УДК 62.771, 62.519, 629.3.02
DOI: 10.22213/2413-1172-2021-1-64-70

Mobile Platform for Car Service

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The analysis of the use of drives of mobile and transport robots is given. Various options for design solutions are considered, including the main selected drive of a mobile platform with four Omni-wheels, ensuring maximum mobility and maneuverability. Masses and ground clearance of vehicles of various classes are estimated to determine the overall dimensions of the mobile platform in terms of height and carrying capacity. It has been established that the necessary elements of a mobile platform are universal mounting plates and trailed equipment.

The control systems of two variants have been developed. The first is automatic, for an autonomous mobile platform, and the second is for remote control. Control systems include 3 microcontrollers, 5 drivers, 6 motors, 4 sensors. The position of the mobile platform can be controlled by the operator remotely using a mobile application. Power supply of the MP is carried out from its own battery, from the car network or an external network. An algorithm for the operation of the control system for different versions is proposed. 3D models of the mobile platform and suspension unit models have been developed. Calculations of the lifting mechanism of the MP are given. The layout of the nodes of the mobile platform is presented.

Keywords: mobile platform, robot, Raspberry Pi 3, Omni wheel, ultrasonic, Bluetooth, image processing.

Introduction

Mobile platforms (MP) for servicing cars are in essence transport robots of various carrying capacities and several versions of the drive part. The platform is designed to accommodate additional equipment that facilitates and automates heavy human labor in a car service. MP can be used for lifting a car, removing wheels, diagnostics from the bottom of the body and many other operations, which eliminates the possibility of injury to a person during operation. There are well-known technical solutions [1-3], providing high platform maneuverability. The principles of movement of such platforms are based on the use of various combinations of drive wheels.

Variants of wheels of combinations with mobile platforms

The analysis showed that for the selected range of tasks the most suitable platform is on four sprung Omni-wheels, which makes it possible to obtain high mobility [4, 5], wheel suspension increases the permeability of the installation and increases its capabilities. Justified assignment of the characteristics of the stiffness of the suspension springs allows you to save the rollers and bearings of the Omni-wheels from overload, thereby ensuring the operability of the structure.

One of the factors that determines the platform's capabilities is the availability of universal mounting plates for trailed equipment. Based on the geometry of the mobile platform, there can be 5 universal mounting plates. Thus, the lifting robot can be equipped with one upper or two side universal mounting plates.

The design of the platform depends on its carrying capacity. To assess the possibility of creating such platforms, an analysis of a number of vehicles of various classes, purposes and designs was carried out.

The article presents the development of two types of mobile platform. The first platform is designed for automatic lifting of the car, which eliminates human involvement in manipulating equipment and the car, thereby ensuring the safety and health of the driver, especially when performing operations on the roadway and at night. The position and position of the mobile platform is controlled by the operator (driver) remotely using a mobile application and a Rasspberry Pi 3 microcontroller during the entire operation period. The mobile platform is powered either from its own source or from the vehicle's battery. Power supply from an external network is possible.

The second robot, made on the basis of a mobile platform, uses additional attachments to remove the wheels from the car. It is semi-automatic and controlled by the Raspberry Pi 3 microcontroller.

The peculiarity of two robots made on one universal platform is that their dimensions allow, on the one hand, to easily fit in a car or bus, on the other, the capabilities of the platform and the attachments installed on it depend on the selected configuration. In addition, the capabilities and cost of the platform depend on the selected model range in terms of carrying capacity.

