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Design of structure and control of planar robots with rigid and cable components

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This paper deals with designing and controlling a robot with rigid and cable elements. This work is the first step which leads to the idea of the 3D serial robot structure driven by cables and joints actuators. A planar robot structure is chosen, see Fig. 1. The structure is formed by

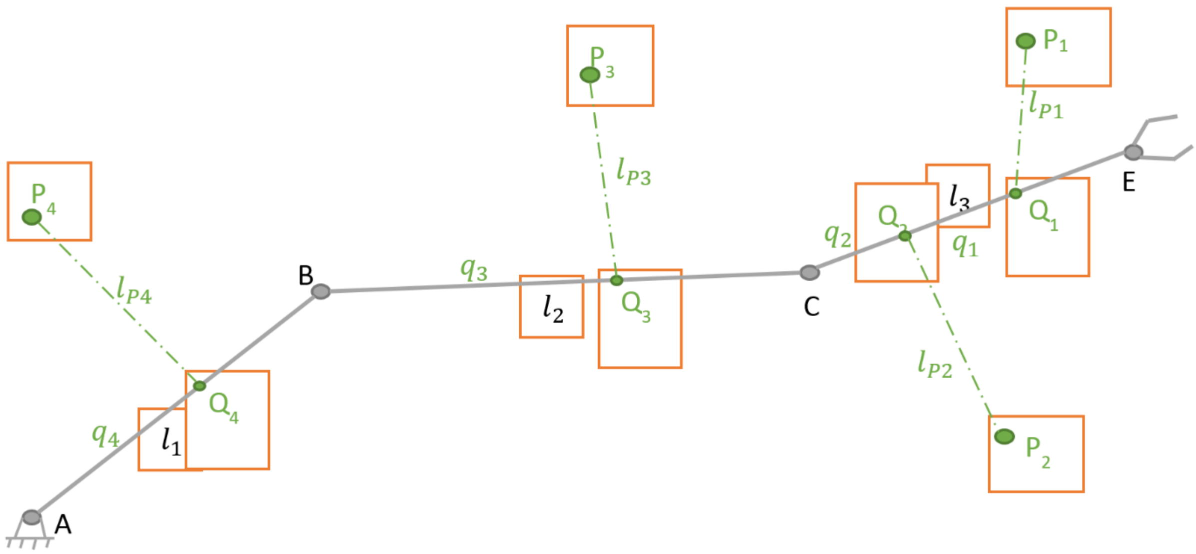

Fig. 1. Planar cable driven serial arm with marked parameters for optimization

a serial part (three beams connected by joint actuators) and a parallel part (four cables attached on serial structure and driven by actuators with pulley [3]).

Consequently, the further step has been optimization. Two different approaches were chosen. The first one is based on the local optimization algorithm method – simplex and the second one is based on the global algorithm method – genetic algorithm. In both methods the cable forces were treated to be only positive [5]. The main aim of this part was to develop, analyze and verify two models of the structure optimization.

The next step was to create the dynamic model of the chosen structure. One can easily see that this model is nonlinear thus the linearization method is needed. In the field of the Flatness theory was derived for this purpose (linearization of the robotic structure) theory “Computed Torque”. By this theory one can transform the nonlinear model to a new linear one which can be written in Brunowski (canonical) form [4]. Once one obtains the linear model the linear control strategy could be used.

The control regulator was divided into two parts, see Fig. 2. The purpose of the first part has been controlling of the robotic structure without cables. And the second part of the regulator has controlled the force distribution of each cable [1]. For the first part of the control regulator were chosen two different regulators – PID cascade with feedforward [2] and Flatness regulator (Fig. 3). It is necessary to note that the control regulator could control the robotic structure without cables and uses only actuators in joints A, B, C. For this case the cables are preloaded and help to hold the robot in desired or actual position. Besides, the preloaded cables help to increase the stiffness of the mechanism.

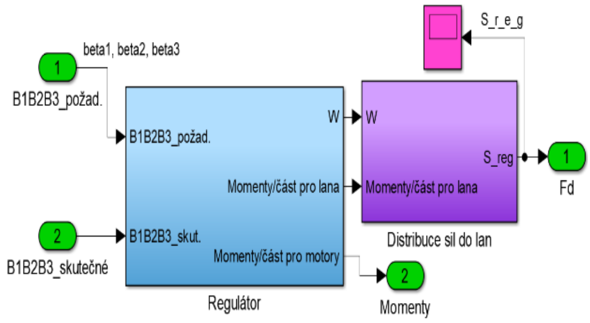

Fig. 2. Schemes of control implementation, distribution of the regulator

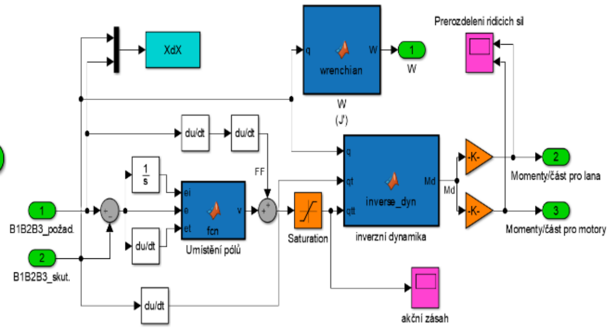

Fig. 3. Schemes of control implementation, flatness regulator

For the simulation were chosen three different trajectories (which tracked the end-effector – the point E) in the workspace determined by the optimization. Trajectories were S-curve (point to point trajectory), circle and rectangle.

The results of simulations showed that the regulation has been stable for all trajectories. Tracking of the desired trajectory was very accurate for the S-curve. For the simulation were used different parameters for the model and the control regulator.

Acknowledgements

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