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Survey of Intelligent Optimization of Multicropping Strategies across Irrigation Types Using Genetic Algorithms, Deep Learning, and Particle Swarm Optimization

N. Amirtha Gowri. M. Sc. , M. Phil. , (Ph. D)
Assistant Professor Department of BCA,
Nallamuthu Gounder Mahalingam College, Pollachi, Tamilnadu, India.

Dr. N. Nandhakumar M. C. A. , M. Phil. , M. B. A. , Ph. D. , SET
Assistant Professor and Head Department of Computer Science
Nallamuthu Gounder Mahalingam College Polllachi, Tamilnadu, India.

Abstract

This research focuses on the intelligent optimization of multicropping strategies across various irrigation systems using advanced Artificial Intelligence (AI) techniques. In regions with diverse climatic and soil conditions, selecting the optimal crop combination is critical to maximize yield, resource efficiency, and sustainability. The study employs Genetic Algorithms (GA), Deep Learning (DL), and Particle Swarm Optimization (PSO) to identify and fine-tune crop combinations suited for clay-dominant soils under drip irrigation. The approach integrates seasonal variation, soil parameters, and crop characteristics to recommend high-performance multicropping plans. The proposed methodology is expected to contribute to sustainable agricultural planning, increased profitability, and efficient resource use in semi-arid regions like Marulpatti in Tamil Nadu, India.

Keywords-Multicropping, Genetic Algorithm, Deep Learning, Particle Swarm Optimization, Irrigation, Optimization, AI in Agriculture

I. Introduction

Agriculture in India is undergoing a significant transformation with the integration of Artificial Intelligence (AI) in decision-making. Among various challenges, determining effective multicropping strategies that align with soil types, irrigation methods, and seasonal conditions remains complex and highly context-dependent. Traditional approaches often fail to capture the nonlinear relationships between environmental factors and crop outcomes. This research aims to address these limitations by developing a hybrid intelligent system that uses Genetic Algorithms (GA), Deep Learning (DL), and Particle Swarm Optimization (PSO) to optimize multicropping combinations. The study is specifically focused on the semi-arid region of Marulpatti, where drip irrigation and clay-heavy soils dominate. By modeling real-world agricultural variables and optimizing crop synergy, the study aims to increase yield, ensure water efficiency, and promote sustainable land use. The system is implemented entirely in Python using Visual Studio Code (VS Code), emphasizing flexibility and reproducibility. This paper outlines the methodology, challenges, and expected contributions of the proposed system.

II. Research Objectives

The primary objectives of this research are:

1. To develop an intelligent multicropping optimization framework integrating GA, DL, and PSO.
2. To optimize crop combinations across three seasonal windows: July- October, November-February, and March-June.
3. To improve decision-making in farming by predicting suitable crop sets under specific irrigation and soil conditions.
4. To contribute to the efficient use of natural resources and increase profitability for farmers.

III. Methodology

This study is implemented using Python in Visual Studio Code (VS Code). Data collected from the rural region includes soil type (75% clay), crop characteristics, and seasonal patterns. The methodology includes the following phases:

A. Data Collection:

Data will be collected from local farms, agricultural reports, and climate databases. The focus will be on variables such as soil moisture, crop compatibility, and seasonal productivity.

B. Data Preprocessing:

Data will be cleaned and normalized. Categorical variables will be encoded, and missing values handled using interpolation or imputation.

C. Algorithm Development:

GA: Generate crop combinations and evaluate them using a custom fitness function.

DL: Train a model using seasonal, soil, and crop data to predict yields.

PSO: Tune the input features and model parameters for optimal prediction and decision making.

D. Evaluation:

The system will be evaluated based on accuracy of yield prediction, water usage efficiency, and cost-benefit analysis.

IV. Challenges and Limitations

This research faces multiple challenges:

1. Climate unpredictability across different cropping seasons.
2. Incomplete or unstructured data from local sources.
3. Lack of standard datasets for crop combinations in Indian multicropping systems.
4. Balancing multiple objectives like water use, yield, and profit simultaneously.

Despite these limitations, the project aims to create a flexible system that can adapt to various farming conditions.

V Future Work

Future phases of the research will involve:

1. Integrating real-time sensor data (if available) for soil and climate.
2. Creating a user-friendly interface for farmers to interact with the model.
3. Collaborating with agricultural experts to validate and refine the model recommendations.
4. Scaling the model to other regions with different soil and irrigation types.

VI. Conclusion

This research presents a novel AI-driven approach to optimize multicropping strategies using Genetic Algorithms, Deep Learning, and Particle Swarm Optimization. By focusing on a specific agro-climatic region and soil type, the study ensures that results are contextually relevant and practical. The use of VS Code and Python makes the system replicable and accessible to a wide audience. The intelligent framework developed in this research is expected to guide farmers toward more sustainable and profitable agricultural practices.

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