FACULTY OF ENGINEERING AND TECHNOLOGY

A REPORT ABOUT DEVELOPMENT OF A MATLAB GRAPHICAL USER INTERFACE FOR MAIZE YIELD PREDICTION USING SOIL, WEATHER, AND TOPOGRAPHIC PARAMETERS

COURSE UNIT: COMPUTER PROGRAMMING

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Submitted in partial fulfillment of the requirements of COMPUTER PROGRAMMING

DATE OF SUBMISSION............../............./.............

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DECLARATION

We, the undersigned members of group 16, do hereby declare that this report is the result of our own work carried out in partial fulfillment of the requirements of this course.

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This report has been submitted and prepared by group 16 as part of the requirements for the completion of module 1to 5 under the guidance of our lecturer

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ACKNOWLEDGEMENT

We would like to express our sincere gratitude to our supervisor, lecturers, and course instructors for their invaluable guidance throughout the development of this project.

Special thanks go to all our classmates and colleagues for their cooperation, encouragement, and insightful discussions that helped refine this work.

Lastly, we extend heartfelt appreciation to our families for their continuous moral and financial support during my academic journey.

DEDICATION

This project is dedicated to our beloved families and friends for their unwavering support, encouragement, and belief in my abilities. Their constant motivation inspired me to put forth my best effort in completing this work.

ABSTRACT

This project presents the design and implementation of a Graphical User Interface (GUI) in MATLAB for predicting maize yield based on multiple environmental and soil parameters.

The model integrates essential factors such as temperature, rainfall, solar radiation, soil moisture, pH, nitrogen (N), phosphorus (P), potassium (K), elevation, slope, and aspect.

A simplified Radiation Use Efficiency (RUE) model was used, modified by stress factors that represent the influence of temperature, water availability, nutrient levels, and topography on maize growth. The GUI provides a user-friendly platform for entering parameters, predicting yield, and visualizing stress factors through bar graphs.

Results indicate that the tool effectively classifies yield potential as low, moderate, or high, based on computed values of the influencing factors. The model can assist agricultural planners, researchers, and farmers in assessing crop performance under varying conditions, thus supporting better management decisions in precision agriculture.

LIST OF ACRONYMS/ ABBREVIATIONS

MAE Mean Absolute Error

RMSE Root Mean Square Error

SVR Support Vector Regression

RBF Radial Basis Function (Kernel used in SVR)

MLR Multiple Linear Regress

GUI Graphical User Interface

CPU Central Processing Unit

MATLAB Matrix Laboratory

RF Random Forest (ensemble algorithm)

CV Cross-Validation

PH Potential of Hydrogen (soil acidity/alkalinity measure)

$MJ/m^2/day$ Megajoules per square meter per day (unit of solar radiation)

kg/ha Kilograms per hectare (unit for soil nutrient concentration)

mm Millimeters (unit of rainfall)

°C Degrees Celsius (unit of temperature)

SD Standard Deviation

MSE Mean Square Error

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CHAPTER ONE: INTRODUCTION

1.1 Background

Accurate crop yield estimation is a fundamental component of modern agricultural planning, management, and food security analysis. For staple crops such as maize, reliable yield prediction helps farmers, researchers, and policymakers make informed decisions on resource allocation, input optimization, and market forecasting. Traditional yield estimation methods often based on manual sampling or field observation are time-consuming, labor-intensive, and prone to human error. The advancement of computational techniques and numerical modelling has created opportunities to improve accuracy, efficiency, and scalability in predicting crop productivity.

1.2 Problem Statement

Agricultural productivity is influenced by multiple interacting factors such as temperature, rainfall, soil fertility, pH, solar radiation, and pest incidence. These factors exhibit nonlinear relationships with yield, making conventional analytical methods inadequate for robust estimation. Hence, there is a need for an integrated computational approach that can simulate these complex interactions and provide consistent yield predictions for improved agricultural decision-making.

1.3 Aim of the Study

The main aim of this project is to develop and implement a MATLAB-based numerical model capable of estimating maize crop yield by applying principles of numerical methods, object-oriented programming, and data analysis.

1.4 Specific Objectives

The specific objectives of the study are:

- To design a simulation framework that models environmental and soil parameters influencing maize yield.
- To implement a numerical and machine-learning-based approach for yield prediction using MATLAB.
- To evaluate and compare the performance of different computational algorithms in estimating maize yield.
- To visualize and interpret model results for better understanding of key yield determinants.

