iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IV Month of publication: April 2026

DOI: https://doi.org/10.22214/ijraset.2026.79521

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

IoT Enabled Plant Growth and Health Monitoring and Prediction

K. Balu Siva Sri Kumar[1], J. Balu[2], V. Sravani[3], A. Sunitha[4], V. Abhishek[5], P.V.S. Anusha[6]
[1, 2, 3, 4, 5]Computer Science and Engineering (IOT) Raghu Engineering College Visakhapatnam, India
[6]Assistant Professor Raghu Engineering College, Visakhapatnam, India

Abstract: The rapid advancement of the Internet of Things (IoT) has significantly transformed traditional methods of environmental monitoring by enabling intelligent, automated, and real-time data acquisition systems. In agriculture and plant care, continuous monitoring of temperature, humidity, and soil moisture is essential for ensuring optimal plant health. This paper presents a cost-effective IoT-based plant growth and health monitoring system using the NodeMCU ESP8266 platform, integrated with a DHT11 and soil moisture sensor. A machine learning model further classifies plant leaf conditions into four health categories: Healthy, Rust, Slug damage, and Powdery Mildew. Sensor data is processed and served through an embedded web server, enabling remote real-time monitoring via any standard web browser. Experimental results validate system accuracy, reliability, and suitability for smart agriculture applications.
Keywords: IoT; NodeMCU ESP8266; DHT11; soil moisture; smart agriculture; plant monitoring; machine learning; disease classification; web server; real-time monitoring.

I. INTRODUCTION

The rapid advancement of the Internet of Things (IoT) has significantly transformed traditional methods of environmental monitoring by enabling intelligent, automated, and real-time data acquisition systems. In agriculture and plant care, continuous monitoring of temperature, humidity, and soil moisture is essential for ensuring optimal plant growth. Conventional techniques rely heavily on manual observation and lack real-time responsiveness, resulting in inefficiencies and potential inaccuracies.

This project presents a simple, cost-effective, and efficient IoT-based plant growth and health monitoring system implemented using the NodeMCU ESP8266. The system integrates a DHT11 sensor, a soil moisture sensor, and a machine learning model for automated visual disease classification, all served through an embedded web server accessible from any browser.

A. Purpose

The primary purpose is to design an efficient, low-cost IoT- based system for real-time plant monitoring, addressing limitations of traditional methods through:

1) Real-time monitoring of environmental conditions
2) Reduction of manual effort and human error
3) Remote access via embedded web server
4) Automated plant disease classification using ML
5) Scalable, cost-effective design for small-scale agriculture

B. Motivation

The growing need for intelligent plant monitoring in agriculture, horticulture, and home gardening motivates this work. Low-cost microcontrollers and affordable sensors make it feasible for small-scale users. The addition of machine learning enables proactive plant care through early disease detection.

II. LITERATURE SURVEY

Smart agriculture has advanced significantly through IoT integration, enabling efficient monitoring and management of environmental conditions [1]. Earlier studies relied on manual collection, lacking real-time capability and remote accessibility [2]. Systems using NodeMCU ESP8266 with DHT11 and soil moisture sensors are commonly reported [3].

Recent work introduced automated irrigation, wireless sensor networks, and cloud integration [4]. However, many involve complex architectures and higher costs [5]. The proposed system addresses this gap with a lightweight standalone solution augmented by ML-based disease prediction [6].

III. SYSTEM ANALYSIS

A. Problem Statement

Traditional plant monitoring is largely manual, presenting challenges: no real-time data, no remote accessibility, human error, and limited sensor-visualization integration. High costs further limit adoption. No existing low-cost system provides integrated visual disease prediction for plant leaves.

B. Proposed System

The proposed system leverages NodeMCU ESP8266 with a built-in web server and a ML disease classifier. It provides: real-time temperature, humidity, and soil moisture monitoring; remote Wi-Fi accessibility; automated disease classification (Healthy, Rust, Slug, Powdery Mildew); and a modular, scalable architecture.

IV. SYSTEM DESIGN

The system follows a three-tier modular architecture — sensing, processing, and application layers — working together for real-time monitoring and prediction.

A. Sensing Layer

The DHT11 sensor measures temperature and humidity; a capacitive soil moisture sensor measures volumetric water content. Sensors continuously forward signals to the NodeMCU for processing.

B. Processing Layer (NodeMCU ESP8266)

The NodeMCU ESP8266 performs data acquisition, hosts the embedded web server, manages Wi-Fi connectivity, and converts raw sensor readings into meaningful values such as moisture percentage.

