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Design and Development of Autonomous Ground Vehicle for Wild Life Monitoring

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ABSTRACT: The objective of this work was to develop a cost effective autonomous ground vehicle which would carry out surveillance and tracking missions with respect to animal movements in forest area. The developed system was equipped with a high frequency GPS module and Auto pilot controller, which enabled the user to define the mission path. Thedeveloped system operates on its own, once the way points are assigned, leaving the user free to monitor the mission. Live status of the system’s current position, speed, battery status etc. can be viewed from the ground station. If necessary, the ground vehicle would be switched over from autonomous mode to manual mode, enabling full control. The system was equipped with a down facing optical flow sensor and forward facing SONAR sensor for obstacle avoidance.It was also equipped with a high end wireless, infrared camera for capture and transmission of video under low light conditions. The vehicle is pre-programmed to return to base in case of communication breakdown, thereby minimizing the chances of system loss.

KEYWORDS: autonomous vehicle, efficient algorithms; obstacle avoidance; SONAR sensor, surveillance, wild life tracking

I. INTRODUCTION

Unmanned Ground Vehicles (UGV), have tremendous potential in military and civilian applications, specifically in areas like reconnaissance, surveillance, target acquisition and monitoring etc. Usually, the vehicle will have a set of sensors to perceive the environment, and will either autonomously make decisions about its behaviour or pass the information to a human operator at a different location who will control the vehicle through tele-operation[1,2,3,4].

A fully autonomous robot has the competence to

- Acquire information about the milieu
- Work for aprotracted period without human mediation
- Move either all or part of itself throughout its operating milieu
- Avoid circumstances that are damaging to people, property, or itself.

An autonomous robot may also undergo a process called machine learning for accomplishing its tasks or adapting to changing surroundings.

During the recent years, the researchers have been striving to achieve higher degree of autonomous mode in ground vehicle to enhance operational performance by infusing microcontroller and software approach. However, it is seldom seen in literature, any practitioner reporting the successful implementation of these models in wild life monitoring. The extremely hostile conditions imposed by modern combat, outer space and the deep ocean environments have generated the need for practical autonomous vehicles for military applications, space and ocean exploration. These relatively near-team applications will drive the sophistication and cost of autonomous vehicle technology into the realm where more mundane but more widespread applications such as automated public transportation will be possible. However, significant technology advances will be necessary before even the simplest and most crucial applications can be practically addressed. These advances will only be gained by implementing autonomous vehicle test beds and gaining experience with the developing technology.

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In the following sections, the research efforts taken towards achieving autonomy, the structural analysis and the developmental challenges are reviewed in detail.

II. RELATED WORK

Recent developments in technologies for sensing and control of autonomous unmanned ground vehicles (UGVs) have demonstrated the ability to accurately determine the position and velocity information; thereby leading to better performance of autonomous navigational abilities of UGVs [5]. In 1994, TakashiGomi, Koichi Ide and HirokuzuMatsuo, demonstrated the crucial technique employed in a non- Cartesian way of organizing software agents for the creation of a highly responsive control program [6].In 2007 a modification of an obstacle avoidance algorithm was proposed.A self-sustainable robust system, where the system is able to track the path of travel initially and later when the obstacle is detected, a new path is developed for the vehicle to travel [7]. The present work draws from these articles among others and extends the scope to include the design, analysis and testing of an autonomous ground vehicle for use in wildlife monitoring.

III. HARDWARE AND SOFTWARE DESCRIPTION

Hardware Design

The UGV acts as the surveillance vehicle for capturing video data from the atmosphere and transfers the data to ground station with the help of a wireless module. It can also be switched from autonomous mode to the ground station control mode with the help of wireless TTL module and controlling is done from the ground station. Computer-aided-design was used to design the UGV as seen in Figure 1.

