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Adv Robot Autom, 6:3 (Suppl)
DOI: 10.4172/2168-9695-C1-012

Mathematical and computer simulation of the dynamics of a mobile manipulator with radially deformable wheels

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Statement of the Problem: In the work, a problem of mathematical modeling of a one-link mobile manipulator dynamic is discussed. The manipulator has a geometric constraint and radially deformable wheels. The goal of the manipulator is keeping a work tool-I at a pre-set altitude during a forward motion on uneven ground. Position of the link OD (angle of deviation from vertical) is regulated by the arm AB connected with a motor gear wheel. For mathematical modeling, we supposed that the body of the manipulator is rigid, having mass M and moment of inertia; work tool-I is a material point with mass m; masses of the arm AB and the link OS can be neglected; wheels are radially deformable. Additional motor voltage is used to control. The problem is to find stabilizing control law to keep the work tool at a preset altitude from the ground.

Methodology & Theoretical Orientation: The manipulator is a mechatronic system with a geometric constraint between the tilt angles of the link OD and the motor gear wheel. It is impossible to express directly one angle through another. So, the equations of motion in Shul'gin's form and redundant coordinates were utilized for mathematical modeling. Coefficients of the stabilizing control were calculated by solving linear-quadratic problems using N N Krasovsky method.

Findings: Mathematical and computer modeling of the manipulator was made. Controllability of the system was verified. Coefficients of the stabilizing control were calculated by a special program. The results of the numerical computation are displayed to demonstrate asymptotic stability for all variables.

Conclusion & Significance: Shul'gin's equations for holonomic systems give a convenient method to construct adequate models for mechatronic systems with geometric constraints. They are especially appropriate for solving stabilization problems. It was demonstrated by the example of the manipulator.

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