

## ABSTRAK

**IMPLEMENTASI MACHINE LEARNING DENGAN  
HYPERPARAMETER TUNING UNTUK REKOMENDASI JENIS  
TANAMAN BERBASIS IOT BERDASARKAN KARAKTERISTIK TANAH  
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Pemilihan jenis tanaman yang sesuai dengan karakteristik tanah merupakan faktor penting dalam meningkatkan produktivitas pertanian. Namun, proses penentuan tanaman yang tepat masih sering dilakukan secara manual sehingga kurang efisien dan berpotensi menghasilkan keputusan yang kurang akurat. Penelitian ini bertujuan mengimplementasikan sistem rekomendasi jenis tanaman berbasis *Internet of Things* (IoT) menggunakan algoritma *Catboost* yang dioptimasi melalui *hyperparameter tuning* dengan metode *Bayesian optimization*. Sistem menggunakan Soil Sensor 6 in 1 yang terhubung dengan ESP32 untuk memperoleh data karakteristik tanah berupa nitrogen (N), fosfor (P), kalium (K), pH, suhu, dan kelembaban tanah. Model dikembangkan menggunakan dataset *Crop Recommendation* yang terdiri dari 2.200 data dengan 22 kelas tanaman. Evaluasi model dilakukan menggunakan metrik *Accuracy*, *Precision*, *Recall*, *F1-score*, *Confusion matrix*, serta 5-fold *Cross validation*. Hasil penelitian menunjukkan bahwa algoritma *Catboost* dengan parameter default telah memberikan performa yang sangat baik, sedangkan penerapan *Bayesian optimization* berhasil memperoleh kombinasi *hyperparameter* optimal yang meningkatkan performa model hingga mencapai *Accuracy*, *Precision*, *Recall*, dan *F1-score* sebesar 100% pada data pengujian. Hasil 5-fold *Cross validation* juga menunjukkan rata-rata akurasi di atas 99% dengan deviasi yang rendah sehingga menunjukkan kemampuan generalisasi model yang baik. Implementasi sistem berhasil mengintegrasikan perangkat IoT, model *Machine learning*, dan Telegram Bot sehingga mampu memberikan rekomendasi jenis tanaman secara otomatis berdasarkan karakteristik tanah yang terukur.

**Kata kunci:** *Internet of Things*, *Machine learning*, *Catboost*, *Bayesian optimization*, Rekomendasi Tanaman.

## ABSTRACT

### **MACHINE LEARNING IMPLEMENTATION WITH HYPERPARAMETER TUNING FOR IOT-BASED CROP TYPE RECOMMENDATIONS BASED ON SOIL NUTRIENTS**

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*Selecting crop types suited to soil characteristics is a crucial factor in enhancing agricultural productivity. However, the process of determining the appropriate crop is often still performed manually, leading to inefficiency and potentially inaccurate decisions. This study aims to implement an Internet of Things (IoT)-based crop recommendation system using the catboost algorithm, optimized via hyperparameter tuning through bayesian optimization. The system utilizes a 6-in-1 soil sensor connected to an ESP32 microcontroller to acquire soil characteristic data, including nitrogen (N), phosphorus (P), potassium (K), pH, temperature, and soil moisture. The model was developed using the "Crop Recommendation" dataset, comprising 2,200 data points across 22 crop classes. Model evaluation was conducted using metrics such as accuracy, precision, recall, F1-score, confusion matrix, and 5-fold cross-validation. The results indicate that the catboost algorithm with default parameters already delivered excellent performance; however, the application of bayesian optimization successfully identified an optimal hyperparameter combination that boosted model performance to achieve 100% accuracy, precision, recall, and F1-score on the test data. The 5-fold cross-validation results also showed an average accuracy exceeding 99% with low deviation, demonstrating the model's strong generalization capability. The system implementation successfully integrated IoT hardware, a Machine learning model, and a telegram Bot, enabling automated crop recommendations based on measured soil characteristics.*

**Keywords:** *Internet of Things, Machine learning, Catboost, Bayesian Optimization, Crop Recommendation.*