Reduction of Antagonistic Behavior of Redundant Motion Servosystem

Pavel Píša, Martin Hlinovský, Ondřej Vysoký

Department of Control Engineering
Faculty of Electrical Engineering, Czech Technical University
pisa@cmp.felk.cvut.cz, vysokyo@electra.felk.cvut.cz

Planar Parallel Robot

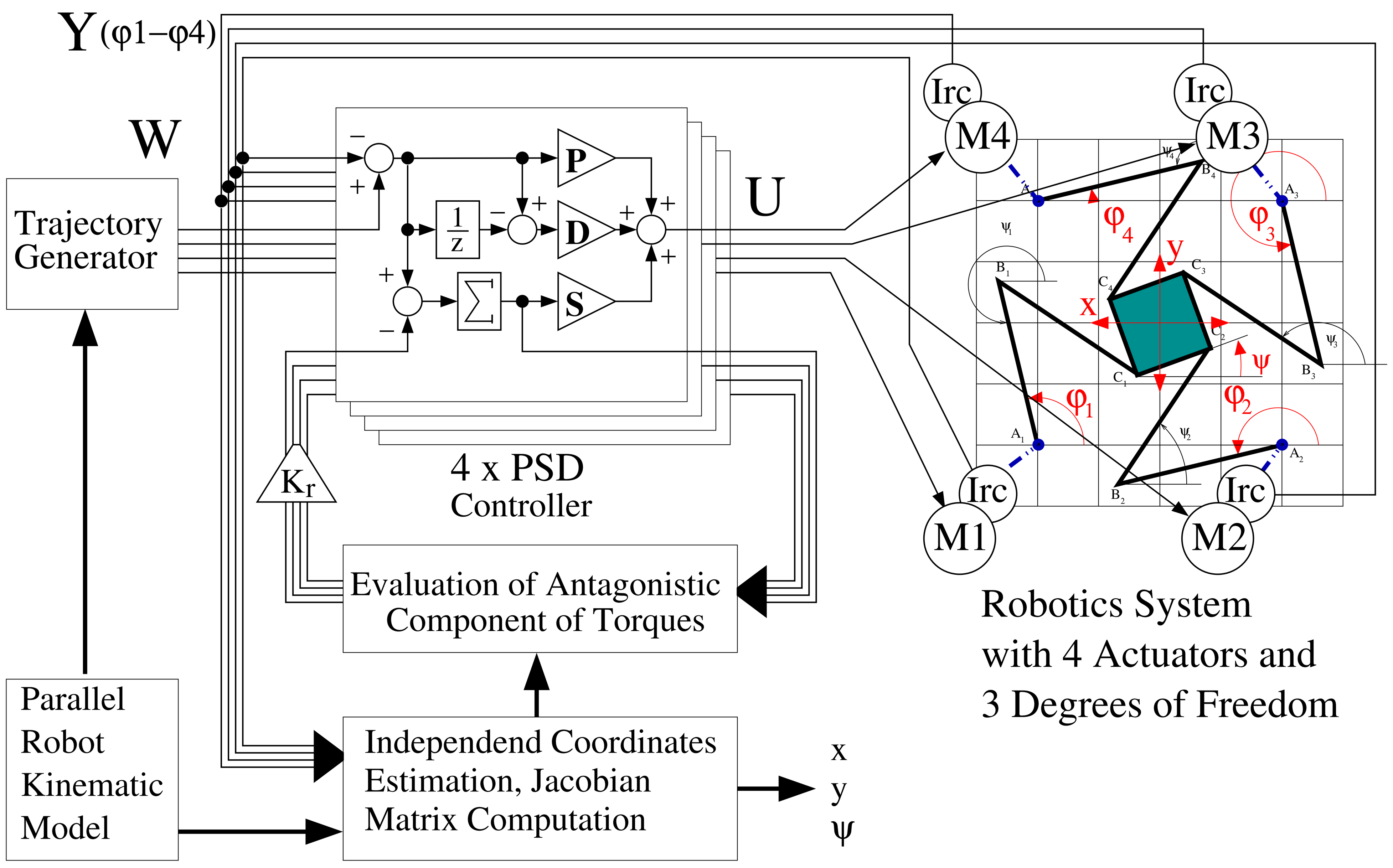
More of alternative robot kinematics are studied by co-operating teams of CTU and UTIA institute. One of tested laboratory models is a planar redundant parallel manipulator, which consists of the basic frame with four DC motor drivers actuating over four pairs of arms moveable platform. Such system has three degrees of freedom for actuated platform and redundant actuators.

One approach to achieve cooperative behavior of the redundant actuators is to introduce feedback control in the space of independent coordinates (x, y, ψ) and transform computed forces and platform torque into torque request for each drive. The force to torque transformation can be evaluated from $\overrightarrow{F} = \mathbf{J^T} \cdot \overrightarrow{M}$, where J is Jacobian matrix of inverse coordinate transformation. After applying pseudoinversion, $\overrightarrow{M} = \mathbf{J} \cdot (\mathbf{J^T} \cdot \mathbf{J})^{-1} \cdot \overrightarrow{F}$. Main difficulty of this approach is necessity of fast actual position computation from measured actuators angles.

Second way to achieve cooperative actuation is to use conventional servo system for each driver and to add subsystem solving minimization of antagonistic forces. Main source of antagonistic forces is integration of difference of requested and actual positions of drivers, which cannot be eliminated by growing forces. The differences in such case are caused by any infinitively small discrepancy of model used for computation of requested dependent (redundant) requested motor coordinates.

The second solution was tested with local PSD controllers modified as shown in the block diagram. This way sum of errors is stabilized and antagonistic component of torques can be arbitrarily reduced by K_r. Advantage is moving of the computation of the antagonistic component of the forces out of the main control loop and elimination of influence to the dynamics of the system. The antagonistic components of torques can be computed from the Jacobian matrix used in the position estimation block and is equal to $\overrightarrow{M_{ant}} = (\mathbf{1} - \mathbf{J} \cdot (\mathbf{J^T} \cdot \mathbf{J})^{-1} \cdot \mathbf{J}) \cdot \overrightarrow{M}$.

Described solution was successfully tested on laboratory model. We expect, that future combination of high-level controller with described fast local loops could lead to advanced distributed hierarchical control system with excellent dynamics properties.



Acknowledgement:
This research has been supported by GAČR grant No. 101/99/0729.

Measured Results