ABSTRAK

Nama	:	REVAL FAOZY SUPRIADI
Program Studi	:	Fisika
Judul	:	Rancang Bangun Sistem Robot Arm dengan Kendali Suara Berbasis Lightweight Transformer Encoder Block (LTEB) dan Deteksi Warna HSV

Perkembangan teknologi robotika menuntut hadirnya sistem kendali yang lebih intuitif, adaptif, dan mampu berinteraksi secara alami dengan pengguna. Sistem kendali *robot arm* yang masih mengandalkan tombol fisik atau *joystick* memiliki keterbatasan dalam fleksibilitas gerak, akurasi respons, dan efisiensi operasional, sehingga kurang efektif untuk aplikasi modern yang membutuhkan interaksi dinamis dan real-time. Penelitian ini mengusulkan pengembangan sistem kendali *robot arm* berbasis pengenalan suara dan deteksi warna sebagai solusi untuk meningkatkan efisiensi dan kemudahan operasi. Sistem ini dibangun menggunakan metode *Lightweight Transformer Encoder Block* (LTEB) untuk mengklasifikasikan instruksi suara ke dalam tiga warna target (merah, kuning, dan biru) melalui pemrosesan fitur suara menggunakan *Log-Mel Spectrogram*, serta metode segmentasi ruang warna *Hue, Saturation, Value* (HSV) untuk mendeteksi objek berdasarkan warna dan menentukan posisi objek pada grid 3×3 melalui perhitungan centroid. Hasil keluaran dari kedua proses tersebut diintegrasikan sebagai perintah penggerak motor servo melalui komunikasi serial antara Python dan Arduino Uno secara *real-time*. Pengujian dilakukan pada 270 skenario dengan variasi tiga warna dan sembilan posisi objek, menghasilkan total lima kesalahan yang terdiri dari dua kesalahan klasifikasi suara pada warna biru dan tiga kesalahan mekanik dalam proses pengambilan objek, sehingga diperoleh akurasi pengenalan suara sebesar 99,26%, akurasi mekanik sebesar 98,89%, dan akurasi integrasi keseluruhan sistem sebesar 98,15%. Hasil ini menunjukkan bahwa integrasi metode LTEB dan HSV memberikan performa yang stabil, efektif, dan responsif dalam pengendalian *robot arm* berbasis perintah suara dan deteksi warna secara otomatis dan *real-time*. Penelitian ini berpotensi diterapkan pada bidang edukasi robotika, otomatisasi industri skala kecil, serta perangkat bantu berbasis suara bagi penyandang disabilitas, serta membuka peluang pengembangan lebih lanjut melalui penambahan modul *Voice Activity Detection* (VAD), peningkatan torsi servo, dan perluasan dataset suara untuk meningkatkan akurasi sistem. **Kata Kunci:** Robot Arm, Pengenalan Suara, LTEB, HSV, OpenCV, Arduino Uno.

ABSTRACT

Name	:	REVAL FAOZY SUPRIADI
Studies Program	:	Physics
Title	:	*Design and Development of a Robot Arm System with Voice Control Based on Lightweight Transformer Encoder Block (LTEB) and HSV Color Detection*

The development of robotic technology demands control systems that are increasingly intuitive, adaptive, and capable of interacting naturally with users. Robot arm control systems that rely on physical buttons or joysticks still face limitations in movement flexibility, response accuracy, and operational efficiency, making them less effective for modern applications requiring dynamic and real-time control. This research proposes the development of a robot arm control system based on voice recognition and color detection as a solution to improve operational efficiency and ease of interaction. The system utilizes the Lightweight Transformer Encoder Block (LTEB) method to classify voice commands into three target colors—red, yellow, and blue—through feature extraction using Log-Mel Spectrogram, while the Hue, Saturation, Value(HSV) color space segmentation method is employed to detect object color and determine its position on a 3×3 grid using centroid calculation. The outputs from both processes are integrated and transmitted as commands to control servo motors via serial communication between Python and Arduino Uno in real-time. Experiments were conducted on 270 test scenarios across three color categories and nine object positions, resulting in a total of five errors consisting of two voice recognition errors for blue commands and three mechanical handling errors during object retrieval. Based on these results, the system achieved a voice recognition accuracy of 99.26%, a mechanical accuracy of 98.89%, and an overall integrated system accuracy of 99.07%. These findings demonstrate that the integration of LTEB and HSV provides stable, effective, and responsive performance for automatic and real-time robot arm control. This research shows potential applications in robotics education, small-scale industrial automation, and voice-controlled assistive tools for individuals with disabilities, and offers opportunities for further development through the addition of Voice Activity Detection (VAD), increased servo torque, and expanded voice datasets to enhance system accuracy.

Keywords: Robot Arm, Voice Recognition, LTEB, HSV, OpenCV, Arduino Uno.