CONTROL SYSTEM DESIGN USING RAPID PROTOTYPING METHODS ON AN EXAMPLES OF VOICE CONTROLLED MOBILE ROBOT AND 6DOF PARALLEL MANIPULATOR

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Abstract

The article describes examples of control real devices using computer model based rapid prototyping approach. First presented example of the control system is a voice commands guided mobile robot. The structure of control system consisted of some hardware modules cooperating with real time computer controller. In another example described in article analogical method was used in order to control numeric model of 6DOF parallel manipulator. The obtained results in both cases met real time requirements

Control system of mobile robot

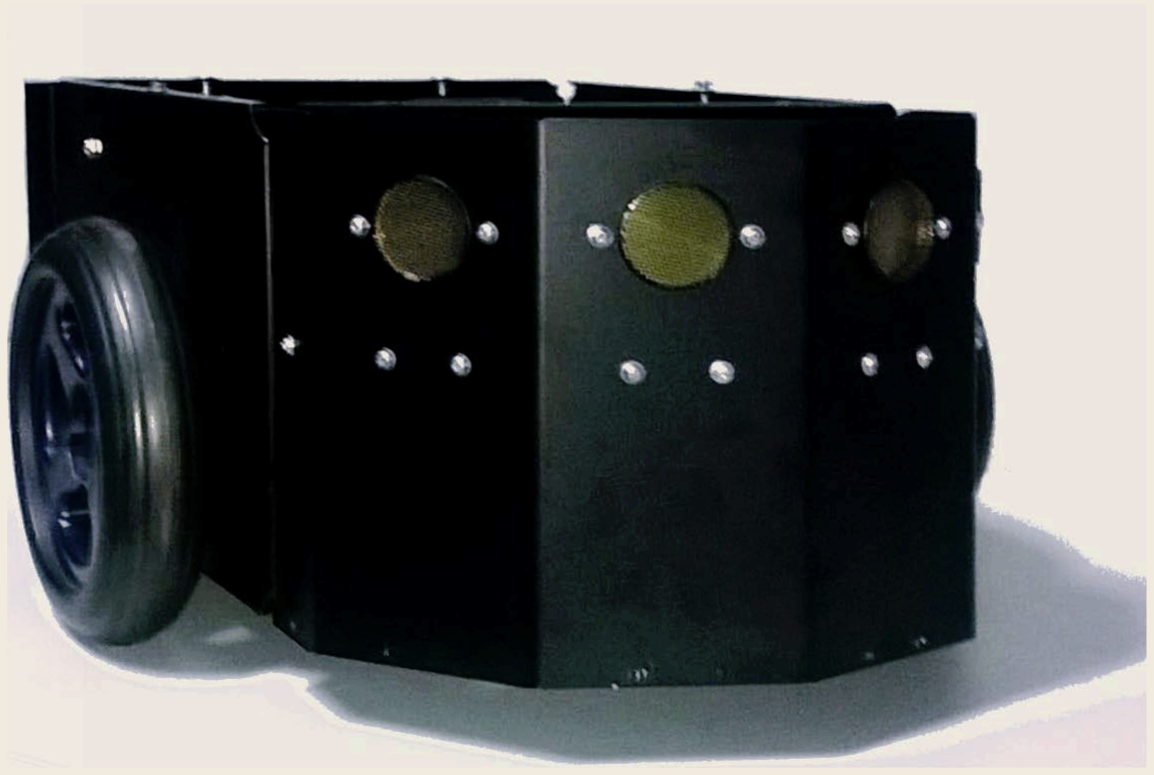

Fig. 1
View of the wheeled robot used in experiment

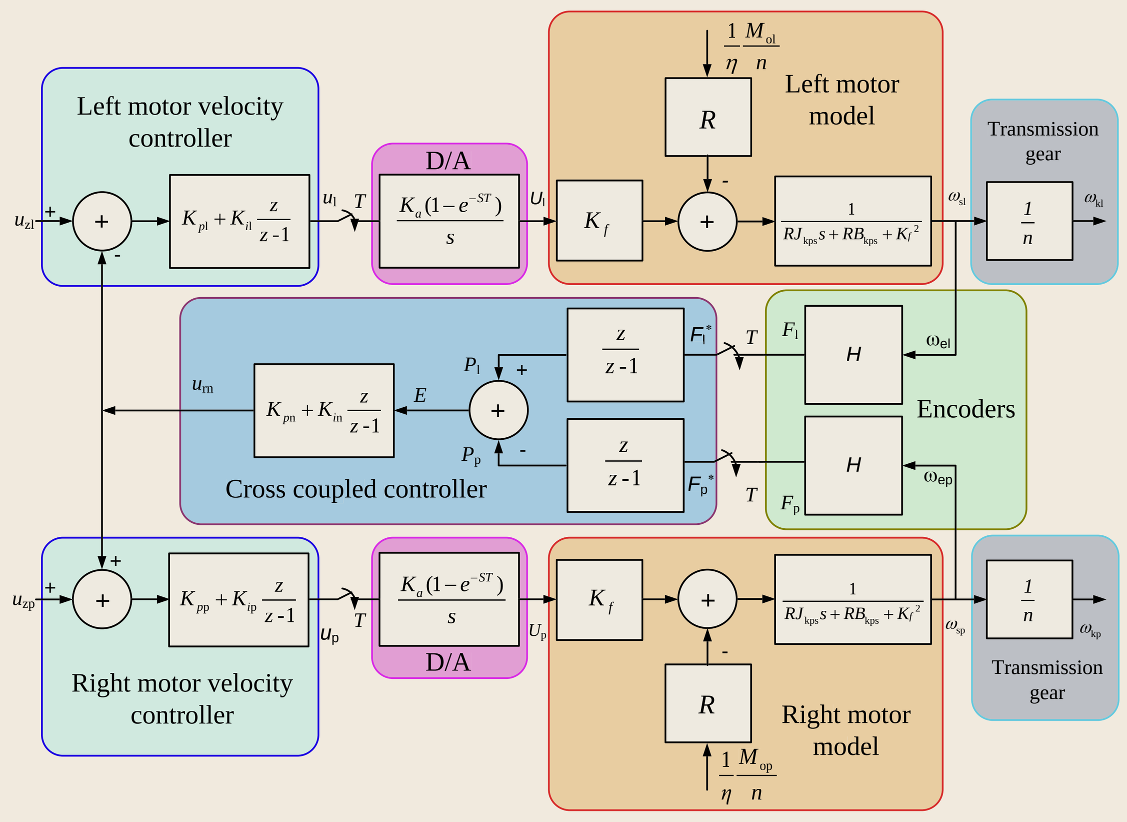

Fig. 2
Two motor drive controller structure

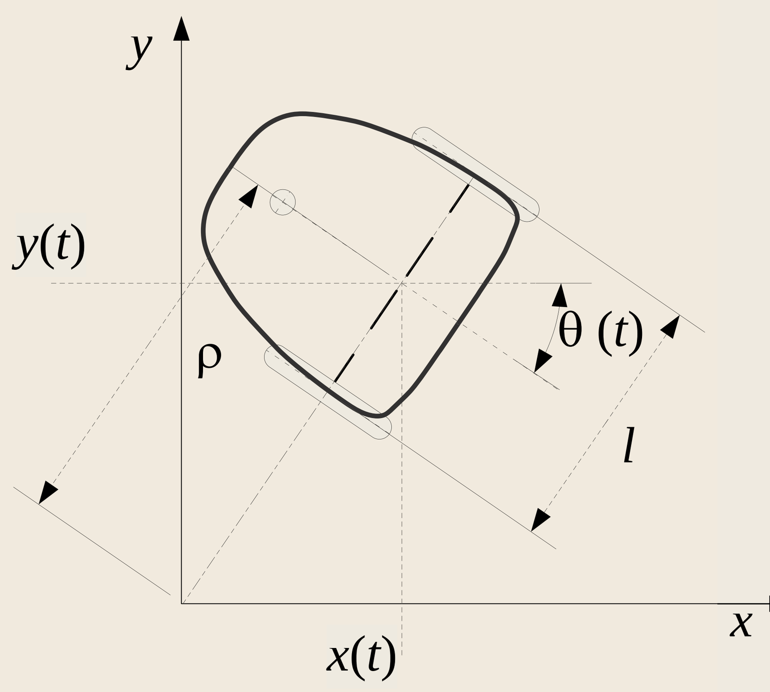

Fig. 3
Electric vehicle kinematics

