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# Design and Development of an Optimal Fault Tolerant 3 Degree of Freedom Robotic Manipulator

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**Abstract :** Kinematic redundancy within the manipulators presents extended dexterity and manipulability to the manipulators. Redundant serial robotic manipulators are very popular in industries due to its competencies to keep away from singularities during normal operation and fault tolerance because of failure of one or more joints. Such fault tolerant manipulators are extraordinarily beneficial in applications where human interference for repair and overhaul is both impossible or tough; like in case of robotic arms for space programs, nuclear applications and so on. The design of this sort of fault tolerant serial 3 DoF manipulator is presented in this paper. This work was the extension of the author's previous work of designing the simple 3R serial manipulator. This work is the realization of the previous design with optimizing the link lengths for incorporating the feature of fault tolerance. Various measures have been followed by the researchers to quantify the fault tolerance of such redundant manipulators. The fault tolerance in this work has been described in terms of the worst-case measure of relative manipulability that is, in fact, a local measure of optimization that works properly for certain configuration of the manipulators. An optimum fault tolerant Jacobian matrix has been determined first based on prescribed null space properties after which the link parameters have been described to meet the given Jacobian matrix. A solid model of the manipulator was then developed to realize the mathematically rigorous design. Further work was executed on determining the dynamic properties of the fault tolerant design and simulations of the movement for various trajectories have been carried out to evaluate the joint torques. The mathematical model of the system was derived via the Euler-Lagrange approach after which the same has been tested using the RoboAnalyzer© software. The results have been quite in agreement. From the CAD model and dynamic simulation data, the manipulator was fabricated in the workshop and Advanced Machining lab of NED University of Engineering and Technology.

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