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INCLINATION MEASUREMENT BASED ON MEMS ACCELEROMETER USING AI

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1. Overview

Measurements of the inclination of an object's orbit around a celestial body it is expressed as the angle between a reference plane and the orbital plane or axis of direction of the orbiting object. For a satellite orbiting the Earth directly above the Equator, the plane of the satellite's orbit is the same as the Earth's equatorial plane, and the satellite's orbital inclination is 0°. The general case for a circular orbit is that it is tilted, spending half an orbit over the northern hemisphere and half over the southern. If the orbit swung between 20° north latitude and 20° south latitude, then its orbital inclination would be 20°.
The inclination is one of the six orbital elements describing the shape and orientation of a celestial orbit. It is the angle between the orbital plane and the plane of reference, normally stated in degrees. For a satellite orbiting a planet, the plane of reference is usually the plane containing the planet's equator. For planets in the Solar System, the plane of reference is usually the ecliptic, the plane in which the Earth orbits the Sun. This reference plane is most practical for Earth-based observers. Therefore, Earth's inclination is, by definition, zero. Inclination can instead be measured with respect to another plane, such as the Sun's equator or the invariable plane (the plane that represents the angular momentum of the Solar System, approximately the orbital plane of Jupiter). The inclination of orbits of natural or artificial satellites is measured relative to the equatorial plane of the body they orbit, if they orbit sufficiently closely. The equatorial plane is the plane perpendicular to the axis of rotation of the central body. An inclination of 30° could also be described using an angle of 150°. The convention is that the normal orbit is prograde, an orbit in the same direction as planet rotates. Inclinations greater than 90° describe retrograde orbits (backward).

- Inclination of 0° means the orbiting body has a prograde orbit in the planet's equatorial plane.
- An inclination greater than 0° and less than 90° also describes a prograde orbit. An inclination of 63.4° is often called a critical inclination, when describing artificial satellites orbiting the Earth, because they have zero apogee point in the orbit of the moon or satellite at which is far from the earth)drift.
- An inclination of exactly 90° is a polar orbit, in which the spacecraft passes over the poles of the planet. An inclination greater than 90° and less than 180° is a retrograde orbit.
- An inclination of exactly 180° is a retrograde equatorial orbit.

For impact-generated moons of terrestrial planets not too far from their star, with a large planet–moon distance, the orbital planes of moons tend to be aligned with the planet's orbit around the star due to tides from the star, but if the planet–moon distance is small, it may be inclined. For gas giants, the orbits of moons tend to be aligned with the giant planet's equator, because these formed in circumplanetary disks. Strictly speaking, this applies only to regular satellites. Captured bodies on distant orbits vary widely in their inclinations, while captured bodies in relatively close orbits tend to have low inclinations owing to tidal effects and perturbations by large regular satellites.

2. Related work

[1] SUN Yuntao, DI Qingyun, ZHANG Wenxiu, CHEN Wenxuan, YANG Yongyou, ZHENG Jian: **"Dynamic Inclination Measurement"** In this article, the author defines the Dynamic inclination measurement using MEMS accelerometer which is integrated with Geo-Steering Drilling technology that is associated with well Drilling, logging, and reservoir engineering technology. This measures the inclination angle "At-Bit" based on MEMS acceleration by using five axis accelerometer and four compartment Geological Steering tools. In order to ensure the accuracy of measurement, and avoid the impact of strong shock, vibration for the impact of sensor is far from bit. The output of the gravity accelerometer is added by radial centrifugal acceleration, that has a great influence on the measured value.

[2] Minh Long Hoang, Marco Carratú, Moises Avoci Ugwiri, Vincenzo Paciello and Antonio Pietro Santo: **"New Technique for Optimization of Linear Displacement Measurement"** In this article the author defines the measurement of linear displacement by means of acceleration acquisition that is MEMS accelerometer which is a potential candidate in linear displacement. This paper presents a new algorithm, **"**No Displacement Zero Translation. Accumulation (NDZTA) to solve the cumulative error of linear measurement when the sensors stay at stationary points. The proposed filter removes noise by pulling down the current velocity and acceleration to 0 immediately when the sensor finishes its motion. The accelerometer calibration has been done to minimize the noise on acceleration data. The idea of algorithm NDZTA is to reach the Zero error accumulation at every single stationary point, with this the enhancement of measurement quality is apparently demonstrated.