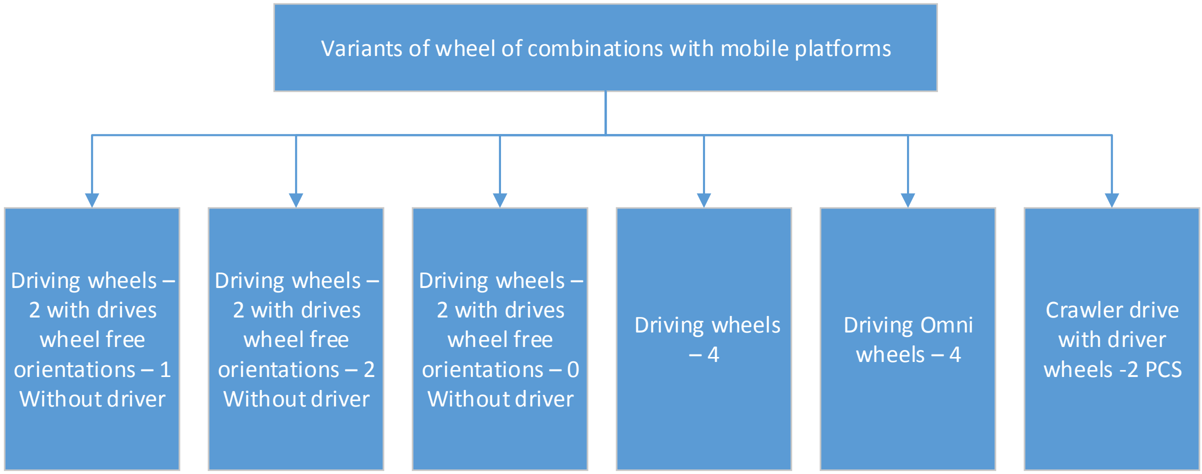

Fig. 1. Variants of wheel combinations of mobile platforms

Control system

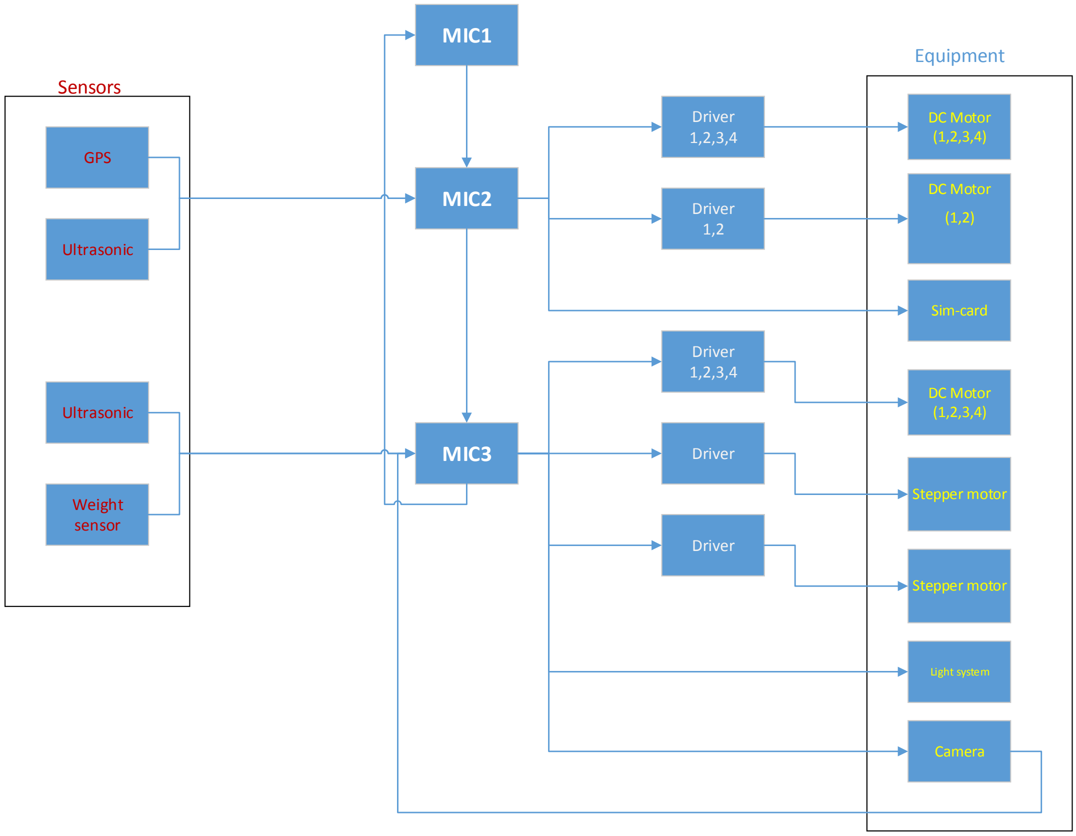

Fig. 2. Block diagram of the control system

The proposed control is implemented using a multi-point system that connects three bluetooth to send and receive signals. There are two options for implementation, No. 1 - semi-automatic, and it depends on the design of the selected vehicle, because according to this project 4 points for each system No. 2 is a manual system that has a control system for the owner of these systems in special cases.

The proposed system consists of an ultrasonic sensor for each system, a GPS and sim card for the first system, a weight sensor, a light system and a camera for the second system.

System operation algorithm

The block diagram (Fig. 4) shows how two lifting systems are controlled simultaneously.