Figure 1: CAD design of UGV

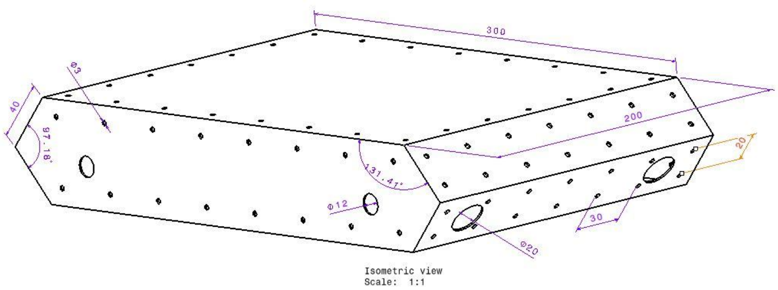

Figure 2: Isometric view of the body of UGV

The hardware consists of DC motors to drive the ground vehicle, a camera installed with remapping algorithm which ensures fail safe mechanism during any kind of signal loss.This would ensure that the robot would return to the base station (or pre-determined location) [8]. The Atmel ATmega2560 Microcontroller, chosen for its low cost, high efficiency and ease of programming, acts as processing hub for vehicle; it is fabricated with the following components:

- Auto pilot system
- GPS

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- Wireless Infrared Camera
- Electronic Speed Controller
- Optic flow and Ultrasonic Sensor
- Radio Trans-receiver

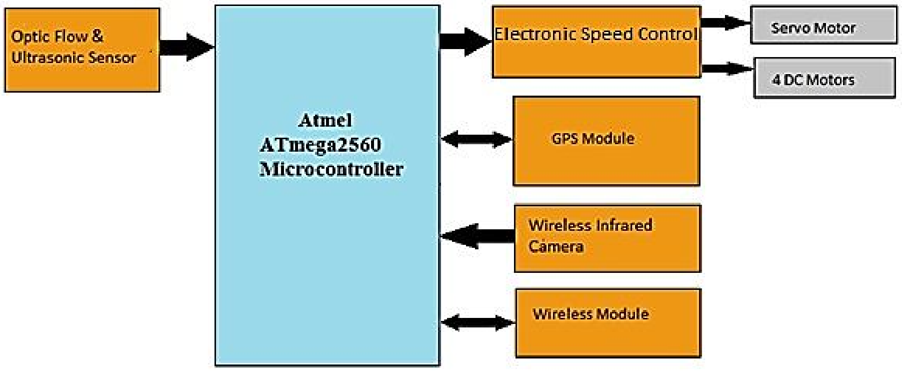

Figure 3: Block diagram of on board computer with sensors

Fabricated Model

The outer structure (see figure 4 and 5)was fabricatedusing Acrylic material for the following reasons:

- can be molded into various shapes
- can withstand high stress and strain
- weather proof and shock proof property

The AGV is integrated with microcontroller, sensors, sonar, GPS, auto pilot controller, telemetry device, servo motors, ESC, gyro meter, accelerometer, magnetometer, barometer etc. to enable the wildlife monitoring application. The software was been compiled in Keil using Embedded 'C' language [9].

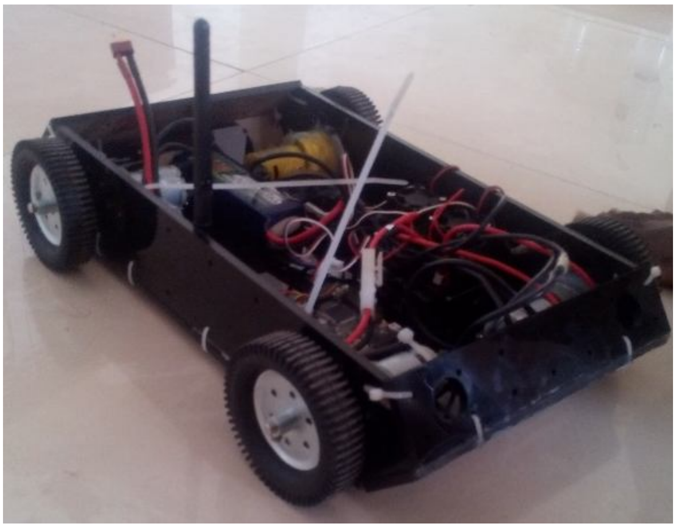

Figure 4: Fabricated model of the AGV

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Figure 5: Completed model of the AGV

IV. ANALYSIS AND TESTING

In static structural analysis the focus was towards testing fortotal deformation. Von Mises stress which is also known as equivalent stress, shear stress and stress intensity was induced in the ground vehicle. The four wheels are fixed and given a load of 14.709 N, force acting towards downward direction as seen in figure 6. The yield strength of acrylic material is 69 MPa. For the applied load the Von Mises stress is 3.648 MPa, see figure 7. The result indicates thatthe ground vehicle can withstand the applied load with no structural compromise.For the applied load strain created is 1.3097e-3 mm.The resulting stress and elastic strain diagram is shown below.

