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ADAPTABLE MOBILE ROBOT FOR ROUGH TERRAIN

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Abstract: The paper deals with didactic model of mobile four wheeled robot which is able to adapt to rough terrain. The geometry of undercarriage can be changed in accordance with rough terrain. Mechanism for change of chassis clearance is placed in robot body. In case of very rough terrain with large irregularities, the robot can lift own body as prevention of collision with ground. In case when it moves on inclined plane, it can move down own body as prevention before the side overturning.

1 Introduction

Currently, there are many applications, where a mobile robot is better solution for solving of any problems. The application includes also inspection of undercarriage of cars, inspection of mines and caves, fire and rescue tasks, bomb destroying and pyrotechnical tasks, handling the unknown objects, vacuum cleaning, cutting the grass, health care activities, cleaning of floors and walls etc.

The example of the inspection robot (Fig. 1) shows the divided chassis for better crossing through the rough terrain. All wheels are driven with independent motors and controller. This configuration allows to sustain the contact between the wheels and ground. Therefore, the traction of robot is more effective and powerful.

Figure 1 Four wheeled robot with divided chassis

Velocity of rotation is synchronized via using of controller. Direction of locomotion is adjusted with difference of wheel velocity rotation. If obstacle is as stair or street curb, this concept is not useful, because the undercarriage could be locked on irregularities and robot would not able to locomote. The concept with changeable chassis clearance can solve this problem and in case when irregularities is too high, the clearance is increased to necessary height.

2 Concept of robot undercarriage with changeable chassis clearance

Model of system (Fig. 2) consists of lever mechanism, which is able to adjust clearance of chassis for successful crossing through the irregularities.

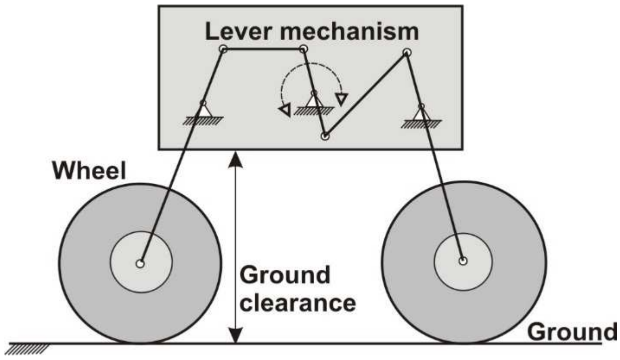

Figure 2 Concept of water tank model

Lever mechanism has been proposed for adjusting of chassis clearance. Left and right side has independent lever mechanism. So, it means that, robot chassis can be adjusted to the different height and it enables to locomote on tilted terrain. It will help to prevent to side overturning.

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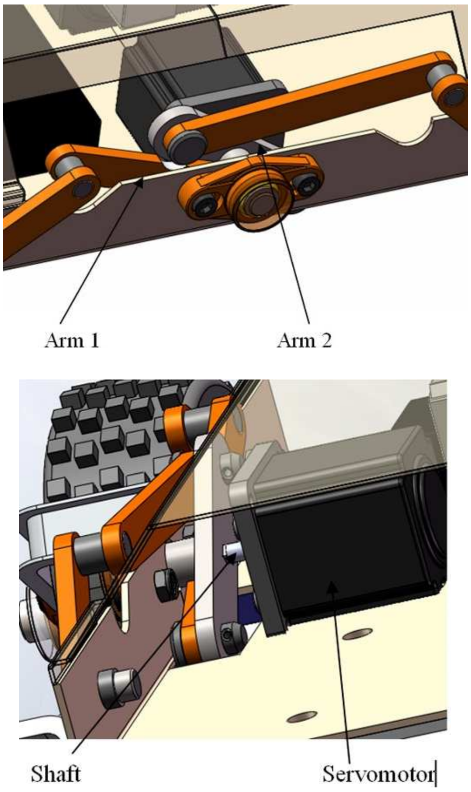

Figure 3 Lever mechanism with servomechanism

The setting of the chassis position is locked with lock mechanism actuated with small servomechanism. There are several default positions where it is possible to lock the adjusted height of chassis. Left and right side has independent lever mechanism and also servomechanism with locking system.

