1. **Main challenges of controlling an anthropomorphic robotic arm.**

One of the fundamental control challenges is to maintain the desired control variable . The anthropomorphic robotic arm has to meet the position and force control goals. The position control goal ensures minimum error between the desired and actual movement. Depending on shape of the object to grasp, the finger joints must acquire desired position.

Force Control - When the robot hand does contact with the object, the challenge is to minimize the error with respect to the desired force. The sensors must ensure the system feedback given is comparable with a human hand. Impedance control force is once such strategy controlling the exerted force by the robotic arm over the environment.

Besides the above factors sensory noise would require attention in eliminating noise from the measure output.

2. **Approach guidelines of control design**

Goal : To build an efficient robot in terms of power consumption, precision) , and should have greater flexibility (modular structure).

The Approach and choice of the controller

Conception : The choice of end application drives the robot build process. The type of environment present in-front of the robot plays a crucial role in setting up the primary goals of the robot design such as type of gripper and choice of sensors for perception. Based on this factors , a preliminary road map of robotic structure is laid out. At this stage, the final structure of the robot is decided along with the choice of gripper and technology.

At first , it is essential to develop the mechanics of the robot. Based on the preliminary dimensions , I will work-out the forward kinematics , inverse kinematics, dynamics of the robot from the first principles. The joint angles and torques are derived based on the trajectory of the robot to be followed or planned.

Developing the plant of Robotic system : At this stage , building a plant model of the entire system in a robotic simulator environment (such as MATLAB-Simulink) is essential to optimise and minimize the control errors. The desired control variables will be achieved by tweaking the gains in the model and this process continues till a satisfactory response curve is achieved.

The final robot shape contains integration of relevant modules such as programing the onboard computer, mechanical design of the actuators , cabling, and building an API to interact with robot.

The choice of controller :

For precise jobs such as welding, milling, it is required to have excellent repeatability and robustness . Classical hard control techniques can be deployed in this situations. Compared to sliding mode, computed torque control - adaptive control has upper hand in minimising the error between the desired and actual control variable. Nevertheless, the cost of computation technique must be accounted.

In case of uncertain environments , it is important to have an intelligent robotic controller rather than focussing on precision. Fuzzy logic , Genetic algorithms , Neural Network were some of the existing techniques under

research and choice of controller depends on the degree of precision and resources available. Neural networks can be accurate to use but comes with high computation cost.