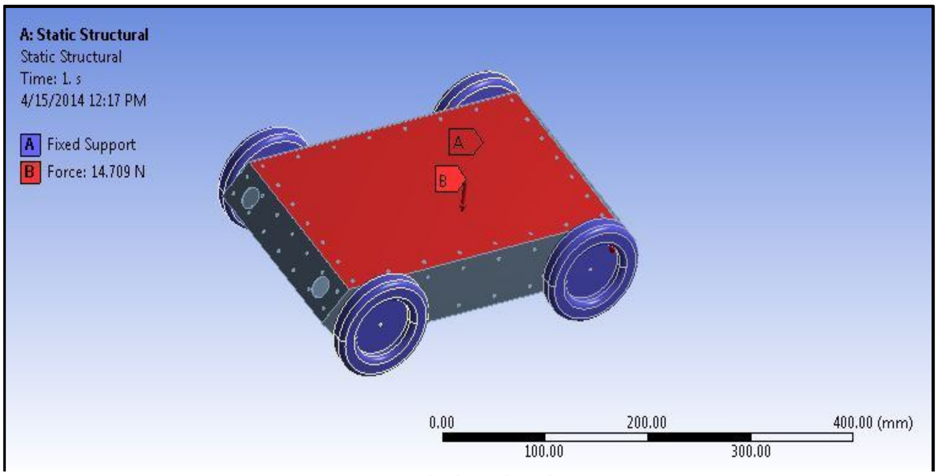

Figure 6: Applied Load on the AGV

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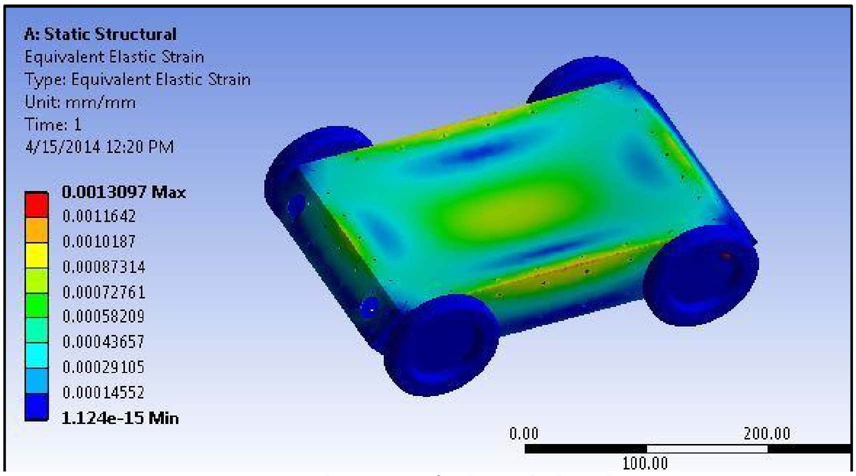

Figure 7: Elastic Strain for the Applied Load

Distortion energy theory is widely considered the most preferred failure theory used in the industry. Von Mises stress is an excellent indicator of failure criterion. As seen in figure 8, the Von Mises stress on the AGV is lower than the yield strength of acrylic material. Similarly, the combination of the principal stresses would also allow us to calculate Von Mises strain or equivalent elastic strain as seen in figure 9.