As shown in Figure 4, two jacks used to lift a car or buses can have different lifting capacities and vertical movement, in addition, the method of attachment may also differ. To prevent the destruction of the Omni wheel from overloads, the latter

(Fig. 5) is spring loaded. The spring is calculated in such a way that its stiffness and travel are sufficient to move the MP over uneven surfaces with good adhesion, and when loaded, i.e. lifting the car, it is deformed by such an amount that the main load is taken up by the body of the mobile platform, while the wheel receives the load from the suspension spring.

Table 1 shows the data on the lifting capacity and the course of the jacks.

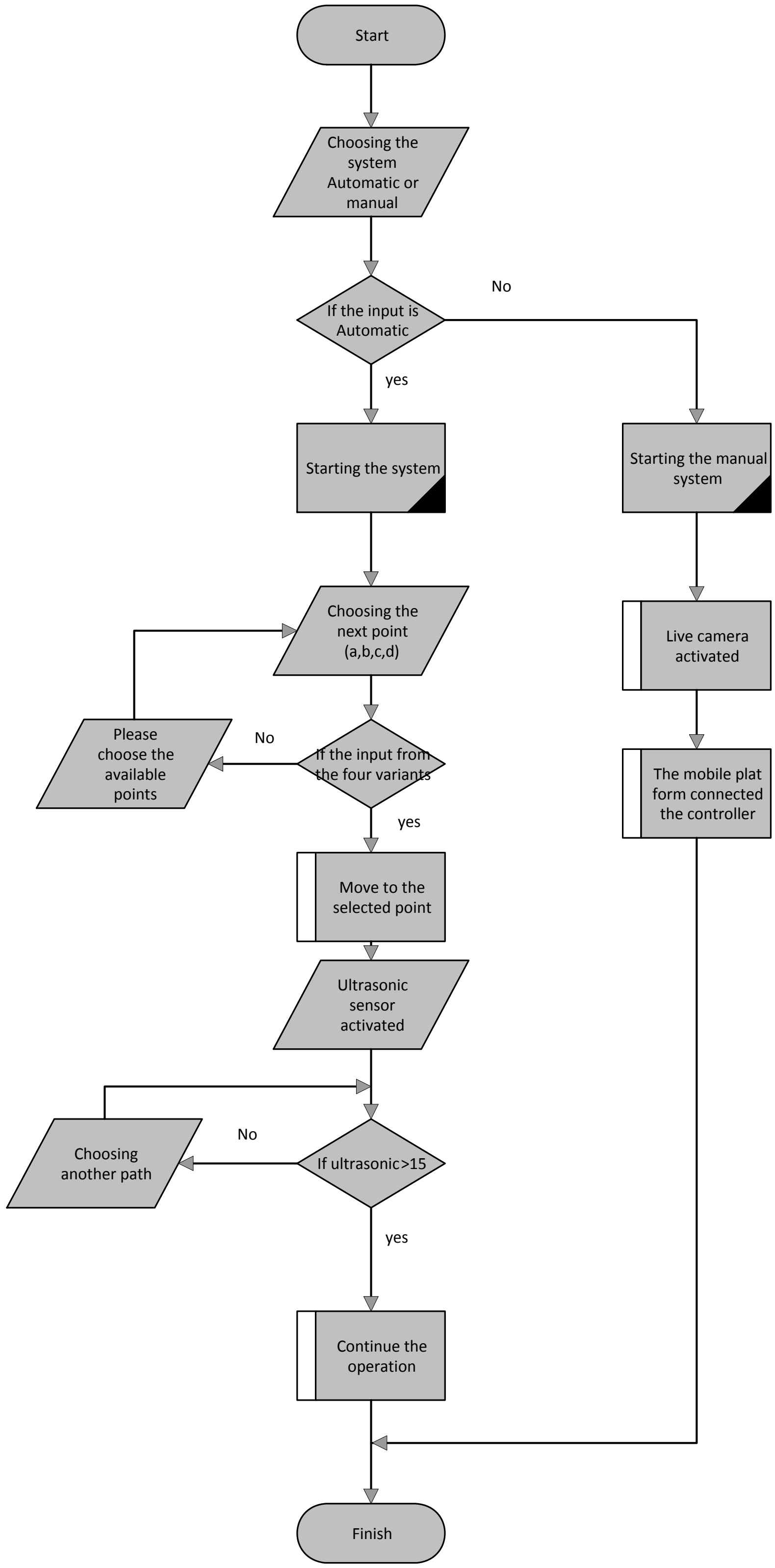

Fig. 3. Algorithm of control systems