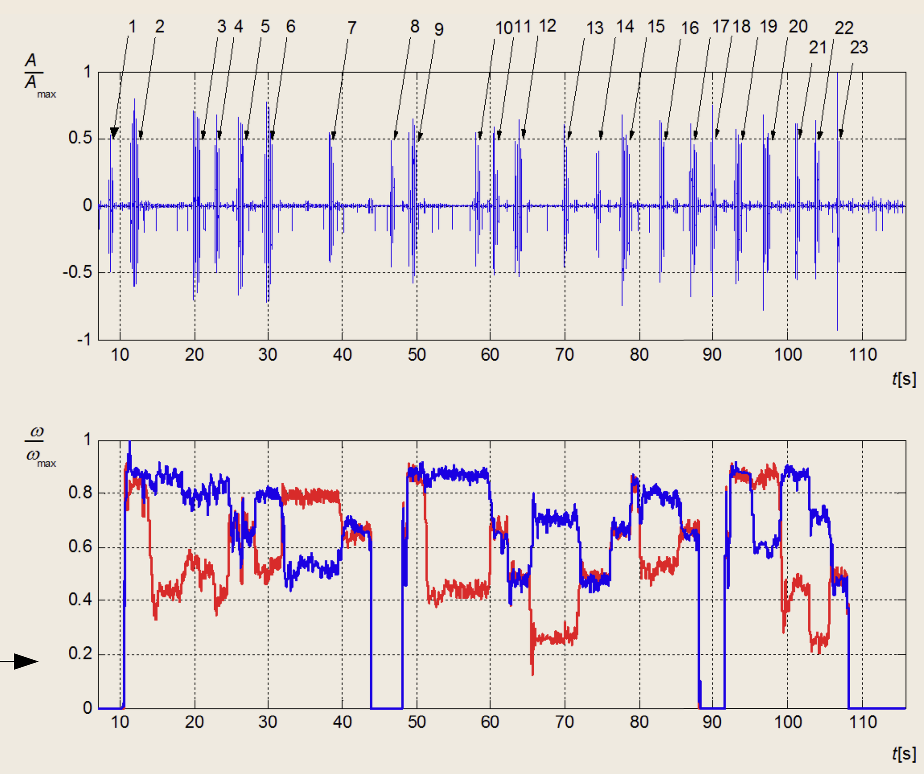

Fig. 4
Voice commands velocities of the motors waveforms acquired within laboratory tests

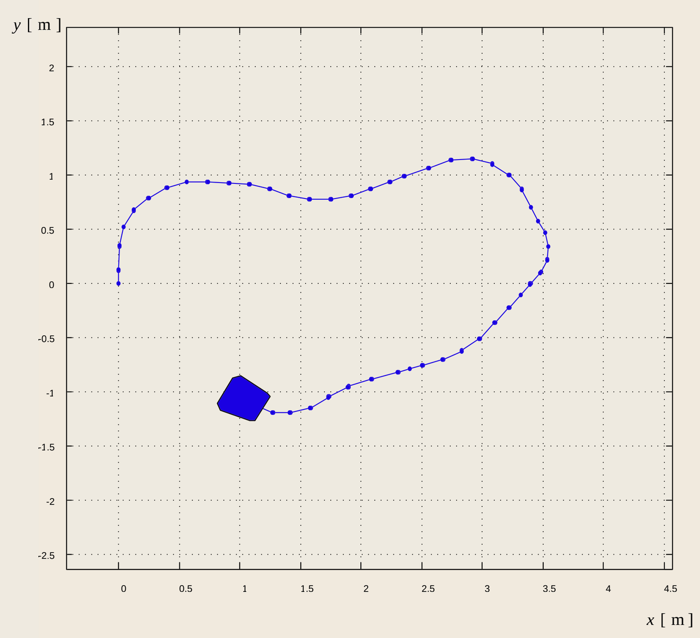

Fig. 5
Trajectory of voice guided mobile robot obtained during laboratory tests

$$\mathbf{q}=\left(x,y,\theta\right)^{\mathrm{T}}$$

$$\mathbf{u}=\left(v_{\mathrm{r}},v_{\mathrm{l}}\right)^{\mathrm{T}}$$

$$\rho=\frac{l}{2}\frac{\left(v_{\mathrm{l}}(t)+v_{\mathrm{r}}(t)\right)}{v_{\mathrm{l}}(t)-v_{\mathrm{r}}(t)}$$