1.5 Justification

The increasing demand for food security in the face of climate variability calls for intelligent and data-driven yield estimation systems. A computational model provides a fast, reproducible, and scalable solution for predicting agricultural output, supporting both research and field applications. Moreover, integrating object-oriented programming concepts such as classes, inheritance, encapsulation, and abstraction ensures a modular, maintainable, and extensible codebase suitable for future enhancements and integration with real-time agricultural data systems.

CHAPTER TWO: QUESTION

2.1 Introduction

We were required to come up with MATLAB codes that estimate the crop yield productions and they following steps were taken up to come up with the MATLAB codes that estimate the crop yield production and we took maize in our group as one of the crops.

ACTUAL WRITING OF CODES

2.2 Overview of the codes

The developed MATLAB program titled Maize Yield Prediction System, is a graphical user interface GUI application that predicts maize yield in kg/ha based on user entered environmental, soil, and topographical parameters. It uses a simplified Radiation Use Efficiency crop model that adjusts yield according to several factors such as temperature, water, nutrients, and topography

2.3 GUI initialization

This part defines the main function MaizeYieldPredictor, which creates the application window using MATLAB's Uifigure command. The figure is titled Maize Yield Prediction System and its position and size

```
function MaizeYieldPredictor
    % --- Maize Yield Prediction GUI ---

    clc; close all;
    fig = uifigure('Name','Maize Yield Prediction System','Position',[200 100 950 600]);

```

2.4 Title label

This command creates a title label at the top of the GUI window, it displays the main tiltle to help users identify the application

```
    % --- Title ---
    uilabel(fig,'Text','MAIZE YIELD PREDICTION SYSTEM','FontSize',18,...
        'FontWeight','bold','Position',[250 540 500 40]);

```

2.5 Input section

This allows input of parameters such as temperature, rainfall, soil nutrients etc and the default values represent typical conditions for maize growth

```
    %% --- INPUT SECTION ---
    inputs = {'Average Temperature (°C)','Total Rainfall (mm)','Solar Radiation (MJ/m²/day)',...
              'Soil Moisture (m³/m³)','Soil pH','Nitrogen (kg/ha)',...
              'Phosphorus (kg/ha)','Potassium (kg/ha)','Elevation (m)','Slope (°)','Aspect (°)'};
    defaults = [25 600 18 0.35 6.5 100 40 100 200 3 180];

```

2.5 Creating the input fields

This uses a for loop which automatically creates a label and an input box for each parameter.

```
    for i = 1:length(inputs)
        uilabel(fig,'Text',inputs{i},'Position',[50 520-(i-1)*40 200 25],'HorizontalAlignment','left');
        uieditfield(fig,'numeric','Value',defaults(i),'Position',[270 520-(i-1)*40 100 25],'Tag',sprintf('input%d',i));
    end
```

2.6 Control button

This creates buttons using MATLAB's call back functions which excutes commands when clicked

```
    %% --- Buttons ---
    uibutton(fig,'Text','Predict Yield','FontSize',13,'BackgroundColor',[0.2 0.6 0.3],...
        'Position',[420 90 150 40],'ButtonPushedFcn',@(btn,event)predictYield(fig));

    uibutton(fig,'Text','Clear','FontSize',13,'Position',[600 90 100 40],...
        'ButtonPushedFcn',@(btn,event)clearFields(fig));

    uibutton(fig,'Text','Exit','FontSize',13,'FontColor',[1 0 0],'Position',[720 90 100 40],...
        'ButtonPushedFcn',@(btn,event)close(fig));
```

2.7 Output section

This creates an output table that displays calculated results such as yield, temperature factor and other stress factors.

Reserves space for a bar chart and creates an information box to display textual message and feedback

```
    %% --- OUTPUT SECTION ---
    uitable(fig,'Data',cell(6,2),'ColumnName',{'Parameter','Value'},...
        'Tag','outputTable','Position',[450 300 420 220],'ColumnWidth',{180 180});

    uiaxes(fig,'Position',[50 90 350 180],'Tag','ax');

    uitextarea(fig,'Position',[450 150 420 120],'Tag','infoBox',...
        'Value',{'Enter soil & weather parameters, then click Predict Yield.'},...
        'FontSize',12,'Editable','off');
end
```