[3] ZHANG YU, XUE YAMENG, HUANG XINJING, LI JIAN AND CHEN SHILI : **"Pipeline inclination measurements"** In this article author defines that spherical detector is a novel and promising magnetic shielding based approach for long subsea pipeline orientation and localization with low risk of blockage. And also, this paper proposes a new inclination measurement method without utilizing the magnetic shielding model of the pipeline**.** The different phase between the acceleration and magnetic signals are used to calculate the pipeline inclination which are the value of the acceleration. Here numerical simulations are carried out to analyze and design reasonable structural parameters of the career for fixing the MPS and the accelerometer**.** As Marine oil and gas industries prosperously developed the length sum of subsea pipeline increase rapidly which brings you demand for subsea pipeline. Numerical stimulation and structural design have finite elements simulation with different geometric configuration were performed in order to obtain the maximum approaching signal**.** At the result and discussion stage the magnetic and acceleration signal measured upward while the career is rolling inside the pipe.

[4] Minh Long Hhoang, Antonio Pictrosanto "**An effective method on vibration immunity for inclinometer based on MEMS accelerometer"*:*** The author of these article defines that the MEMS accelerometer is the Pioneer in the field of inclination sensors the acceleration can be used to measure the slope Oriental angles which have a critical role in industry the inclination sensor is used to measure two parameters the first one is rotation around the front to back X-axis called role and another one is rotation around the side to side Y-Axis called pitching real applications vehicle vibration causes severe fluctuation in data acquisition consequently the inclination measurement contains many noises that need to be filter here the accelerometer calibration correct the acceleration to its proper value and a normal condition but this calibration method cannot solve the vibration issue there for the digital filter is good solution to solve the considerable issue. Under inclination measurement we use the orientation formula, LP filter.in VI I technique the VI filter contains the good capability of noise removal from both the LP filter and a MA filter at the experiment stage the sensor involved in acquiring data for experiment are LSM9DSI from STMicroelectronics.

3.Existing System

Currently they have made use of dynamic inclination using MEMS Accelerometer which is integrated with underground drilling, logging technologies. The output of the near bit, the output of the acceleration sensor is not only the gravity acceleration, but also the centrifugal acceleration generated by the rotation of the tools, the vibration and shock acceleration

Disadvantages

- During drilling operation, the factors that affect the measuring result includes vibration, shock and the rotation of the droll tools
- First environmental condition near that place will be worst, the vibration, the impact, pressure and temptation than the conventional Geo-Steering position are much more severe.
- In the case of static or slow rotation state, the influence of centrifugal acceleration on the measuring is very small

4.Proposed System

A MEMS-based accelerometer or inclinometer can be used to measure the tilt of an object with respect to a horizontal plane. The sum of forces measured on all three axes equals the force due to gravity. Rotating the object changes the amplitude of the sensed acceleration.

Here with the help of sensors and Microprocessor we will detect the obstacles and then this will help the rocket to launch in the proper direction .

Advantages

- Here it will find the obstacles during the launching period and then help the rocket to launch in a proper direction
- In this way we can also save the obstacles (birds/in the space satellites) and smoothly we can launch the rocket without effect the obstacles and also with less damage of rockets.
- This is one of the most efficient way to launch the satellite or rockets and it will not affect any one of the celestial bodies

5.System Specifications

Hardware Requirements

- Raspberry PI PICO
- Ultrasound sensor
- PIR sensor
- Stepper motor
- LCD display

