Unmanned and autonomous ground vehicle

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Article Info	ABSTRACT
	Unmanned and Autonomous Ground Vehicle (UAGV) is a smart vehicle that capable of doing tasks without the need of human operator. The automated vehicle can work during off and on road navigation and also used in military operation such as detecting bombs, border patrol, carrying cargos, search, rescue etc reducing soldier's exposure to danger, freeing them to perform other duties. This type of vehicle mainly uses sensors to observe the environment and automatically take decisions on its own in unpredictable situation and with unknown information or pass this information to the operator who control the UAGV through various communication when it requires support. This UAGV can send visual feedbacks to the operator at the ground station. An onboard sensor gives the complete environment of the vehicle as signals to the operator.

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1. INTRODUCTION

Unmanned ground vehicles (UGV's) are developed for many applications such as the army, in dangerous waste management. Such applications are having limitations on communications which needs navigation autonomously. UGV's have the potential to significantly reduce the critical mistakes that human drivers make. The performance of the UGV's are also better than human drivers because of the better perception and better decision making [1, 2]. The capability of controling an autonomous vehicle is critical which can impact the public acceptance of autonomous vehicles and also the automotive industry [3]. Under these situations, UGV's should be furnished with sensors for spotting obstacles. This paper deals with combination of mechanical, electronics, sensors, image processing and computer vision to make the ground vehicle manual and autonomous enabling the people safety in transportation by eliminating the risk involved in the transportation [4, 5]. The UGV's are embedded with three mobility levels such as teleoperation, computer aided driving and autonomous control. The control station has the capability to simultaneously control the operation and manage UGV's. They are built to handle any missions' missions such as border patrol, surveillance and in active combat both as a standalone unit and as well as a human soldiers (manual). An operator can control comfortably from a remote place wirelessly. This system of ours has two units- one is the control unit (to control mobility) and the other is the motion tracking unit. Both these units have two modes- Automatic and Manual [6]. This robot would be armed with an automatic weapon mounted onto a turret and a remote operator would be getting a live video feed from the camera to help him manually control both the above mentioned units of the rover. The rover is also capable of automatically tracking movement of objects in its range of vision. In the automatic mode, the boat uses Image Processing techniques to track motion. The vehicle has GPS [7, 8] navigation and commands to navigate can be given wirelessly. Additionally, infrared sensors aid in obstacle detection and path mapping. There is one onboard computer,

which receives command from command center control and issues commands to the onboard microcontroller for controlling the stepper motors, servo motors, wireless data reception, GPS navigation, and obstacle detection [9]. The command center control computer allows the remote user to see the direct video stream and control the various features of the rover, using a GUI [10]. This allows the user to access the vehicle remotely and as well as without hands on the steering and peddle, which is shown in Figure 1.

Figure 1. Autonomous car

2.   PROPOSED APPROACH FOR DESIGNING UGV

The various technologies involved in this UAVG are as follows
−   Mechanical design analysing
−   Electronics
−   Control system
−   Image processing
−   Computer vision
−   Sensor fusion
−   Artificial Intelligence

LabView is generally used for data acquisition, instrument control, and industrial automation on a variety of platforms [11, 12]. Vision software used in LabVIEW has the following components.
−   NI Vision Acquisition system
−   NI Vision Development Unit
−   NI Vision for Automated Inspection

NI Vision Acquisition syatem is the elementary requirement for creating vision kind of applications. The NI Vision software includes the necessary drivers, such as NI – IMAQ and NI – imaqdx. The NI – imaqdx driver software gives you the ability to acquire the image with IEEE 1394 (firewire), Ethernet and Usb cameras. For more advance machine vision image processing you will need NI Vision Development Module. Hundreds of image processing and machine vision functions for labview is available in the Vision development module. This module has pattern matching, texture recognition, counting functions inbuilt [13, 14]. NI Vision Builder is used for automated inspection, gauging, part presence, guidance, and counting. This is external and independent application for building and machine vision application without the need for programming NI visionni Vision Assistant are the tools used in labview.NI Vision is used to create machine vision and scientific imaging applicationwhich helps for basic image analysis, image processing, and machine vision [15]. NI Vision tool helps to create image processing and machine vision applications. Control, and industrial automation on a variety of platforms.