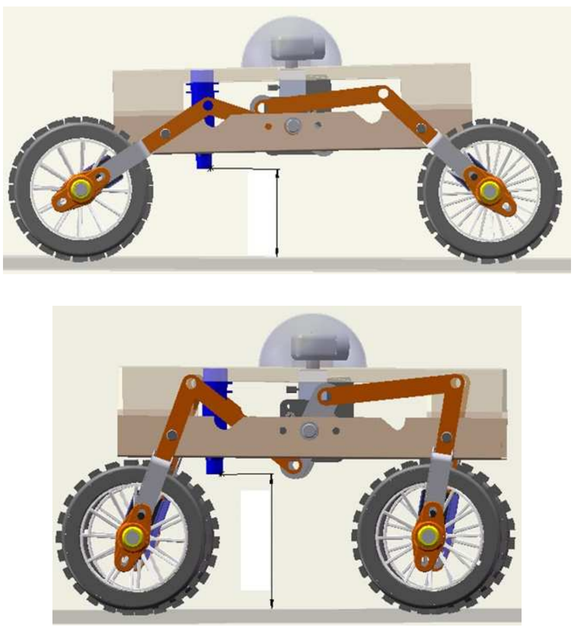
Figure 4 Change of the position of robot chassis

Distance between the chassis and ground is detected via using of optical distance sensors and control system can change automatically chassis clearance.

Lever mechanism consist of two arm levers for synchronized moving with both wheels on chassis. Moving of levers is ensured with servomechanism (Fig. 3).

This concept allows to set the chassis clearance to relatively large range of clearance (Fig. 4)

Selection of suitable servomechanism has been made on the base of static analysis results (Fig. 5) and simulation results (Fig. 6) which shows the all positions from the viewpoint of loading force and torque.

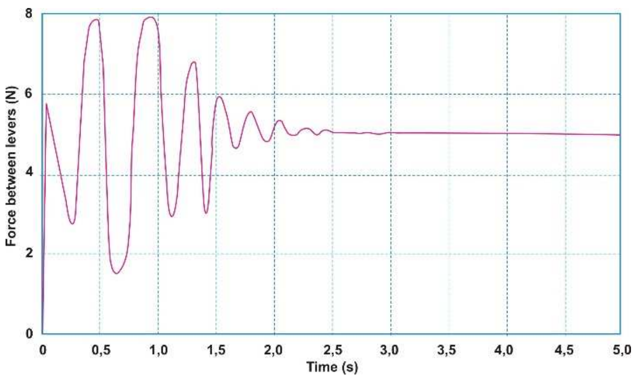

Figure 5 Static analysis of lever

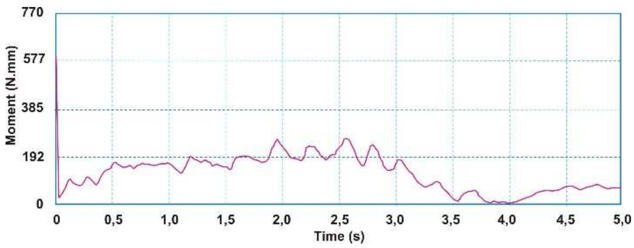

Figure 6 Simulation of lever motion for selection of servomechanism

3 Design of robot parts

Every wheel is driven the separate BLDC motor. Simulation of locomotion has been executed and it shows the requirements on torque on output shaft before wheels (Fig. 7). The extreme value on starting point of the dependence is related to rotation starting and it is typical for this type of motion.

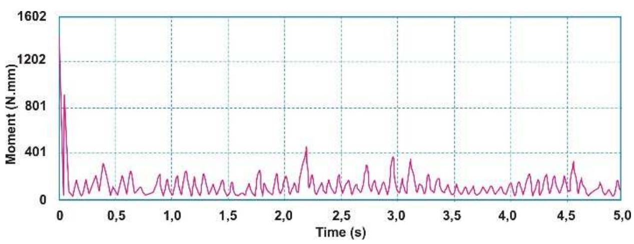

Figure 7 Simulation of locomotion for selection of drive servomechanism for wheels

Motor is completely placed into wheel for because of space saving and there is no need for system of motion transfer from drive to wheel (Fig. 8 and Fig. 9). This concept brings the contribution of mass saving because the overall weight is significantly decreased. Selected drive motor is supplied also with gearing and control unit with sensors.

