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Model of Mobile Robot with Divided Chassis

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Abstract This article is about designing and constructing a four-wheel chassis, which will possess better negotiability of diverse terrain. Analyzed is a used concept of chassis motion control of mechatronic systems on the principle of differential wheel control for the task of active tracking of planned chassis path. Created was a simulation model of chassis mobile system in terms of kinematics, which will be usable in concept of chassis locomotion control on diverse terrain. A model is also required for examining behavior of chassis on diverse terrain, for examining the influence of dimensions on chassis behavior during crossing over roughness of terrain.

Keywords: *mobile robot, simulation*

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1. Introduction

One of the main features of mechatronic approach to designing advanced products is complex understanding of the technical object and its computer modeling. The kinematic description of mechanical system issue from an abstraction – simplification of reality.

If we model mechanical and electrical elements as systems with centralized parameters, then it is possible to say, that drawing up the model of mechanical part is clearly the most difficult.

2. Concept of Mobile Robot

Mobile robot poses a solution of four-wheel chassis with autonomous wheel drive 4x4 designed for diverse terrain. It has two degrees of freedom, i.e. linear and rotational motion.

It is possible to use it for various tasks such as inspection of automobile chassis and explosives disposal, pipeline, cavity and difficult to reach location inspection, manipulation with dangerous materials, telecommunication and cable network installation, tactical tasks in fight against terrorists and so on. The device should also be used in educating students from mechatronics and engineering fields of study.

Basis of the device is chassis frame composed of two pieces connected by a passive joint. [14]. Robot chassis has a four-wheel drive that does not lose traction even on diverse terrain surface thanks to the passive joint It enables both parts of frame to randomly tilt depending on terrain difficulty. Hence it is achieved that every wheel in any moment keeps contact with terrain surface [2].

Technical parameters of functional chassis model:
• wheel base: 190 mm
• gauge: 370 mm
• inner diameter: 30 mm
• total mass: 3 kg
• maximal loading capacity: 10 kg
• average motion velocity: 0,3 m/s

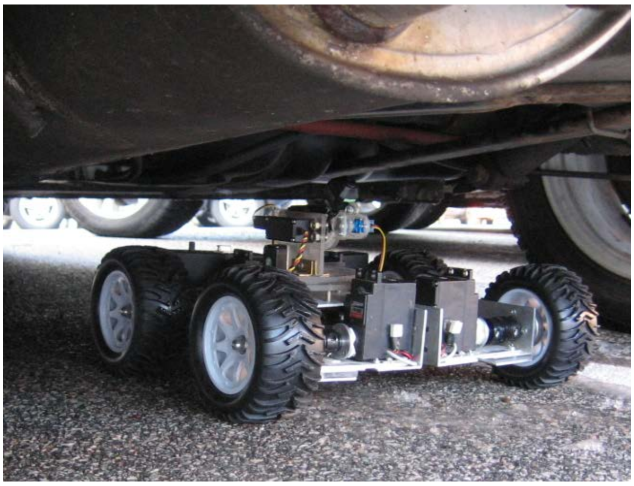

Figure 1. Mobile robot with divided chassis

3. Control Concept

The designed chassis uses for its motion differential method of wheel control. Chassis motion should be stable and fluent to avoid slipping between wheels and terrain and to avoid mechanical shock resulting from rapid changes in chassis motion. However during chassis motion unavoidable trajectory deviations between current position and requested trajectory do occur because of path tracking control imperfection using wheels velocity and fault variables from environment (terrain roughness, friction forces changes between wheels and terrain and so forth) [7,8,9].

Trajectory deviations should be corrected online using requested linear and rotational chassis motion velocities by path tracking control [5,11].

In work [7] layout of kinematic control is designed, comprising of three levels of links (dynamic, kinematic and planning). This approach is similar to those, which are applied in robotic manipulators. The designed construction was applied in mobile three-wheel chassis of industrial forklift manipulator.

