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Mechanism to Detect Space Debris, using MM Wave sensor in Cleaning Satellite.

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Abstract:-This project is all about the mechanism by which a cleaning satellite orbiting earth can detect space junk[6] left behind by humans and catch them using other collection methodology like powerful magnets, harpoon, slingshot or snagging techniques. The satellite will be using multiple mm Wave sensors along with camera modules. It will also include GPS and other location detecting modules fosr detection of specific location in space and distance from other satellites.

Keywords:-Space junk, mmWave[2], GPS, Camera modules.

I. I.INTRODUCTION

Fig 1: Space junk

Space debris / space junk / space waste / space trash / space litter or space garbageis a term for the mass of discontinued, artificially or man-made created objects in space, most notably in Earth orbit, such as old satellites, solid fuel remnants, frozen coolant, paint flakes, spent rocket stages and also tools lost by astronauts working outside space stations in outer space. It includes fragments or parts from their fragmentation, erosion or collisions. In December 2016, collisions among 5 satellites have resulted in generating space waste.

Collisions with debris is a hazard to spacecraft; they cause damage alike sandblasting, especially to solar panels of satellites and space stations and optics like telescopes or star trackers and space observatories. According to Kessler's Syndrome, colliding debris creates more orbital debris in space.

In this paper we have proposed a mechanism of detecting space junk with high accuracy and precision. The advantage of using mmWave is that they have penetrating properties due to which we can enclose those sensors inside rugged enclosures. They can precisely detect and measure object dimension and its velocity with a high angular precision.

II. EXISTING SYSTEM

Currently there are no existing system that can detect debris in real time in space. Space debris are spotted by ground stations and then their location and dimension is fed to an algorithm that along with other debris calculates its possible orbit around the earth and possible orbit of other debris and their orbit that might form when two or more debris collide.

III. PROPOSED SYSTEM

This project is all about building an autonomous system that can detect orbital space debris in real time and capture them for safe disposal by some debris cleaning mechanism. The process shall be fully automatic without human intervention but certainly monitored by ground stations on earth.

All the decisions taken by the satellite to detect debris shall be manipulated via an internal algorithm we set for it.

The biggest advantage of using mmWave sensors are that they are extremely lightweight and since mmWave have penetrating properties, they can be enclosed in high density polycarbonate enclosures to protect them from space radiation yet functioning properly in the desired manner. mmWave can precisely detect and measure object dimension and its velocity with a high angular precision.

A. *Basic Design Of Debris Detection Module*

The module will work on the mmWave technology.

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

Here we have designed a basic prototype module for the detection of space debris to be captured. The parts required for this are:

- *IWR1642[3] mmWave Chip:*

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 manufactured with TI's low-power 45-nm RFCMOS process, which enables it to possess unparalleled extent of integration into an extremely tiny form factor. IWR1642 is the perfect provision for industrial applications such as construction automation, industry automation, drones, self-driving vehicles, traffic supervision, and surveillance.

Fig 2: IWR1642 mmWave chip

- *TIDEP-0094 Evaluation Module (EVM)[4]*

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[1] (azimuthal plane) along with the velocity of the objects at a distance of up to 84 m.

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.

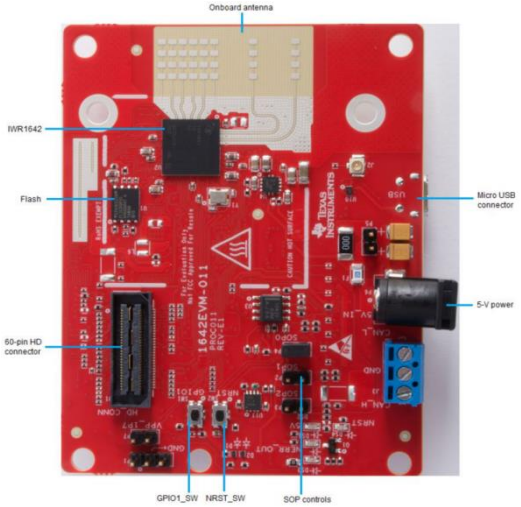

Fig 3. TIDEP-0094

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. The L-brackets provided with the IWR1642 EVM kit, along with the screws and nuts help in the vertical mounting of the EVM.