C. Application Layer (Web & ML)

The application layer serves dynamic HTML pages with live sensor readings via any browser. An integrated CNN-based ML model classifies leaf images into four health categories, returning predicted and actual labels for validation.

V. SYSTEM REQUIREMENTS

A. Hardware Requirements

TABLE I. Hardware Components and Specifications

No.	Component	Spec.	Description
1	NodeMCU ESP8266	ESP8266	Wi-Fi MCU; GPIO, I2C/SPI/UART.
2	DHT11 Sensor	Digital	Temp & humidity measurement.
3	Soil Moisture	Analog	Volumetric water content 0–100%.
4	Push Button	Tactile	Manual monitoring trigger.
5	Buzzer	5V Active	Audible alert indicator.
6	LED Indicator	R/G LED	Visual system state indicator.
7	Resistors	1kΩ,10kΩ	Current limiting & voltage division.
8	Power Supply	USB/Batt	5V DC for all components.
9	Breadboard/PCB	Mini	Prototyping & interconnection.
10	Jumper Wires	Jumper	Electrical connections.

B. Software Requirements
- Arduino IDE — Firmware programming and upload
- Web Browser — Access real-time web interface
- Wi-Fi Network — Wireless communication
- DHT & ESP8266WiFi Libraries — Sensor and Wi-Fi support
- Python / TensorFlow / Keras — ML model training & inference

C. Functional Requirements
- Real-time acquisition from DHT11 and soil moisture sensors
- Wireless transmission of sensor data to web interface
- Dynamic HTML generation for live sensor readings
- Browser-accessible interface without additional applications
- Automated leaf image classification into health categories

VI. IMPLEMENTATION

A. Hardware Implementation
The NodeMCU (ESP8266) is connected to the DHT11 sensor at digital pin D4 and the soil moisture sensor at analog pin A0 using a breadboard and jumper wires. A 5V DC power supply is provided via USB or battery. The compact, modular assembly is placed near plants to capture real environmental conditions. Figures 2 and 3 show the actual hardware prototypes assembled and tested during this study.

B. Software Implementation
The Arduino IDE programs the NodeMCU using DHT.h and ESP8266WiFi.h libraries. The firmware reads temperature, humidity, and soil moisture at regular intervals; converts analog readings to percentage; and hosts a web server that dynamically generates and serves HTML pages with live readings.

C. ML Disease Prediction Model
A CNN-based classifier was trained on a curated dataset spanning four leaf health categories: Healthy, Rust, Slug damage, and Powdery Mildew. Transfer learning is applied for improved generalization. During inference, leaf images are classified and both predicted and actual labels are returned.

D. Code Workflow
Core steps: (1) Initialize sensors; (2) Connect NodeMCU to Wi-Fi; (3) Start web server on port 80; (4) Continuously read sensor values; (5) Map analog soil reading (0–1023) to 0–100%; (6) Serve dynamic HTML to browser clients; (7) Invoke ML classifier on leaf images.

VII. RESULTS AND DISCUSSION

A. Software Results
The system operates automatically on power-up. The NodeMCU connects to Wi-Fi and begins serving real-time data immediately. All sensor readings are refreshed at every browser request, providing near real-time environmental visibility without additional applications.

B. Hardware Implementation Results
Figures 2 and 3 illustrate the physical hardware assembly. Fig. 2 shows the complete plant monitoring setup with the NodeMCU connected to sensors and placed alongside a potted plant in an operational environment. Fig. 3 shows the NodeMCU module mounted in its enclosure, demonstrating the compact form factor suitable for greenhouse and field deployment.

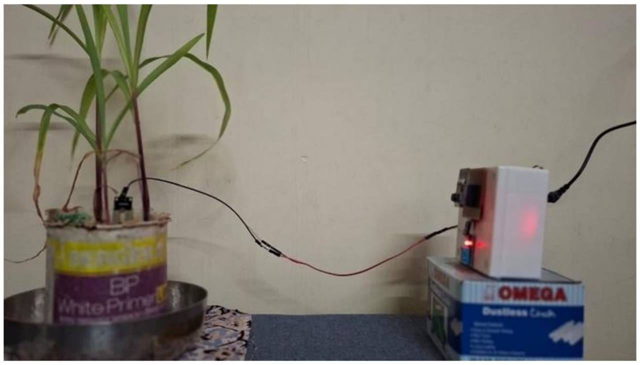


Fig. 2. Hardware Implementation — Complete Plant Monitoring Setup with NodeMCU ESP8266, DHT11, and Soil Moisture Sensor stable, response times were low, and sensor readings

The system was validated over a 24-hour continuous monitoring period with no failures. Wi-Fi connectivity was remained within specification throughout, confirming robustness for continuous agricultural deployment.