3.   RESEARCH METHOD FOR DESIGN AND CALCULATIONS OF THE PROPOSED MODEL

This UAGV consists of a camera, ultrasonic sensors, video transmitter and receiver, Zigbee, high torque motors, gps module, digital compass, microprocessor and microcontrollers all combined, the data from all the sensors are collected analysed, fused, processed and finally the limited data is sent to actuators. This combination of all sensors enables the vehicle to take decision in unpredictable and unknown situation to take a right decision to navigate autonomously, Software being used – NI LabVIEW is shown in Figure 2.
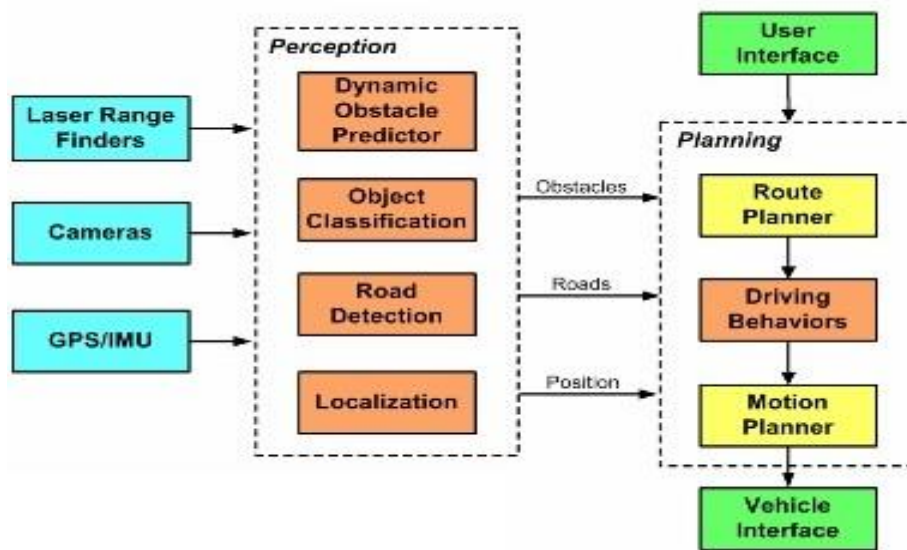
Figure 2. Software being used – NI LabVIEW

The chassis of the vehicle is brought from the outside and analysed the complete mathematical model and the measurements of the vehicle to make a complete redesign in the solid work for virtual prototyping and model in the loop [16, 17]. This allows checking the control system of the vehicle virtually according to the mechanical design so that the control system is tuned virtually in hit and trailing method with approximate parameters from the mechanical design's parameter which is extracted from the solid works. The electronics in this are power distribution board, protection board, safety kill and motor driver switch are major electronics involved in the UAGV [18, 19]. The power distribution board and protection board protects the sensors and other logic circuits from high voltage and current. This also protects reverse polarity and isolation. The emergency and safety kill switches are of two ways, they are mechanical kill switch and remote kill switch. Kill switches are very important in emergency situation as the vehicle consists of up to 50 amps. The motor driver allows controlling the motor from the microcontroller [20, 21]. The operational diagram is given in Figure 3.
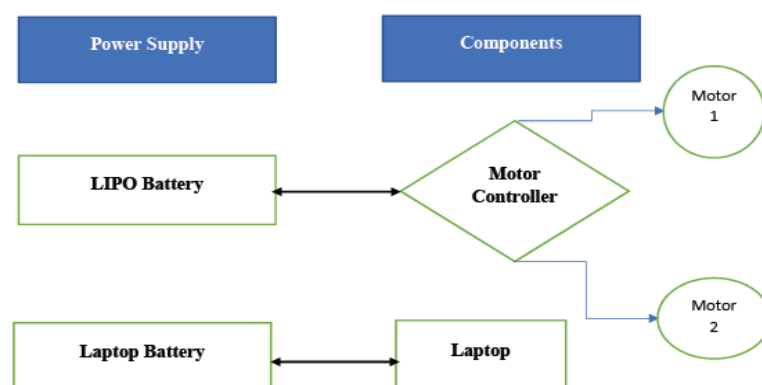

