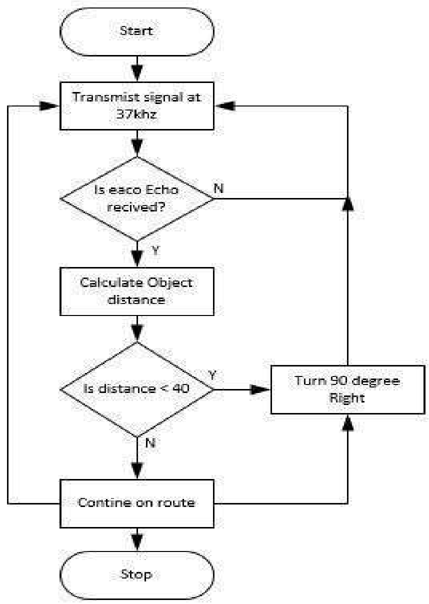


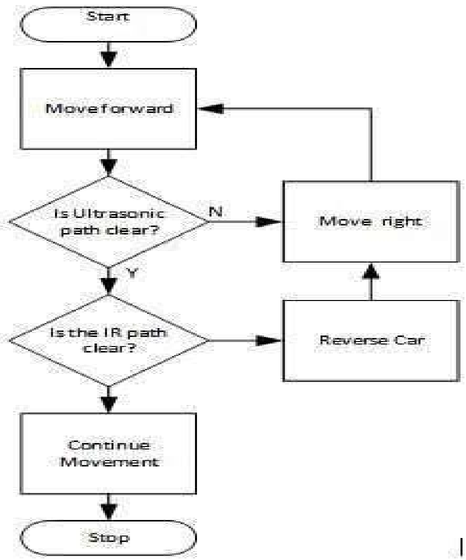
Figure-3. Obstacle detection and avoidance using ultrasonic sensor.

c. DATA COLLECTION

Two separate sensors were deployed to scavenge information from the surrounding area, digitise that data, and transmit it to the microcontroller, which then processed the information and carried out the users' specified commands. The IR sensor module and Ultrasonic sensor are two examples of the sensors used for data collection.

Side-by-side IR emitter and receiver make up the IR sensor module, with the latter sending a low output in response to a reflection and a high output in the presence of an input signal. The robot's frame is equipped with a pair of infrared (IR) sensors that face the ground and scan just above the grass level for obstacles in the robot's path. Another IR sensor module is installed in the robot's front opening to serve as an obstacle detector.

The microprocessor measures the distance between the robot and the pavement using the ultrasonic sensor, and then the robot turns right or left when it reaches the end of the wall to prevent colliding with the grass.



igure-4. Flow chart of the developed system.

d. SIGNAL PROCESSING

All of the sensors on the board have their outputs wired directly to the Arduino microcontroller board. Given the digital nature of the collected information, if an IR sensor module does not detect an incoming reflection, it will transmit a signal with a high bit value. Because of their digital nature, these input devices for the automobile avoidance system are wired to the digital pins on the Arduino. When the Arduino microcontroller receives data from the sensors, it consults a stored set of instructions to determine what to do with the information. The Arduino microcontroller's output devices are dc motors that steer the vehicle and power the mower's blade.

e. Chassis design and fabrication

The car's outline was created with the Autodesk investor programme seen in Figure-5. Changes were made to the drawing and mistakes were fixed to ensure accurate component meshing and simulation throughout this design phase. Aluminum plate of 1mm thickness was used to realise the design. There are three wheels total on the robotic chassis: two in the back and one in the front. Plastic wheels are mounted directly to the servo motor on the back.

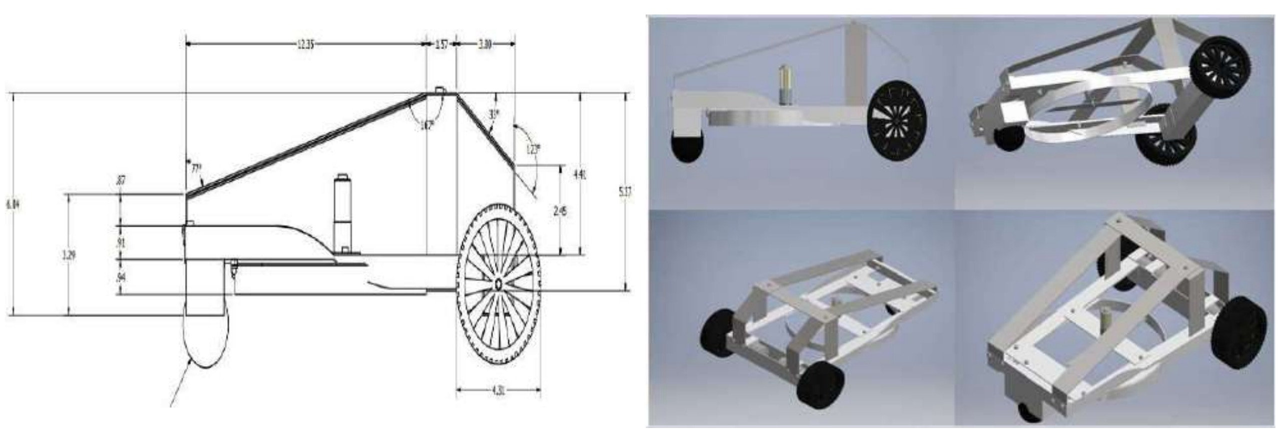
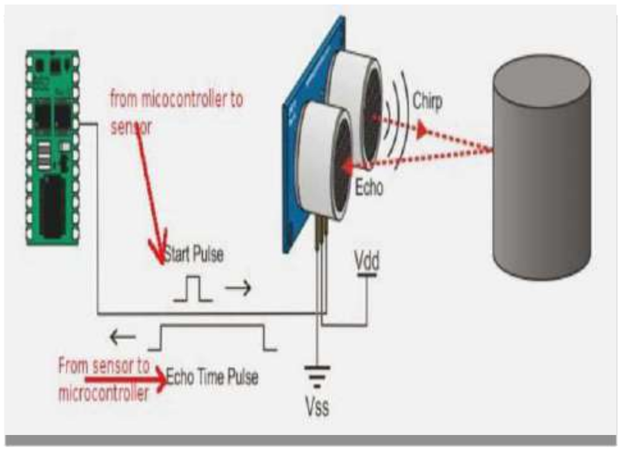


Figure-5. Design and simulation of sketched car robot

The small weight of a caster wheel was a major factor in its selection for usage on the robot. The robot's chassis was intended to house all necessary system components. The infrared (IR) sensor module is mounted low on the chassis so that it can see the ground and check for obstructions just above the grass. The robot's ultrasonic sensor is mounted high enough so that it can avoid paving over the grass as it moves along. In a similar vein, a quick experiment was run in the Arduino IDE to see how long it takes for the ultrasonic sensor to accurately pinpoint an object's location, and the results, acquired through the serial monitor, are shown in Table-2. Figure 6 depicts a



simple experiment using an ultrasonic sensor for object detection.

Figure-6. How the ping sensor works [13].

RESULTS AND DISCUSSIONS

In order to keep the robot from becoming too heavy, caster wheels were utilised. The robot's chassis was built to house all the necessary components. The infrared (IR) sensor module is mounted low on the chassis, where it can look out for obstacles just above the grass's surface. The robot's ultrasonic sensor is mounted high enough so that it may avoid colliding with the grass while still following the pavement. Again, a quick experiment was run in the Arduino IDE to see how long it takes for the ultrasonic sensor to accurately pinpoint an object's location, and the results, retrieved through the serial monitor, are summarised in Table 2. Figure 6 depicts a common experimental setup for using ultrasonic sensors for object detection.

$$T_o = A_{c1} + A_{c2} \qquad (2)$$

So, we have an 85% success rate and a 15% failure likelihood. Table-2 displays a comparison between the estimated and measured times it takes for an ultrasonic sensor to determine the distance to an item. To determine tIN, we use the aforementioned Equation (1) and make certain assumptions about the obstacle's distance (duration).

ISSN: 2456-4265

DOI: https://doi-ds.org/doilink/01.2023-81262776

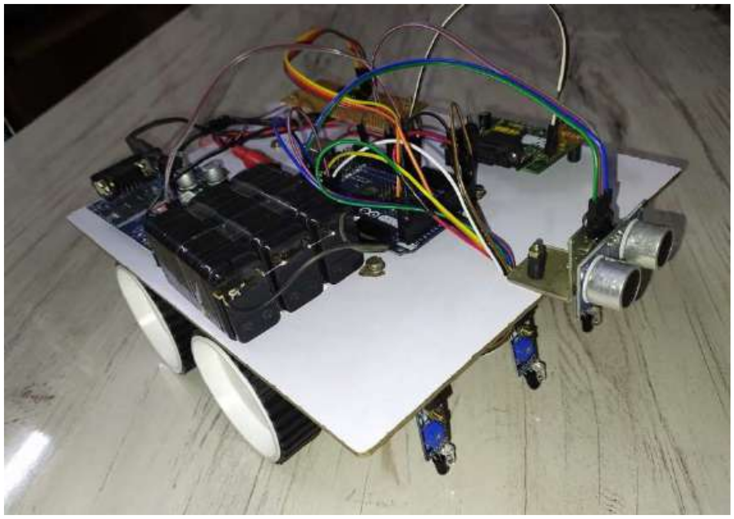


Figure-7. The robot completed frame work.

Table-1. Analysis of Ultrasonic sensor for different actual object distances.

S. no.	**Calculated** t_{IN} (Duration)(ms)	**Experimental**t_{IN} (Duration) (ms) **by ultrasonic sensor**	**Actual distance of object** (cm)
1	680	580	10
2	1360	1160	20
3	2040	1754	30
4	2720	2322	40
5	3400	2956	50
6	4080	3510	60
7	4760	4031	70
8	5440	4656	80
9	6120	5262	90
10	6800	5859	100
11	19040	1651 4	280
12	20400	2000 0	300

As can be seen in Figure-8, the characteristic profile produced by the ultrasonic sensor is linear and steady. This is because the refraction surface of the barrier employed in the experiment was very smooth and effective. Figure-8 further shows that there is some discordance between the estimated and experimental profiles produced during the same time period. It has been determined that the time needed for the ultrasonic sensor to detect the item grows linearly with the distance between the obstacle and the sensor.

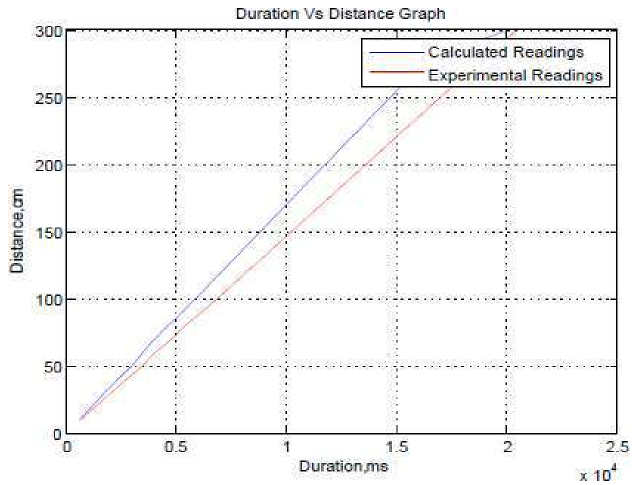


Figure-8. Response of the Ultrasonic sensor with respect to the obstacle detection at various distances.

f. CONCLUSIONS

In this study, we introduced a basic, low-cost obstacle detection and avoidance system for an autonomous ground vehicle. The mobile robot used two sets of sensors that were completely different from one another to identify potential hazards in its route. The chances of failure were reduced and an acceptable level of accuracy was achieved. The results of the examination of the autonomous system prove its capacity to navigate around hazards, avoid collisions, and adjust its location. It's obvious that additional features can be added to this design to enable it to carry out more tasks autonomously. In the end, an infrared (IR) receiver and a remote control were added so that the robot could be operated from a distance. The areas of defence, security, and dangerous environments will all benefit from this effort.

g. References

[1] J. Seja and M. Banshidhar. 2013. Obstacle detection and avoidance by a mobile robot. National Institute of Technology, Rourkela. B.Sc. thesis. pp. 1-9.

[2] E. Daniel Wang. Obstacle Avoidance Algorithms and Sensors for Autonomous Robots. www2.ece.gatech.edu/academic/courses/ece4007/10fa ll/ECE4007L03/.../ewang9.doc.

[3] L. Navarro-Serment, C. Paredis and P. Khosla. 1999. A beacon system for the localization of distributed robotic teams. Proceedings of the International Conference on Field and Service Robotics. pp. 232- 237.

[4] T. Bailey, E. Nebot, J. Rosenblatt and H Durrant- Whyte. 1999. Robust distinctive place recognition for topological maps. Proceedings of the International Conference on Field and Service Robotics. pp. 347- 352.

[5] N. Harper and P. McKerrow. 1999. Detecting plants for landmarks with ultrasonic sensing. Proceedings of the International Conference on Field and Service Robotics, pp. 144-149, 1999.

[6] R. Chatila, G. Andrade, S. Lacroix and A. Mallet. 1999. Motion control for a planetary rover. Proceedings of

DOI: https://doi-ds.org/doilink/01.2023-81262776

the International Conference on Field and Service Robotics. pp. 381-388.

