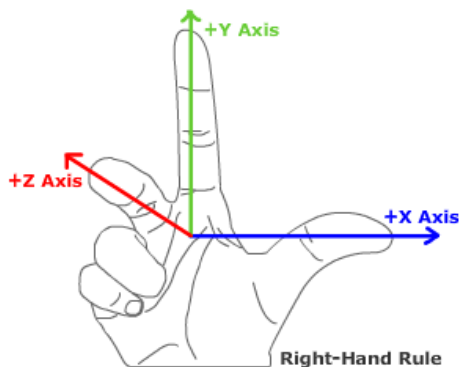# 07. Kinematics, inverse kinematics, Programming of a simulated robotic arm

Repetition

3D transformations

- **Position:** 3 element offset vector

+Y Axis

+Z Axis

+X Axis

Right-Hand Rule

- **Orientation:** 3 x 3 rotation matrix
    - additional orientation representations: Euler angles, RPY, angle axis, quaternion
- **Pose** (pose): 4 × 4 transformation matrix
- **Coordinate system** (frame): zero point, 3 axis, 3 base vector, right-hand rule
- **Homogeneous transformations:** rotation and translation together
    - e.g. $\mathbf{R}$ for rotation and $\mathbf{v}$ for translation:

$$ \mathbf{T} = \left[\matrix{\mathbf{R} & \mathbf{v}\\\mathbf{0} & 1 }\right] = \left[\matrix{r_{1,1} & r_{1,2} & r_{1,3} & v_x\\r_{2,1} & r_{2,2} & r_{2,3} & v_y\\r_{3,1} & r_{3,2} & r_{3,3} & v_z\\ 0 & 0 & 0 & 1 }\right] $$

- **Homogeneous coordinates:**
    - **Vector:** add 0, $\mathbf{a_H}=\left[\matrix{\mathbf{a} \\ 0}\right]=\left[\matrix{a_x \\ a_y \\ a_z \\ 0}\right]$