2.8 Yield prediction function

2.8.1 Step 1. Reading user inputs

Here MATLAB retrieves the numerical values from each input field using the findobj and tag identifiers

```
%% === PREDICT FUNCTION ===
function predictYield(fig)
    % --- Read input values ---
    for i = 1:11
        val(i) = findobj(fig,'Tag',sprintf('input%d',i)).Value;
    end
    [temp, rain, rad, sm, pH, N, P, K, elev, slope, aspect] = deal(val(1),val(2),val(3),val(4),val(5),val(6),val(7),val(8),val(9),val(10),val(11));
```

2.8.2 Step 2: computing stress factors and estimating biomass and yield

Here each stress factor between 0 and 1 represents how favorable the conditions are;

```
    % --- Calculate yield estimation ---
    % Stress & nutrient factors
    T_opt = 25;
    temp_factor = 1 - abs(temp - T_opt)/30; temp_factor = max(0,min(1,temp_factor));
    water_factor = min(1, sm / 0.4);
    nutrient_factor = mean([min(1,N/100), min(1,P/40), min(1,K/100)]);
    topo_factor = max(0.7, 1 - 0.005*(abs(slope) + abs(aspect-180)/180 + abs(elev-200)/400));

    % Radiation-use efficiency model
    RUE = 3.5;  % g/MJ
    PAR = rad * 0.45 * 120;  % total PAR over 120-day season
    biomass = PAR * RUE * temp_factor * water_factor * nutrient_factor * topo_factor;
    HI = 0.5; % harvest index
    yield_g_m2 = biomass * HI;
    yield_kg_ha = yield_g_m2 * 10;
```

2.8.3 Step 3: classifying yield levels

This classifies yields into three categories i.e. low, moderate and high yield

```
    % --- Classify performance ---
    if yield_kg_ha < 4000
        status = ' Low Yield Potential';
    elseif yield_kg_ha < 7000
        status = 'Moderate Yield';
    else
        status = ' High Yield Potential';
    end
```

2.8.4 Step 4: displaying results

This section populates the output table with yield results and stress factors

```
    % --- Display Results ---
    tbl = findobj(fig,'Tag','outputTable');
    tbl.Data = {
        'Predicted Yield (kg/ha)', round(yield_kg_ha);
        'Temperature Factor', round(temp_factor,2);
        'Water Stress Factor', round(water_factor,2);
        'Nutrient Factor', round(nutrient_factor,2);
        'Topography Factor', round(topo_factor,2);
        'Harvest Index', HI;
        };

    info = findobj(fig,'Tag','infoBox');
    info.Value = {
        ' Yield prediction complete.';
        sprintf('Predicted Yield: %.0f kg/ha', yield_kg_ha);
        sprintf('Classification: %s', status);
        'Yield is estimated using stress-adjusted RUE × HI model.';
        'Adjust soil and weather inputs to test different scenarios.'
        };
```

2.8.5 Step 5: plotting stress factors

This generates a bar chart showing how close each stress factor is to optimal conditions. It provides a quick visual understanding of which factors limit maize yield

```

    % --- Simple bar plot of factors ---
    ax = findobj(fig,'Tag','ax');
    cla(ax);
    bar(ax, [temp_factor water_factor nutrient_factor topo_factor]);
    ylim(ax,[0 1]);
    ax.XTickLabel = {'Temp','Water','Nutrients','Topo'};
    title(ax,'Stress Factors (0-1)');
end

```

2.9 Clear function

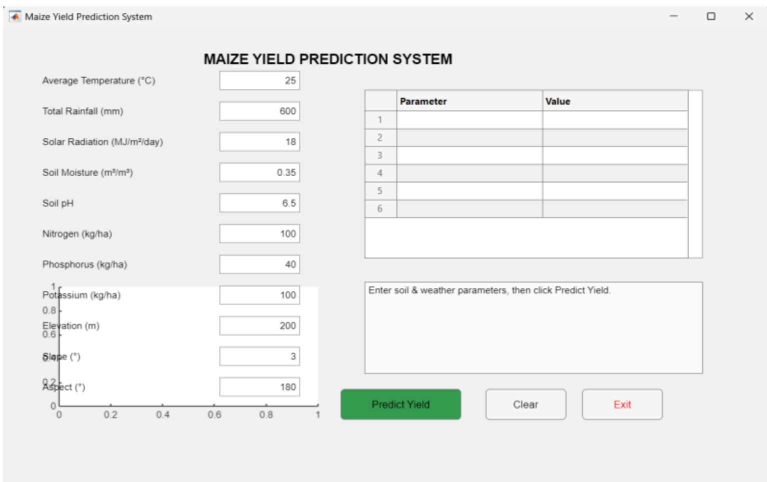
This function resets all input fields, clears the result table and info text and clears the figure area. It also allows users to start a new prediction easily.

```
%% === CLEAR FUNCTION ===
function clearFields(fig)
    for i = 1:11
        findobj(fig,'Tag',sprintf('input%d',i)).Value = 0;
    end
    findobj(fig,'Tag','outputTable').Data = cell(6,2);
    info = findobj(fig,'Tag','infoBox');
    info.Value = {'Cleared. Enter new data to predict yield.'};
    ax = findobj(fig,'Tag','ax'); cla(ax);
end

