

SIMULATION OF TRAJECTORY GENERATION FOR DUAL ARM ROBOT

MANGA V, SEETHARAMAN N*

Lecturer, IRT Polytechnic College, Chennai 600044 , India

Scientist G, CVRDE, Chennai 54, India

* Corresponding Author

vmanga2007@gmail.com, roboraman2007@gmail.com

ABSTRACT

A This paper aim is to carry out the simulation of dual arm cooperative manipulator and develop different mission demanded custom based trajectories. Since the dual arm will be in folded condition on a mobile platform, it has to be deployed during mission to detect buried objects below the ground by means of remote control from a base vehicle through telemetry command and control. This paper discusses the method to control dual arm robot for task-space system with highly uncertain kinematics and dynamics. Trajectory generation simulations are presented to validate the performance of the developed control algorithms dual arm robot. The MATLAB based deployment of dual arm manipulator using simulation is discussed. The simulation generated trajectory of dual arm cooperative manipulator for mission requirement of deploying from folded condition for using in unmanned teleoperated vehicle is accomplished and high scope of using this method in embedded system is elaborated. By porting on to a real time embedded controller with ease of feeding parameters of any serial or dual arm robot, the trajectories can easily be generated in physical hardware.

Keywords

algorithm; modelling; simulation; Controller; actuators; robot

1. Introduction

The main objectives of this paper is to carry out the simulation of dual arm cooperative manipulator and develop different mission demanded custom based trajectories. Since the dual arm will be in folded condition on a mobile platform, it has to be deployed during mission to detect buried objects below the ground by means of remote control from a base vehicle through telemetry command and control. This work aims for developing a robust trajectory to manoeuvre the dual arm end effector to scan the ground surface for presence of land mine in front of the mission vehicle. This situation

compels to develop suitable algorithms and simulate trajectory autonomously without a manned control. Methodology of obtaining a time schedule of velocities and accelerations along the path that the manipulator may adopt to obtain a minimum traveling time, under the constraints of composite linear and angular velocities and accelerations with Cartesian limit has been considered as presented by Luh and Lin [1]. Also proposed a method of control system parameter design by a numerical simulation and heuristic optimization for the mobile robot. As it is difficult to decide suitable parameters by analytical technique because of its non-linearity and complexity, it is described by the model of the system as iterative numerical calculation instead of analytical time function. A controller demonstrated by Yen-Chen Liu (2014) [3] based on the adaptive laws and the position tracking in the task space when robots are in free motion or subject to passive force has been considered to address the control scheme. This paper discusses the control problem for task-space system with uncertain kinematics and dynamics. Numerical simulations are presented to validate the performance of the developed control algorithms for trajectory generation.

2. DUAL ARM ROBOT MANIPULATOR TRAJECTORY GENERATION

2.1. Description of robot

Dual arm robotic arm mounted to the remotely controlled land platform. Mobile platform is operated from a manned control station through telemetry technology. Double arms will deploy scanning sensor for acquiring images of material below the ground surface. Using embedded programming the joints are operated and controlled by means of embedded controller with suitable closed loop control based on the signals from onboard sensors like acoustic ultrasonic distance sensors, Inertial Measurement Unit (IMU) and array of accelerometers. The 5 Degree of Freedom (DoF) in each robotic arm are base turret twist (T), back arm rotation (R), fore arm rotation (R), fore arm linear actuation (L) and rotation of end effectors (R). The configuration of this arm is TRRLR and is represented in Figure.1

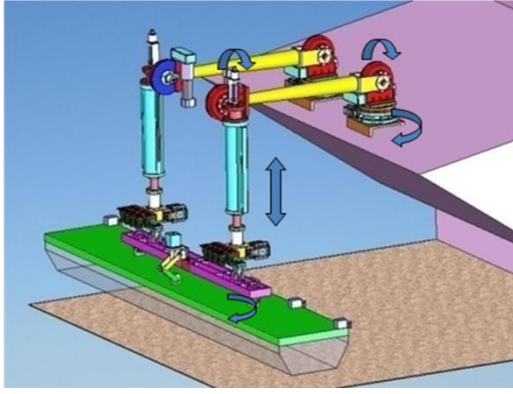


Fig. 1. Dual arm robotic manipulator with sensor

2.2. Proposed Trajectory Generation Method

The dual arm has to be deployed from folded condition to mission position for mine detection role as in figure 2. The position of each link is continuously monitored by the respective encoder in each joint and these will facilitate to control the corresponding actuator accurately. The goal of motion planning of a robot is to generate a function depending on the robot task according to which a robot will move. The point- to-point and continuous-path motion are the general types of motions for which the trajectory planning algorithm computes the inputs for the motion controller to generate the desired trajectory.

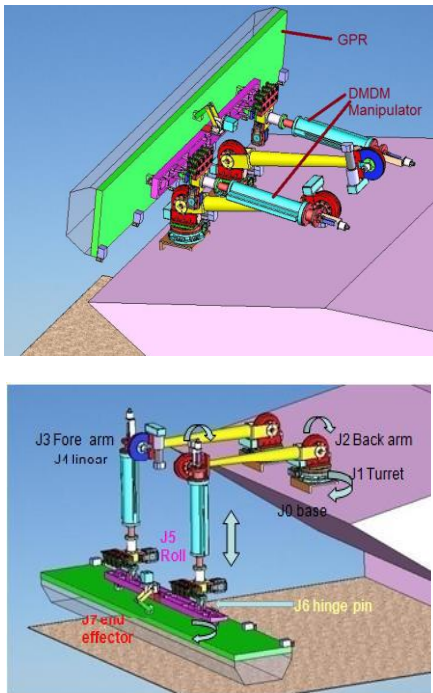


Fig. 2. Folded and deployed condition of dual arm manipulator

A trajectory is a function of time $q(t)$ such that $q(t_0) = q_{init}$ and $q(t_f) = q_{final}$. In this case, $t_f - t_0$ represents the amount of time taken to execute the trajectory, where q is position. Since the trajectory is parameterized by

time, velocities and accelerations are computed along the trajectories by differentiation.

2.3. Linear Segment Parabolic Blend (LSPB)

Linear segment parabolic blend (LSPB) [4] is an appropriate joint space trajectory generation method when a constant velocity is desired along a portion of the path. In LSPB trajectory the velocity is initially “ramped up” to its desired value and then “ramped down” when it approaches the goal position. To achieve this we specify the desired trajectory in three parts. The first part from time t_0 to time t_b is a quadratic polynomial. This results in a linear “ramp” velocity, ‘V’. At time t_b , called the blend time, the trajectory switches to a linear function. This corresponds to a constant velocity. Finally, at time $t_f - t_b$ the trajectory switches once again to a quadratic polynomial so that the velocity is linear. The blend time t_b is chosen that the position curve is symmetric.

The portion of the trajectory between $t_f - t_b$ and t_f is found by symmetry considerations. The complete LSPB trajectory is given as

$$q(t) = \begin{cases} q_0 + \frac{a}{2}t^2 & 0 \leq t \leq t_b \\ \frac{q_f + q_0 - Vt_f}{2} + Vt & t_b < t \leq t_f - t_b \\ q_f - \frac{at_f^2}{2} + at_ft - \frac{a}{2}t^2 & t_f - t_b < t \leq t_f \end{cases}$$

2.4. Trajectory for deployment of dual arm

Here the arm is deployed from its safe storage position to the ready position with 300mm clearance from the ground as shown in figure 3. The folding and deployment operations are carried with maximum velocity of 4°/sec for revolute joints and 5mm/sec for prismatic joints to meet the power requirement of the actuating Brushless DC motor (BLDC).

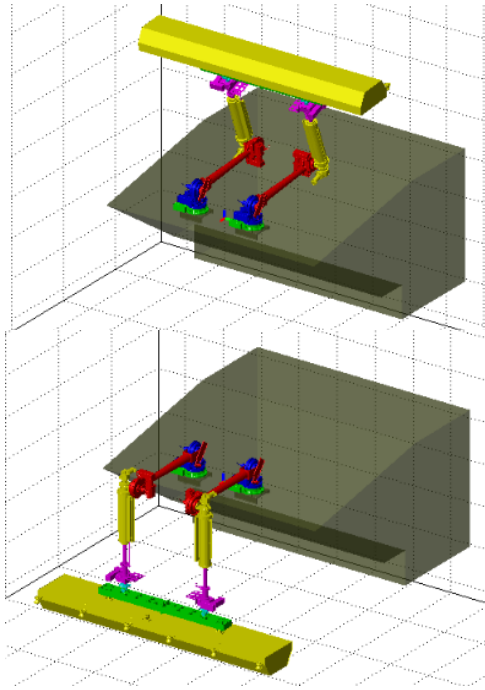


Fig. 3. Initial and final position of deployment

2.5. Joint parameter for folded and deployed conditions

Table 1. Joint values of dual arm for deployment

Joint Values		
Joint	Initial	Final
Turret	0°	0°
Shoulder	-175°	0°
Elbow	0°	15°
Forearm	0 mm	0 mm
Wrist	0°	0°
Sensor	0.0°	0.0°

Table 2. Joint values of dual arm for folded position

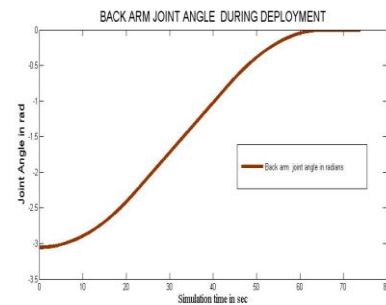
Joint Values		
Joint	Initial	Final

Turret	0°	0°
Shoulder	0°	-175°
Elbow	0°	0°
Forearm	0 mm	0 mm
Wrist	0°	0°
Sensor	0°	0°

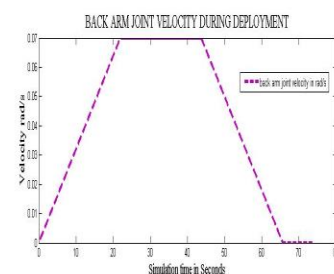
3. Results and Discussion

3.1. Simulation Results of Forward Kinematics for Deployment

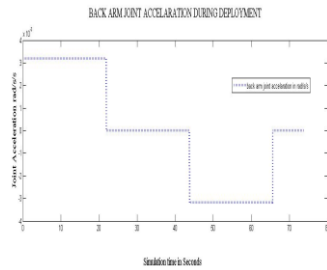
Deployment is performed when the mine detection process is initialized, and the arm is deployed from its home position to the mission position with 300mm clearance of end effector from the ground. The MATLAB based deployment of dual arm manipulator using simulation is as in figure 4. The simulation result shows the angular displacement of back arm was completed by the forward kinematics of the DMDM manipulator from initial position to final position travel. It is observed from joint parameters that for an angular displacement of 175o the angular velocity of the back arm joint ranges from 0 to 4o/s and the angular acceleration of the joint varies from -0.18 to 0.18o/s². The normal, orientation, approach and position vector. This is represented in MATLAB simulation as given in figure 5.



(a)



(b)



(c)

Fig. 4. Joint space trajectory of back arm during deployment (a) angular displacement, (b) angular velocity and (c) angular acceleration

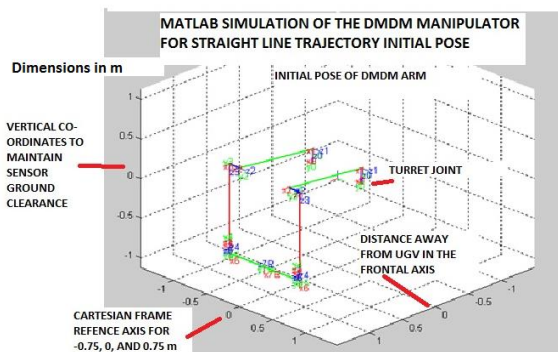


Fig. 5. MATLAB simulation output after deployment

4. Conclusion

The simulation generated trajectory of dual arm cooperative manipulator for mission requirement of deploying from folded condition for using in unmanned teleoperated vehicle is accomplished. Since the dual arm will be in folded condition on a mobile platform, it has to be deployed during mission by commanding and controlling for 5x2 degree of freedom to detect buried objects below the ground by means of remote control from a base vehicle through telemetry command and control. This work of developing the algorithm and modelling and simulating in MATLAB to generate the robust trajectory to manoeuvre the dual arm end effector to scan the ground surface for presence of land mine in front of the mission vehicle is a fore runner for porting to the embedded real time controller. The development of suitable algorithms and simulate trajectory autonomously without a manned control has high scope of future implementation for any complex serial or dual arm robotic arm.

References

- [1] Luh, Y.S. & Lin C.S. 1981, "Optimum path planning for mechanical manipulators", Journal of Dynamic System Measurements and Control, vol .103, no. 2, pp. 142-151
- [2] Watanabe, A. Ohya, A. Yuta, S. 2011, "Control parameter design for robot vehicle based on numerical simulation and heuristic optimization - Feed-back controller design for trajectory tracking under strict

physical constraints in wide speed range", IEEE Symposium on Computational Intelligence in Control and Automation(CICA), pp. 137 - 142

- [3] Yen-Chen Liu. 2014, "Control of bilateral teleoperation system for robotic manipulators with uncertain kinematics and dynamics", Cyber Technology in Automation, Control, and Intelligent Systems (CYBER), 2014 IEEE 4th Annual International Conference on, On page(s): 521 – 526
- [4] KeJun Ning, Tomas Kulvicius, Minija Tamosiunaite & Florentin Wörgötter 2012, 'A novel trajectory generation method for robot control', J. Intell. Robot System, pp.165-184.
- [5] Seetharaman, N, Sivaramakrishnan, R & Abin John Thomas 2013, 'Geometry Based Recursive Algorithm To Control The End Effector Of Coordinated TRRLR Manipulators', International Review of Mechanical Engineering (IREME), vol. 7, no. 5, July 2013, pp. 807-812, ISSN 1970-8734
- [6] Seetharaman, N & Sivaramakrishnan, R 2014, 'Fuzzy Control of Robotic Arms with Mine Detection GPR Sensor for Unmanned Mission Application on Undulated Terrain', International Journal of Trend in Research and Development, vol. 2, no. 1, pp.1-12, ISSN 2394-9333 <http://www.ijtrd.com>
- [7] Seetharaman, N & Sivaramakrishnan, R 2015, 'Joint Control of a TRRLR Mobile Manipulator for Unstructured Terrain', International Journal of Applied Engineering Research, vol. 10, no.3, pp.7673-7686, ISSN 0973-4562



Manga.V. received B.E degree in Computer Engineering from, Madurai Kamaraj University, India in 1991. Completed PG in M.E System Engineering and Operations Research from Anna University in year 2009. Serving as Lecturer for 26 years in IRT Polytechnic College



Seetharaman.N. received B.Tech degree in Automobile Engineering from Madras Institute of Technology, Anna University, India in 1987 and MTech degree in Modelling and Computer Simulation from University of Poona, India in 1992. Contributing to Ministry of Defence as Scientist in Defence Research and Development Organization. Awarded Best innovative and futuristic Technology award, 2009 of DRDO.