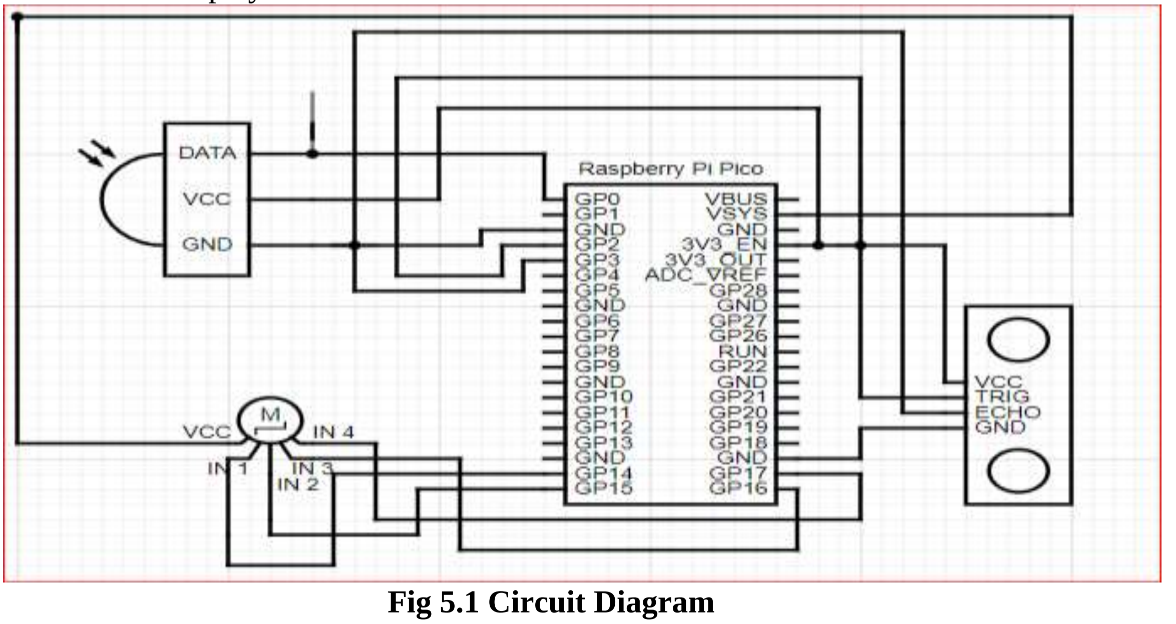

Fig 5.1 Circuit Diagram

RASPBERRY

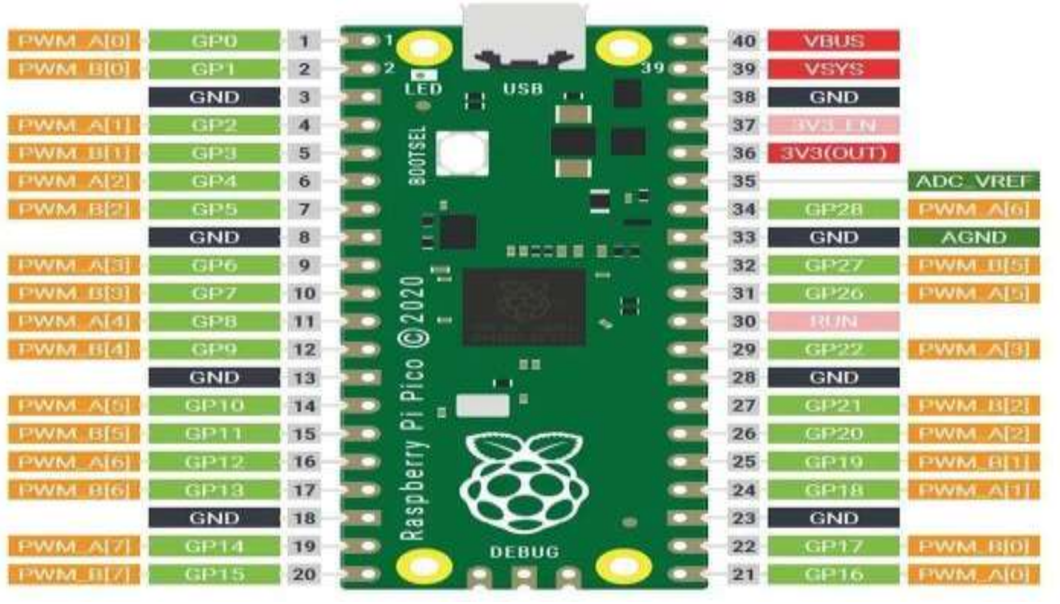

Fig.5.2 Raspberry Pi Pico

It comes as a castellated module allows soldering direct to carrier boards, while the Pico H comes with pre-soldered headers.

