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The Dynamics of Robots

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Robotics is a rapidly developing field of science and technology related to the creation and use of robots and robotic systems, which arose from mechanics and cybernetics.

Any robotic system moves in space to complete the tasks. The science that provides the movement of robots in space is the dynamics of robots. Dynamics is the branch of classical mechanics concerned with the study of forces and their effects on motion [1].

Manipulation and mobile robots are the most interesting robots from the point of view of dynamics features. Manipulation robots include such types of robots as:

– collaborative robots or co-bots, which are structures of controlled stiffness, equipped with torque sensing and force control systems and designed for direct physical interaction with humans, including light manipulators of excessive kinematics and modular structure with an increased ratio of payload to own mass, hyper redundant bionic manipulators, as well as two-handed manipulators [1];

– parallel kinematics robotic manipulators designed for high-speed sorting, where the static and dynamic balancing of the robot is of great importance, or used for robotic marine, automobile and aviation simulators that should simulate the dynamics of a real flight or movement over rough terrain or during a storm [1];

– manipulators of high carrying capacity and for a large work area, in which, firstly, design flexibility is manifested and

one of the main tasks is not to ensure high speed and accuracy, but to damp unwanted vibrations during movements, and secondly, hydraulic drives are often used;

– multi-finger adaptive grips with tactile feedback systems for manipulating fragile objects of arbitrary shape and dynamic manipulation; which are described in the motion phase before capture as a branched structure of sequential kinematics manipulators with a common base, by analogy with two-armed manipulators, and when in contact with an object, they are already described as a closed kinematic chain, by analogy with parallel manipulators [1];

– mobile manipulators located at the junction of manipulation and mobile robots and used to work with extended objects (welding, painting, machining) or in warehouse logistics, where it is necessary to coordinate the movement of the arm and moving platform;

Mobile robots are divided into the following types:

– "classic" mobile robots, in which the dynamics of the system is extremely important in the tasks of high-speed maneuvering, or vice versa, ensuring stability of movement under external disturbances: wind, wave, complex surface, etc.;

– biologically-inspired robots, which are complex multi-link systems using various methods of movement, the purpose of which is to increase energy efficiency, maneuverability and stability of movement in various environments and cross-country terrain, including dynamic balancing: walking with a different number of legs and jumping, flying, floating, etc.;

– prostheses and orthoses (exoskeletons), for which, based on the requirements of safety and ease of use, an important requirement is the movement along trajectories that are natural for humans [1].

From this review it is clearly seen that at present there are many different types of robots for which the construction of adequate dynamic models is a popular and non-trivial task.

There are a lot of companies in the world, which are closely connected with the development of robots. Firstly, it's worth mentioning our national company called "Rozum Robotics". They started selling their collaborative robots in 2019. This company has a manipulator or robotic arm called "PULSE". PULSE by Rozum Robotics is a lineup of arm-manipulators intended for automation of commercial and industrial workflows as well as research and education projects. The arms are most efficient in repetitive tasks with minimum variations in process parameters, such as pick-and-place, machine tending, gluing, etc. [2].

PULSE robots boast modular design and six degrees of freedom which will allow you to cope with up to 95% of all production tasks. The machines consist of aluminum linking elements and self-designed servo motors embedded into joints. They can be integrated with a variety of end effectors, depending on intended use—grippers, welding equipment, laser tools, video cameras, etc. [2].

The built-in servo drives enable precise angular displacement of joints within the span from -360 to +360 degrees. PULSE robotic arms are safe, require no costly protective caging and are allowed to work in direct contact with a human. Teaching trajectories by hand guiding makes setup, configuring the robots quickly and easily, even for a user with no coding or engineering background. For advanced control, Rozum Robotics has implemented an Application Programming Interface (Java or Python) [2].

There is one more company which is engaged in the development of mobile robots. It is Boston Dynamics created in 1992. Spot is a Boston Dynamics' first commercially available robot, introduced in 2017. Spot is a nimble robot that climbs stairs and traverses rough terrain with unprecedented ease, yet is small enough to use indoors. Spot can go where wheeled robots cannot, while carrying payloads with endurance

far beyond aerial drones. Its speed is nearly 1.6 m/s. Moreover, Spot can run 90 minutes using swappable battery. Spot uses stereo cameras to avoid obstacles and people as it moves through dynamic work sites. It has a vision of 360 degrees [3].

Furthermore, Spot is absolutely durable. Spot is built to withstand dusty and wet industrial environments. It can easily perform in temperatures from -20°C to +45°C. Spot was created for military purposes to drag heavy cargo, food, weapons on long distances. Boston Dynamics points out that the robot can be used in the areas of construction, oil and gas production, as well as maintaining public safety [3].

Thus, all robots can be divided into manipulation and mobile. Manipulation robots include such types of robots as: collaborative robots, parallel kinematics robots, manipulators, multi-finger adaptive grips and mobile manipulators. Mobile robots are divided into the following types: "classic" mobile robots, biologically-inspired robots, prostheses and orthoses. Robotic systems are classified by the nature of the ongoing processes (movements), type of base, the ratio of the number of degrees of freedom of the system and the number of independent controls, the type of relations between the generalized coordinates.

References:

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