D. Wilczyński, A. Augusciński, M. Dudziak, K. Talaśka

Poznan University of Technology (Poland),
Chair of Basis of Machine Design

CONTROL DESIGN OF PARALLEL MANIPULATOR IN LABVIEW SYSTEM

Запропоновано методи і критерії виведення за аналогією. Ці методи реалізовані у програмній системі "Аналогія".

This paper is devoted to the solving task of control design of parallel manipulator in labview system.

Introduction

Present-day technical knowledge uses computer technique for tasks of controlling, collecting data and their analysis. This process is constantly improved and strictly connected to ability of different signals and measuring results programming. At present programming may be facilitated thanks to applying tools such as environment LabVIEW. Characteristic feature of this software is its graphical language. Environment LabVIEW found wide application in many branches of technique and science. It enables to user building of virtual measuring tool, such as multimeter or oscilloscope and also more complex control-measuring system. This elaboration demonstrates applying of this software for preparation of design conception of parallel manipulator controlling [1, 2, 3].

Genesis of parallel structure

Typical parallel structure constitutes serial chains systems, each of them is connected to basis platform on one side and to operating platform on the second side. Chains are arranged parallel in kinematical structure in such a way that the change of each of them has an influence on operating platform position in space [4, 5].

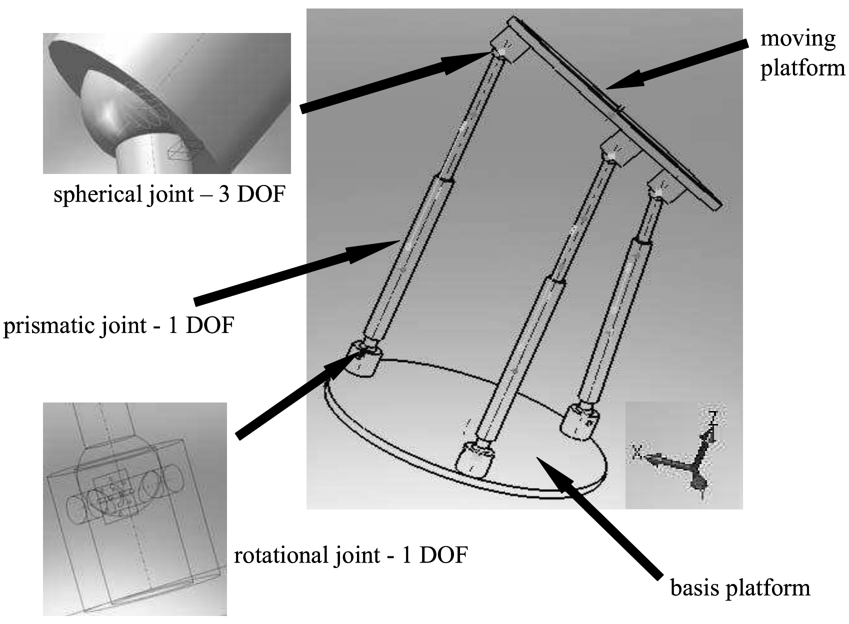
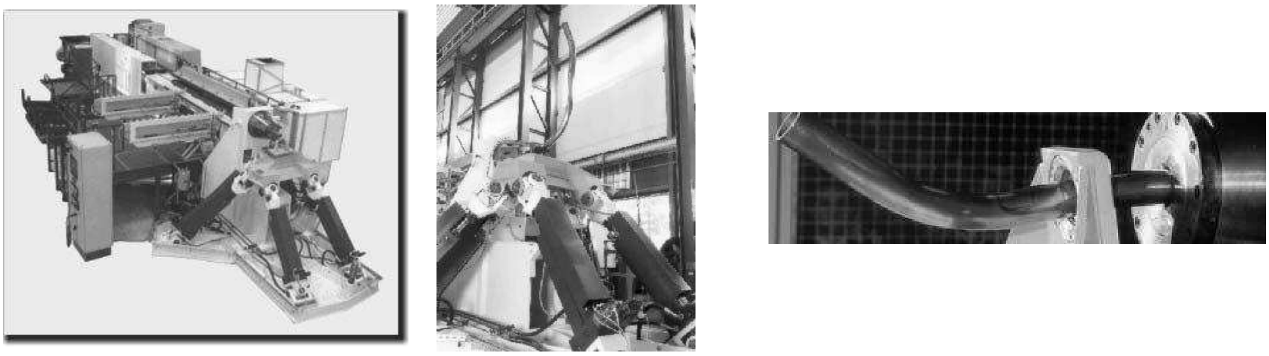


