Design and fabrication of unmanned ground surveillance vehicle

Mohammad Khalfan A'amir Al-Habsi[a], Mohankumar Kalimuthu[a]

Unmanned ground surveillance vehicle is a remote-controlled vehicle used to survey the required environment at any terrain condition. The main objective of this vehicle is the Self Lifting mechanism that lifts itself when the vehicle has encountered a “topple” which is triggered by the user far away from the vehicle. This UGSV not only can save manpower but also ensure the operation of surveillance being well performed. Due to the limitation of manpower and the fixed camera positions, using surveillance is different from the traditional patrolling system. The Unmanned Ground Surveillance Vehicle which can be able to maneuver automatically to a wider range and record the monitored image within a predefined patrolling route to improve the performance of the traditional patrolling system. Besides, UGSV can be connected to the mobile device, Laptop at anytime and anywhere. Furthermore, the vehicle can be remote controlled by user to move to the position to get the indoor image we want. The AV-CAM is also mounted on the proposed robot to record the images and transmit them back by radio waves.

Keywords: UGSV, self-lifting, surveillance,robot,camera

Introduction

An unmanned ground vehicle (UGV) is a vehicle that operates while in contact with the ground and without an onboard human presence. UGVs can be used for many applications where it may be inconvenient, dangerous, or impossible to have a human operator present. Generally, the vehicle will have a set of sensors to observe the environment, and will either autonomously make decisions about its behavior or pass the information to a human operator at a different location who will control the vehicle through tele operation.The UGV is the land-based counterpart to unmanned aerial vehicles and remotely operated underwater vehicles. Unmanned robotics is being actively developed for both civilian and military use to perform a variety of dull, dirty, and dangerous activities.

Three ultrasonic sensors are used to sense movements over a range of 600mm and three corresponding LED bulbs are used as trigger so as to inform the operator. The ultrasonic sensors are controlled using Arduino UNO board and mini bread board.A worm gear drive setup is incorporated in the vehicle which is connected to the arm that lifts the vehicle whenever the vehicle topples. The worm gear setup and arm are controlled by the operator through RADIO FREQUENCY (RF). The arm is rotates 180 degree. A 75rpm DC motor (High Torque) drives the worm.

Belt drives with 6 pulleys (3 on either sides) is used to drive the vehicle. Four 300 RPM DC motors are used to drive the tracks and the pulley.

Recent developments in technologies for sensing and control of autonomous ground vehicle have demonstrated the ability to accurately determine the position and velocity information, thereby leading to better performance of unmanned vehicles. In 1994, Takashi Gomi, Kooichi Ide and Hirokuzu demonstrated the technique employed in non-cartesian nway of organizing software agents for creating control programs. Saurav Chakraborty, Subhadip Basuet al discussed on designing a smart Unmanned Vehicle which is designed and developed for some application specific missions to operate predominantly in hazardous environments. In their work, they have developed a small and lightweight vehicle to operate in general cross country terrains in or without daylight. The unmanned vehicle can send visual feedbacks to the operator at a remote location. On-board ultra violet sensors can detect the obstacles around the unmanned vehicle and sends signals to the operator. The present work draws from these articles and extends scope to design, analysis and testing of an unmanned vehicle which can lift itself by the help of an lifting arm provided with worm gear drive.

Fig 1: An image of the UGSV

MECHANICAL DESIGN OF THE VEHICLE

An unmanned vehicle is capable of working on its own or based on the commands given to it remotely in any environment. However, the major problem in operating unmanned vehicle is reliability and failures due to control system, power, and communication. The data transfer for the motion and operation of the unmanned vehicles with the remote operator is the major problem where the communication signal weakens. Another problem in the operation of unmanned vehicles is safety in urban environments. In the proposed unmanned vehicle a lifting mechanism is introduced for keeping the vehicle stay afloat. The practical difficulties in designing such a system are weight, and space restrictions.

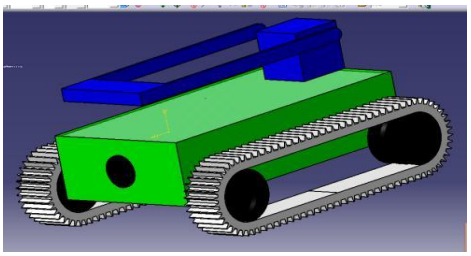

Fig 2: Mechanical design of the UGSV

Various components in the unmanned ground surveillance vehicle are 4 numbers of 300 RPM DC motors, A worm gear drive,11.1V Li-Po battery, Arduino UNO controller,3 numbers of Ultrasonic sensors, 3LEDs, AV camera, 2 Radio controls, 4 pulleys, 2 belt drives.

4 DC motors are used to drive the pulleys. The DC motor is connected to 9V battery and RF of frequency 0.5 Hz. The motor rotates in same direction when the vehicle moves forward and backward. When the vehicle makes a turn the direction of rotation of the motor in the left and right direction will be opposite. By

a.Middle East College, Muscat, OMAN

adapting this mechanism usage of differential is avoided there by reducing the weight of the vehicle.

A worm drive is a gear arrangement in which a worm (which is a gear in the form of a screw) meshes with a worm gear (which is similar in appearance to a spur gear). The two elements are also called the worm screw and worm wheel. The worm gear drive is used to transmit power to an arm that will lift the entire vehicle. The worm is driven by a high torque 75 RPM DC motor. The worm wheel rotates at 3 RPM and the torque is transmitted to the arm through a shaft. The gear ratio is 25:1. The number of starts in the worm is 1 and the number of teeth in the worm wheel is 25.

