International Journal of
Scientific Engineering and Technology Research

www.ijsetr.com

ISSN 2319-8885
Vol.07,Issue.02,
February-2018,
Pages:0196-0198

Obstacle Avoidance Robot using mmWave

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Abstract: This project is all about building an autonomous obstacle avoiding robot making use ofmmWave sensors for its navigation. TIDEP-0094 or IWR1642BOOST evaluation board embedded with IWR1642 chipand XDS110 MCU is used to perform the required operation. An obstacle avoidance is an intelligent robot which can automatically sense and overcome unexpected obstacles on its path. It contains a micro-controller to process the data and sensors to detect obstacles on it's path. This project proposes an autonomous robotic vehicle which has an intelligence integrated in it such that it can direct itself whenever an obstacle comes in its path of movement. This project is based on the IWR1642BOOST evaluation board. The mmWave sensor (IWR1642) is used to detect any obstacle near it. It sends the data to the MCU XDS110 where it is processed and the robot is made to move in the alternate direction using motors interfaced through a motor driver (LM293D).

Keywords: Obstacle Avoidance Robot, mmWave, IWR1642BOOST Evaluation Board, ROS, Object Detection.

I. INTRODUCTION

Obstacle Avoidance is one of the most important requirements of any autonomous mobile robot. Obstacle Avoidance robots[1] are designed to allow the robot to navigate through any environment by detecting obstacles and detouring it's path across them. All kinds of mobile robots has some kind of collision avoidance system by detecting obstacles and stopping whereas some robots include collision avoidance and can also also detour the obstacle. However such robots include complex algorithms as they need to acquire knowledge regarding the obstacle's dimension or velocity of any moving obstacle and finding ways to detour it. Among other kinds of navigation techniques for autonomous robots there are robots that follows obstacles like wall following robots and edge detecting robots which are used to solve mazes. In this paper the proposed algorithm navigates the robot using mmWave while precisely detecting obstacles and obstacle velocity with high angular precision. The advantage of using mmWave for this is that it can work in any environment like foggy conditions along with precise detection of the aforementioned quantities.

II. EXISTING SYSTEM

In the existing system, robots are steered or navigated by a driver or a human being using a remote. In some cases ultrasonic sensors or infrared sensors are used to navigate the robot to avoid obstacles. However in such technologies the navigation is not autonomous since they are completely controlled by a human while with ultrasonic or infrared sensors the robots can only detect obstacles and stop themselves in order to avoid collision but they cannot steer across the obstacles.

III. PROPOSED SYSTEM

The proposed project is all about building an autonomous robot which can intelligently detect obstacles and steer a new path across them without the use of any remote or intervention of any human. All the decisions taken by the robot will be based on an internal algorithm we set for it. The biggest advantage of this robot is that it can work in any environmental conditions like rain, dust, smoke, fog, or frost and in complete darkness or in the glare of direct sunlight due owing to the mmWave which can penetrate through them. These sensors are also small and lightweight when compared to other types of LIDAR based sensors.

A. Basic Design Of Robot

The robot was built on a IWR1642BOOST evaluation board. Two DC motors were connected to this board via motor driver (L293D)[2]. The motor driver provides power to the actuators which enable the robot to move forward, backward, right and left. Two grippy wheels and a castor wheel were used with the chassis for navigation purpose. A brief description of the pin configuration of the motor driver is given in the following table.

TABLE I:

Bot Movement	L+ (pin 3)	L- (pin 6)	R+ (pin 14)	R- (pin 11)
↑	high	low	high	low
←	low	high	high	low
→	high	low	low	high
↓	low	high	low	high
×	low	low	low	low

The movement of the robot will be manipulated by the mmWave sensors mounted on the board. mmWave sensor will detect obstacles along with their dimension as shown in

Fig.1. This data will be fed to the algorithm on the IWR1642BOOST evaluation boardas input to be manipulated for navigation purposes.