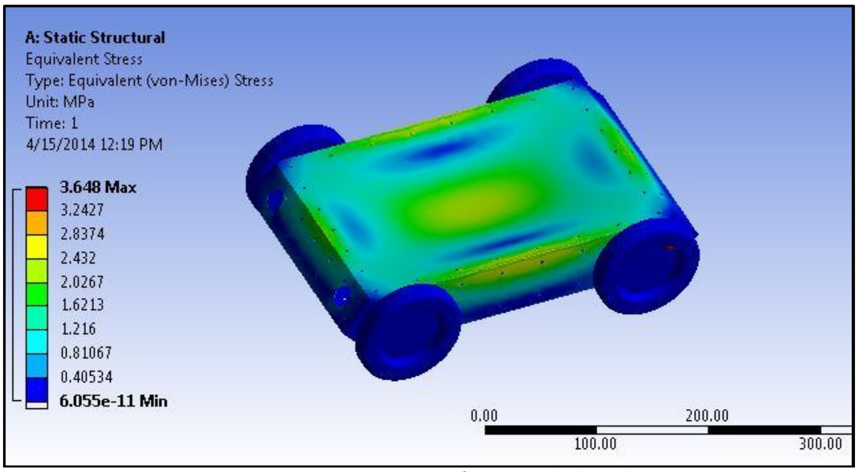

Figure 8: Von Mises Stress for the applied Load

Impact Analysis

Since, it was proposed to operate the AGV in rough terrains, like forests, a mechanical impact analysis was conducted. Cad modelling for impact design has been carried out in Catia V5 R21 software [10]. The vehicle is tested by driving it into a test wall at 3 m/s and 10 m/s.

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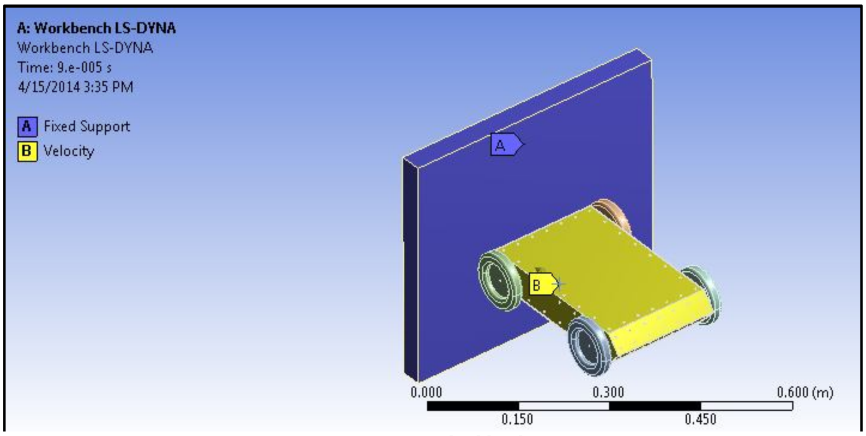

Figure 9: Applied load

The model for the contact-impact force was developed while keeping in mind the material and the geometric properties of the colliding surfaces. The information on the relative positions and velocities contributed to the development of an efficient test model, as seen in figure 9, and also accounted for energy dissipation. These features were ensured with a continuous contact force model and the deformation (if any) is considered a continuous function during the total period of contact.

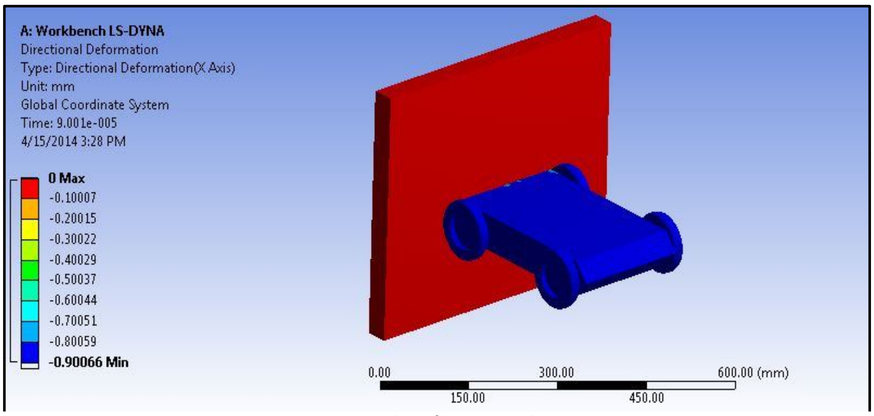

Figure 10: Directional Deformation along X – Axis

The deformation generated on the robot design is .0600044 for 3m\s velocity. The deformation is very low along x-axis as seen in Figure 10.