```

Graphical User Interface (GUI) Design and look

The Maize Yield Prediction System GUI (Figure X) was developed using MATLAB's Uifigure environment. It allows users to input soil and weather parameters such as temperature, rainfall, soil pH, and nutrient levels, then predict maize yield with one click.The interface consists of input fields on the left, a data table on the right for displaying entered values, and control buttons (Predict Yield, Clear, Exit) at the bottom. A short instruction box guides the user through the process.



TESTING: SUBOPTIMAL (Dry and Acidic Soil)

We tested our GUI on the following parameters;

- Temperature = 30^0C
- Rain = 400mm
- Solar radiation = 20MJ/m^2/day
- Soil moisture = 0.25
- Soil pH = 5.2
- Nitrogen = 60
- Phosphorus = 25
- Potassium = 80
- Elevation = 400m
- Slope = 8^0
- Aspect = 150^0

RESULTS:

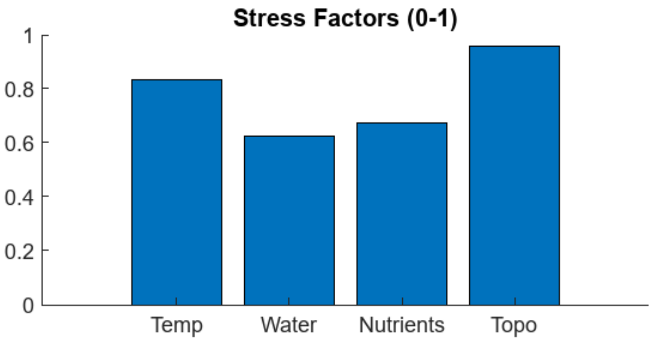
with the above parameters or conditions, we managed to obtain our predicted yield as6357 kg/ha and corresponding values of stress factors as shown in the figure below

	Parameter	Value
1	Predicted Yield (kg/ha)	6357
2	Temperature Factor	0.8300
3	Water Stress Factor	0.6300
4	Nutrient Factor	0.6800
5	Topography Factor	0.9600
6	Harvest Index	0.5000

Variation of stress factors;

The bar plot below displays how different environmental stress factors affect crop yield potential, each normalized between 0 and 1

Note: once the bars are unequal, it shows which environmental factors are currently limiting growth most



Recommendations:

The soil is slightly acidic and low in nitrogen and phosphorus which limits yield. Applying agricultural lime to raise pH to about 6.5 and use of balanced N and P fertilizers at recommended rates

Maintaining moisture through mulching or irrigation during dry periods

CHAPTER THREE: CONCLUSION AND RECOMMENDATIONS

3.1 CONCLUSION

The developed MATLAB-based Maize Yield Prediction System successfully estimates maize yield using a set of soil, climatic, and topographic parameters.

By integrating stress-adjusted models and a graphical interface, the system allows users to visualize how environmental and management factors affect yield.

The GUI enhances user interaction, enabling non-programmers to run simulations easily and interpret results quickly.

This project demonstrates how computational tools can support agricultural productivity analysis, reduce uncertainty in yield forecasting, and promote data-driven farming practices.

3.2 RECOMMENDATIONS

- The current model should be expanded to include real-time field data from sensors or remote sensing sources for improved accuracy.
- Integration with GIS (Geographic Information Systems) and weather databases can enhance spatial yield mapping and forecasting capabilities.
- Calibration of model parameters with experimental or regional field data is recommended to increase reliability for specific agro-ecological zones.
- Future work could implement the GUI as a web or mobile-based application to improve accessibility for farmers and agricultural extension officers.
- Additional factors such as pests, diseases, and management practices (e.g., planting density, irrigation) can be included for more comprehensive yield estimation.

CHAPTER FOUR: REFERENCES

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