- RP2040 microcontroller chip designed by Raspberry Pi in the United Kingdom Dual Core Arm Cortex M0+ processor, flexible clock running up to 133 mhz.
- 264kb of SRAM, and 2MB of on-board flash memory.
- USB 1.1 with device and host support.
- Low-power sleep and dormant modes.
- Drag-and-drop programming using mass storage over USB.
- 26 × multi-function GPIO pins.
- 2 × SPI, 2 × I2C, 2 × UART, 3 × 12-bit ADC, 16 × controllable PWM channel.
- Accurate clock and timer on-chip. Temperature sensor.
- Accelerated floating-point libraries on-chi ,8 × Programmable I/O (PIO) state machines for custom peripheral support.

ULTRASOUND SENSOR

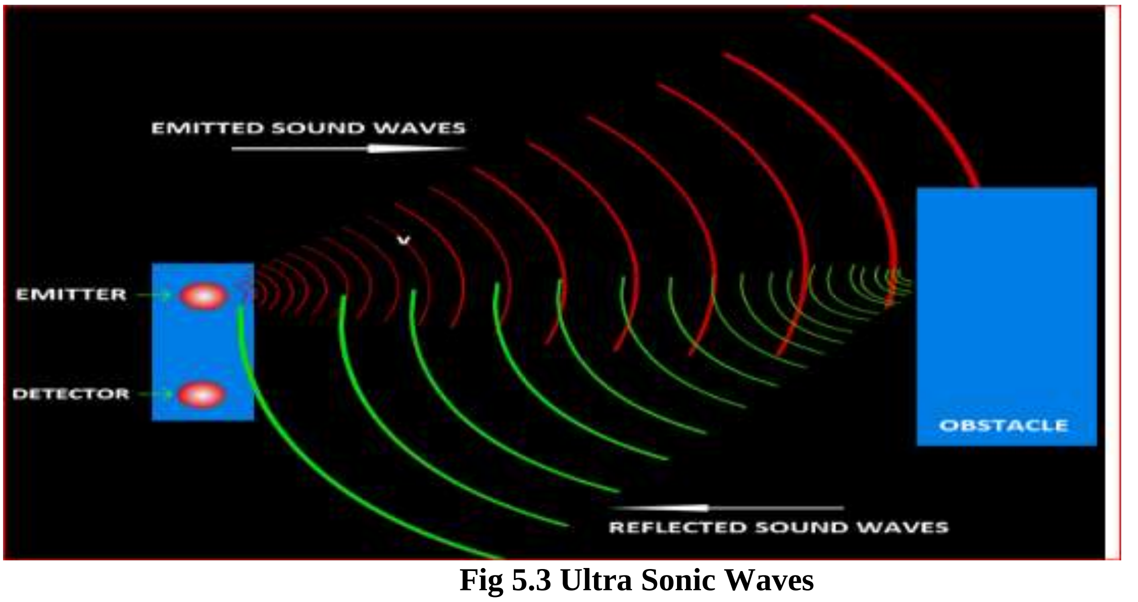

Fig 5.3 Ultra Sonic Waves

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal. Ultrasonic waves travel faster than the speed of audible sound. Ultrasonic sensors have two main components: the transmitter (which emits the sound using piezoelectric crystals) and the receiver (which encounters the sound after it has travelled to and from the target). Ultrasonic sensors are also utilized as level sensors in closed containers to detect, monitor, and manage liquid levels such as vats in chemical factories.

