TECHNICAL UNIVERSITY OF CLUJ-NAPOCA
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Ph.D. THESIS
-ABSTRACT-

RESEARCH REGARDING MODELING AND CONTROL
OF PARALLEL ROBOTS WITH DECOUPLED MOTIONS

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ABSTRACT

Stability, robustness and performance depend on a specific control system that meets all the criteria required for the proper functioning of the system. The general objective of the thesis is Research regarding modelling and control of parallel robots with decoupled motions.

The paper is structured on 6 chapters and is ending with bibliographical references and annexes.

The first chapter entitled "Introduction" presents and analyses the state of art and the fundamentals of Mechatronics systems. In the beginning is presented the research motivation. Next is presented the stat of art in robotics and purpose and thesis objectives, ending with conclusions. The purpose and thesis objectives are:

- Modelling and simulation of parallel robots with decoupled motions;
- Design of two parallel robots with decoupled motions;
- Control of these structures.

The second chapter “State of the art regarding control of robots”, present classical and advanced solutions used in robots control. In the first part are mentioned the theoretical considerations regarding the control of robots continuing with the classical solution control that uses the well known controller in industry (PID controller), also speaks about advanced solutions using Model Based Predictive Control (MBPC), Fuzzy Logic, Adaptive PID and on-line identification.

At the end is presented the Rapid prototyping control (RPC) based on dSpace platform and also the conclusions of this chapter.

Chapter 3, "Modelling and simulation of robotic systems", is dedicated to the modelling and simulation of three parallel robots with decoupled motions. The first robot modelled is the Isoglide 3 parallel robot, the second is the T3R1 parallel robot with decoupled motions made at IFMA (French Institute of Advanced Mechanics) and the third robot is the T3R1 V2 parallel robot with decoupled motions made in Technical University of Cluj-Napoca. For all these robots are made the kinematics calculations of the structures, CAD models, FEA analysis and simulations in MATLAB. Two of these structures were designed and realised.

Chapter 4, “Control of Isoglide 3 parallel robot” presents the control in simulation of the Isoglide 3 parallel robot with decoupled motions. At the beginning is presented the Model Predictive Control (MPC) in MATLAB/Simulink, the dynamic model of this robot and the DC motors. On this robot structure is applied a classical controller (PID) and an advanced controller (MPC). On the final effector of robot are imposed trajectories (circular, rectangular, spiral type, etc.), also are presented the forces on the DC motors during the mobile platform execute these trajectories. The results obtained with this kind of controllers are presented and compared, the chapter is ending with the conclusions.
The fifth chapter entitled "Experimental results" is dedicated to the control of the parallel robot Isoglide 3 with decoupled motions, here are described the components that are part of the structure:

- DC motors;
- Rapid prototyping platform of control dSpace;
- Arms;
- Rotation joints;
- Steel bellows coupling;
- Mobile platform;
- Drivers;
- Prismatic joints.

Chapter 6, "General conclusion Contributions", presents a synthesis of the thesis and marks the major contributions that are:

- Analysis and approach of specific methods for modelling, simulation and control of robots in MATLAB/Simulink;
- Explaining the approaches for modelling, simulation and control of the robotic systems;
- Presentation of two approaches on three robot structures, concerning modelling and simulation of these structures;
- Field study of predictive control and the applications realised in MATLAB/Simulink with help of “Model Predictive Control” Toolbox;
- Explaining the notion of simulation and its importance in robotics;
- Explaining the notion of graphical interface and the role between users and robots;
- Graphical user interface (GUI) for two robotic structures;
- Graphical user interface in MATLAB/Virtual Reality for two parallel robots;
- Developing of two robotics structures;
- Design of the experimental stand (Isoglide 3 parallel robot with decoupled motions);
- Design of the Isoglide T3R1 V2 parallel robot;
- Control of Isoglide 3 parallel robot using dSpace platform.

The chapter also includes details regarding further usage of the research results, also been presented the 11 scientific papers, out of which 7 as main author. The scientific papers was presented an national and international conferences also was published in national and international journal.
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