Fig. 1. Diagram of typical parallel structure [5]

Parallel structure in industry

Parallel structures used in industrial solutions are designed for strictly formulated tasks. Input data for designing process are mainly: quantity of degrees of freedom and their feature, operating space and its ratio to building space, and also kind of drive. Important matter is assurance of possibility of ready elements and modules usage as widely as possible, that way shortening and facilitating designing process. That way this process is much cheaper. Below there are presented examples of parallel structures applying in different fields of technique. In drawing 2 there is presented bending machine type HexaBend for three-dimensional shaping of pipes and steel sections – movement of bending die is realized by parallel structure.



a) *b)* *c)*

Fig. 2. Bending machine type HexaBend with parallel kinematics, where a – general view of bending machine, b – view of parallel structure with die, c – result of bender operation [8]

Consecutive example is presented on fairs Hannover Messe 2002 parallel structure named dodekapod. It is 12-axial manipulating appliance designed for disassembly processes.

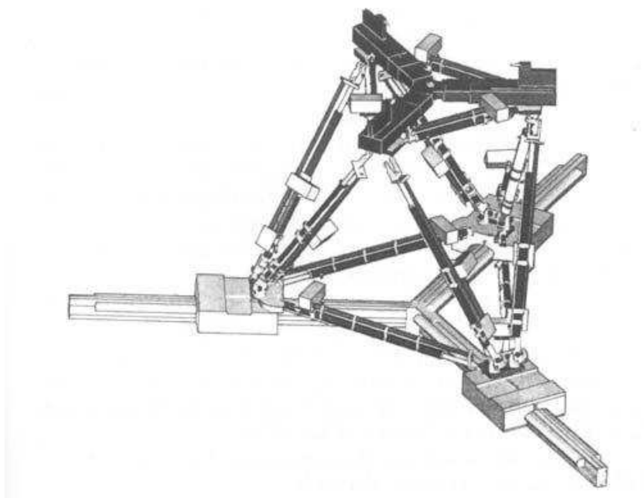
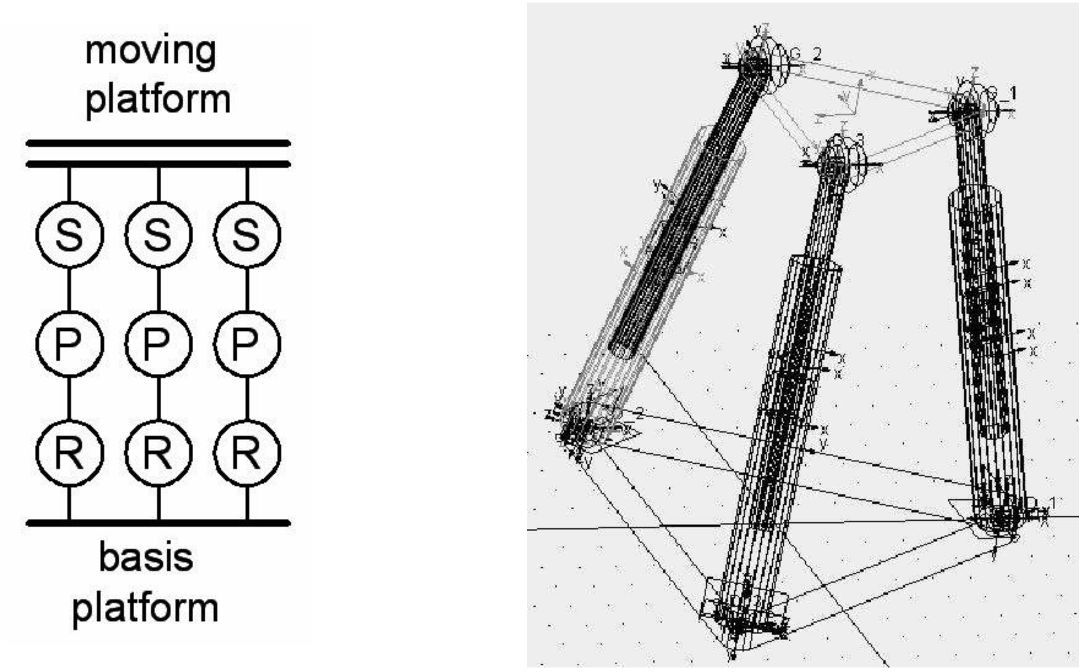