Wheel mobile robots can be controlled from the aspect of kinematics or dynamics.- Kinematics based control consists of dividing the device into two levels namely kinematic and dynamic loop.

- Dynamics based control considers just one loop of global dynamic control. This has a few disadvantages. Very complex analyses and calculations are needed. This control is very sensitive to parameter uncertainties of model.

Kinematic control is simpler and its global stability is guaranteed if the low-level control link (dynamic loop) is much faster than the middle level of control (kinematic loop). Majority of works solving this kind of problem are based on this assumption.

Input into mobile wheel robot control is tracking reference ref p generated by the high level – planning block. If this reference is dynamically generated (i.e. specified in real time) it is acquired from outer loop, so called planning loop [7].

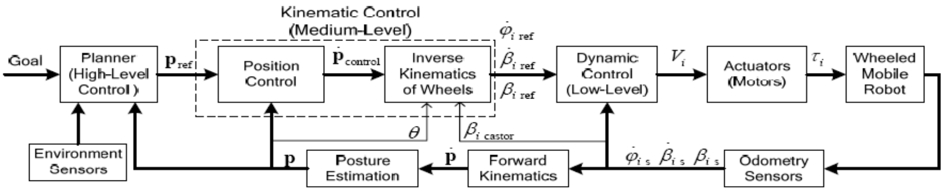

Figure 2. Control scheme of the wheeled mobile robot [7]

4. Kinematic Model

Creation of kinematic model was based on mobile robot, which was designed and constructed in department of applied mechanics, and also on experience

Chassis with four wheels is controlled differentially. Each one of the wheels is independently driven by separate speed servomechanism [10].

Mobile robot always moves in circular trajectory with diameter R (on trajectory projection of which on plane XY is circle). Direct motion occurs when trajectory radius approaches infinity. This radius changes in time depending on desired motion direction [1].

Axes of all wheels have to intersect in one point and that point is an immediate center of rotation [2].

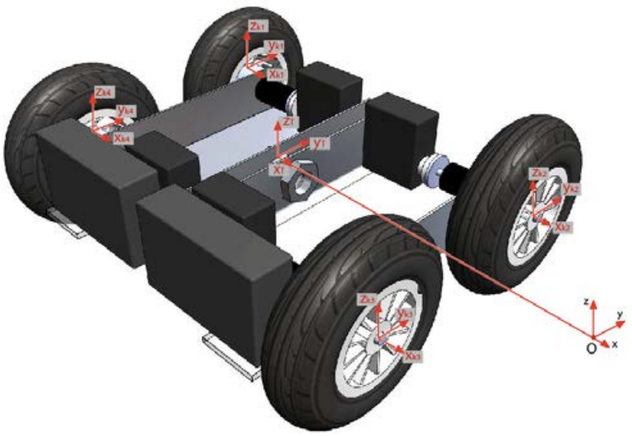

Figure 3. Location of local coordinate systems in linkage

In this case it is difficult to draw up a kinematic model of chassis using common methods, because in the center of gravity there is a joint that enables chassis to better overcome terrain roughness. For description of resulting kinematic variables, such as position and velocity of chassis center of gravity, or positions and velocities of individual wheels, we used transformation matrices [1].

In general cases it is very difficult to directly find matrix of direction cosines and beginning accompaniments. It is however possible to essentially simplify by motion decomposition to a sequence of simple motions composed of so called basic motions [6].

Decompositions such as these are natural component of practically every task layout about body motion. So called matrix kinematics method is effective and general method for solving body motion and basically whole kinematics [4].

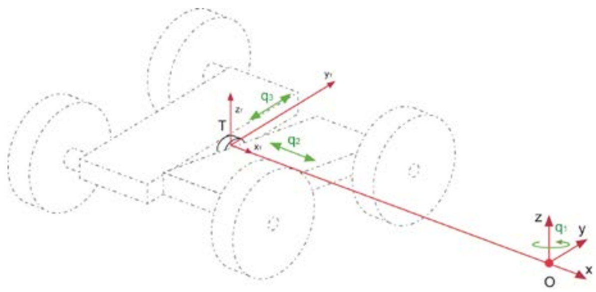

Figure 4. Coordinates q1, q2, q3, q4 implementation

Kinematic model of chassis takes into account real dimensions of GTR2010 robot.

Distance between wheel 1 and geometric center of gravity of chassis in direction of axis x is c = -175 mm and in direction of axis y is a= 95mm.

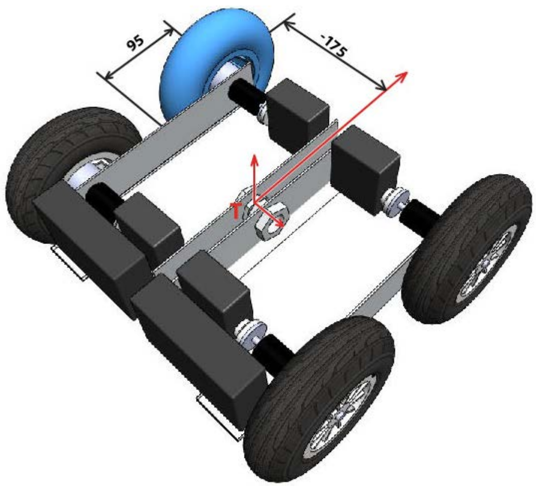

Figure 5. Position of wheel 1 from geometric center of gravity of chassis

Based on constructed transformation matrices it is possible to construct simulation models for defining center of gravity geometric position of chassis and wheels in Matlab/Simulink environment.

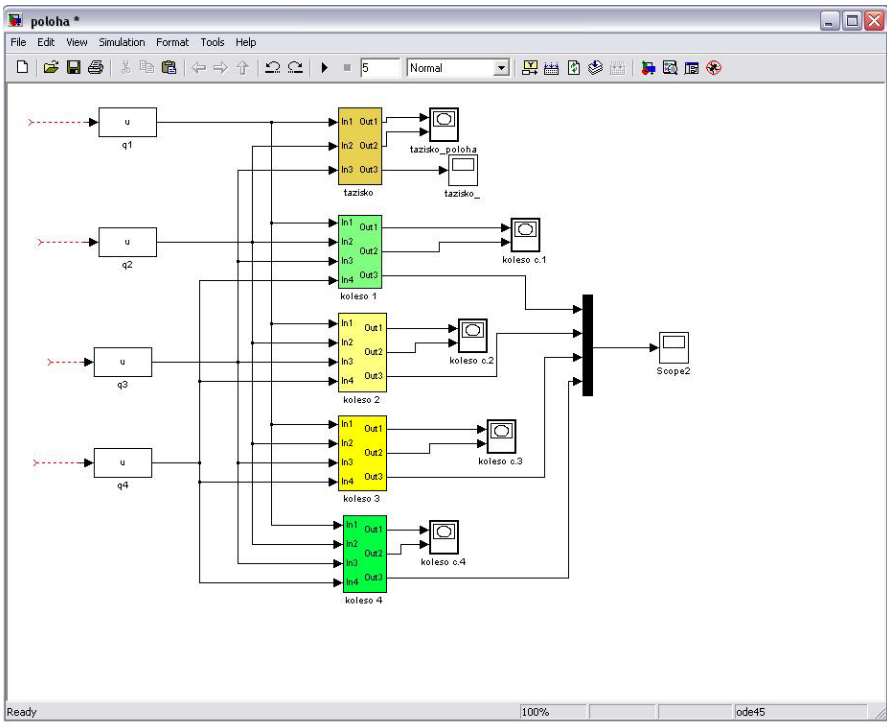

Figure 6. Position Simulation model of position of center of gravity and wheels

Simulation model of position of geometric center of gravity of chassis and individual wheels comprises of several subsystems that have common input. Every subsystem represents position of wheel, or position of center of gravity to beginning O (Instantaneous Center of Rotation).

