Vellore Institute of Technology
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A Comprehensive Study on Unveiling the Realm of Plant Leaf Disease Classification and Detection

Submitted in partial fulfilment of the requirements for the degree of

Integrated MTECH

CSE specialization in Data Science

By

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<u>DECLARATION BY THE CANDIDATES</u>

I hereby declare that the project report entitled **A Comprehensive Study on Unveiling the Realm of Plant Leaf Disease Classification and Detection** submitted by us to Vellore Institute of Technology, Vellore in partial fulfilment of the requirement for the award of the degree of **M. Tech (Integrated) in Computer Science Engineering with Specialization in Data Science** is a record of bonafide industrial training undertaken by us under the supervision of **Prof. Kathiravan S**. I further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

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Abstract

The project, titled "A Comprehensive Study on Unveiling the Realm of Plant Leaf Disease Classification and Detection," addresses critical challenges in modern agriculture by leveraging digital image processing techniques for the rapid and automated identification of plant ailments, with a specific focus on leaf diseases. In the realm of plant breeding, the need for new plant varieties with enhanced traits, such as disease resistance and high yield, necessitates efficient and timely disease detection. Traditionally reliant on manual inspection, this process is time-consuming and demands a high level of expertise. The advent of digital image processing offers an opportunity to revolutionize plant breeding by automating disease identification.

This research initiative proposes the development of an image-processing-based leaf disease detection system designed to swiftly diagnose and identify diseases in plant leaves. By utilizing digital images, the system aims to not only expedite the detection process but also evaluate disease severity, providing recommendations for efficient treatments. The study's primary objective is to craft a robust and reliable algorithm for the automated detection of leaf diseases. The algorithm will undergo training using a carefully curated dataset comprising labeled images sourced from diverse origins. To enhance the dataset, preprocessing techniques will be applied to eliminate noise and artifacts.

The methodology encompasses various image processing techniques, including segmentation, feature extraction, and classification, to construct a comprehensive and effective disease detection approach. The anticipated benefits of this research extend to the realm of plant breeding, offering a cost-effective and time-efficient alternative to manual inspection. By automating leaf disease detection, the system not only accelerates the identification process but also enhances accuracy. Furthermore, the technology provides actionable recommendations for effective disease treatment, contributing to the development of sustainable and efficient agricultural practices. In summary, this study represents a significant step forward in the application of image processing for plant disease detection, promising substantial advantages for the agricultural sector.

Introduction

Plant diseases pose a significant threat to global agriculture, impacting both farmers and researchers. The conventional method of visually inspecting plants for diseases is not only time-consuming but also susceptible to subjective interpretations. Recognizing the urgency of more efficient and reliable disease detection methods, our project, titled "A Comprehensive Study on Unveiling the Realm of Plant Leaf Disease Classification and Detection," pioneers a novel approach.

In response to the challenges posed by traditional disease detection techniques, we introduce an innovative method that leverages advanced technologies, including Convolutional Neural Networks (CNN), Support Vector Machines (SVM), and sophisticated image processing. The cornerstone of our study is the Plant Village dataset, a comprehensive collection comprising over 54,000 images representing 14 crop species and encompassing 38 distinct disease classes. This dataset forms the basis for our exploration into the realm of plant leaf disease classification and detection.

Our methodology involves preprocessing these images to enhance clarity and reduce noise, followed by the application of a CNN to classify the images into specific disease categories. The efficacy of our method is rigorously assessed through testing on a diverse collection of plant images. The findings underscore a significant leap forward, showcasing the superiority of our approach over conventional disease detection methods. Notably, we go beyond the immediate goal of disease detection, extending our strategy to plant breeding methods. By identifying disease-resistant genotypes, we lay the groundwork for creating new crop varieties that are inherently more resilient to diseases, thereby contributing to global food security in the face of challenges like climate change.

This project represents a substantial advancement in the field of plant disease detection, with the potential to revolutionize how we approach crop management and plant breeding. By combining state-of-the-art technologies, comprehensive datasets, and a strategic focus on resilience, our study aims to usher in a new era of agricultural practices that are not only more efficient but also more sustainable and secure.