Figure 3. Operation of motor control

Image processing and computer vision plays a vital part in this autonomous navigation. This gives the complete map using camera and also detects the obstacle for the navigation and decision making purpose. Working principle of image processing and computer vision is shown in Figure 4.
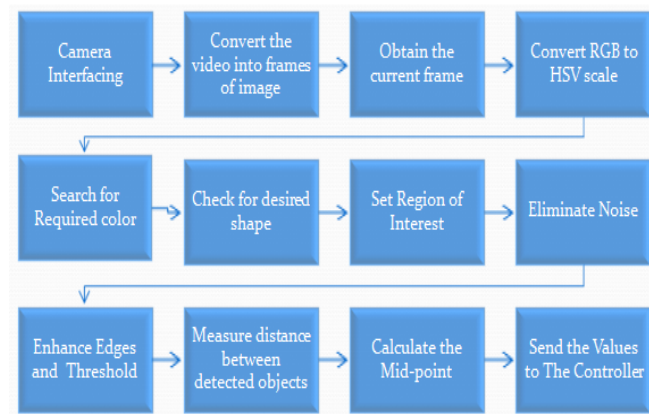
Figure 4. Working principle of image processing and computer vision

In this vision based navigation many algorithms are used. But the basic algorithm is as shown in the chart. In addition to this, human being is also detected for the autonomous navigation purpose, search and rescue. The artificial intelligence provides the thinking process to the vehicle, this make the vehicle smart and intelligent by choosing the shortest path from gps and vision based data for navigation by various algorithms such as Dijkstra's algorithm. The calculation of various parameters are given as follow as;

3.1. Acceleration UAGV
Acceleration of UGV on flat terrain probably wants the acceleration to be about half of maximum velocity. So, if say UAGV velocity is 3 feet per second and if the acceleration is around 1.5 feet per sq. second, then this would take 2 seconds to reach maximum speed.

3.2. Force
Force = Mass × Acceleration
Torque × Rps = (Mass × Acceleration × velocity × 2π)/ Efficiency
Now,
UAGV total weight = 9 kgs
Desired velocity = 2 m/s
Desired acceleration = 1 m / sq. sec
Expected efficiency = 75 %
Wheel Diameter = 0.215 cm
Powered wheels   = 2
$$= 9 \times 2 \times 2 / 2\pi$$
$$= 36 / 6.75$$
$$= 11.5 \text{ Kg M Rps}$$

3.3. A super heavy duty DC gear motor of 200 RPM side shaft
Rpm – 200 at 10 Volts
Voltage – 4 to 12 Volts
Stall Torque – 47.19 Kg Cm at stalling current of 10.6 A
Diameter of the shaft – 8mm
Length of the shaft – 25 to 30 mm
Assembly of the Gear – Spur
Type of Brush– carbon
Total weight – 370 grams
So according to motor specification,
Torque × rps = 47.19 × 3.33
= 15.7 Kg M Rps
Therefore
Torque × Rps > (Mass ×Acceleration × Velocity) / 2π
Therefore 200 Rpm heavy duty motor is sufficient for UAGV.

3.4. Runtime calculation for UAGV

Battery used for two motor is 11.1 V,2200 MAH, 25 C, Zippy LipoBattery.

Now one motor requires 10.6 A at peak for 47.19 Kg Cm Torque

Therefore

Maximum current drawn by 2 motors = 21.2 A

The Ampere of the battery = 2200 MAH= 2.2 A/H

The Coulomb rating of the battery = 25 C

The maximum Discharge of the battery = $2.2 \times 25 = 55$ A

So the battery can provide sufficient power to both the motors.

The time the battery would take completely to drain at 2.2 A = 60 Mins

The time the Battery would take completely to drain at 21.2A = $2.2 \times 60 / 21.2 = 6.22$ Mins

Connecting one more battery in parallel can give = $6.22 \times 2 = 12.44$ Mins.

4. RESULTS AND DISCUSSION

The UAGV operational results can be find by two modes:

Command Centre Control mode:

Based on the video record received from the on board camera located at the vehicle will be sent to the base station wirelessly. From the inputs, the reqired commands are sent to the UAGV remotely using wireless communication technologies.

Algorithm Design

User side
- The movement of the vehicle have been assingned with th Up Down Left and Right arrow keys.
- The input (pressed key) is converted as a special character to the Arduino device.
- The special characters sent will do the assigned function for them.

UAGV side
- The receiver unit in the UAGV monitors the input received from the special characters and also it acts as per the decision sent.
- Followed by the input the vehicle can move to the forward, reverse, left and right
- The forward and reverse operation uses a Clockwise and anticlockwise pin respectively.
- A Pulse Width Modulation (PWM) signal pin is assigned for for 80 - 120 degrees' turn. Finally, a d and H - Bridge is utilized for braking.