Layout representing velocity of individual chassis points consists of several subsystems, which represent velocities of wheels 1 - 4 and chassis center of gravity.

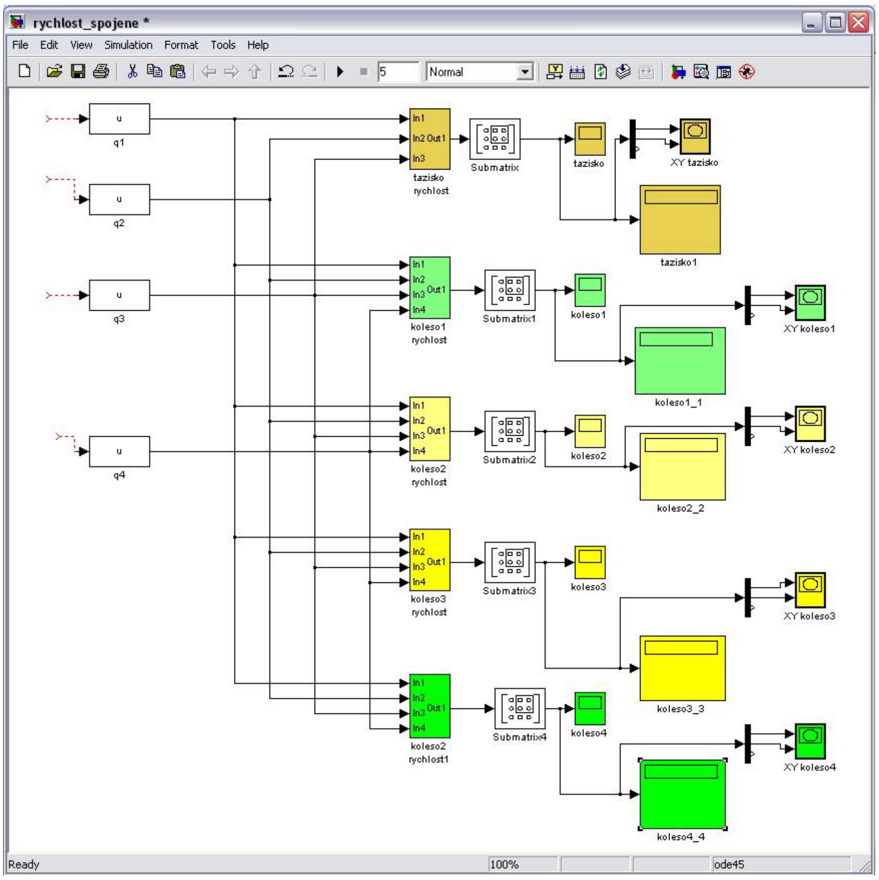

Figure 7. Simulation model of velocity of chassis, center of gravity and wheels

It is possible to use this simulation model to calculate estimated trajectory of center of gravity and wheels of chassis. It is also possible to examine behavior of model in any given combination of chassis dimensions. In connection to this there is also an option of chassis geometry optimization. Furthermore created model provides room for examining influence of terrain roughness on behavior of chassis of mechatronic system.

A significant asset is the option of testing model of such chassis composition of mechatronic system, what enables to find optimal chassis geometry in terms of various aspects of assessment before constructional vehicle solution itself.

5. Conclusion

The concept of control structure using kinematic and dynamic model at the same time provides the benefit of economical utilizing of energy sources. In terms of practical realization it is being considered to implement this structure into functional model, where this structure would in real time ensure chassis locomotion control of mobile mechatronic system. With this application the mobile mechatronic system gains a certain amount of intelligence.

Hence it is possible to use the model for calculating estimated or requested trajectory of chassis center of gravity and wheels. At the same time it is possible to examine model behavior in any given combination of chassis dimensions and relating to this there is an option of chassis geometry optimization in terms of obstacles negotiability on diverse terrain. Furthermore the created model provides room for examination of the influence of terrain roughness on behavior of mechatronic system chassis.

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