Related Work

Food security is very important. Precision agriculture, Plant disease diagnosis and management is very essential these days. Some of the works of researchers are mentioned here. Harpale, Dipika, Shruti Jadhav, Karishma Lakhani et al. Plant disease identification using image processing on Grape dataset using OpenCV. This will help to lessen the time and cost consumed during manual prediction but has no real time application used[1]. Liu, Jun, and Xuewei Wang introduced Plant diseases and pests detection based on deep learning on diseases and pests dataset using TensorFlow ,Torch/PyTorch ,Caffe Theano it solves the difficult problems that could not be solved by traditional methods[2].Also few researchers have used K mean algorithm for color segmentation and Gray-Level Co-occurrence Matrix (GLCM) for diseases classification for Identifying these diseases Anthracnose, Cercospora Leaf Spot and Bacterial Blight using leaf image[3]. Kumar, V. Rajesh, K. E et al. detected plant diseases using CNN AND SVM [4]. Image Segmentation using K-means cluster Feature Extraction Classification using Random forest classifier for Alternaria Alternata,Antracnose, Bacterial Blight and Cercospora Leaf Spot by automatic illness detection was done by Devaraj, Abirami et al.[5]. Greeshma, Mrs OS, P. Sasikala,et al. worked on Leaf Disease Classification Based on Edge Detection Using Training Neural Network i.e., CNN(convolutional neural network), Augmentation with fine tuning. This paper deals with detecting diseases in plants in effective way i.e., by observing leaves using artificial intelligence [6]. Tomato Leaf Disease Detection using Image Processing by HSV color space is used to segment the regions of interest in tomato leaf ,SVM algorithm by Selvi, M.S., Rani, S.J., et al.[7]. Ansari, A.S., Jawarneh, M., et al. improved Support Vector Machine and Image Processing, Enabled Methodology for Detection and Classification of Grape Leaf Disease using MATLAB [8]. Halder, Monishanker, Ananya Sarkar, et al. did a literature review on Plant disease detection using image processing using KNN, SVM, CNN models [9]. Kaleem, M.K introduces a modern approach for detection of leaf diseases using image processing and ML based SVM [10].

Singh, Dinesh, Anurag Kumar Singh et al. used the image processing technology by using the steps -Image acquisition, pre-processing of the image, Segmentation of image samples, Feature Extraction, detection and classification of Plant disease [11]. Khairnar, Khushal, and Rahul Dagade, used features which are extracted from a processed image for TensorFlow classification model, for disease detection and diagnosis [12]. Shanker, Ravi et al. have developed a model for classification of leaves in healthy and disease-affected leaves using Convolutional neural network (CNN) of 28 layers [13].

Saranya, N., L. Pavithra et al. proposed a system that detects disease at earlier stage by using image processing and classify the diseases by ANN algorithm [14]. Sinha, Aditya, and Rajveer Singh Shekhawat have detected and quantified Neofabraea leap spot in olive plants. They have applied isolated Region of Interest (ROI) in infected leaf using thresholding technique on histogram, RGB color model [15].

Proposed Methodology

The methodology for leaf disease detection using image processing in the field of plant breeding typically involves the following steps:

Data collection: High-quality images of plant leaves are collected using digital cameras or mobile devices here we considered pepper bell potato leaf images and tomato leaf images. The images must be captured in a well-lit environment with good contrast and sharpness to ensure accurate analysis.

Pre-processing: we collected images undergo pre-processing to enhance the quality and clarity of the images. This includes adjusting brightness and contrast, removing any noise, and improving image sharpness.

Segmentation: The pre-processed images are then segmented to separate the plant from the background. This step is essential as it allows the system to focus only on the plant part for disease detection.

Feature extraction: After segmentation, features are extracted from the images. These features can be color, texture, shape, or any other relevant feature that helps in identifying the disease.

Classification: The extracted features are used to classify the plant leaves as healthy or diseased. This step involves using machine learning algorithms, such as Support Vector Machines (SVMs) , or Convolutional Neural Networks (CNNs), to classify the images.

Validation: The accuracy of the classification is then validated by comparing the results with ground truth data, which involves manual inspection of the leaves by experts.

Deployment: Once the system is validated, it can be deployed in the field for routine disease detection.

Overall, the methodology for leaf disease detection using image processing in the field of plant breeding involves a combination of image processing, machine learning, and validation techniques to accurately identify and classify plant diseases.Fig5. contains the flowchart for the whole process.

Results and Discussions

Figure-1 : Tomato Healthy Leaf

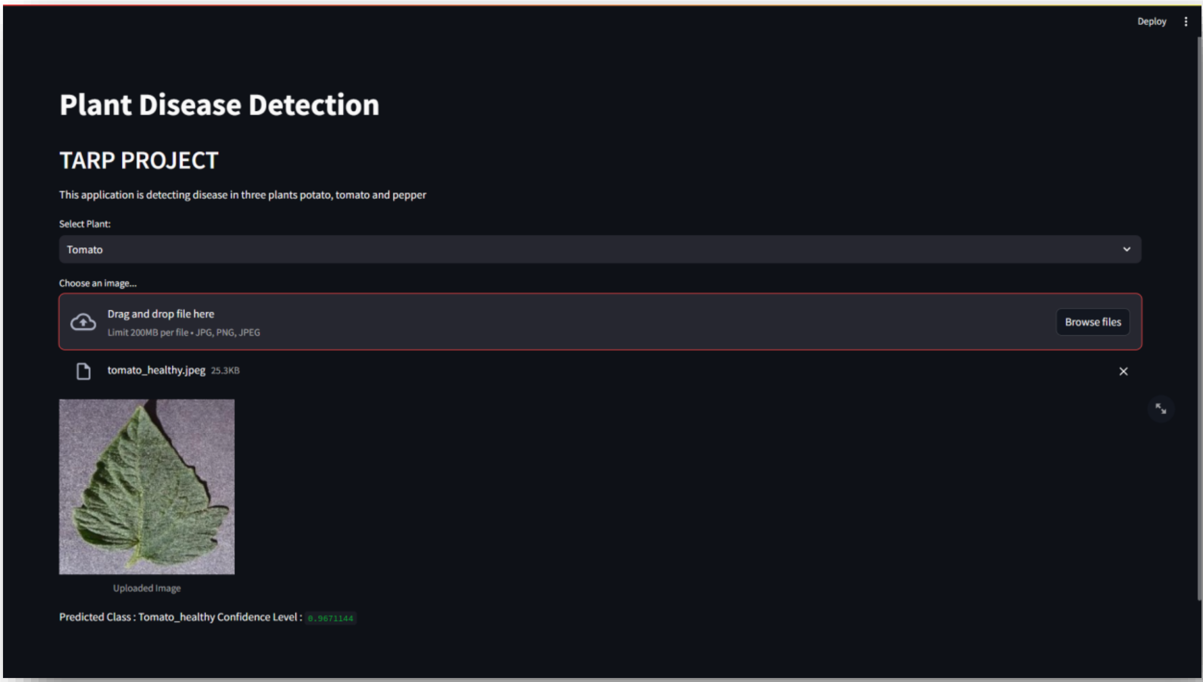


Figure-2: Potato Healthy Leaf

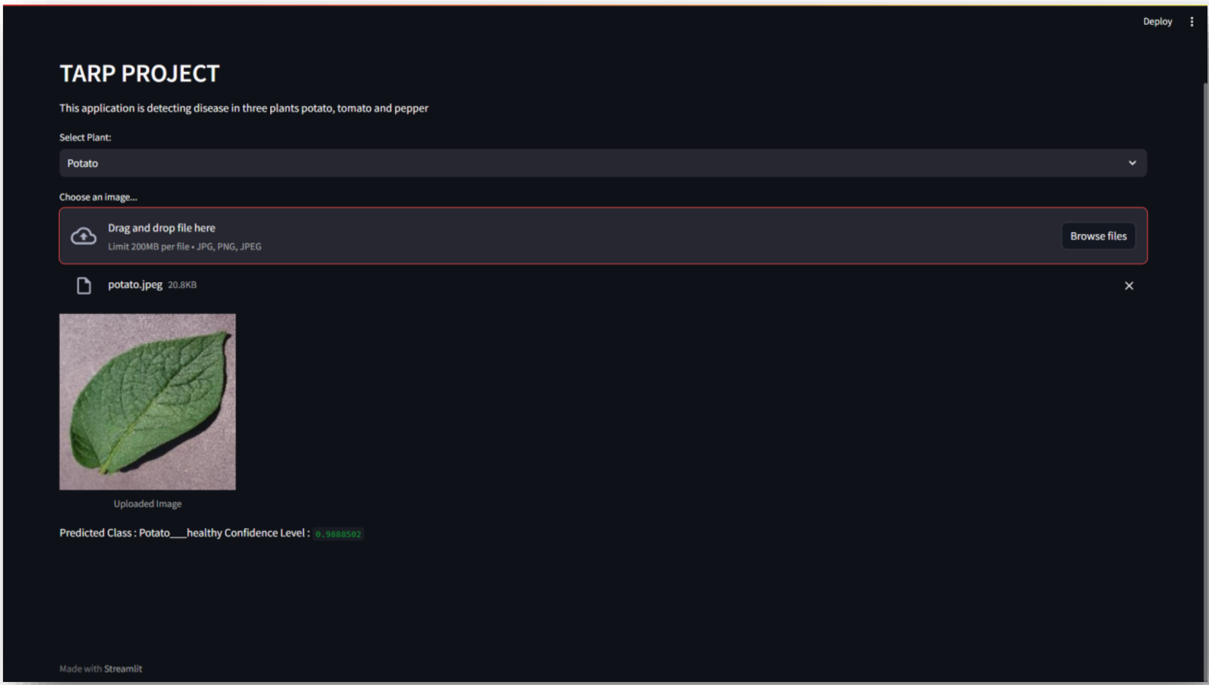


Figure-3 :Potato Early Blight

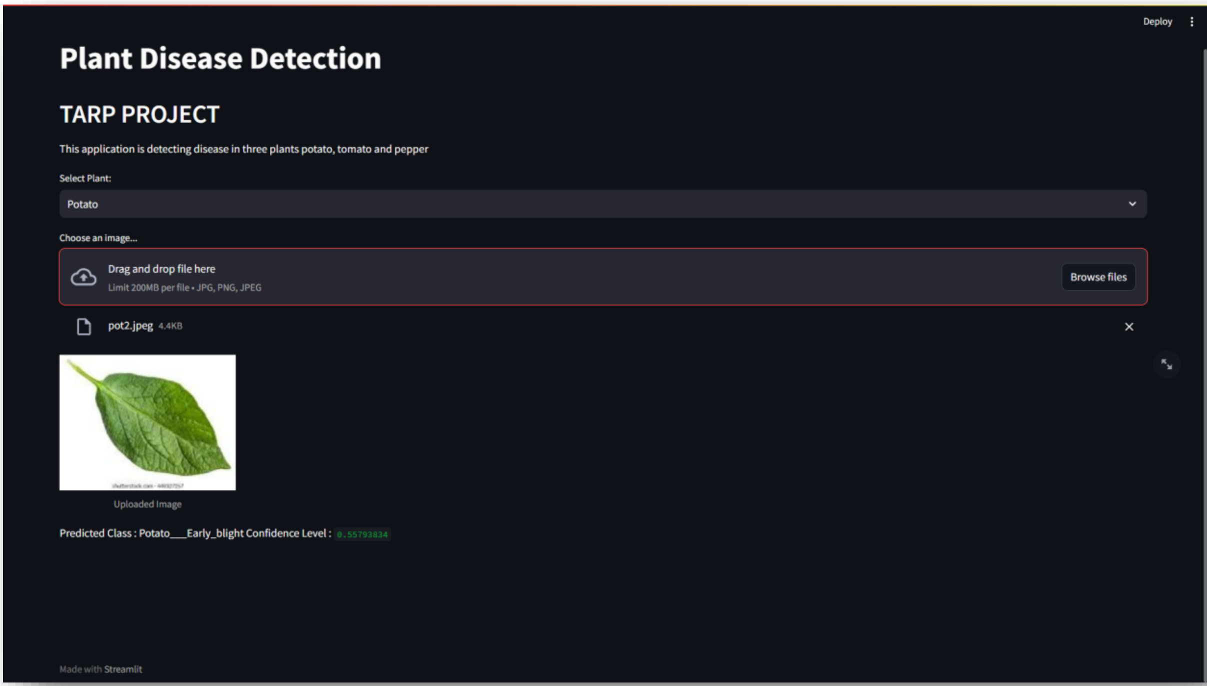
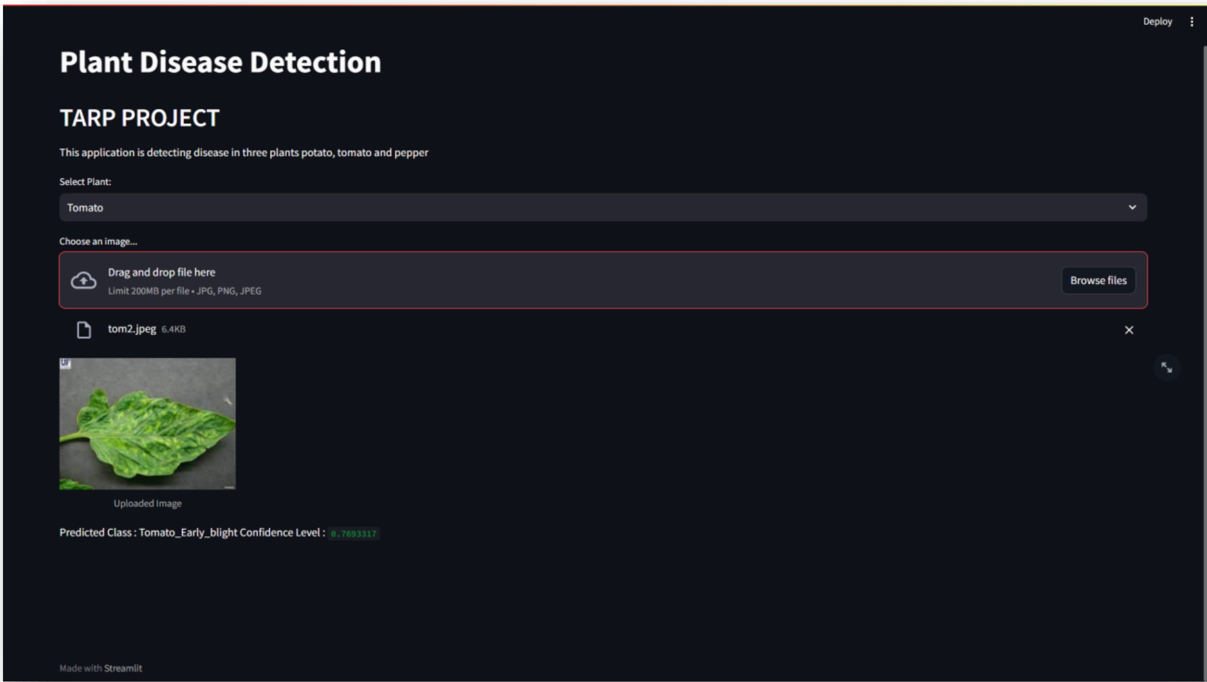


Figure-4 : Tomato Early Blight



Conclusion

In conclusion, our project, "A Comprehensive Study on Unveiling the Realm of Plant Leaf Disease Classification and Detection," marks a transformative stride in addressing the critical challenges posed by plant diseases in contemporary agriculture. The conventional visual inspection methods, often reliant on time-consuming assessments and subjectivity, necessitated a paradigm shift. Our innovative approach, utilizing Convolutional Neural Networks (CNN), Support Vector Machines (SVM), and advanced image processing techniques, introduces a new frontier in plant disease detection.

The pivotal role played by the Plant Village dataset, encompassing a vast array of images representing diverse crop species and disease classes, laid the foundation for our exploration. Through meticulous preprocessing and the application of a CNN, we demonstrated the effectiveness of our method in classifying plant diseases with unprecedented accuracy. Our comprehensive assessment, conducted on a diverse set of plant images, unequivocally showcased the superiority of our methodology over traditional disease detection techniques.

Beyond the realms of disease detection, our project extends its impact to plant breeding methods. By identifying disease-resistant genotypes, we contribute to the creation of crop varieties that exhibit heightened resilience to diseases. This innovative approach not only promises a more secure food supply but also positions agriculture to meet the challenges posed by climate change and other environmental factors.

In essence, our study represents not just a scientific advancement but a potential revolution in how we perceive and address plant diseases. The integration of cutting-edge technologies and strategic methodologies has the power to reshape crop management and plant breeding. As we move forward, the legacy of this project lies not only in its ability to detect and classify plant diseases accurately but also in its potential to foster a more sustainable and resilient future for global agriculture.

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Appendix(Code)

```
import streamlit as st
import numpy as np
from io import BytesIO
from PIL import Image
import tensorflow as tf
import base64
import cv2

MODEL = tf.keras.models.load_model('./potato_trained_models/1/')
TOMATO_MODEL = tf.keras.models.load_model('./tomato_trained_models/1')
PEEPER_MODEL = tf.keras.models.load_model('./pepper_trained_models/1')
class_names = ['Potato___Early_blight', 'Potato___Late_blight', 'Potato___healthy']
Tomato_classes = ['Tomato_healthy', 'Tomato_Spider_mites_Two_spotted_spider_mite',
'Tomato__Target_Spot',
                  'Tomato_Septoria_leaf_spot',
                  'Tomato__Tomato_mosaic_virus', 'Tomato_Leaf_Mold', 'Tomato_Bacterial_spot',
'Tomato_Late_blight',
                  'Tomato_Early_blight', 'Tomato__Tomato_YellowLeaf__Curl_Virus']
pepper_classes = ['pepper_healthy', 'pepper_bell_bacterial_spot']
st.set_page_config(
    layout="wide",
    page_title='plant disease detection',
)
st.title("Plant Disease Detection")
st.header("TARP PROJECT")
st.write("This application is detecting disease in three plants potato, tomato and pepper")
options = ["Select One Plant", "Tomato", "Potato", "Pepper"]

# Create a selectbox for the user to choose one option
selected_option = st.selectbox("Select Plant:", options)

# st.write("You selected:", selected_option)

uploaded_file = st.file_uploader("Choose an image...", type=["jpg", "png", "jpeg"])


def read_file_as_image(data) -> np.array:
    image = np.array(data)
    image = cv2.resize(image, (256, 256))
    return image


async def potato():
    if uploaded_file is not None:
        image = Image.open(uploaded_file)
        st.image(image, caption="Uploaded Image", width=250)
        image = read_file_as_image(image)
        image_batch = np.expand_dims(image, axis=0)
        predictions = MODEL.predict(image_batch)
        predicted_class = class_names[np.argmax(predictions[0])]
        confidence = np.max(predictions[0])
```

```python
        print("prediction", class_names[np.argmax(predictions)])
        st.write("Predicted Class : ", predicted_class, " Confidence Level : ", confidence)


async def tomato():
    if uploaded_file is not None:
        image = Image.open(uploaded_file)
        st.image(image, caption="Uploaded Image", width=250)
        image = read_file_as_image(image)
        image_batch = np.expand_dims(image, axis=0)
        predictions = TOMATO_MODEL.predict(image_batch)
        predicted_class = Tomato_classes[np.argmax(predictions[0])]
        confidence = np.max(predictions[0])
        print("prediction", Tomato_classes[np.argmax(predictions)])
        st.write("Predicted Class : ", predicted_class, " Confidence Level : ", confidence)


async def pepper():
    if uploaded_file is not None:
        image = Image.open(uploaded_file)
        st.image(image, caption="Uploaded Image", width=250)
        image = read_file_as_image(image)
        image_batch = np.expand_dims(image, axis=0)
        predictions = PEEPER_MODEL.predict(image_batch)
        predicted_class = pepper_classes[np.argmax(predictions[0])]
        confidence = np.max(predictions[0])
        print("prediction", pepper_classes[np.argmax(predictions)])
        st.write("Predicted Class : ", pepper_classes, "         Confidence Level : ", confidence)


import asyncio

if __name__ == "__main__":
    # if st.button('Predict'):

    if selected_option == 'Potato':
        asyncio.run(potato())
    elif selected_option == 'Tomato':
        asyncio.run(tomato())
    elif selected_option == 'pepper':
        asyncio.run(pepper())
    else:
        st.write("not available")
```

Github Link:

https://github.com/sainitishmitta04/Plant-Leaf-Disease-Detection

THE END