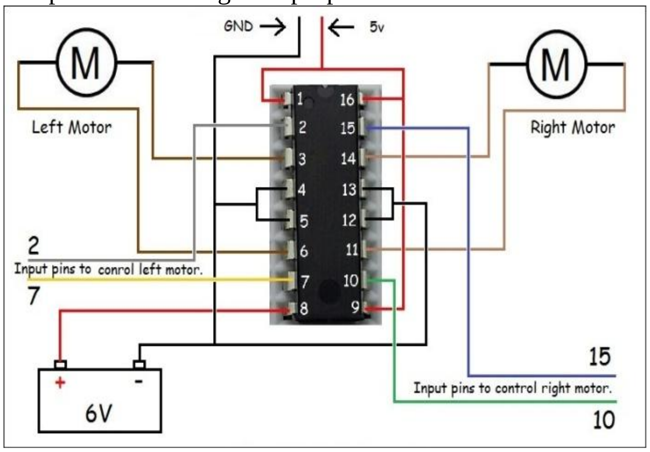

Fig.1. Pin Configuration Diagram of Motor Driver.

B. Sensors To Avoid Obstacles And Detour Them

A variety of sensors are available today for obstacle detection like ultrasonic and Infrared sensors, mounted camera modules which is also utilized as a part of SONAR or Computer Vision. In this project we will be using mmWave sensors(IWR1642) which is the latest and advanced technology in this field.

Millimeter wave (also mmWave)[3] is the band of spectrum between 30 gigahertz (Ghz) and 300 Ghz.

IWR1642[4] is a very large scale integrated single-chip mmWave sensor which is based on FMCW radar technology. It has the ability to operate in the 76- to 81-GHz band with continuous chirp up to 4 GHz . This device is built with TI's low-power 45-nm RFCMOS process, which enables it to possess unparalleled extent of integration into an extremely tiny form factor as shown in Fig.2. IWR1642 is the perfect provision for industrial applications such as construction automation, industry automation, drones, self driving vehicles, traffic supervision, and surveillance. This advanced module can work in any weather condition and poor visibility conditions making it extremely robust to use in practical and real life implementation.

Fig.2. IWR1642.

TIDEP-0094[5] is a development platform which is used to detect object using IWR1642 evaluation module (EVM). This will help to determine the position (azimuthal plane) along with the velocity of the objects at a distance of up to 84 m as shown in Fig.3.

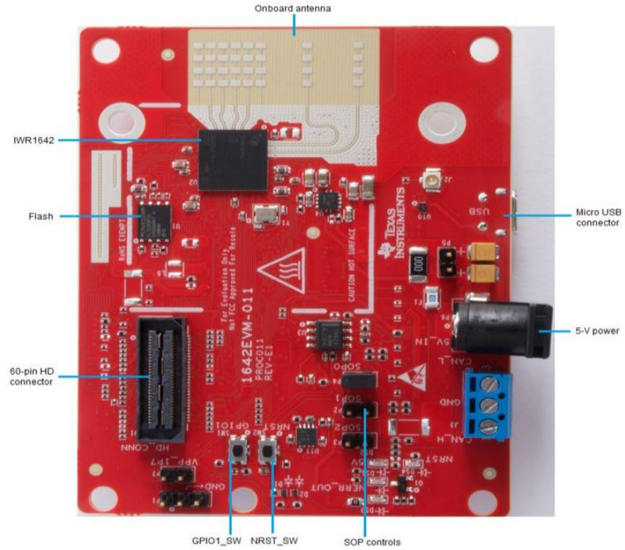

Fig.3. TIDEP-0094.

Key Features:

- Two 20-pin LaunchdPad connectors that leverages the ecosystem of the TI LaunchPad
- XDS110 based JTAG emulation with a serial port for onboard QSPI flash programming
- Back-channel UART through USB-to-PC for logging purposes
- Onboard antenna
- 60-pin, high-density (HD) connector for raw analog-to-digital converter (ADC) data over LVDS and
- trace-data capability
- One button and two LEDs for basic user interface
- 5-V power jack to power the board.

