Experiment: 5

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1. Aim/Overview of the practical:

Local v. global coordinate frames; homogenous transforms

2. Task to be done:

Discuss the local & global coordinate frames and homogenous transforms. In Addition, implement as well as write down the steps to perform the homogenous transforms.

3. Theory :

Local Coordinate System:
A neighbourhood coordinate device (LCS) is fixed of x, y and z axes related to every node withinside the model. It is frequently ideal to apply a neighbourhood coordinate device for assigning constraints and masses to simplify the constraint or load to 1 direction.

With the Local Coordinate System tool, you may create and keep more than one neighbourhood coordinate system, however simplest one may be lively at a given time. All next modelling could be created relative to the lively LCS. If you set off the LCS as a modelling aircraft, new geometry could be created withinside the new XY plane for less difficult modelling.

Global Coordinate System:
The geographic coordinate gadget (GCS) is spherical or ellipsoidal coordinate gadget for measuring and speaking positions at once at the Earth as range and longitude. It is the simplest, oldest and maximum extensively used of the diverse spatial reference structures which might be in use, and paperwork the premise for maximum others.

The difference between Local and Global Coordinate Forms:

- Local coordinates with the origin within the element help facilitate algebraic operations in deriving the element matrix. Global coordinates help specify the position of each node, the orientation of each element, boundary conditions, and loads.

- For the entire domain, Local coordinate systems correspond to specific elements throughout the body and are commonly used to define nodes throughout the body. The global coordinate system corresponds to the body and is commonly used to define nodes for the entire body.

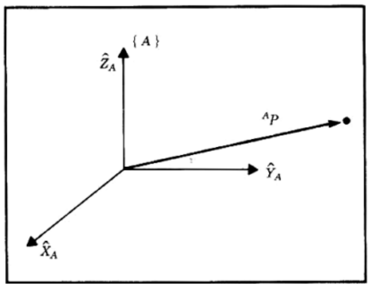
- The local coordinate system is an object-oriented system of frame or body elements. This is determined by the movement of the element, but the global coordinate system is often used to represent the entire structure or body. Not affected by object orientation. If an element moves, its position cannot be changed.

Homogeneous Transformation:
Homogeneous transformation matrices integrate each the rotation matrix and the displacement vector right into a unmarried matrix. You can multiply homogeneous matrices collectively much like you could with rotation matrices.

Homogeneous Vector

Cartesian Vector

$$^{A}P = \begin{bmatrix} p_x \\ p_y \\ p_z \end{bmatrix}.$$



Homogeneous Vector

$$^{A}P = \begin{bmatrix} p_x \\ p_y \\ p_z \\ 1 \end{bmatrix} \qquad ^{A}P = \begin{bmatrix} p_x \\ p_y \\ p_z \\ 0 \end{bmatrix}$$

(1) for position , (0) for direction (orientation)

Homogeneous Transformation

A 4x4 matrix which describes the motion of vector u to vector v

$$T = \begin{bmatrix} n_x & o_x & a_x & p_x \\ n_y & o_y & a_y & p_y \\ n_z & o_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

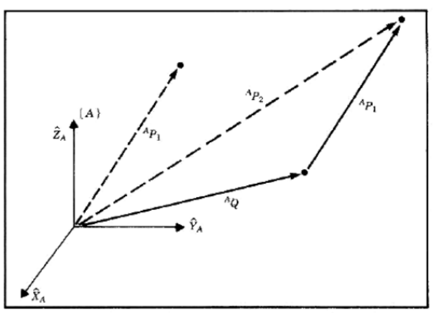
$$v = T\ u$$

Translation with q_x, q_y, q_z

$D_Q(q)=\text{Trans}(q_x, q_y, q_z)$

$$^{A}P_2 = D_Q(q)\ ^{A}P_1,$$

$$D_Q(q) = \begin{bmatrix} 1 & 0 & 0 & q_x \\ 0 & 1 & 0 & q_y \\ 0 & 0 & 1 & q_z \\ 0 & 0 & 0 & 1 \end{bmatrix},$$



Rotational Transformation

Rotation about z-axis with an angle Θ , R(z, Θ)

$$R(z,\theta)=\begin{bmatrix}\cos\theta & \sin\theta & 0 & 0\\ -\sin\theta & \cos\theta & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

Rotation about x-axis with an angle Θ , R(x, Θ)

$$R(x,\theta)=\begin{bmatrix}1 & 0 & 0 & 0\\ 0 & \cos\theta & \sin\theta & 0\\ 0 & -\sin\theta & \cos\theta & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

Rotation about y-axis with an angle Θ , R(y, Θ)

$$R(y,\theta)=\begin{bmatrix}\cos\theta & 0 & -\sin\theta & 0\\ 0 & 1 & 0 & 0\\ \sin\theta & 0 & \cos\theta & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

Homogeneous Transform- Four Definitions:

1. A matrix which specifies frame B in terms of frame A.
2. A matrix which maps a point expressed in frame B, BP, to a point represented as seen from frame A.
3. A description of an operator from frame A to frame B as in the case of a physical turn of rotation.
4. A 4x4 matrix with the structure given above and the inherited mathematical constraints on the included rotation matrix.