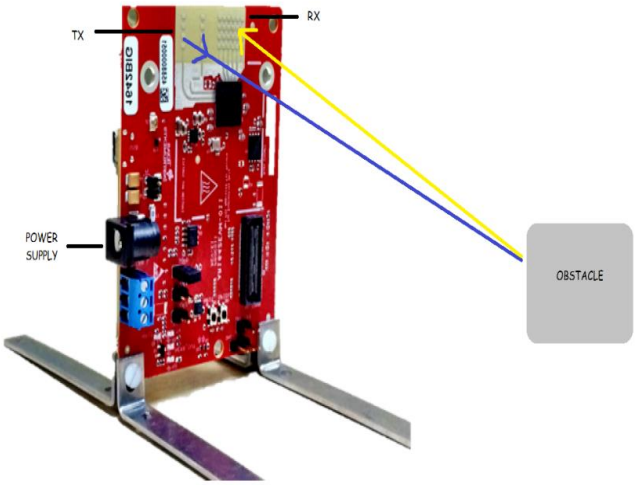

Fig 4. Schematic Diagram

- *GiGE-vision camera module*

GigE Vision is a worldwide camera interface developed using the "Gigabit Ethernet communication protocol".GigE Vision allows fast image transfer over low cost standard cables for long lengths. GigE Vision is a globally adopted interface, with dozens of leading manufacturers currently offering multiple GigE Vision products. GigE Vision includes many benefits like:

FAST	High bandwidth **(125 MB/s)** transfers large images quickly in real time
ABUNDANT	Data transfer upto 100 meters in length
STANDARD	Low cost CAT5 CAT6 cables and connectors
LOW COST	Standard hardware and cheap integration

GiGE VISION

Fig 5: GiGE Vision camera module

- *Database*

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A Database consisting of multiple images of objects will be present. The captured data from the module will be compared to the data stored inside the database via image recognition process. The work of the database is to act as a storage for data. New data will be regularly fed to the database. This data will mostly be consisting of images of known objects which are not debris.

- *Wi-Fi Module*

The ESP8266 is able to give any microcontroller access to a Wi-Fi network. It is a Wi-Fi Module (SOC) integrated TCP/IP protocol stack. The ESP8266 has the capability to host an application or offload all Wi-Fi networking functions from another application processor. Every ESP8266 module is manufactured by integrating it with an AT command set firmware.

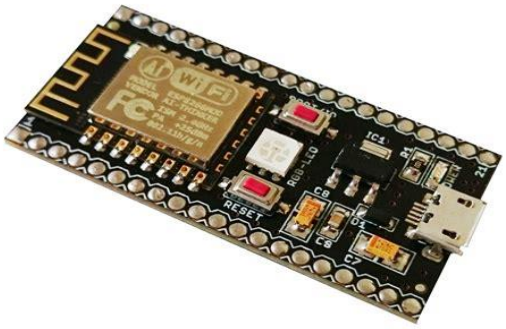

Fig 6: ESP8266 Wi-Fi module

- *RASPBERRY PI3 MODEL B*

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. It is a powerful credit-card sized single board computer can be used for many applications. Additionally, it is integrated with wireless LAN & Bluetooth connectivity making it the perfect solution for powerful connected designs like in fields of IoT or any development.

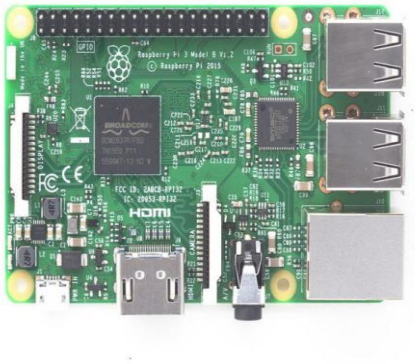

Fig 7: Raspberry Pi 3 Model B

B. Robot Operating System[5]

Robot Operating System (ROS) is a robotics middleware, fully open source. It provides services designed for heterogeneous computer cluster such as packet-management, hardware abstraction, low-level device control, , message-passing between processes, implementation of commonly used functionality. In other words it is used to connect software with hardware thereby providing an advance programming environment along with simulations and 3d visualizations for controlling low level hardware.

- **Working**

The TIDEP0094 board detects an object via mmWave sensors mounted onboard. The cloud point data obtained from any object in the vicinity of the module gives the module an estimate about its dimension and velocity. The cloud point data is obtained using ROS (Robot operating System) running on Linux. This triggers the camera modules to take multiple snaps of the detected object. The cameras connected to the TIDEP0094then sends the captured images of the detected object to a Raspberry PI board via the ESP8266 Wi-Fi Module. The captured images of the detected object are then processed via image recognition algorithms by comparing them with the images stored in the Database connected to the Raspberry Pi board. Now depending on the result the module gets from manipulation, the object is either captured or ignored.