Fig. 3. Dodekapod being 12-axial manipulating appliance with parallel kinematics designed for disassembly processes [9]

Model of parallel manipulator

There was built virtual model and there was carried out kinematical analysis of parallel manipulator type tripod in system MSC Adams. Kinematical analysis had to answer many questions connected to manipulator designing parameters, and for needs of controlling had to give the image of manipulator operating space and approximate coordinates of platform movement trajectory, which would be input data to control system.

Below there is presented manipulator virtual model with kinematical diagram.



a) *b)*

Fig. 4. a – kinematical diagram,
b – model of parallel manipulator in system MSC Adams

Elaborating of kinematical model conception is one of stages of the way leading to building up of real parallel manipulator model. Presented in drawing 4 kinematical diagram shows that single serial chain being a part of kinematical parallel structure, consists of three kinematical pairs. Starting from basis there are as follows, kinematical pair type R (rotational joint) of one degree of freedom. Serial with that pair there is connected kinematical pair type P. It is a translational kinematical pair, which in real model is double-acting piston type pneumatic cylinder. This kinematical pair provides controllable changing of single serial chain. Length changes of particular kinematical chains are strictly connected to platform operational point coordinates changes. Through controlled change of cylinders length we can obtain intentional position of platform operational point. Kinematical pair connecting serial chain with operational platform is a kinematical pair type S (spherical joint) with three degrees of freedom. Presented manipulator model (drawing 4) of such kinematical pairs configuration has three degrees of freedom. It is single course mechanism [6], what means that a change of each serial chain length causes at the same time a change of platform operational point coordinates in space. This significant aspect was confirmed by analysis in system MSC Adams.