[7] A. Soto, M. Saptharishi, A. Ollennu, J. Dolan and P. Khosla. 1999. Cyber-ATVS: dynamic and distributed reconnaissance and surveillance using all terrain UGVS. Proceedings of the International Conference on Field and Service Robotics. pp. 329-334.D. Langer, M. Mettenleiter, F. Hartl and C. Frohlich. 1999. Imaging laser radar for 3-D surveying and cad modelling of real world environments. Proceedings of the International Conference on Field and Service Robotics. pp. 13-18.

[8] A. Foessel, S. Chheda and D. Apostolopoulos. 1999. Short-range millimeter-wave radar perception in a polar environment. Proceedings of the International Conference on Field and Service Robotics. pp. 133- 138.

[9] T. Oomichi, N. Kawauchi and Y. Fuke. 1999. Hierarchy control system for vehicle navigation based on information of sensor fusion perception depending on 85 measuring distance layer. Proceedings of the International Conference on Field and Service Robotics. pp. 197-201.

[10] E. Prassler, J. Scholz and P. Fiorini. 1999. Maid: A robotic wheelchair roaming in a railway station. Proceedings of the International Conference on Field and Service Robotics. pp. 31-36.

[11] S. Thrun, M. Bennewitz, W. Burgard, A. Cremers, F. Dellaert, D. Fox, D. Hahnel, G. Lakemeyer, C. Rosenberg, N. Roy, J. Schulte and W. Steiner. 1999. Experiences with two deployed interactive tour-guide robots. Proceedings of the International Conference on Field and Service Robotics. pp. 37-42.

[12] R. Meier, T. Fong, C. Thorpe and C. Baur. 1999. A sensor fusion based user interface for vehicle teleoperation. Proceedings of the International Conference on Field and Service Robotics. pp. 244- 249.

[13] M. Torrie, S. Veeramachaneni, B. Abbott. 1998. Laser-based obstacle detection and avoidance system. Proceedings of the SPIE Conference on Robotics and Semi-Robotic Ground Vehicle Technology. pp. 2-7.

[14] I. Ulrich and J. Borenstein. 1998. VFH+: Reliable obstacle avoidance for fast mobile robots. Proceedings of the 1998 IEEE Conference on Robotics and Automation. pp. 1572-1577.

[15] J. Borenstein and Y. Koren. 1991. The vector field histogram - fast obstacle avoidance for mobile robots. IEEE Journal of Robotics and Automation. 7(3): 278- 288.

[16] J. Borenstein and Y. Koren. 1990. Real-time bstacle avoidance for fast mobile robots in cluttered environments. Proceedings of the IEEE Conference on Robotics and Automation. pp. 572-577.

[17] B. Holt and J. Borenstein. 1996. Omni Nav: Obstacle avoidance for large, non-circular, omni directional mobile robots. Robotics and Manufacturing. 6: 311- 317.

[18] H. C. Moon and H.C. Lee and J. H. Kim. 2006. Obstacle Detecting System of Unmanned Ground Vehicle. SICE-ICASE, 2006. International Joint Conference.

[19] C. Qingyang and S. Zhenping and L. Daxue and F. Yugiang and L. Xiaohui. 2012. Local Path Planning for an Unmanned Ground Vehicle Based on SVM. International Journal of Advanced Robotic Systems. 9: 246.

[20] P. Fofilos and K. I. Xanthopoulos and E.A. Romanos and K. Zikidis and N. Kanellopouls. 2014. An Unmanned Ground Vehicle for Remote-Controlled Surveillance. Journal of Computations & Modelling. 4(1): 223-236.

[21]

[22] P.N. Nguyen and H. J. Titus. 2009. Reliability and Failure in Unmanned Ground Vehicle (UGV). Ground Robotic Research Center Technical Report University of Michigan.

DOI: https://doi-ds.org/doilink/01.2023-81262776

[23] I. Karabegovic and E. Karabegovic and E. Husak. 2012. Trend of Industrial Robot Share in Different Branches of Industry in America. International Journal of Engineering Research and Applications (IJERA). 2(2): 479-485.

[24] J. Izquierdo and P. Feldman. 2014. Trends in Robotics

[25] - Market Assessment. The Association for Packaging and Processing Technologies 11911 Freedom Drive, Suite 600 Reston, Virginia 20190, February.

[26] K. Bhagat and S. Deshmukh and S. Dhonde and S. Ghag. 2016. Obstacle Avoidance Robot. International Journal of Science, Engineering and Technology Research (IJSETR). 5(2).