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A Review On SCARA Manipulator For Various Applications

[1]Dr.PVS Subhashini, [2] L Sai Sandeep, [3] E Karnuakar, [4] Dr.NVS Raju
[1] Assistant Professor ,[2] M.E Student, [3]M.E student [4] Professor

Abstract: -- Selective Compliance articulated robot arm (SCARA) is an accepted robotic manipulator for industrial applications. Earlier SCARA manipulator was used exclusively for assembly purposes like printed circuit board, pick and place etc. But at present research on SCARA widens in the areas of production operations and for medical applications.The present paper will be a review on SCARA manipulator for various applications which includes literature on SCARA kinematics, dynamics and applications. This paper presents kinematics and dynamics of a SCARA robot using techniques like modeling, mathematical etc. In the literature most of the authors used packages like solid works, NX, MATLAB, ANSYS for analyses purpose. Overall this paper presents literature for the SCARA manipulator to a greater extent.

Keywords: SCARA manipulator, Review, Literature, Kinematics, Dynamics, Applications

I. INTRODUCTION

SCARA is an acronym for Selective Compliance Assembly Robot Arm (or) Selective Compliance Articulated Robot Arm which can be anywhere from 3-6 axis. It has two revolute joints that are parallel which allows the Robot to move in a horizontal plane, plus an additional prismatic joint that moves vertically. Generally, the applications of SCARA robot vary depend on the type of work. They are compact in size, High speed and has low vibrations. SCARA robots can be used in Transport and assembly of electronic components, automobile components, Medical applications, packaging and many more.

Fig (a) SCARA Robot [Courtesy - ADEPT]

II. SCARA KINEMATICS AND TRAJECTORY

B. Francisco Franco Obando et al. [2] discussed the merits of operational space control for a SCARA robot. The proposed Controller is correlated to an identical one but determined in the join space. The simulation results were considerable which led to the capability of approach mentioned earlier. Tracking performance was tested with various complicated trajectories in order to enhance the functioning of SCARA robot.

C. Serena Ruggeri et al. [3] introduced a new algorithm named kinetostatic calibration which doesn't need the aid of a sensor to measure robot pose which ignores the problems related to the device used. Paradoxically, a robot gripper with a force sensor is used in order to record the contact forces as locations on the robot gripper, whereas the end effector pose can be predicted utilizing a kinetostatic manipulator model. The predefined force used to touch the gripper is known as calibration object. The calibration parameters are geometrical dimensions, the robot compliance and the backlash. The calibration portrays the algorithm used to obtain experimental results of a SCARA robot.

E. Ignacio Herrera-Aguilar et al. [5] consolidated various kind of sub-systems which permits a service robot to gain more capability in different areas of work. An alternative method was applied to manipulator robots by concurrence of unique techniques were implemented in different areas of robotics like motion planning, trajectory planning and control strategies. Finally the configured SCARA robot is simulated and validated.

K. Ibrahim et al. [11] developed a CAD model using solid works in order to overcome the complexity involved in mathematical modeling and this model is imported to matlab for further analysis. PID controllers have been used to control the motion of joints for robots in order to get the required trajectory. It was observed that the performance for pick and place applications was less than 1% error and also suggested that SCARA manipulator can be used in medical applications if its accuracy can be enhanced.

P. Durga Rao et al. [16] proposed some major changes of a SCARA robot which are capable of pick and place operations like part handling, assembly etc. Many controllers were designed and used to control SCARA robots which meet the desired requirements of positioning. Basically, if plant parameter changes it affects the performance which is the major setback. In order to overcome the drawback, Quantitative feedback theory (QFT) is proposed for a single and two link SCARA robot.

T. Ma et al. [20] developed a high speed SCARA robot which has the possibility for fast handling. After analyzing the mechanical structure of SCARA robot, the kinematics equations were augmented to understand the forward and inverse kinematics problems established using modified D-H co ordinate system. The trajectory was achieved by utilizing the cubic polynomial interpolation method. The kinematics and trajectory planning were simulated with the help of MATLAB and the output showed that robot parameter design is decent enough and trajectory planning with the use of interpolation calculation is attainable.

