

ABSTRAK

Penelitian ini merancang robot lengan 5 *Degree of Freedom* (DoF) untuk melakukan *pick and place* objek berbentuk persegi dan lingkaran dengan kamera *onboard* menggunakan metode *inverse kinematics*. Sistem memanfaatkan mikrokontroler ESP32 sebagai pengendali utama serta satu motor *stepper* dan lima motor servo sebagai aktuator. Kamera mendeteksi objek berdasarkan warna dan bentuk menggunakan algoritma *Hue, Saturation, Value* (HSV) dan algoritma Canny dengan bantuan *library* OpenCV. Metode *inverse kinematics* diterapkan untuk menghitung sudut servo agar *end-effector* mencapai posisi target, sedangkan interpolasi linier menghaluskan pergerakan antar servo. Hasil pengujian menunjukkan algoritma HSV stabil terhadap perubahan cahaya, algoritma Canny (*threshold* 50–150) menghasilkan nilai *circularity* 0,999 untuk lingkaran dan 0,785 untuk persegi serta deteksi gabungan bekerja menggunakan sudut kamera 45° dengan rata-rata *error* pemetaan posisi sebesar 4,99 mm pada sumbu x dan 6,13 mm pada sumbu y. Pengujian *pick and place* terhadap objek merah dan biru berbentuk persegi maupun lingkaran menunjukkan robot berhasil mengidentifikasi, mengambil, dan memindahkan objek sesuai warna dan bentuknya secara konsisten.

Kata kunci: Robot Lengan 5 DoF, *Inverse Kinematics*, *library* OpenCV, HSV, Canny, Interpolasi Linier.

ABSTRACT

This research designs a 5-Degree of Freedom (DoF) robotic arm to perform pick and place operations on square and circular objects using an onboard camera and the inverse kinematics method. The system utilizes an ESP32 microcontroller as the main controller, along with one stepper motor and five servo motors as actuators. The camera detects objects based on color and shape using the Hue, Saturation, Value (HSV) algorithm and the Canny algorithm, assisted by the OpenCV library. The inverse kinematics method is applied to calculate the servo angles so that the end-effector reaches the target position, while linear interpolation smooths the movement between servos. Test results show that the HSV algorithm remains stable against lighting changes, the Canny algorithm (threshold 50–150) produces a circularity value of 0.999 for circles and 0.785 for squares, and combined detection works using a 45° camera angle with an average position-mapping error of 4.99 mm on the x-axis and 6.13 mm on the y-axis. Pick-and-place testing on red and blue objects, both square and circular in shape, shows that the robot successfully identifies, picks up, and transfers objects according to their color and shape consistently.

Keywords: *5-DoF Robotic Arm, Inverse Kinematics, OpenCV Library, HSV, Canny Edge Detection, Linear Interpolation.*