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PHD THESIS SUMMARY

CONTRIBUTIONS TO THE FUNCTIONAL AND CONSTRUCTIVE PARAMETERS IMPROVEMENT OF ELEPHANT'S TRUNK ROBOTIC ARMS

by
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Robotic arms with the structure similar to elephant's trunk are an increasingly concern for design engineers because of their usage in industrial and medical applications through some advantages as: spatial positioning, flexible positioning and accuracy, inside narrowed spaces of various bodies and human body. The scientific study aims to improve functional and constructive parameters of elephant's trunk robotic arms by theoretical and experimental researches conducted on a novel robotic arm structure.

The thesis content is organised in 6 chapters as follows:

- The 1st chapter refers to a critical study of current accomplishments on performances and designs of elephant's trunk robotic arms. It is highlight, firstly, the followed and accomplished objectives of this type of robotic arm according to the requirements of practical applications. This chapter includes both a classification of current worldwide existent solutions with specific performances and spatial positioning potentials according to different types of mechanical systems used to provide motion transmission between motor axis and the robotic arm joints. Also, it is emphasised the current accomplishments on theoretical and experimental researches referring to the kinematics and dynamics of elephant's trunk robotic arms with a high number of freedom degrees. The dynamics of elephant's trunk robotic arms is taken into account both for ideal and real (elastic) actuation wires/cables to highlight the variation of transitory regime in the work space which is differentially influencing the end-effector trajectory error.
- The 2nd chapter refers to original researches regarding the influence determination of geometrical parameters variation on positioning precision for different types of elephant's trunk robotic arms structures: one with 8 degrees of freedom which consist in 4 joints with two degrees of freedom and another one with 6 degrees of freedom which consist in 6 joints with one degree of freedom. It is determined the inverse and direct geometric model of the mentioned robotic structures to obtain the positioning errors for different quality specifications of structural elements (IT6, IT7 and IT8). The analytical method is used to determine the values of positioning errors of both mentioned robotic arms structures which are included afterwards in the command system algorithm for compensation and, thus, for obtaining an increased positioning precision. Based on the obtained mathematical model, it is further determined the work space of a novel elephant's trunk robotic arm structure with 6 degrees of freedom.
- The 3rd chapter refers to original theoretical contributions regarding the conceptual execution of an elephant's trunk robotic arm structure driven by wires through inner structure

and with a closed loop actuation system for each joint. The novel robotic arm conceptual design enables to obtain a small diameter reported to its length through modular serial coupling of several joints which guarantee a high flexibility as well as spatial positioning. The novel structure design has an indirectly measuring system to each joints position for which reason the mechanical wire transmission system stands out of the closed loop control system, and all disturbance factors during operation affect positioning precision of the robotic arm.

The main disturbance factors of positioning precision taken for the research study are given by:

- The influence of actuating wires length change as a cause of winding and unwinding on inner circular surfaces form structure interior. Each joints of the robotic arm has a different length variation of actuating wire according to the radius of circular surfaces and the rotation angle of previous joints.

- The influence of actuating wires stiffness on positioning precision comes as a consequence of resistant moment on each joint according to the manipulated object weight, the weight of carried joints, and the instant resistant moment of joint.

- The influence of accumulated wires elastic deformations on positioning precision.

- The influence of actuating wires friction to joints interior on positioning precision with a rolling friction between wires and interior surfaces of the robotic arm.

A method for improving positioning precision is studied approaching the actuating wire stiffness optimisation by pretensioning mechanisms. Thus, for each joint it is analytically obtained the value of pretensioning forces applied on actuating wires according to joint moment of resistance. The analysed method is provides a stiffness optimisation of mechanical transmission with wires by maximum 50%.

- The 4th chapter refers to the experimental test stand and the measuring systems used for data colleting. The experimental test stand is designed for analysing positioning precision of a poly articulated robot arm with irregular shape workspace and controlled joints axis driven by wires through the interior arm structure. Experimental researches emphasise the variation of positioning precision in the workspace depending on the disturbance factors theoretically analysed in chapter 3: the friction of actuating wires, the deviations of structural elements, the applied pretesioning force on actuating wires.
- The obtained results of experimental tests regarding positioning precision of the poly articulated robotic structure are given in chapter 5.
- Chapter 6th refers to synthesised general conclusions given from thesis content and original contribution regarding the methodology of theoretical and experimental researches approached for positioning precision optimisation of the novel elephant’s trunk robotic arm. Also, it is emphasised the possibility for further original researches regarding poly articulated robotic arms optimisation through industrial applications requirements with structure arms of one degree of freedom joints.