U. Jian Fang et al. [21] proposed a model for 4 DOF SCARA robot. With the use of MATLAB, robotics toolbox forward kinematics of the robot inverse kinematic simulation is done. From the simulation results it is inferred that the motion of each joint SCARA robot state verification, the proposed model is correct which the desired requirements.

III. SCARA DYNAMICS

A. Vigen Arakelian et al.[1] presented the shaking force and shaking moment of the SCARA robot. The dynamic reaction forces on the frame of the manipulator were terminated by conventional approach in order to make the movable links immobile. The reaction forces on the manipulator were excluded with the aid of a optimal control. A Numerical simulation has been carried out using ADAMS package such that the SCARA robot doesn't disseminate inertia loading.

D. Mahdi Salman Alshamasin et al. [4] developed a mathematical model of a SCARA robot including servomotor dynamics conferred with dynamic simulation. The equations of kinematics were derived using D-H Notations. The SCARA robot was designed so as to accomplish the drilling operation using solid dynamic package. The robot-actuator system performance is scrutinized with the help of solid dynamics package and the results were verified using MATLAB/simulink software.

F. Aliriza Kaleli et al. [6] studied about the RRP-SCARA serial type manipulator. In order to obtain the complete dynamic model of the moving based manipulator, Lagrange-Euler approach is used. In addition to this, Virtual Instrumentation (VI) is prospered for kinematics and dynamics simulation and the animation is also collaborated with the moving-base system. Utilizing the designed VI in lab view; the alliance between frequency of disturbances of the moving base and the joint torques are scrutinized and the results are obtained by plotting graphs.

G. Fernando Passold et al. [7] illustrated the experimental results achieved by applying artificial neural networks (NNs) so as to perform the position control of a SCARA robot. A Neural controller is used which operates in parallel with a conventional controller containing a feedback system. Two NNs are used, one for position loop control and another to the force loop control. The main purpose was to compensate the dynamical effects of a manipulator when it is in contact with the surroundings. Successfully, the results were achieved and also the potential problems regarding the force loop control were included.

H. Nitish Kumar Jaiswal et al. [8] developed a 3 DOF SCARA robot manipulator and implemented dynamic modeling which is based on Lagrange Euler formulation with the aid of Mazami based fuzzy controller. The need of using Mazami based fuzzy controller is used in order to overcome the limitations conventional PID controllers which cannot give adequate result. The performance of controller is calculated with the help of MATLAB/simulink and is measured in terms of time response.

I. Selwin et al. [9] developed a mathematical model for a 3 link SCARA manipulator in order to suit for several applications and also can be utilized for many purposes. A mathematical model for a 3 link SCARA manipulator was developed using Lagrangian mechanics in order to find the torque calculation and also to meet the desired specifications for trajectory planning. The path description is confirmed with use of matlab and then analyzes the effective movement of end effector using the values generated from the model. Finally, a prototype is developed in order to enhance the redundancy, maneuverability, workspace, complexity with more degrees of freedom.

J. Navalerk Prajumkhaiy et al. [10] proposed a friction compensation method for a SCARA robot. While in operation, the friction is generated in robot which causes heat generation to the system which leads to the damage of robot. The heat which is accumulated for a longer time in the system affects the performance and stability in the robot. Therefore, in order to increase the performance and stability a disturbance observer is utilized with mathematical modeling of friction compensation. From the simulation results, the friction force compensation can further increase the stability and performance.

L. Niphun Surapong et al. [12] mentioned that force sensors are used so as to measure the external force and also advised that the action is not found outside the end effector. They designed a disturbance (DOB) observer in order to control the force and position which is replaced in the place of force sensors which are not affordable. To enhance the performance and the robustness, SCARA robot is made to draw a parabola on the board with a pen at end effector.