FUNCTION	IWR1642
Number of receivers	4
Number of transmitters	2
On-chip memory	1.5MB
Max I/F (Intermediate Frequency) (MHz)	5
Max real sampling rate (Msps)	12.5
Max complex sampling rate (Msps)	6.25

Fig.4. General features of IWR1642.

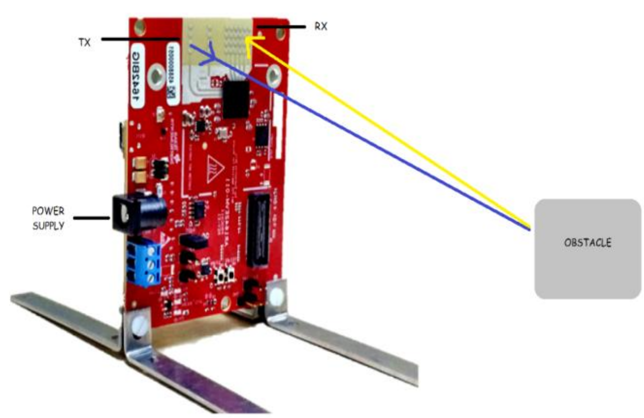

Fig.5. Schematic Diagram.

The operational angle of the radar is orthogonal to the PCB. To enable easy measurements on the sensing objects on the horizontal plane, the PCB can be mounted vertically as shown in Fig.4. The L-brackets provided with the IWR1642 EVM kit, along with the screws and nuts help in the vertical mounting of the EVM as shown in Fig.5.

IV. ALGORITHM- WORKING PRINCIPLE

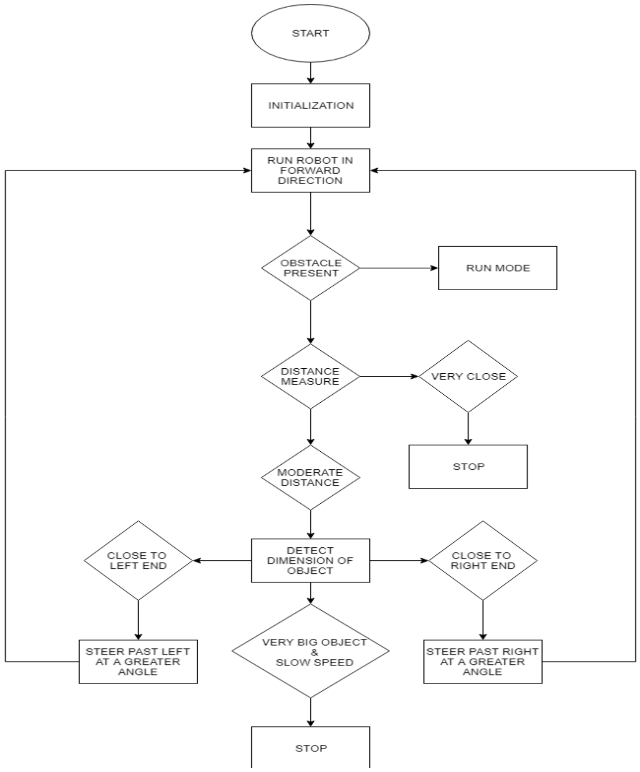

Fig.6. Algorithm and Working principle.

The mmWave sensors are used to detect obstacles and avoid them through the use of ROBOT OPERATING SYSTEM that accepts point cloud output from the mmWave sensor or the TIDEP-0094 board as shown in Fig.6. This EVM projects a point cloud of the detected object's position, range, velocity and angle to a computer running Robot Operating System or ROS[6]. ROS uses this point cloud data to detect and avoid obstacles in the robot's path by creating a new path for the robot according to the following algorithm as shown in Figs.7 and 8.

