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Approach on Conceptual Design and Dimensional Synthesis of the Linear Delta Robot for Additive Manufacturing

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Abstract : In recent years, robots manipulators with parallel architectures are used in additive manufacturing processes – 3D printing. These robots have advantages such as speed and lightness that make them suitable to help with the efficiency and productivity of these processes. Consequently, the interest for the development of parallel robots for additive manufacturing applications has increased. This article deals with the conceptual design and dimensional synthesis of the linear delta robot for additive manufacturing. Firstly, a methodology based on structured processes for the development of products through the phases of informational design, conceptual design and detailed design is adopted: a) In the informational design phase the Mudge diagram and the QFD matrix are used to aid a set of technical requirements, to define the form, functions and features of the robot. b) In the conceptual design phase, the functional modeling of the system through of an IDEF0 diagram is performed, and the solution principles for the requirements are formulated using a morphological matrix. This phase includes the description of the mechanical, electro-electronic and computational subsystems that constitute the general architecture of the robot. c) In the detailed design phase, a digital model of the robot is drawn on CAD software. A list of commercial and manufactured parts is detailed. Tolerances and adjustments are defined for some parts of the robot structure. The necessary manufacturing processes and tools are also listed, including: milling, turning and 3D printing. Secondly, a dimensional synthesis method applied on design of the linear delta robot is presented. One of the most important key factors in the design of a parallel robot is the useful workspace, which strongly depends on the joint space, the dimensions of the mechanism bodies and the possible interferences between these bodies. The objective function is based on the verification of the kinematic model for a prescribed cylindrical workspace, considering geometric constraints that possibly lead to singularities of the mechanism. The aim is to determine the minimum dimensional parameters of the mechanism bodies for the proposed workspace. A method based on genetic algorithms was used to solve this problem. The method uses a cloud of points with the cylindrical shape of the workspace and checks the kinematic model for each of the points within the cloud. The evolution of the population (point cloud) provides the optimal parameters for the design of the delta robot. The development process of the linear delta robot with optimal dimensions for additive manufacture is presented. The dimensional synthesis enabled to design the mechanism of the delta robot in function of the prescribed workspace. Finally, the implementation of the robotic platform developed based on a linear delta robot in an additive manufacturing application using the Fused Deposition Modeling (FDM) technique is presented.

Keywords : additive manufacturing, delta parallel robot, dimensional synthesis, genetic algorithms
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