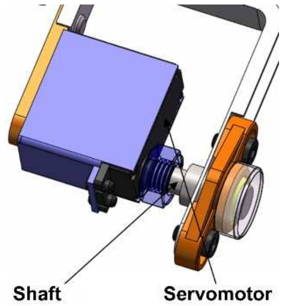

Figure 8 Drive and bearing for output shaft

Special focus has been done to design of bearing system for output shaft (Fig. 8), which will carry the load and vibration coming from the contact between the wheel and ground.

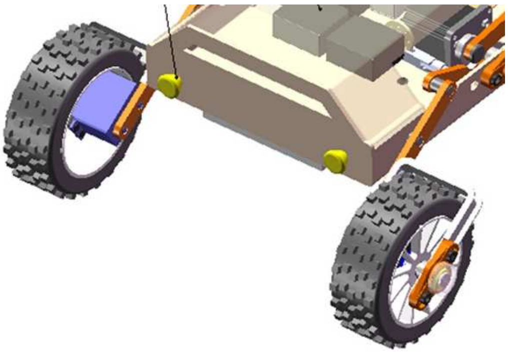

Figure 9 Wheel drive placement inside wheels

Finite element method analysis has been used for checking of the suitable design of chassis part (Fig. 10, Fig. 11, Fig. 12, Fig. 13).

