ABSTRACT

Conventional waste management systems often face limitations in detecting fill levels in real-time, leading to inefficiencies in the waste collection process. This study designs and implements an Internet of Things (IoT)-based smart trash bin system utilizing the Mamdani Fuzzy Logic approach to detect waste volume and control the lid actuation adaptively. The system employs four HC-SR04 ultrasonic sensors to simultaneously measure the height of the waste, and an MG996R servo motor as the actuator. Sensor readings are fuzzified into linguistic categories (Empty, Medium, Full) and processed using 81 fuzzy rules, with the centroid defuzzification method used to generate the servo angle. Data is transmitted in real-time to Firebase and visualized via a Kodular-based application. System evaluation was conducted by comparing the defuzzification results between the ESP32 and MATLAB, and by calculating the error rate using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), which were found to be 0.346° and 0.431°, respectively. The results indicate that the system delivers precise actuator responses with slightly lower power consumption, while maintaining accurate classification of waste volume. The implementation of fuzzy logic has proven effective in enhancing energy efficiency and providing a data-driven solution for automated waste management.

***Keywords**: ESP32, Fuzzy Logic, IoT, Smart Trash Bin, Ultrasonic Sensor.*