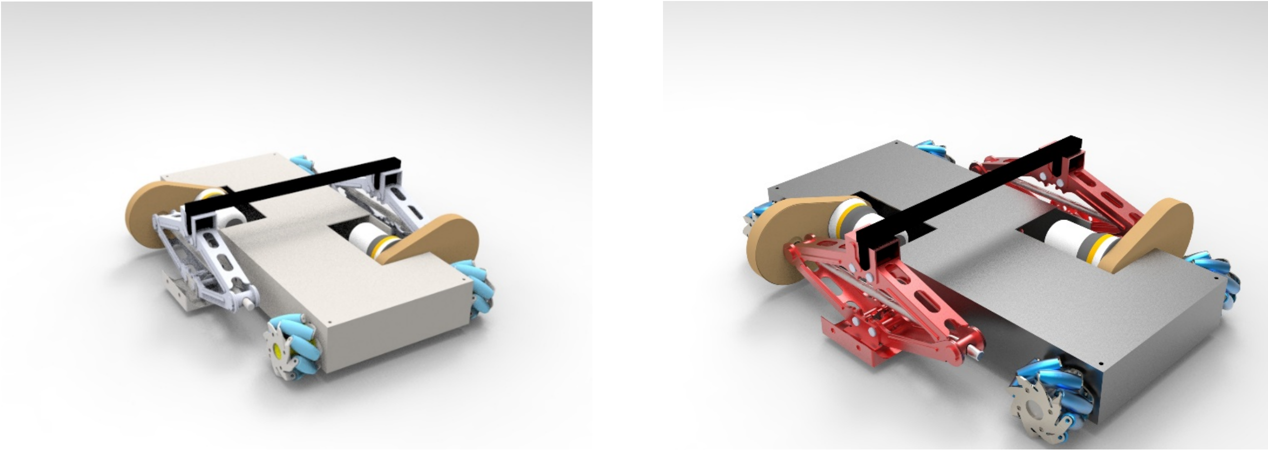

Fig. 4. Firstrobot - carjack

Table 1. **Variants of jacks**

Type	Mass, Kg	Heights from till, mm	Type of volume of cars
Electromechanical jack	700	127…355,6	Normal car
Electromechanical jack	1500	139,7…370,84	Normal car and big car
Electromechanical jack	2500	190,5…419,1	Big car and microbus
Electrohydraulic jack	5000	154,94…444,5	Microbus and buses

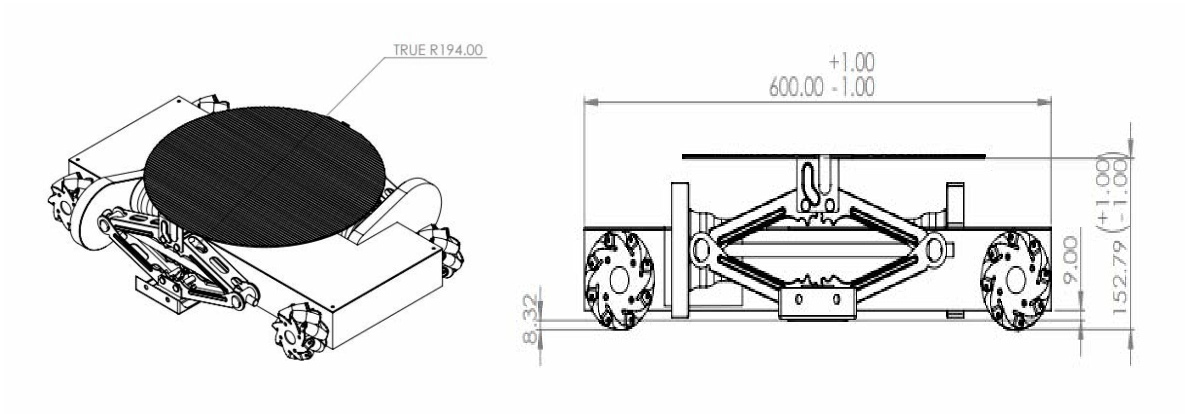

Fig. 5. Jack with a DC motor

The lifting capacity of the jack and the required engine power are determined by the known relations

$$d_0 = d_c + x,$$

where d_0 – screw outer diameter; d_c – screw shank diameter; x– the ad height; $d_0 = 12$ mm; $p = 2$ mm; $d_c = 10$ mm.

$$d = d_0 - \frac{x}{2},$$

where d – mean screw diameter; $d = 11$ mm.

To check the main voltages, we know it

$$\tan(\alpha) = \frac{x}{\pi d},$$

where α – helix angle; $\alpha = 3{,}3°$.

Helix angle of inclination of the spiral the force required to rotate the screw is

$$P = w_1 \tan(\alpha + \theta) = \frac{w_1(\tan(\alpha) + \tan(\theta))}{1 - \tan(\alpha)\tan(\theta)},$$

where P – required to rotate the screw; θ – friction angle; w_1 – the maximum weight that the car jack can support; $w_1 = 7000$ N; $\theta = 16°$ – minimum angle to obtain maximum torque for lifting the vehicle; $P = 2451{,}365\,[\text{N}]$.

The torque required to rotate the screw is given by

$$T = P\frac{d}{2},$$

where T – Torque, $T = 13{,}483\,[\text{N} \cdot \text{m}]$.

The shear stress in the screw due to the torque is given by

$$t = \frac{16T}{\pi\left(d_c\right)^3},$$

where t – shear stress.

Therefore, the forward tensile stress in the screw can be calculated as

$$\partial t = \frac{4w_1}{\pi d^2},$$

where ∂t – forward tensile stress;

$$\partial t = 6189358{,}98\left[\frac{\text{N}}{\text{m}^2}\right].$$

Main components used for the robot

Compression springs work in parallel and are sized accordingly.

The control system is based on the Raspberry Pi 3 microcontroller.

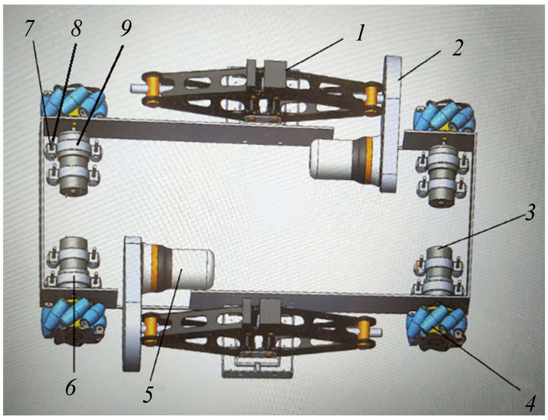

Fig. 6. Main components used for the robot: *1* - jack; *2* - gearbox; *3* - DC motor; *4* - meconium wheel; *5* - DC motor for car jack; *6* - DC motor holder for robot; *7* - spring; *8* - hex bolt for holder; *9* - motor's holder

The second version of the mobile platform is designed for lifting vehicles.

The mobile platform design is shown in Figure 7, 8.

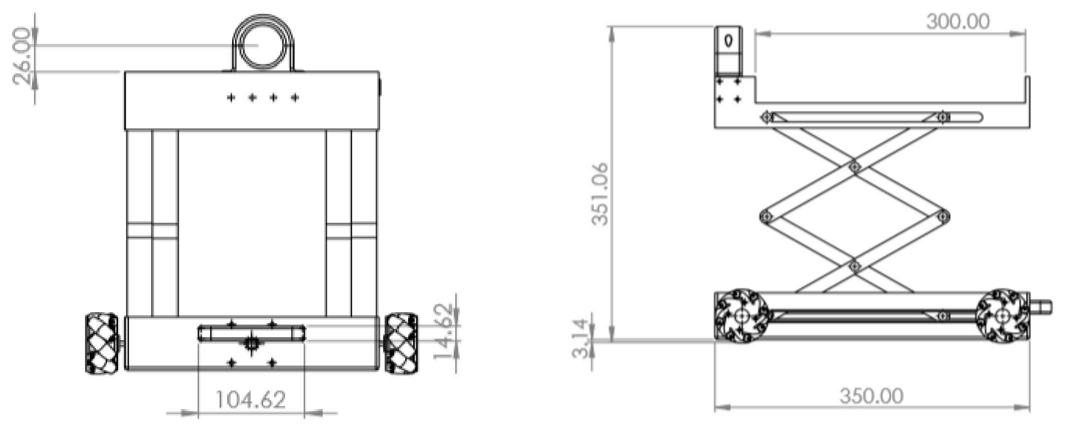

Fig. 7. Conceptual design for our robot

Fig. 8. Robot design: *1* - stepper motor for lifting and stepper motor for driving DC motor; *2* - camera; *3* - omni steering wheel; *4* - bearing; *5* - rod

Features

There are two types of control offered, one of them manual, and it will be used for the automatic system, as well as for stepper motors and camera, and image processing. for this operating system, so we can see in the figure in our project has a size and weight that can be easily carried and worn, as we can see in the following figure. This robot looks like a laptop bag made of steel because this material can support good weight and is not heavy (Figure 9).