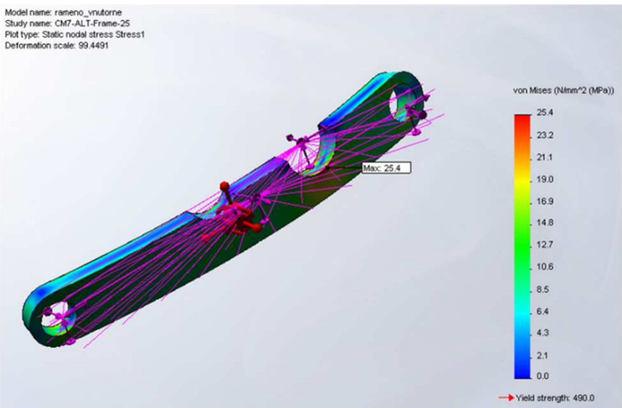

Figure 10 Finite element method analysis – von Misses stresses in lever

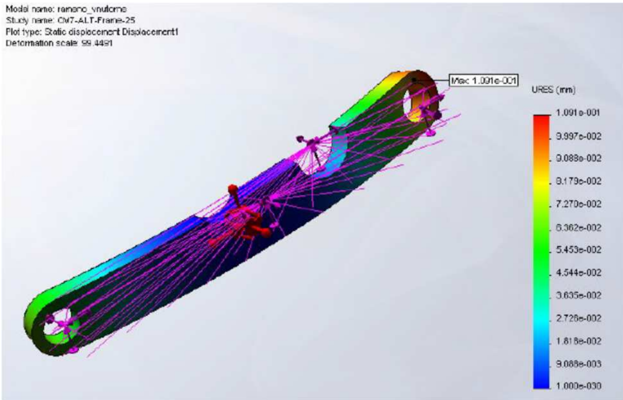

Figure 11 Finite element method analysis – displacements in lever

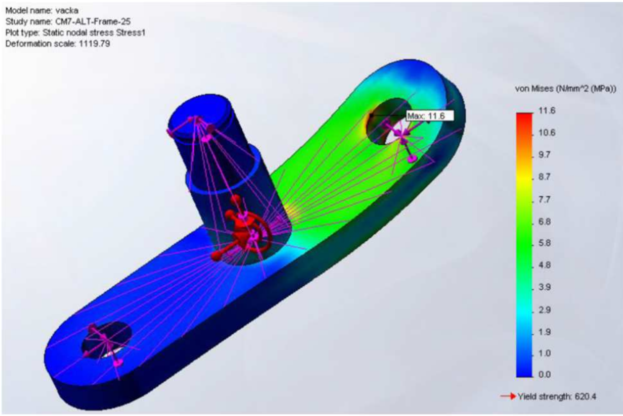

Figure 12 Finite element method analysis – von Misses stresses in cam

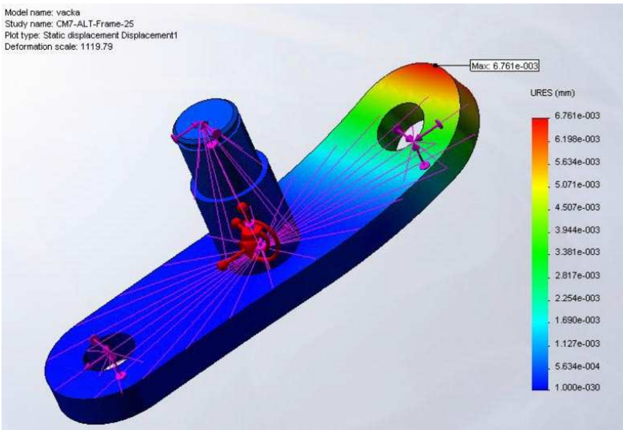

Figure 13 Finite element method analysis – displacements in cam

4 Overall design of the robot

Overall design (Fig. 14) also includes the lights (1) for better visibility of scene before the robot. The locking mechanisms (2) are placed inside the robot body near the lever mechanisms. CCD camera (3) is placed on the top of the robot for visual feedback for teleoperation controlling. Communication unit for wireless teleoperation control (4) is also installed on the robot body. Robot is powered by the two batteries placed in back side of the robot body.

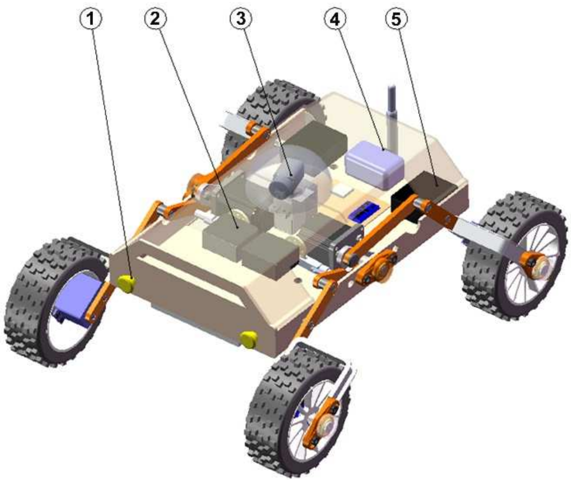

Figure 14 Overall design of the robot

Collision sensors (Fig. 15) are also placed on the robot body and they are used as automatically operated system for collision prevention to avoid of robot damage. The sensors use ultrasonic principle for detection of obstacles.

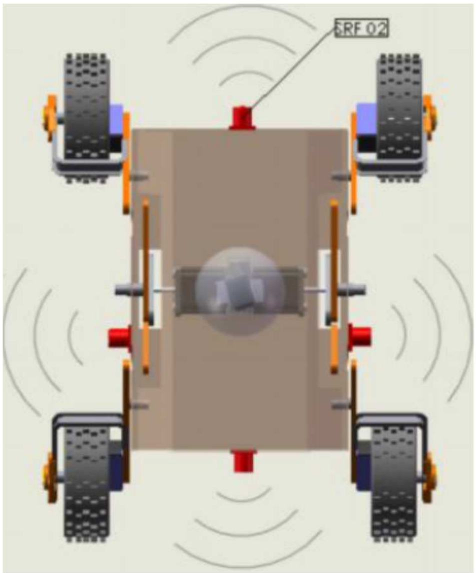

Figure 15 Collision sensors on the robot

5 Conclusion

The aim of this work is to design the mobile robot for locomotion on rough terrain. Irregularities often are bigger than clearance of the robot. It can be solved via using of bigger wheels and higher chassis, but we lost the advantage of low-profile chassis for cases, where we have so much space for robot locomotion. For this reason, it is necessary to adapt chassis clearance in accordance with irregularities height. Also, if robot locomotes on side tilted terrain, the robot can adjust only one side of robot chassis, for sustain the stability of the robot. Centre of gravity is moved into suitable position for reaching of stabile locomotion. This adaptation should be automatically executed. The robot will take care about yourself for safely locomotion. There is also other application, where the intelligent properties of products help to prevent the collisions or other accidents [3-17].

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Review process

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