For the given velocity 3 m/s (figure 11), the Von-misses stress created in the AGV is 56.511 Mpa, the material did not fail because the yield strength of acrylic is 69 Mpa.For the given velocity 10 m/s (figure 12), the VonMises stress created in the AGV is 79.978 Mpa.At this velocity, the material would fail because the VonMises stress value is greater than the yield strength of the acrylic material.

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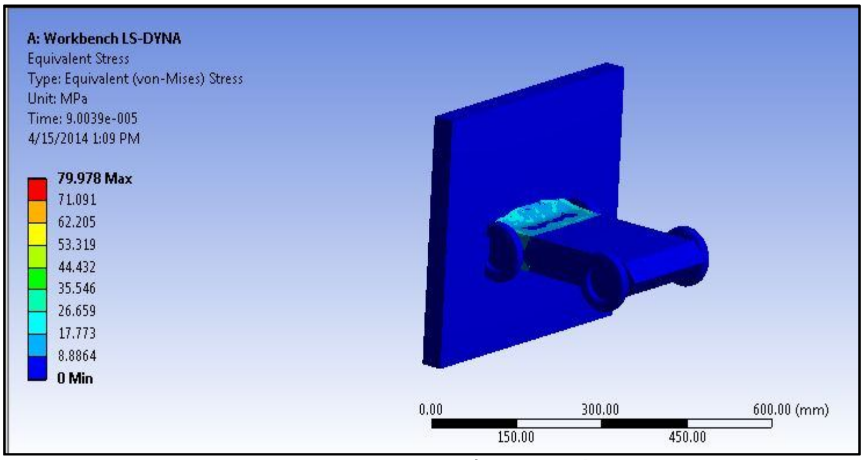

Figure 11: Von Mises stress for 10 m/s velocity

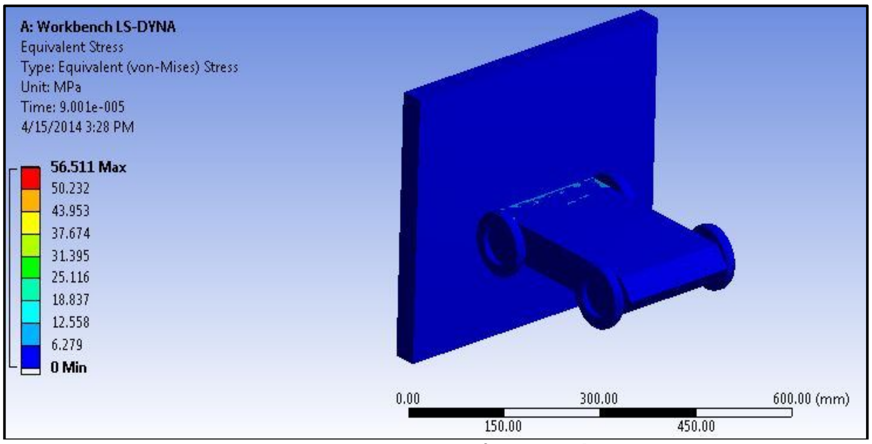

Figure 12: Von Mises stress for 3 m/s velocity

V. Conclusion and Future Work

The autonomous unmanned ground vehicle was developed successfully and tested for structural integrity. A literature review was conducted to study the sensor system used in autonomous UGV design, the challenges and techniques of autonomous UGV navigation. Based on the results as seen in the testing and analysis section, it was concluded that the system would be able to operate under harsh conditions, such as a forest zone, without compromising the intended mission.The future prospect of project is to develop an intelligent automated guided vehicle (i-agv) based on the current system, with defense functionalities. It can be achieved by introducing target locating and tracking mechanism. The autonomous system could also be equipped with functionalities like high definition image and video recording, terrain mapping, self-localization etc.Future systems could be developed utilizing an intuitive graphic user interface for UGV navigation and thereby allowing a single station operator to command multiple UGVs simultaneously. This would enable swarm technology or group behavior.

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BIOGRAPHY

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