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DESIGN OF REMOTE COMPUTER CONTROLLED FOUR-WHEELED MOBILE PLATFORM

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ABSTRACT
The article presents a new concept of a mobile robot platform for application having multiple purposes to be applied in open space on uneven terrain. The platform has four drive wheels with independent drive. An original spatial leverage mechanism has been designed in order to transmit motion from the motor worm gearing to the system of the drive wheels suspension. A solution that has been selected for controlling the mobile robot platform is presented. This mobile robot platform has been created mainly for service and development-research purposes, but it is also intended for the educational purposes.
Keywords: off-road mobile robot, mobile robot platform, robot moving, 4-wheel-drive/steer robot, robot control.

1. INTRODUCTION
The question arising at the beginning of mobile robot design is what would be the best construction of the mobile robot? This problem is not simple to resolve. Before starting a phase of the robot projecting, it is important to define the terrain and the environment the robot is supposed to move within. According to these data, a mode of moving and locomotive robot system will be defined. In this process a requirement to keep the robot price as lower as possible has been constantly imposed.
At the University of Montenegro the project of designing a mobile service robot is in progress. Design of a mobile platform on which a manipulator could be placed is required to be made. A robot named *ROBECO* is intended to move within an open area and not only along a flat road but along an uneven road as well, performing certain task. A task assigned to a robot could be: taking samples (water, gas, soil) from contaminated zone, recording critical terrain, detecting and marking mine-explosive appliance, etc.

2. WORK ENVIRONMENT
Terrain (off-road) robot that should be designed will move on the roads and off the roads, that is, on uneven terrain, but without extreme bumps which would require development of a special mechanism for overcoming high slopes i.e., bumps on the road.
Based upon the research of available information on existing terrain robots, the following guidelines for development of the terrain (off-road) robot can be given: 1) A robot should move in natural, unstructured and a-priori unknown environment; terrain mobile robot needs to have a moving mechanism adjusted to uneven terrains; 2) Information on robot and the environment need to be received by the robot sensors; 3) Terrain robot is often required to be equipped with a robot arm for

handling the object; 4) Terrain mobile robot requires on-board power supply; 5) Terrain robot should drive on uneven terrain with high stability and when carrying material; 6) Mechanical structure and moving control must be robust and safe to ensure the robot is capable of completing the task.
The first four aspects make the moving on unknown terrains a difficult issue for robotics. These limitations imply the robots with semi-autonomous capacities.

3. LOCOMOTION AND DRIVE SYSTEM OF THE MOBILE ROBOT *ROBECO*

A concept of four standard drive wheels has been chosen for the mobile platform for the robot *ROBECO* which needs to be designed; this will ensure very good conditions for application on uneven terrains. Additionally, four drive wheels will provide the robot with higher mobility compared to a robot with two drive wheels. The mobile platform will have each wheel equipped with its motor which will ensure the wheel speed to be controlled independently. The steering of all wheels will be interdependent and one motor has been predicted for this purpose. Such concept allows existence of rotation centre which is required to enable maneuverability of the platform. The controlling concept by steering wheels through a motor requires designing of a special transmission mechanism which makes a mechanical construction of the platform complex. From the other side, lower number of motors (5 motors) compared to the existing solutions (8 motors) makes controlling demands more simple.

4. MOBILE PLATFORM FOR SERVICE ROBOTS

Service robot consists of a mobile platform and a manipulator. Mobile platform is designed to have a high clearance (distance from the base), independent suspension of each wheel and wheel turns at ±45º, which ensures good performances for off-road driving. It is important to emphasis that sizes, distance between wheels axis, and a frame construction allow high angle of clearance which is very important for overcoming the obstacles. A mobile platform drawing is shown in Figure 1. Basic dimensions of the platform are given in the Figure 2.

Figure 1: Mobile platform appearance.

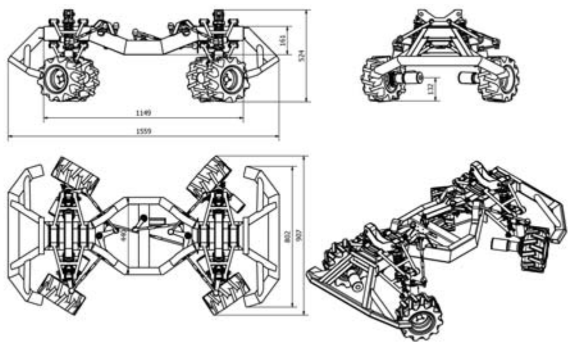

Figure 2: Basic dimensions of mobile platform.

Mobile platform frame generally consists of a system of mechanical elements whose basic task is to ensure rigidity of the platform (the vehicle) and to allow attachment of other assemblies of the vehicle chassis (control servo motor, wheels supporting system, manipulator, battery (accumulator), control system, camera, sensor, car body, etc.). The frame should be light (small mass), to prevent shape deformation under force pressure generated when driving in extremely difficult, but anticipated conditions, following the purpose of the mobile platform. For the stated reasons, the frame has been designed by principles of a light steel construction.
Independent wheels suspension is provided by a double frame (upper and lower) in the vertical plane. Both frames are installed over the center of each wheel aiming to enable the wheel turning at the angle of ±45º around the axis inclined for the angle β against the vertical axis. The frames have been installed so high for the following reasons: to provide high clearance i.e., distance between the frame and the base which allows mobile platform to move along uneven terrain (off-road); to have possibility to overcome obstacles along uneven terrain; wheels turning freely (the wheel drive is set-up in the wheel axis).

