Department of Robotics & Mechatronics Engineering
University of Dhaka

Course code : RME 4111
Course name : Advanced Robotics Lab

Experiment no : 04
Experiment name : Forward kinematics of a manipulator using MATLAB.

Group no : 02
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Objective:

- Develop a MATLAB-based forward kinematics model
- Validate the forward kinematics model experimentally

Theory:

Industrial robotics frequently employs serial manipulators, which are made up of a chain of links connected by motor-actuated joints that stretch from a base to an end-effector. Often, the arm structures of these manipulators resemble a "shoulder," "elbow," and "wrist." Based on known link characteristics and angular locations, the forward kinematics of a serial chain manipulator entails identifying the location and orientation of two links. The position and orientation of the end-effector with respect to the base link are commonly determined using this method.

In many facets of manipulator simulation and control, forward kinematics is essential. In order to avoid collisions and determine the robot's present location, it makes it possible to determine the center of mass of the complete robot body. The Denavit-Hartenberg (D-H) approach, Product of Exponential methods, trigonometric methods, Cyclic Coordinate descent methods, and dual quaternion methods are a few of the methods frequently used to develop forward kinematics.

On the other hand, inverse kinematics is the opposite of forward kinematics. It calculates the necessary angular parameters required to achieve the desired position and orientation of the connections based on the desired position and orientation of the links as input. Geometric link parameter information is needed for inverse kinematics, just like it is for forward kinematics. Closed-form solutions and numerical solutions are two categories that inverse kinematic techniques fall under.

Due to its consistency and succinctness, the D-H approach is frequently employed for serial-chain manipulators, but it has several drawbacks. Methods including Taylor series approximation, support vector regression, quasi-closed solution, and neural network estimation are used for parallel manipulator robots. For the development of forward kinematics for cable-driven robots, neural network techniques are also appropriate.

In general, serial-chain manipulators and humanoid robot modeling, simulation, and control all require an understanding of forward and inverse kinematics. Depending on the requirements and limitations of the robotic system, several techniques are used.

Equipment:

- MATLAB Software

Procedure:

- First, The transformation matrices were defined to conduct the forward and inverse kinematics in MATLAB.
- Then, for the sake of simplicity and convergence the parameters of the transformation matrices were given the following values
- Finally, The D-H parameters were defined which were later given different values for simulation purposes.

Result:

The result obtained:

```
ans(4) =
   -0.5474   -0.8369         0     1.299
   -0.0000    0.0000    1.0000-1.629e-05
   -0.8369    0.5474   -0.0000    -4.436
         0         0         0         1
```

Simulation:

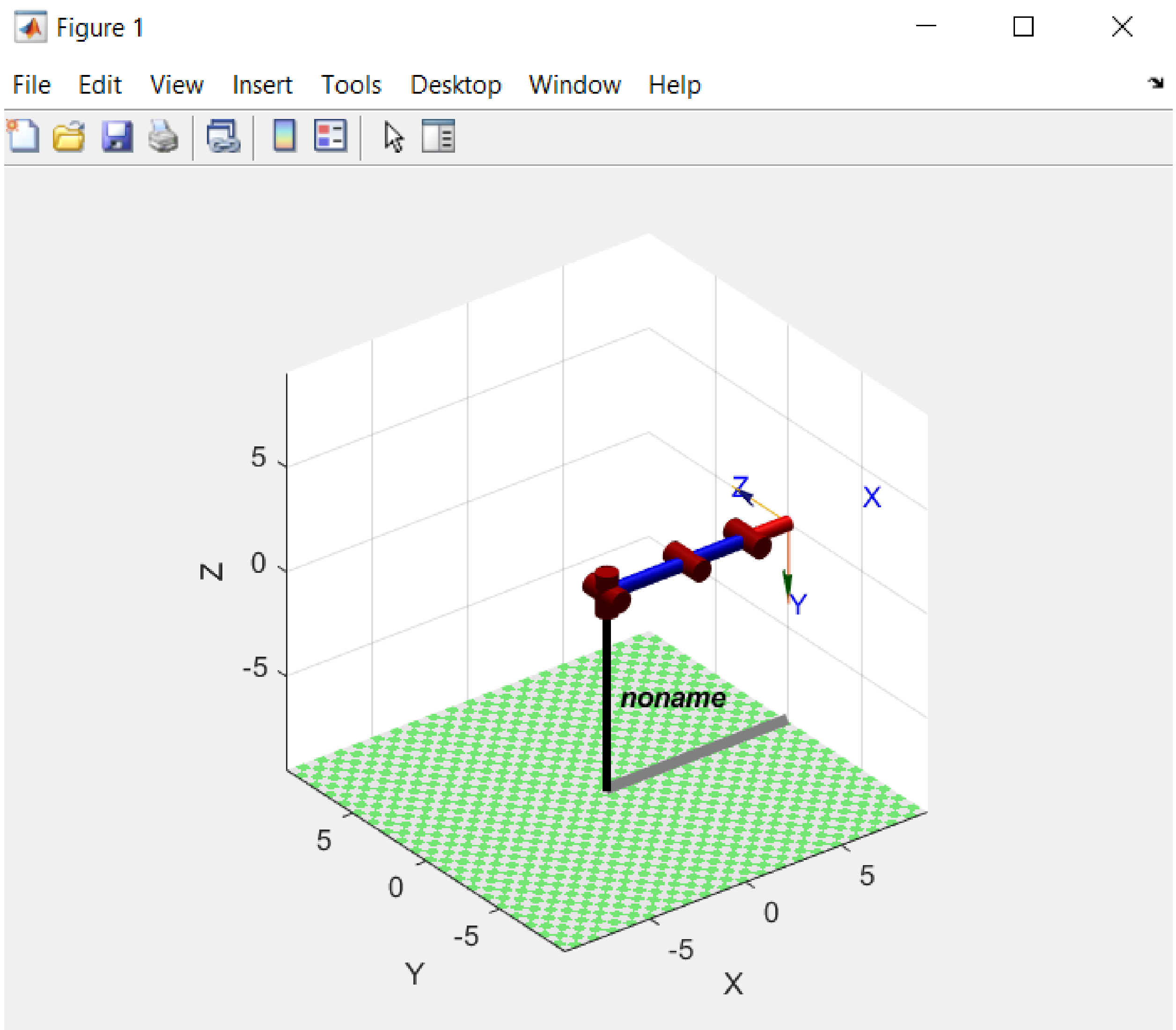

Figure 1
File Edit View Insert Tools Desktop Window Help
noname
Z
X
Y
Z
5
0
-5
Y
5
0
-5
X
5
0
-5

Discussion:

For a serial manipulator, the simulations of forward and inverse kinematics yielded important insights into the link between motion and important elements including transformation matrices and Denavit-Hartenberg (DH) parameters. These simulations made it possible to fully comprehend how to impact and regulate the motion of serial manipulators.

An improved understanding of how transformation matrices and DH parameters affect the motion of the serial manipulator resulted from the analysis of the simulations. The forward kinematics simulations demonstrated how the known joint variables and DH parameters can be used to determine the location and orientation of the manipulator's end-effector. The precise determination of the manipulator's workspace, the planning of trajectories, and collision avoidance depend on this information. The inverse relationship was clarified by the inverse kinematics simulations, which also made it possible to identify the joint parameters needed to accomplish the appropriate end-effector position and orientation. For jobs like motion planning, control, and robot programming, this knowledge is crucial.

The forward and inverse kinematics simulations using transformation matrices and DH parameters gave a thorough grasp of the manipulator's motion capabilities and control systems. This information can be used to enhance the reachability, performance, and overall operational effectiveness of the manipulator.

In different industries, including manufacturing, automation, and robotics, serial manipulators can be designed and developed using the insights from these simulations. Engineers and scientists may effectively describe, simulate, and regulate the motion of serial manipulators by utilizing the power of transformation matrices and DH parameters, which leads to better task execution, increased productivity, and improved robotic systems.

Group no-02

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Experiment no-04

Experiment name- Forward ~~and Inverse~~ Kinematics of a manipulator using MATLAB.

$$dh = \begin{bmatrix} 0 & 0 & 0 & -1.5708 \\ 0 & 0 & 4.2 & 0 \\ 0 & 0 & 3.15 & 0 \\ 0 & 0 & 2.15 & 0 \end{bmatrix}$$

$q_1 = 50.9$

$q_2 = 23.5$

$q_3 = -74.3$

$q_4 = -47$

$R = -97.827$

$P = -50.869$

$Y = -90.000$

$x = 3.501$

$y = 4.303$

$z = 2.900$