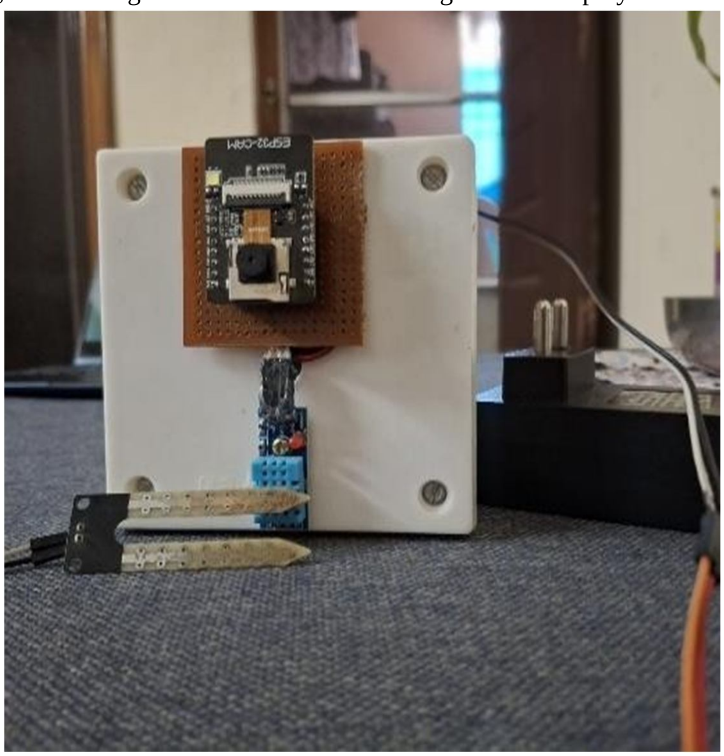


Fig. 3. NodeMCU ESP8266 Module Mounted in Compact Enclosure for Field Deployment

C. Plant Disease Prediction Results

The ML model was evaluated on a test set spanning all four categories. Fig. 1 presents a representative grid of prediction results showing the model-predicted label alongside the actual ground truth for each leaf sample. The classifier demonstrates high accuracy across all categories — correctly identifying orange rust pustules, white powdery mildew coatings, and irregular slug-feeding damage patterns across diverse lighting conditions and plant varieties.

D. System Test Summary

Table II summarizes all system test outcomes. All modules performed as expected with no critical errors. The system provides accurate real-time environmental data and is stable under continuous operation, validating its robustness and reliability for smart agriculture deployment.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