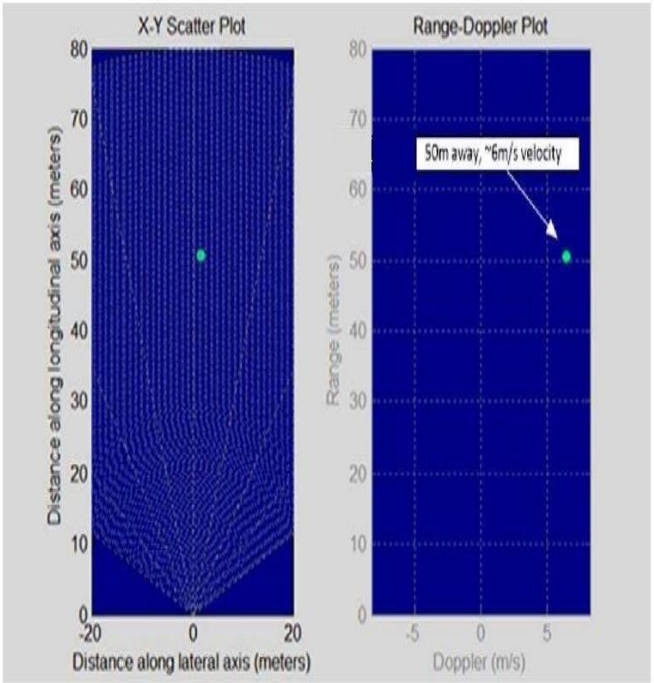

Fig 7. Small test object at ~50m distance.

- *ALGORITHM*

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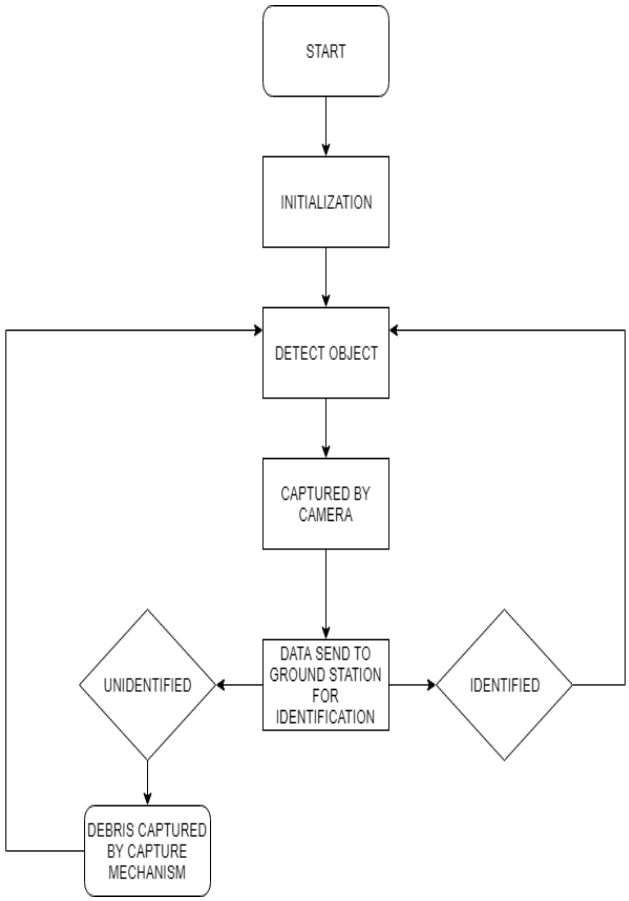

Fig 8. Algorithm and Working Principle of the satellite

The module detects an object via mmWave sensors mounted onboard. The camera modules then takes multiple snaps of the detected object. The cloud point data of the detected object and the captured images of the detected object are then send to a ground station where they are compared with other photos in their database.

If they find that the detected object is not in their database, the object is identified as debris. The satellite then triggers its capture mechanisms to capture the junk.

IV. IMPLEMENTATION

This technology to detect space debris using mmWave can be used for making of obstacle avoidance robots, swarm robots, autonomous self-driving cars and in various other fields like in military and medical field.

MM Wave 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 spectrum 30GHz and 300GHz.

Operating in this spectrum makes mmWave sensors much more valuable for the following reasons:

- Penetrate materials like plastic, drywall and clothing.
- It can produce a compact beam with 1º angular accuracy.
- It can be focused and directed using standard optical procedures.
- It has the capability to distinguish between two nearby objects owing to its large absolute bandwidth.

V. CONCLUSION

The autonomous module we built for detection of space debris will detect debris in real time rather than depending on the probability of a debris as predicted by any algorithm. Every debris detected will be captured by the cleaning module in the satellite thereby aiding in the cleaning of space junk around the earth and make future space flights safer. The robustness of mmWave sensors will allow it to work under extreme conditions of outer space since the sensors can be enclosed in a rugged enclosure, thanks to the penetrating property of mmWave. This will allow durability and longevity of the module.

REFERENCE

[1] Construction of an obstacle avoiding robot: https://www.youtube.com/watch?v=t3kXWSctj2Q

[2] mmwave:

http://ethw.org/Millimeter_Waves

[3] IWR1642 chip:

http://www.ti.com/product/IWR1642

[4] TIDEP-0094 EVM:

http://www.ti.com/tool/TIDEP-0094

[5] ROBOT OPERATING SYSTEM for Linux:

http://www.ros.org/

[6] Space Junk & orbital debris

https://www.space.com/16518-space-junk.html