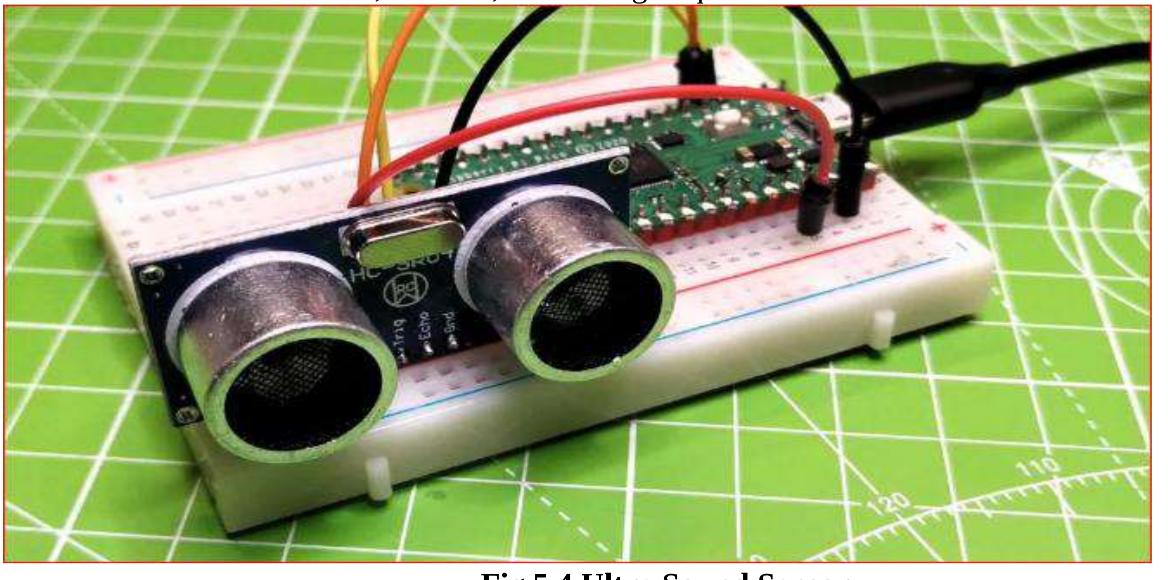

Fig 5.4 Ultra Sound Sensor

Ultrasonic sensors, use pulses of sound and a simple calculation to determine the distance between themselves and the objects in front them. They are often used in robots to make sure the bot doesn't walk or roll into an obstacle.

PIR Sensor

Fig 5.5 Position Sensor

There are many ways to detect movement and distances with the electronics. But the position
Tells us the correct position of the object whether is left side or right side.