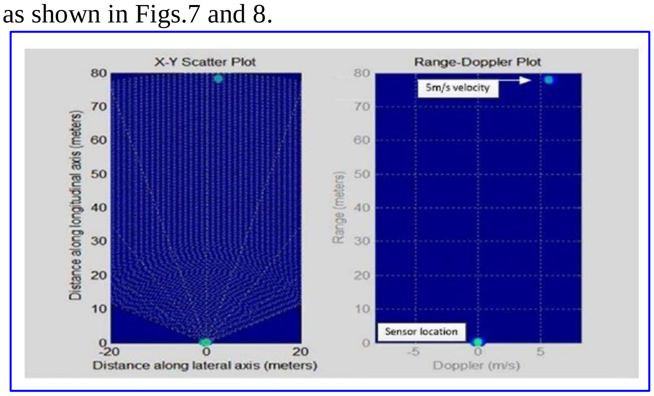

Fig 7. Small test object at ~80m distance.

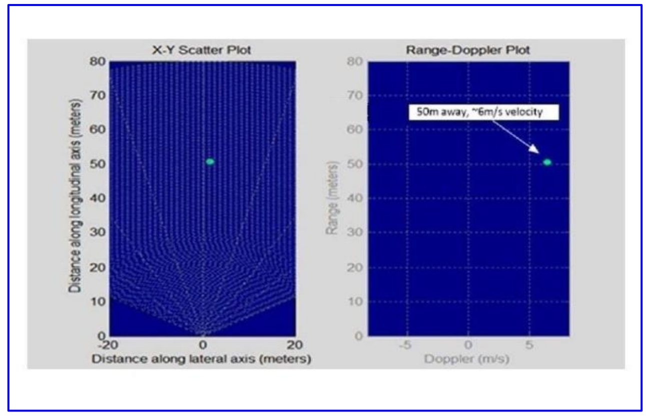

Fig.8. Small test object at ~50m distance.

V. IMPLEMENTATION

This technology of obstacle avoidance and detouring using mmWave can be used in various like fields like making of autonomous robots like swarm drones and swarm robots and in various field like in military to develop autonomous stealth bots and also in medical application. They can also be used to make autonomous parking system for vehicle and autonomous delivery robots. The flowchart for the complete operation is as follows: mmWave is a very robust sensing technology for detection of objects and determination of the range, velocity and angle of the objects. It is a contactless-technology which can operate in the spectrum30GHz and 300GHz. Operating in this spectrum makes mmWave sensors much more valuable for the following reasons

- Ability to penetrate materials like plastic, drywall and clothing
- It is highly Directional: It can produce a compact beam with 1^{o} angular accuracy
- Light-like: It can be focused and directed using standard optical procedures.
- Large bandwidths: It has the capability to distinguish between two nearby objects owing to it's large absolute bandwidth.

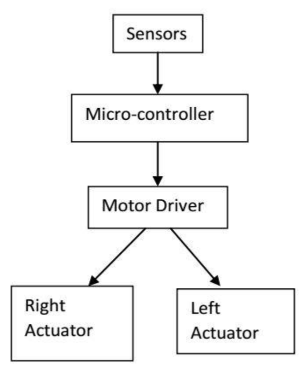

Fig.9. flowchart.

VI. CONCLUSION

The robotic vehicle we builtnavigates in different directions like front, back, left and right as per the instructions given to it from the data compiled and manipulated by the TIDEP-0094. Our project is to make an autonomous robot that can detect obstacle and take necessary path to detour it while in motion or stop based on certain conditions we mentioned in its algorithm. The robustness of the mmWave sensors i.e IWR1642 allows this robot to work in poor visibility conditions like fog, dust, smoke, humidity, ambient lighting. Also they can see through plastic and can be enclosed in rugged enclosures.

VII. REFERENCE

[1]Construction of an obstacle avoiding robot: https://www.youtube.com/watch?v=t3kXWSctj2Q
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[3]mmwave:http://ethw.org/Millimeter_Waves
[4]IWR1642 chip:http://www.ti.com/product/IWR1642
[5]TIDEP-0094 EVM:http://www.ti.com/tool/TIDEP-0094
[6]ROBOT OPERATING SYSTEM for Linux: http://www.ros.org/