5. THE MOBILE PLATFORM STEERING

The biggest challenge for the driving mechanism of the road vehicles is to realize complete rolling with good traction of wheels in the curve. This requirement is met only if the turning center of each wheel is placed in one point- rotation center, that is, if the axes of all wheels are crossed in one point
In addition to a basic function - turning the platform, driving wheels need to be able to keep a neutral position when the platform moves, i.e., turned wheels (intentionally or accidentally) tend to return to neutral position. Such ability is called - stability of the driving wheels. Additionally, the wheels get stable by having a sleeve shaft installed at certain angles against the vertical axis. These angles are, as shown in Figure 3, in cross section, the angle β – the angle of supporting the wheel, and in horizontal section the angle γ. The angle α (figure 4) is called the side angle of incline or the wheel inclination.

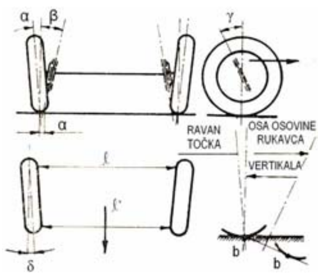

Figure 3: Position of the wheels against the vertical axis.

Figure 4: Connection of the spatial leverage mechanism for controlling direction of the mobile platform and the wheels.

Turning, i.e., controlling the mobile platform will be preformed through a servo motor with an encoder that will be placed on a frame of the mobile platform and the system of leverage with spherical joints (figure 4). Such constructive solution of the leverage system enables the wheels turning at $\pm 45^\circ$ against the vertical axis of the vehicle. Such big angle at which the wheels turn will allow extremely high mobility of the platform.
Considering that the position, i.e., the wheels direction is controlled by the same spatial leverage mechanism which turns all four wheels simultaneously, it is clear that the position of wheels is interdependent. The analysis of the wheels position has been done for general case when inner wheels are directed at the angle α against the vertical axis of the vehicle, and outer wheels at the angle β against the same axis (figure 5).

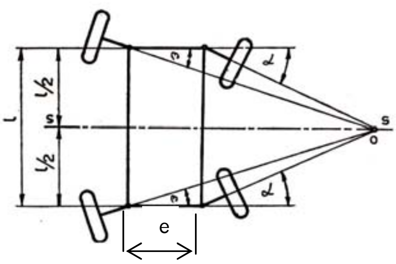

Figure 5: Wheels position when turning.

For the mobile platform with four driving wheels, the analysis results with the following dependence:

$$ctg\beta - ctg\alpha = 2e/l = const$$

6. CONTROLLING A MOBILE SERVICE ROBOT *ROBECO*

Four servomotors with a gearbox and an encoder controlled by a central controller are designed to drive a mobile platform. Executive modules and user interface will be made particularly for this vehicle. The vehicle is turned, i.e., all four wheels are controlled by a servomotor with a gearbox which turns the wheels using the system of leverage connected by the sphere joints.

As the robot has been predicted to move in natural, unstructured and a-priori unknown environment, and considering restricted resources for the robot development, it has been decided for the robot control to be remote, semi-autonomous.
The mobile platform and a manipulator will be controlled by a PC (Figure 6)) through a WIFI connection with a central processing unit – a module, which will be made particularly for this service robot. CPU will be placed in the frame of the platform. PZT IP WIFI camera will be installed on the service robot.
to enable the operator to observe on the screen space in front of the robot and to control its motion. Similar model used when driving the platform will control a manipulator (robot hand) which will be installed on the platform.
Service robot will be supplied by batteries through a module supplier 24 VDC, which will be also placed in the platform frame.

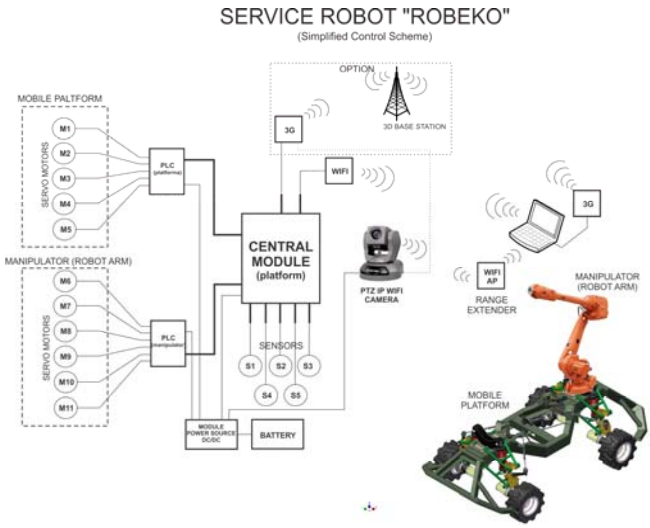

Figure 6: Simplified scheme of controlling the mobile service robot"ROBECO"

7. CONCLUSION

The article shows an original solution of mechanics of the mobile platform has been presented with original spatial leverage mechanism for controlling the wheels turning. Advantages of the proposed mode of the wheels suspension have also been highlighted. The turning angle of ± 45º will ensure extremely high mobility of the platform. The work provides short description of the drives and mode of the platform moving control.

8. ACKNOWLEDGMENT

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