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STEPPER-MOTOR

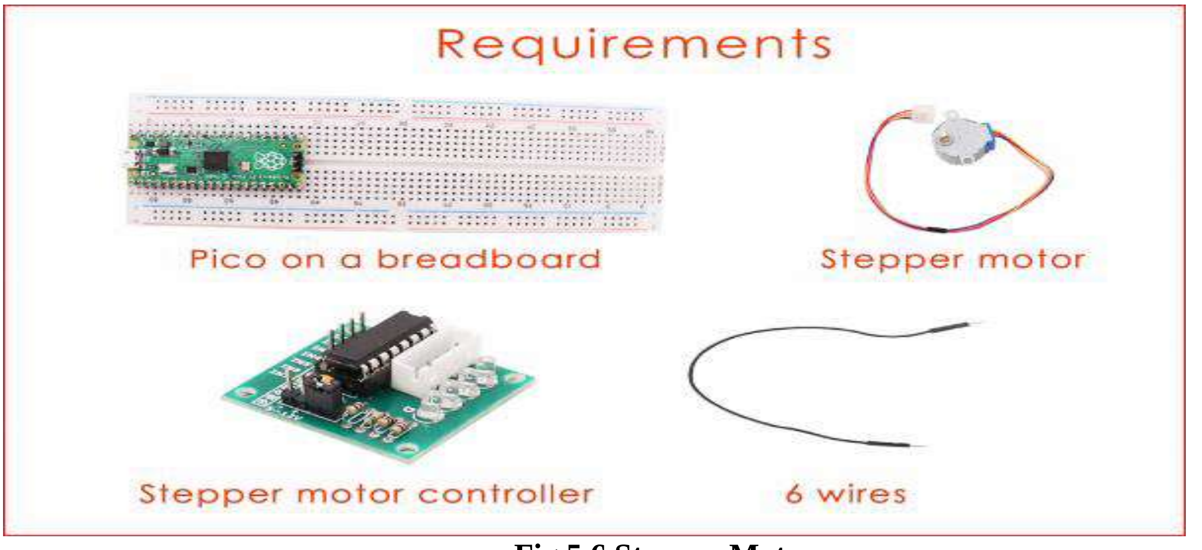

Fig 5.6 Stepper Motor

A stepper motor is an electromechanical device converting electrical energy into mechanical power. At the same time, a stepper motor is a brushless, synchronous motor that can divide a full rotation into a huge number of steps. When a stepper motor is applied with electrical command pulses in the proper sequence, the shaft or spindle of the stepper motor rotates in discrete steps, allowing precise control of the motor's position without any feedback mechanism, as long as the motor is sized for the application. It is a synchronous brushless motor where a full rotation is divided into a number of steps. The two main components of a stepper motor are the rotor and the stator. The rotor is the rotating shaft and the stator consists of electromagnets that form the stationary part of the motor. When a discrete DC voltage is applied, the stepper motor rotates in a particular angle called the step angle; thus a stepper motor is manufactured with steps per revolution.

LIQUID-CRYSTAL DISPLAY (LCD)

Liquid Crystal Display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. Liquid crystals do not emit light directly, instead using a backlight or reflector to produce images in color or monochrome. LCDs are available to display arbitrary images or fixed images with low information content, which can be displayed or hidden. A display is made up of millions of pixels. The quality of a display commonly refers to the number of pixels. A pixel is made up of 3 subpixels; a red, a green and a blue- commonly called as RGB. LCDs are made with either a passive matrix or an active matrix display grid. The active matrix LCD is also known as a thin film transistor (TFT) display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control the light for any pixel. LCDs are used in wide range of applications, including LCD televisions, computer monitors, instrument panels, aircraft cockpit displays, indoor-outdoor signal. Small LCD screen are common in all of the LCD projectors and portable consumer devices such as digital cameras, watches, digital clocks, calculators and mobile telephones, including smartphones LCD screen have replaced heavy, bulky cathode-ray tube (CRT) display in nearly all applications. A display is made up of millions of pixels. The quality of a display commonly refers to the number of pixels. A pixel is made up of three subpixels; a red, blue and green—commonly called RGB. LCDs are made with either a passive matrix or an active matrix display grid.