The graphical user interface (GUI) for common centre control mode is shown in Figure 5.

Figure 5. GUI of unmanned system

Autonomous Mode (Mode-2)

        Autonomous mode is capable of travelling from point A to point B without human navigation commands. Adjust strategies based on surroundings using obstacle detection algorithms. It enables an autonomous function with/without the human super vision. This operation can be accomplished by a navigation technology such as GPS.GUI of unmanned system of autonomous mode is given in Figure 6.
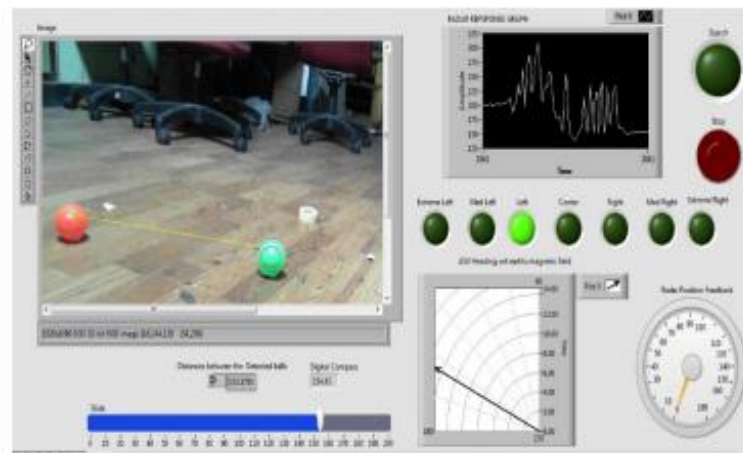

Figure 6. GUI of unmanned system autonomous mode

        To control the movement of the vehicle, it is necessary to obtain the present GPS co-ordinates. The Compass located in the UAGV are used to acquire the data's for the user. By calculating the angles at which it orients with the desired direction by using a simple trigonometric functions. The path planning is based on the path finder algorithms such as shortest path algorithm. Meanwhile, Obstacle avoiding algorithm is incorporated to avoid obstacles while doing task. This can be done at hand in a most efficient manner based on the UR sensors values. The object detection and measuring the distance between the obstacle and the vehicle is given in the Figure 7 and Figure 8.
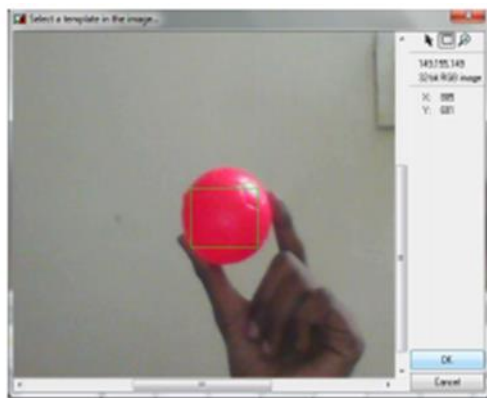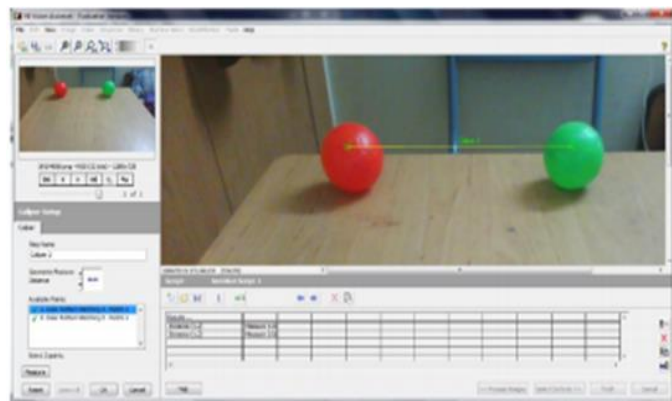

Figure 7. Object detection

Figure 8. Distance between two objects using Image Processing

5. CONCLUSION

        UAGV is a smart vehicle which is capable of driving without a driver. This can work during off and on road navigation. It can achieve the reduction of road accidents made by human error, and also used in military operation, carrying cargos, search, rescue etc reducing soldier's exposure to danger, freeing them to perform other duties. The operation is depending on the sensors to observe the environment also it reqires a high range of communication infrastructure. However, it can automatically take decisions on its own during any unpredictable situation.

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