$$\text{for } v_{\mathrm{l}}(t)\neq v_{\mathrm{r}}(t)$$

$$v(t)=\frac{1}{2}\left(v_{\mathrm{r}}(t)+v_{\mathrm{l}}(t)\right)$$

$$\omega(t)=\frac{1}{l}\left(v_{\mathrm{r}}(t)-v_{\mathrm{l}}(t)\right)$$

$$\dot{x}(t)=v(t)\cos\theta(t)$$

$$\dot{y}(t)=v(t)\sin\theta(t)$$

$$\dot{\theta}=\omega(t)$$

Fig. 6
Basic formulas describing motion

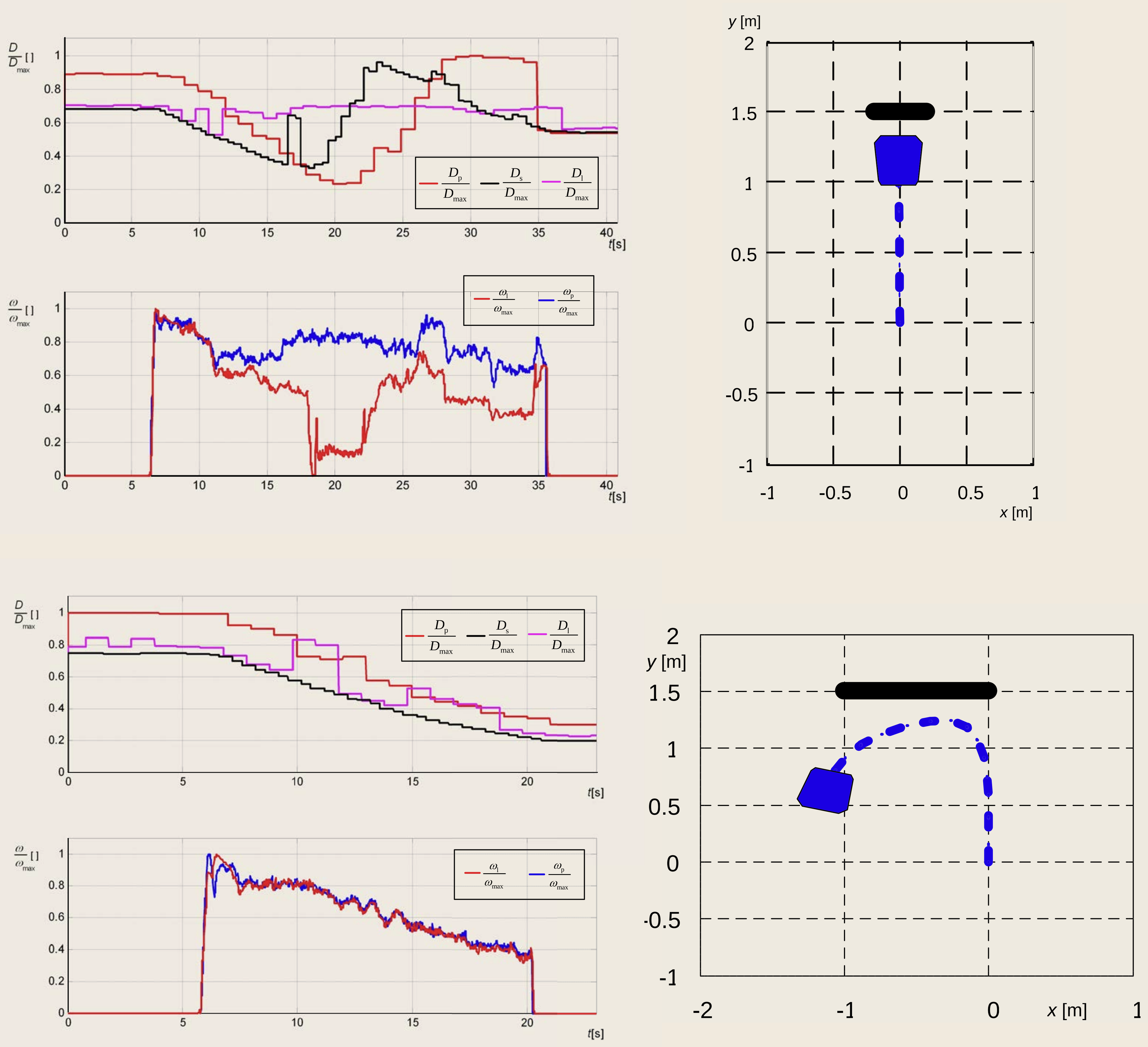

Fig. 7
Trajectories and corresponding waveforms of motors velocities and distances from the nearest obstacle

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Parallel manipulator

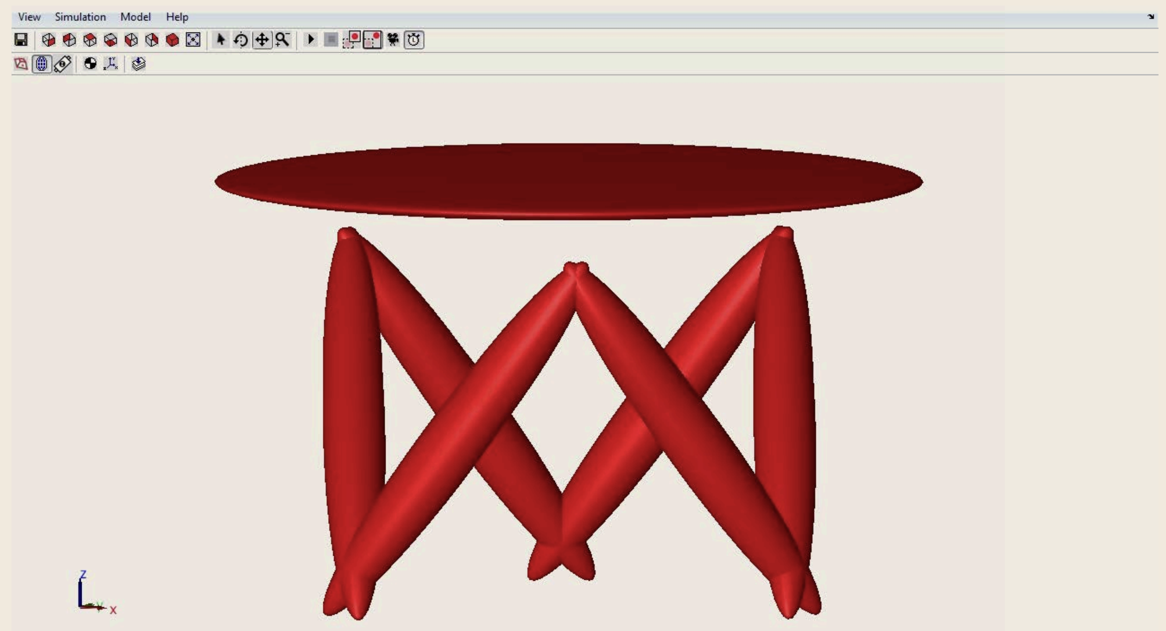

Fig. 8
Visualization of the 6DOF parallel manipulator MATLAB-SIMULINK model

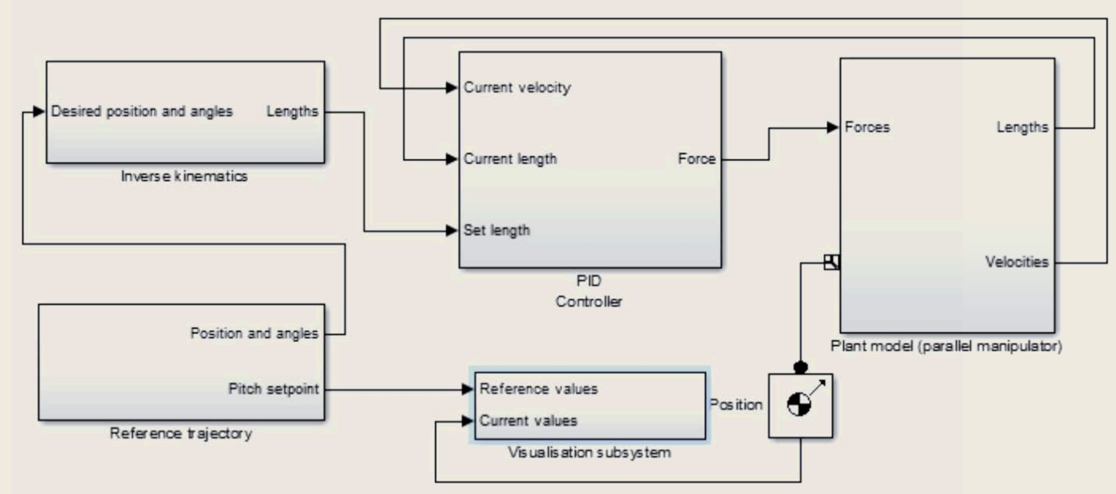

Fig. 9
Structure of the inverse kinematics based controller for 6DOF parallel manipulator implemented in MATLAB/Simulink