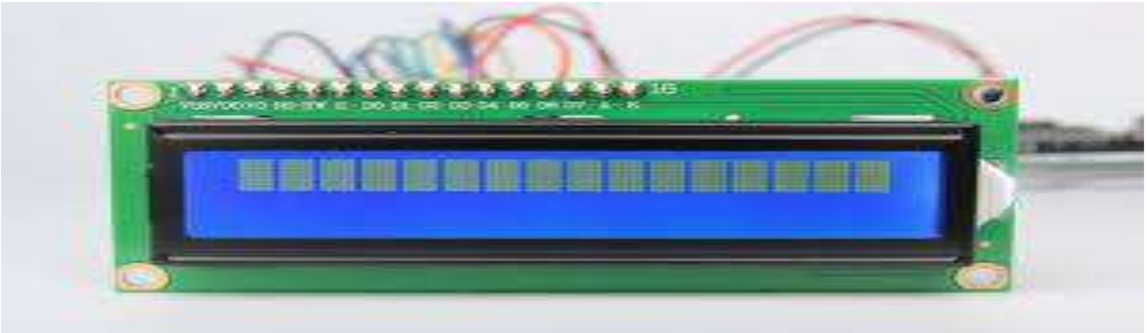

Fig 5.7 LCD Display

A current is sent across two conductors on the grid to control the light for any pixel. LCDs are used in a wide range of applications, including LCD televisions, computer monitors, instrument panels, aircraft cockpit displays, and indoor and outdoor signage. The active matrix LCD is also known as a thin film transistor (TFT) display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control the light for any pixel. LCDs are used in a wide range of applications, including LCD televisions, computer instrument panels, aircraft cockpit displays, and indoor and outdoor signage. Small LCD screens are common in LCD projectors and portable consumer devices such as digital. cameras, watches, digital clocks, calculators, and mobiles including smartphones LCD screens have replaced heavy, bulky cathode-ray tube (CRT) displays in nearly all applications. LCD screens are available in a wider range of screen sizes than CRT and plasma display, with LCD screens available in sizes ranging from tiny digital watches to very large television receivers.

Conclusion

Research groups are modifying the previously designed model for new enhanced purpose and with different aspects. We started our project from scratch. Our best understanding and combine searches on the parallel fields helped us to accomplish our work correctly. Now we can say that we can do more efficient work and can perform difficult task in an easy way. Our idea is mainly for the space researchers like NASA, ISRO as they are doing researches and lab work on space and celestial bodies through satellite. Our project will help the satellite reach the destination without being pulled by the gravity or any kind of obstacle that can divert satellites from its destination. We are very hopeful with our idea that it will bring change in our technical field and our mind.

Future Enhancement

Future scope of our project is that

- It can be used to measure the displacements in the ground and in structures that lie below the ground.
- If it is built in a large scale it can measure the inclination for larger distance.
- It can be used to retaining structures.
- It can be installed in boreholes, adjacent to the wall face or can be embedded within the structure.
- Monitor landslides as in detection of depth and thickness of slide shear zones, the magnitude, direction of land slide.

References

[1]. G. Qinglei, L. Huawei, M. Shifu and H. Jian, "Design of a Plane Inclinometer Based on MEMS Accelerometer," 2007 International Conference on Information Acquisition, Seogwipo-si,2007, pp.320-323.

[2]. L. Da-wei and G. Tao, “Design of Dual-axis Inclinometer Based on MEMS Accelerometer,” 2011 Third International Conference on Measuring Technology and Mechatronics Automation, Shangshai, 2011, pp. 959-961.

[3]. J. Wang, G. Gao and P. Liu, “The study on lange-angle CANBUS 2-axis inclinometer of rotary drilling rig,” 2010 2nd IEEE International Conference on Information Management and Engineering, Chengdu, 2010, pp. 95-97.
[4]. Y. Zhong and Y. Xu, “A calibration method of UAV accelerometer based on levenberg-marquardt iteration algorithm,” 2018 Chinese Control And Decision Conference (CCDC), Shenyang, 2018, pp. 56345638.
[5]. L. Da-Wei and G. Tao, ‘‘Design of dual-axis inclinometer based on MEMS accelerometer,’’ in Proc. 3rd Int. Conf. Measuring Technol. Mechatronics Automat., Jan. 2011, pp. 959–961.
[6]. G. Qinglei, L. Huawei, M. Shifu, and H. Jian, ‘‘Design of a plane inclinometer based on MEMS accelerometer,’’ in Proc. Int. Conf. Inf. Acquisition, Jul. 2007, pp. 320–323.
[7]. M. L. Hoang, M. Carratù, V. Paciello, and A. Pietrosanto, ‘‘A new orientation method for inclinometer based on mems accelerometer used in industry 4.0,’’ in Proc. IEEE 18th Int. Conf. Ind. Inform. (INDIN), Jul. 2020.
[8]. S. Shin D. Kim and Y. Seo "Controlling mobile robot using IMU and EMG sensor-based gesture recognition" Proc. 9th Int. Conf. Broadband Wirel. Comput. Commun. Appl. pp. 554-557 2014.