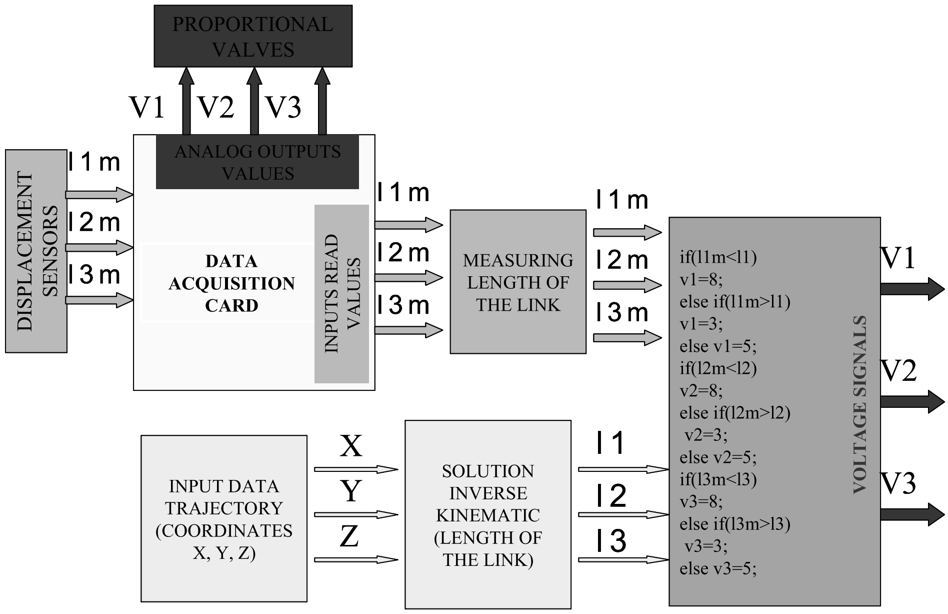


Fig. 5. Realization of control algorithm in LabVIEW system

A change of each of three serial chain length causes at the same time a change of platform operational point coordinates in space. So that platform operational point movement could take place on specified trajectory there is necessary checking and controlling of changes of manipulator operational elements length with pneumatic cylinders. It is connected to necessity of measuring of single serial chain linear length in the given moment and also to possibility of influence on given chain length change. This task can be carried out by proper controlling of pneumatic valves. For realization of this task there was built measuring-controlling system which consists of central unit with data acquisition card with analogue inputs and outputs. Auxiliary tool is environment LabVIEW, which gives possibility of applying this card to read-out of analogue signals from potentiometers measuring strokes of pneumatic cylinders and possibility of giving voltage signals to valves. The set of valves sends operational medium – air to proper cylinders chambers. In drawing 3 there is presented algorithm of software which was elaborated in environment LabVIEW:

Elaborated software in environment LabVIEW, which from one side gets given coordinates X, Y, Z, in which platform operational point should be positioned, as the input and output data. These coordinates can be the successive points of manipulator operational point movements trajectory. These values are also input data for solving of kinematics inverse task [7], of which solution are movements of particular cylinders l1, l2, l3 (in other words lengths of particular serial chains). Calculated lengths are input parameters for block in which there is carried out comparison of calculated values with real lengths of single chains. Real lengths of serial chains are measured with wire potentiometers. These sensors being the sensors of displacements have voltage signals on output, which are collected by data acquisition card. Voltage signals which are read-out and converted into values of movement distances l1m, l2m, l3m are sent to the block where there are compared real and calculated values. Depending on that if particular cylinder must be withdrawn or pushed out, for obtaining demanded value, acquisition card sends voltage signal (V1, V2, V3) to pneumatic valve which depending on voltage value fills proper pneumatic cylinder's chamber. And wire potentiometers will be constantly checking if selected cylinder will be in its proper position.. In drawing 4 there is presented structure of wire potentiometer:

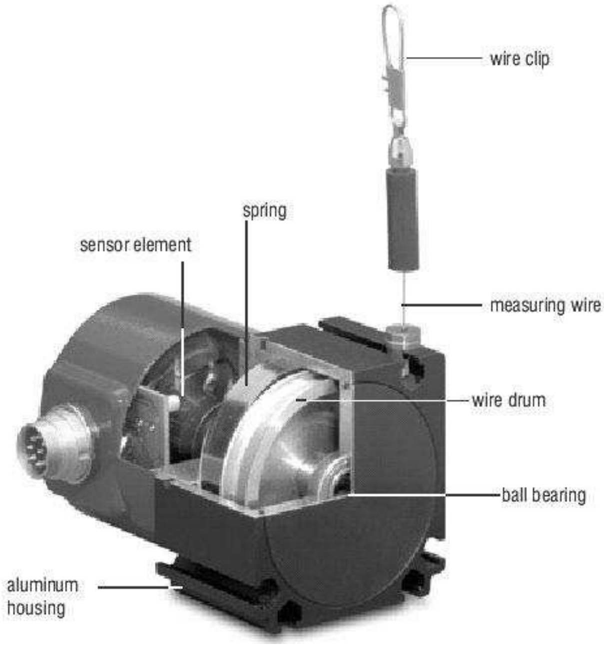


Fig. 6. Fragment of wire potentiometer structure essential elements

Summary

Proposed measuring-controlling system needs verification by parallel manipulator prototype, which is on stage of material manufacturing. There was preliminary verified system of collecting signals from potentiometer and sending proper signals to pneumatic valve. Preliminary analysis positively verified the model conception and confirmed the assumption that controlling in environment LabVIEW is correct and can be applied for controlling of parallel manipulator.

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