M. Ali Medjebouri et al. [13] compared the Feedback Linearization Control and proposed a technique named Active Disturbance Rejection Control which does not require an accurate mathematical representation of the system, as it is based on the online estimation and repudiate the unmodeled elements of the dynamics. Robustness of the closed-loop control system (against external perturbation and uncertainty in parameters) is mentioned here. A model of a SCARA robot manipulator is used in the accompanied case study as an exemplary plant. The above mentioned control strategy for a two–link SCARA robot manipulator electrically controlled has been verified with aid of MATLAB.

N. Sergent et al. [14] provided a detailed study in stability analysis of force controlled robot systems assimilating high frequency structural dynamics. Experimental results were included for the stability analysis of a force controlled system. The outcome of low pass filtering within the closed loop system is calculated. The main is to present a design procedure which reduces the destabilizing effects of structural arm dynamics in force controlled manipulator systems.

R. Philip Voglewede et al. [18] reviewed the polynomial chaos theory (PCT) which can be utilized for manipulator dynamic analysis and controller design in a 4-DOF SCARA manipulator with distinction in the link masses and payload. This includes a simple linear control algorithm into the formulation in order to show the capability of the PCT framework.

IV. LATEST APPLICATIONS OF SCARA ROBOT

O. Arne Burisch et al. [15] described the development of a micro parallel SCARA robot which is altered in the size to MEMS products. The reason for optimization is concerned with smaller structure which has dimensions of almost chip card size so as to enhance the performance. The robot mostly supports the use of four degrees of freedom with a base area of 22500 mm² which is a co-operative between the machine tools and production technology. The company is an innovative manufacturer of zero backlash gears which drives the pivotal robot.

Q. Saravana Mohan Mariappan et al. [17] made an attempt in Modeling of PRRP (Prismatic-Revolute-Revolute-Prismatic) , configuration redundant SCARA (Selective Compliance Articulated Robot Arm), robot with a Multi spindle drilling tool (MSDT) with the aid of SolidWorks package, and the dynamic study is done by utilizing MATLAB/SimMechanics. The SCARA with MSDT is used to drill multiple holes in the printed circuit boards (PCBs) and sheet metal. The main aim was to develop a 3D CAD model of the mentioned robot which is converted into SimMechanics block diagram by exporting it to the MATLAB/SimMechanics. Then the SimMechanics simulation is done with the use of motion sensing

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capability, the dynamic parameters velocity and torque of the manipulator are observed in order to modify the robot structure. The simulation results indicate the favorable change in the dynamic performance.

S. C.Urrea et al. [19] proposed 3 controllers for a SCARA robot named hyperbolic sine-cosine, sliding mode and calculated torque are applied to the mentioned model. The simulation environment was developed with the aid of MATLAB/Simulink programming tools which is employed to perform various tests on the model of the redundant manipulator using different controllers and the results were obtained.

PVS. Subhashini et al. [22] analyzed a SCARA robot which is applied for deburring parts having circular profile and the operation time for deburring was fixed as 6 seconds. A Complete mathematical modeling is carried out for kinematics and equations were derived using Denavit-Hartenberg notation. In the present case, SCARA robot is modeled using CAD software and the motion simulation is carried out. Various kinematic parameters like joint angles, positions and velocities are calculated using CAD software and compared with the output obtained by using MATLAB. All the results obtained matched fairly and the conception for deviations maybe that while MATLAB solves the equations directly through symbolic language code
whereas the analysis by other codes and software's are carried out through numerical schemes.

V. CONCLUSION

The present paper is a review on SCARA manipulator for various applications which presented literature on SCARA kinematics, dynamics and applications. This paper presented kinematics and dynamics of a SCARA robot using techniques like modeling, mathematical etc. In this review most of the authors used software packages like solid works, NX, MATLAB, ANSYS for analyses purpose. Overall this paper described literature of the SCARA manipulator to a greater extent.

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