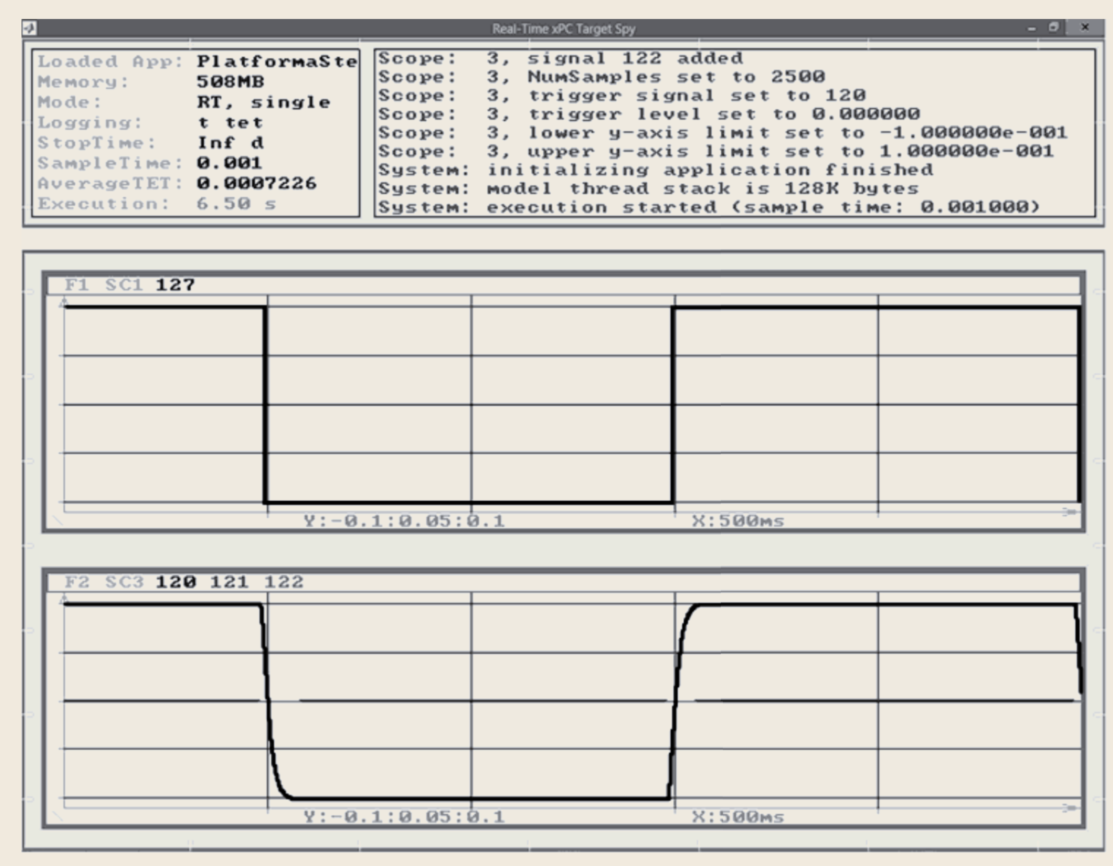

Fig. 10
Waveforms of step response for single coordinate of 6DOF parallel manipulator (upper waveform - the setpoint value of actuator position, lower waveform the actuator response)

Summary

The subject of the research was development of two kind of control systems. One of the systems was designed for electric differential drive mobile robot, guided by voice commands.
Second of the systems was designed for control of parallel manipulator based on six PM BLDC motors.
A common element of the two research paths concerning the systems was implementation based on "software in the loop" design paradigm. In both cases the development platform of the systems was xPC Target Matlab toolbox.
The design and research stages:

- An analysis of the requirements as well as input and output signals for both types of control systems;
- Design of numerical models in Matlab-Simulink environment;
- Determination of controller parameters f.eg. PI controller in case of two motor drive and PID controller for model of parallel manipulator;
- Parameterization of the designed controllers and verification of the models in simulation environment
- Developement of communication framework designed for operation with hardware controllers of the motors:
- Implementation of serial interface binary exchange frames in case of two motor drive and voice commands microcontroller unit;
- Implementation of CAN bus data exchange in case of parallel manipulator drive system;
- Design of Finite State Machines logic for voice control command interpretation and for CANopen protocol operation;
- Design of the detailed models subsystems for implementing complex models of whole controllers structures;
- Determination of sample time for the designed controllers models and appropriate parameters of the controllers tuning;
- Research using designed models in typical control scenarios.