Speed of the worm N1 = 75 RPM
Speed of the worm wheel N2 = 25 RPM
Number of starts in worm Z1 = 1
Number of teeth in worm wheel Z2 = 25
Material: DURACON (Acetyl Copolymer-plastic)

11.1V 3S battery is used as supply for the RF receiver board. 3S denotes 3 cells on the battery. Battery has the highest weight among all the components of the body and hence it is placed at the rear middle end of the body in order to accommodate the perfect balance of the vehicle while lifting it from ground and to concentrate the CG at the rear end of the vehicle.

The Arduino UNO is used to program 3 ultrasonic sensors and 3 LEDs. 3 ultrasonic sensors are fixed at the left, right and at the rear of the vehicle and senses over a range of 60cm. The 3 LEDs are connected with the corresponding 3 ultrasonic sensors. The Arduino switches the LED whenever the ultrasonic sensor sends a pulse within the range of 60cm.

The Ultrasonic Sensor Hc-SR04 belongs to the category of Ultrasonic Proximity Sensors. It emits an ultrasound at 40 000 Hz which travels through the air and if there is an object or obstacle on its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance.

In this paper, LED is mainly used to indicate the presence of an obstacle in the path of the vehicle up to a particular range of distance (30 cm).If an obstacle is present in the range of 30cm from the vehicle, the ultrasonic sensors sense the presence of the obstacle and send a pulse to the LED due to which the LED emits light.

Pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt along its circumference. Pulleys are used in a variety of ways to lift loads, apply forces, and to transmit power

The belt drive used in this case is caterpillar tracks. Caterpillar track is a system of vehicle propulsion in which a continuous band of treads or track plates is driven by two or more wheels. This band is typically made of modular steel plates in the case of military vehicles and heavy equipment, or synthetic rubber reinforced with steel wires in the case of lighter agricultural or construction vehicles.

Acrylic is also known by the trade names Perspex and Plexiglas. Acrylic sheets are made to exacting standards of furniture and accessories. Acrylic is made up of lightweight, rigid thermoplastic material that has many times the breakage resistance of standard window pane glass. It is highly resistant to weather conditions. It is suitable for most utilitarian applications and is ultraviolet light absorbing up to approximately 360 nanometers

The material used for the arm is stainless steel.

Control mechanism for wheels

The most critical challenge for developing an UGSV is to design the navigation and guidance systems. In this work, we have installed a wireless av camera in remote UGV to get visual feedback. There are two separate radio controls used in the vehicle, one for controlling the motors used to drive the wheels and the other one for controlling the movements of the arm.

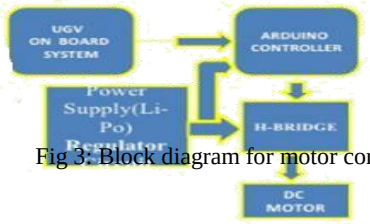

Fig 3: Block diagram for motor control

The vehicle is driven using a radio control. There are 4 sticks on the transmitter for the operation of the four motors driving the wheels of the vehicle. One separate stick is provided for controlling the movement of the arm. The stick movements are interpreted into radio signals from the transmitter and sent to the receiver which sends the signals to the motors which actuates the motion in both the cases of the arm and the wheels. While operating the radio it is necessary to work with the antenna being fully extended. The transmitter has a circuit that is designed to send a signal through that antenna.

Control mechanism of lifting arm:

Integrated circuit has been used with the radio control for the operation of motor actuating the arm movements. There are only two types of movements that the arm is allowed to undergo namely up and down motion. There is only one stick for controlling this up and down movement of the arm. Hence the stick has two axes of motion for performing the up and down movement. The characteristics of the RF module used are given below -

The RF module, as the name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK).

Transmission through RF is better than IR (infrared) because of many reasons. Firstly, signals through RF can travel through larger distances making it suitable for long range applications. Also, while IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter & receiver. Next, RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources.

This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs.

Results and discussion

In our current work we have successfully developed a prototype unmanned ground Surveillance vehicle capable of travelling through difficult terrains The major navigational

difficulty faced during experimentation is the low ground clearance of the vehicle. Wheels with bigger diameter may solve this problem. The wireless camera output is also prone to external noise. Interference from the motor windings often distorts the camera vision at the operator-end

The overall performance of the system may still be improved by inclusion of onboard processing capabilities within the UGV. In our future work, we have planned to develop a lightweight vehicle capable of climbing up and down through stairs.

Acknowledgements

Authors are thankful to the authorities of Ibra College of technology for kindly permitting to carry out the project work.

References

Douglas W. Gage, "A Brief History of Unmanned Ground Vehicle(UGV) Development Efforts", Special Issue on Unmanned Ground Vehicles, Unmanned Systems Magazine, Vol. 13, number 3, Summer 1995.

Anthony Stentz, Alonzo Kelly, Peter Rander, Herman Herman, Omead Amidi, "Real-Time, Multi-Perspective Perception for Unmanned Ground Vehicles", www.rec.ri.cmu.edu/projects/ preceptor.

Parag H. Batavia, Dean A. Pomerleau, Charles E. Thorpe, "Applying Advanced Learning Algorithms to ALVINN", CMU-RI-TR-96-31, October-1996.

M. Anbarasan and Dr. V. Elango," Design and fabrication of unmanned vehicle ", International Journal of Multidisciplinary Research and Modern Education (IJMRME) Volume II, Issue I, 2016.

Robert A. Frederick, "Project Plan: Unmanned Air/Ground Vehicle",http://www.eb.uah.edu/ ipt2001.

J. Anupama, A. Kavitha, S. Harsha, M. Karthick, "Design and Development of Autonomous Ground Vehicle for Wild Life Monitoring",International Journal of Innovative Research in Computer and Communication Engineering,Vol. 2, Issue 5, May 2014.olume 6, Issue 2: pp, 1-6