Fig. 9. The maximum external weight that can be added is 500 N

Omni wheel

Omni or Clinic wheels, such as Meconium wheels, have wheels with small discs (called rollers) around the circumference that are perpendicular to the turning area. As a result, the wheel can be propelled with full force, but it also slides sideways easily, and each wheel can support up to 15 kg, and we have two options: one, whether it will run on a clean surface (indoors), or another type of wheel. outdoors and precisely on fuzzy surfaces, and we used the same wheel in both projects.

$$V_2 = V_x \sin\left(\theta_d + \frac{\pi}{4}\right) + V_\theta,$$

V_x – the voltage multiplier for the x^{th} wheel;

$$V_2 = V_d \cos\left(\theta_d + \frac{\pi}{4}\right) - V_\theta,$$

V_d – desired robot speed [1,1];

$$V_s = V_d \cos\left(\theta_d + \frac{\pi}{4}\right) + V_\theta,$$

θ_d – desired robot angle [0,2π];

$$V_s = V_d \sin\left(\theta_d + \frac{\pi}{4}\right) - V_\theta,$$

V_θ – desired speed for changing direction.

Figure 10 shows the basic function of the Omni wheel and its possible directions of travel.

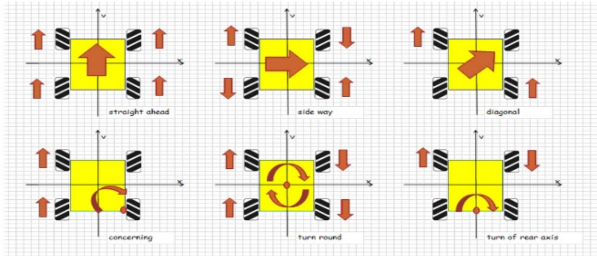

Fig. 10. Omni wheel features
(URL: https://www.casterbot.com/p/mecanum-wheels-64mm-for-raspberry-pi-4-3b-microbit/)

Conclusion

Platforms of mobile transport robots with a load capacity from 1400 to 10000 kg have been developed, which allow lifting the car both in manual and automatic control mode. The high mobility of the platform is ensured by the use of four mecanum wheels with independent drives. Lifting of vehicles is carried out by two jacks with synchronized electric drives. A control system, an electromechanical system, and software have been developed. The proposed solution allows you to apply new car maintenance technologies, which greatly simplifies a number of operations.

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Мобильная платформа для обслуживания автомобиля

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Приводится анализ существующих приводов мобильных платформ и транспортных роботов. Рассмотрены различные варианты конструктивных решений, и в качестве основного выбран привод мобильной платформы с четырьмя омниколесами, обеспечивающими максимальную подвижность и маневренность. Оценены массы и клиренс автомобилей различных классов для определения габаритных размеров мобильной платформы по высоте и грузоподъемности. Установлено, что необходимыми элементами мобильной платформы являются универсальные установочные плиты и прицепное оборудование.

Разработаны системы управления двух вариантов. Первый – автоматический для автономной мобильной платформы, второй – для дистанционного управления. Системы управления включают в себя 3 микроконтроллера, 5 драйверов, 6 двигателей, 4 сенсора. Положение мобильной платформы может контролироваться оператором удаленно с помощью мобильного приложения. Питание мобильной платформы осуществляется от собственного аккумулятора, сети автомобиля или внешней сети.

Предложен алгоритм работы системы управления для разных вариантов исполнения. Разработаны 3D-модели мобильной платформы и модели узла подвески. Приведены расчеты подъемного механизма мобильной платформы, представлена компоновка ее узлов.

Ключевые слова: мобильная платформа, робот, Rasspberry Pi 3, омниколесо, 3D-модель, система управления, микроконтроллер, драйвер, шаговый двигатель, двигатель постоянного тока.

Получено 20.02.2021

For Citation

Abdelhamed M.N., Shchenyatsky A.V. Mobile Platform for Car Service. *Vestnik IzhGTU imeni M.T. Kalashnikova*, 2021, vol. 24, no. 1, pp. 64-70. DOI: 10.22213/2413-1172-2021-1-64-70.