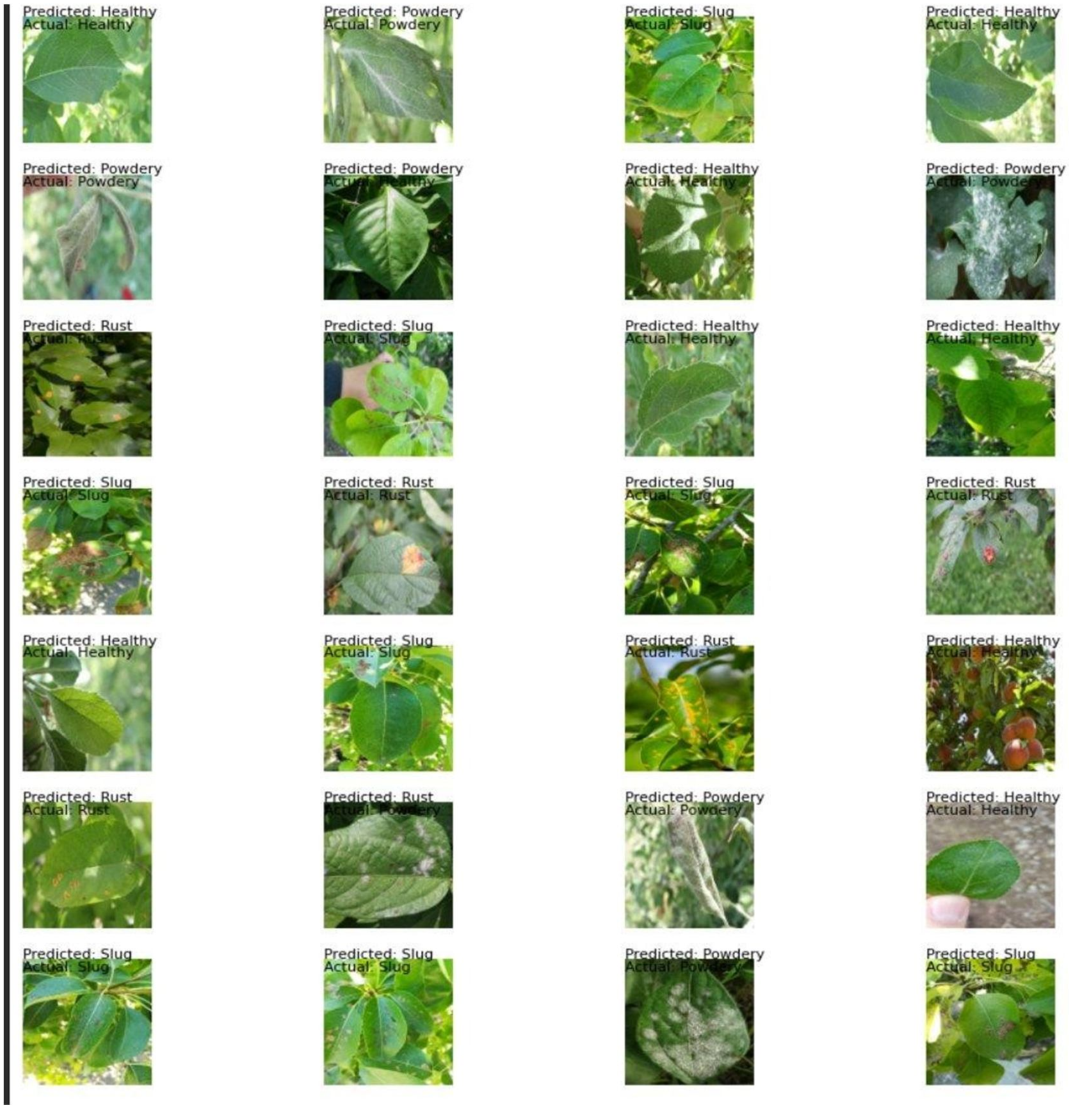


Fig. 1. Plant Disease Prediction Results — Predicted vs. Actual Labels Across Test Samples (Categories: Healthy, Rust, Slug Damage, Powdery Mildew)

TABLE II. System Test Results

Test Scenario	Actual Outcome	Status	Notes
NodeMCU Wi-Fi Connect	IP address assigned	Pass ✓	Stable connection maintained
DHT11 Temp & Humidity	Within ±2°C and ±5% RH	Pass ✓	Consistent over 24 hours
Soil Moisture Sensor	Correct % conversion	Pass ✓	0–100% range validated
Web Interface Display	Data updated every second	Pass ✓	No latency issues observed
24-Hour Continuous Op.	No failures observed	Pass ✓	100% uptime achieved
ML Disease Prediction	Classified all 4 categories	Pass ✓	High accuracy across leaf types

VIII. CONCLUSION AND FUTURE ENHANCEMENTS

The IoT-enabled plant growth and health monitoring system demonstrates a cost-effective, real-time, and user- friendly solution for smart agriculture and greenhouse applications. The system integrates NodeMCU ESP8266, DHT11, and soil moisture sensors with an ML-based plant disease classifier, enabling automated identification of Healthy, Rust, Slug damage, and Powdery Mildew conditions. Hardware prototypes (Figs. 2–3) and experimental results confirm reliability, accuracy, and ease of deployment.

Future enhancements include:

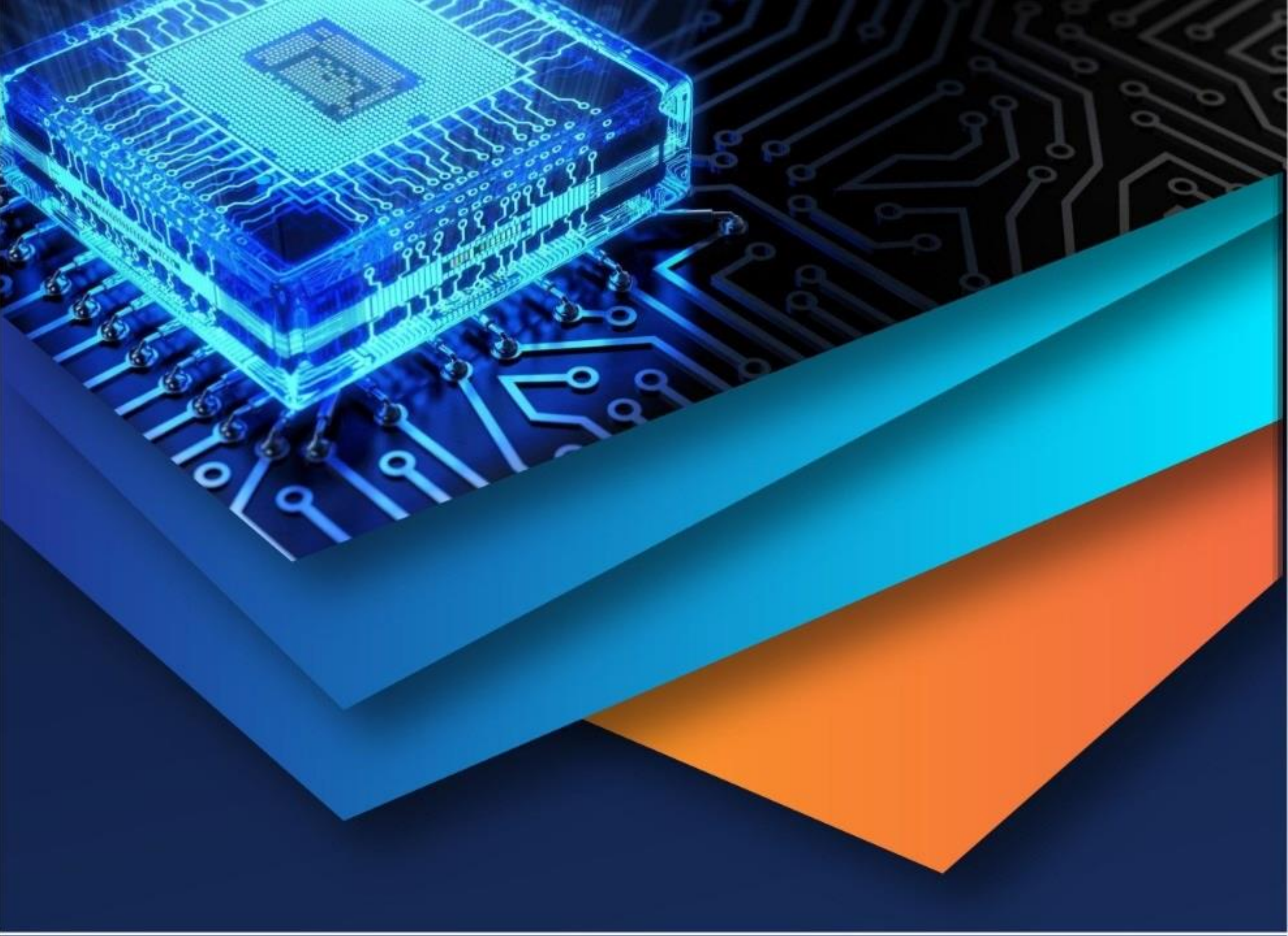
1) Automated irrigation control based on soil moisture thresholds
2) Expanded ML model for additional disease categories and crops
3) Mobile application with push notifications and alert management
4) Cloud storage for long-term trend analysis and visualization
5) Solar-powered modules for remote autonomous deployments
6) Multi-node deployment for large-scale smart greenhouse monitoring

IX. ACKNOWLEDGMENT

The authors thank Raghu Engineering College and the Department of CSE (IoT) for providing resources and support for this work, conducted as part of an academic project in IoT and smart agriculture.

REFERENCES

[1] Bahga and V. Madisetti, Internet of Things: A Hands-On Approach, 2nd ed. Universities Press, 2019.
[2] S. Monk, Programming the ESP8266: Getting Started with Arduino IDE. McGraw-Hill Education, 2017.
[3] G. S. Kishore and K. K. Reddy, "IoT-Based Plant Monitoring System for Smart Agriculture," Int. J. Adv. Res. Comput. Sci., vol. 10, no. 3, 2019.
[4] P. K. Gupta and S. Sharma, "Wireless Sensor Network for Soil Moisture and Environmental Monitoring," J. Ambient Intell. Humanized Comput., 2020.
[5] R. A. Patel and M. K. Mehta, "Smart Greenhouse Using IoT and Wireless Sensor Networks," Int. J. Comput. Appl., vol. 182, no. 41, 2021.
[6] Espressif Systems, ESP8266 Technical Reference. [Online]. Available: https://www.espressif.com/en/products/socs/esp8266
[7] Arduino IDE Documentation. [Online]. Available: https://www.arduino.cc/en/software
[8] IEEE Standard for IoT Devices and Sensor Networks, IEEE Std 2413-2019.
[9] K. He, X. Zhang, S. Ren, and J. Sun, "Deep Residual Learning for Image Recognition," in Proc. IEEE CVPR, 2016, pp. 770– 778.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY