SMART SOIL HEALTH MONITORING SYSTEM

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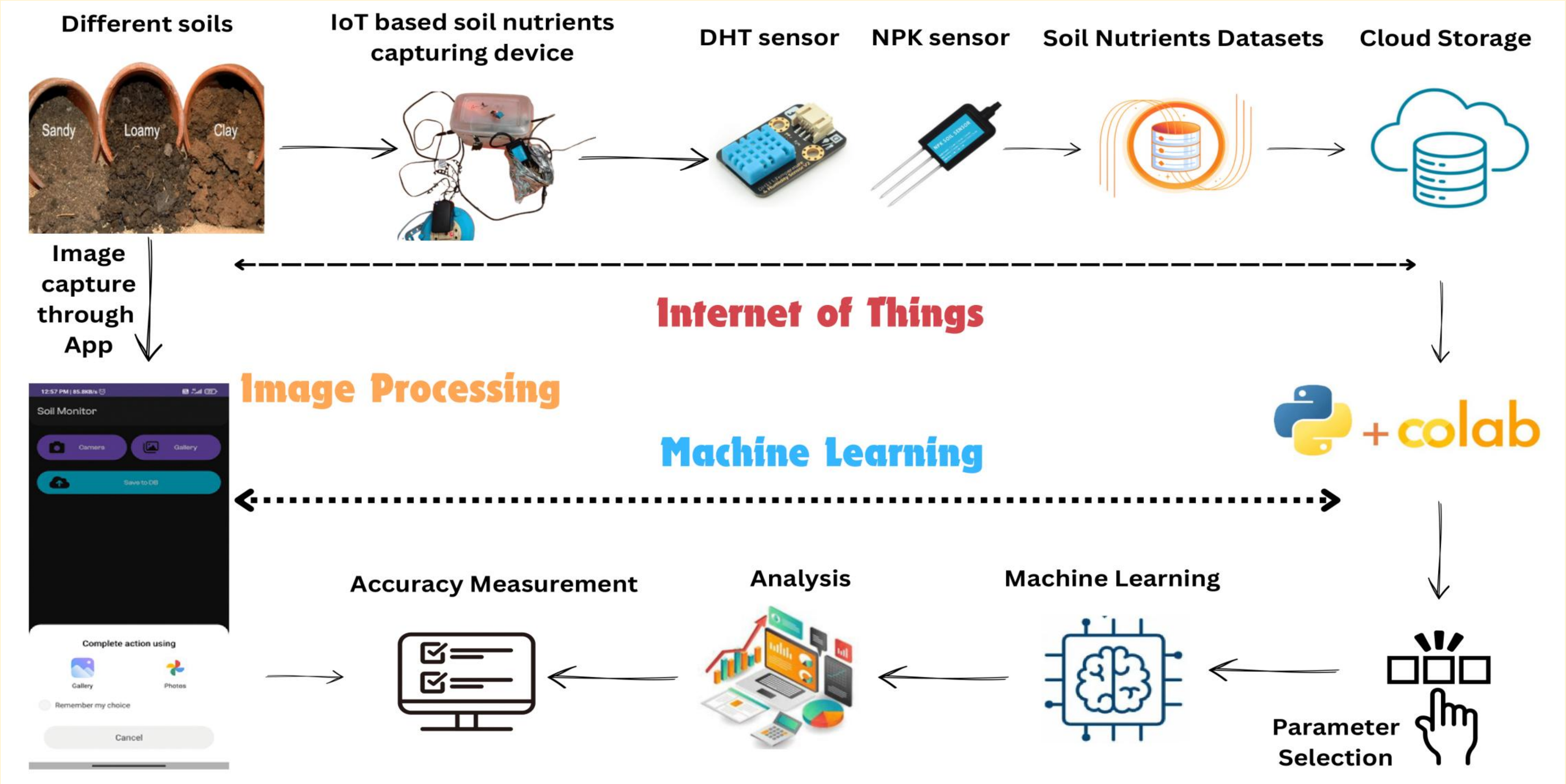
CONTENT

GRAPHICAL EXTRACT



INTRODUCTION

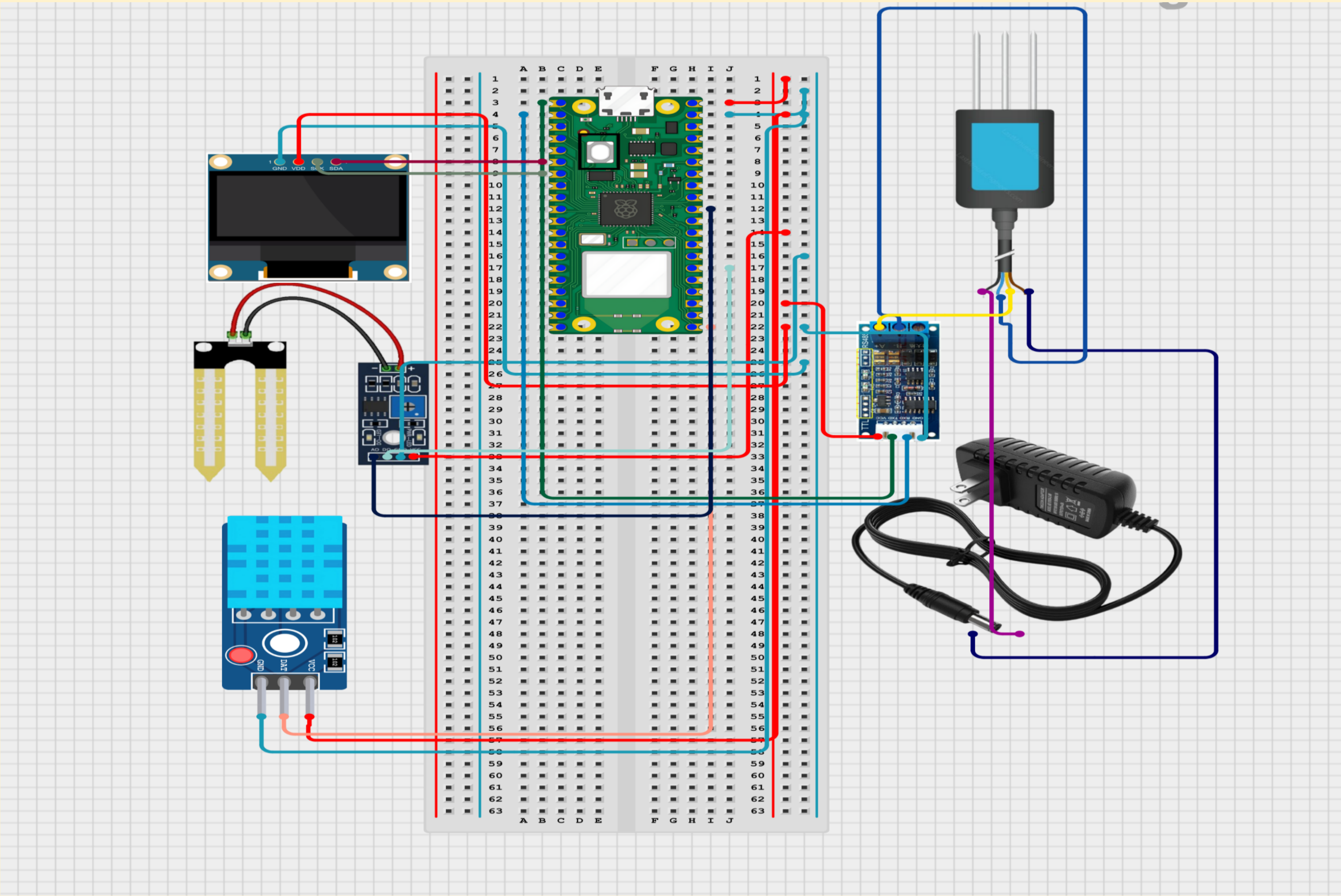
"Smart Soil Health Monitoring System"

- ✓ Sustainable agriculture focus
- ✓ Real-time soil monitoring
- ✓ IoT and data analytics integration
- ✓ Open-source hardware: Raspberry Pi Pico
- ✓ Measures: Moisture, Temperature, NPK
- ✓ Collects images using Soils to perform Image Processing
- ✓ Accurate soil data collection
- ✓ Informed farming decisions
- ✓ Scalable and accessible design
- ✓ Suitable for all farm sizes
- ✓ Promotes resource optimization and productivity

COMPONENTS LIST

SL NO.	NAME OF THE COMPONENTS	NUMBER OF COMPONENT
1.	RASPBERRY Pi Pico	1
2.	DTH11 SENSOR	1
3.	BREADBOARD	1
4.	JUMPER WIRES	30
5.	OLED-96”	1
6.	DS3231	1
7.	NPK SENSOR	1
8.	TTL CONVERTOR	1
9.	RASPBERRY Pi 5MP CAMERA	1

CIRCUIT DIAGRAM



WORKING PRINCIPLE

Sensor Monitoring

- Sensors (humidity, temperature, NPK) connected to Raspberry Pi Pico W, collect real-time soil data, shown on an OLED display.

Soil Image Capture

- User captures a soil image via the mobile app, which is uploaded to Supabase with a soil tag.

Data Storage

- Sensor data and image-based attributes are stored in Supabase for centralized tracking.

AI Classification

- A CNN model analyzes the image to classify soil type and determine key attributes like texture, richness, and suitable crops.

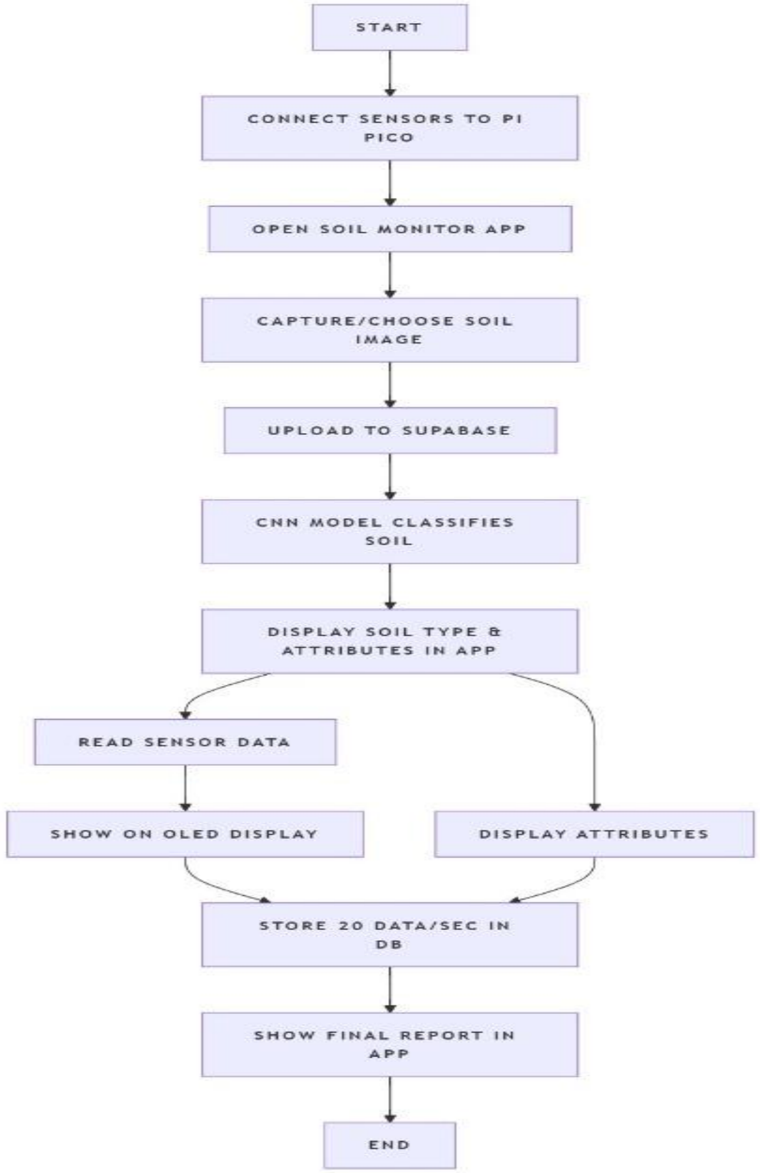
ML Accuracy Measurement

- Accuracy is measured based on the collected data from sensors data.

Final Report Display

- The app presents a combined report with soil type, live sensor data and crop recommendations.

MODEL ALGORITHM



COMPONENTS

Raspberry Pi Pico W

Microcontroller with RP2040, dual-core Arm Cortex-M0+ @ 133MHz

264KB SRAM, 2MB flash, 26 GPIO pins (3 analogue inputs)

2.4GHz Wi-Fi (802.11b/g/n), Bluetooth 5.2, on-board antenna

Interfaces: 2 UART, 2 SPI, 2 I2C, 16 PWM, USB 1.1, 8 PIO

Power: 1.8–5.5V, -20°C to +70°C

Size: 21mm × 51mm

NPK Sensor

Measures soil nitrogen (N), phosphorus (P), potassium (K)

Optical/electrochemical detection, 4-20mA output

2M cable with 3-pin probes

Monitors soil moisture, temperature, humidity

Ideal for precision agriculture, IoT integration

COMPONENTS

TTL Converter

Converts TTL signals (3.3V/5V) to RS-232/USB

USB to TTL chip, supports STC download,

Dual 3.3V/5V output, 500mA self-recovery fuse

Compatible with Win7/Vista/Mac/Linux

Real-time data transfer monitoring

DHT11 Sensor

Measures temperature (0°C–50°C) and humidity (20%–90%)

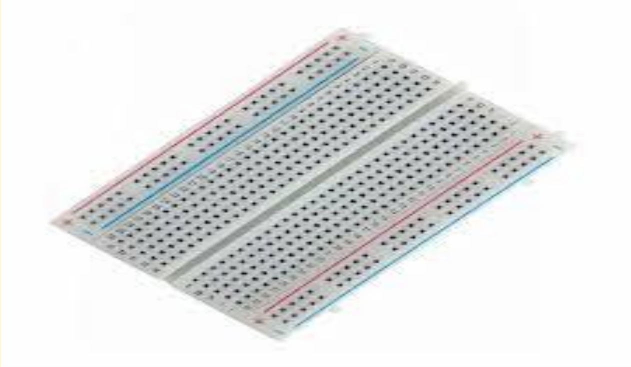
Operating voltage: 3.5V–5.5V, 16-bit resolution

Serial data output, ±1°C/±1% accuracy

High reliability, fast response, anti-interference

COMPONENTS

Breadboard



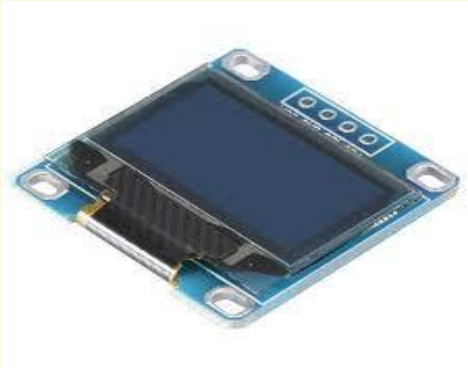
Solderless prototyping, 630 tie-points (IC/circuit), 200 tie-points (distribution)

ABS plastic, 6.5 x 4.4 x 0.3 inches, 2.54mm pitch

300V/3–5A rating, 500MΩ insulation, 1000V AC withstand

Heat distortion temperature: 84°C

OLED-0.96" Display



128x64 resolution, 0.96" PMOLED, no backlight

I2C/SPI interface, 4.0V–5.5V, 65K colors

Size: 32.7 x 23 x 4.9mm, 180° viewing angle

Micro-SD support (64Mb–2GB), GOLDELOX-SGC processor

Displays graphics, text, animations, supports Windows fonts

Jumper Wires

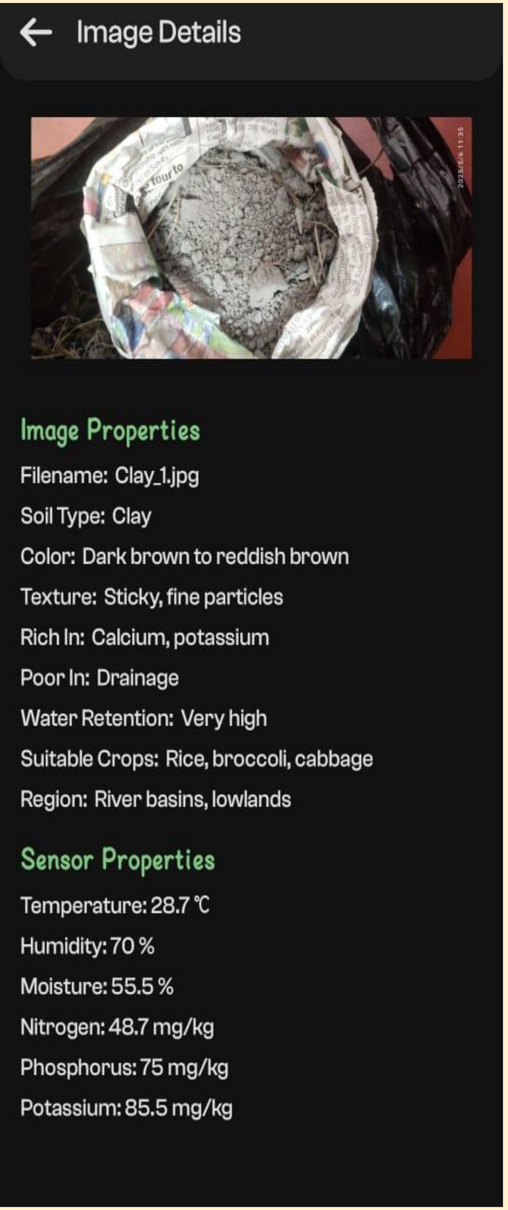
Male-to-male, male-to-female, female-to-female versions

Connector pins for solderless breadboard connections

Color-coded for easy identification (no functional difference)

Used for prototyping, connecting components

OUTPUT: FEATURE EXTRACTION

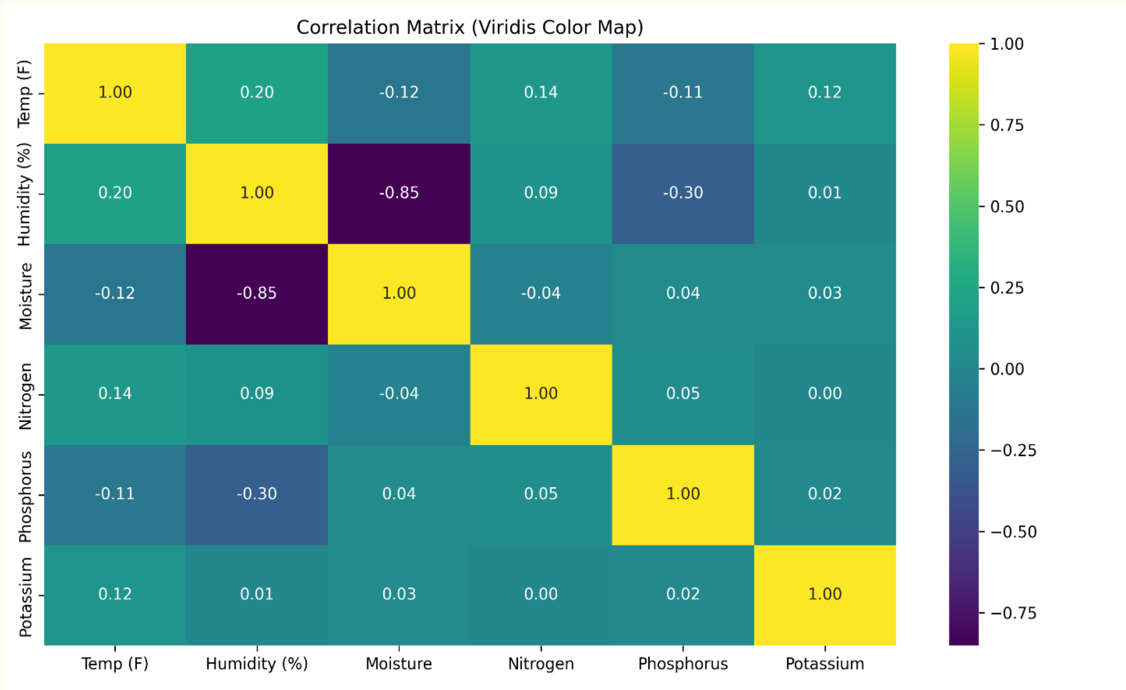


type	color	texture	rich_in	poor_in	water_retention	suitable_crops	region	filename	avg_temperature	avg_humidity	avg_moist	avg_nitrog	avg_phos	avg_potassium
Clay	Dark brown to reddish brown	Sticky, fine particles	Calcium, potassium	Drainage	Very high	Rice, broccoli, cabbage	River basins, lowlands	Clay_1.png	31	78.85	73.349	104.3	66.6	124.4
Clay	Dark brown to reddish brown	Sticky, fine particles	Calcium, potassium	Drainage	Very high	Rice, broccoli, cabbage	River basins, lowlands	Clay_6.png	31	78	82.598	122.75	12.85	47.15
Alluvial	Light grey to sandy brown	Silty to loamy	Potash, phosphoric acid, lime	Nitrogen	Moderate to high	Rice, wheat, sugarcane, jute	Indo-Gangetic plain	Alluvial_2.png	31	78	82.8435	101.85	6.6	0.35
Clay	Dark brown to reddish brown	Sticky, fine particles	Calcium, potassium	Drainage	Very high	Rice, broccoli, cabbage	River basins, lowlands	Clay_7.png	31	78	82.015	128.9	27.15	13.55
Clay	Dark brown to reddish brown	Sticky, fine particles	Calcium, potassium	Drainage	Very high	Rice, broccoli, cabbage	River basins, lowlands	Clay_8.png	31	77	82.369	131.1	59.5	45.35

Feature Extracted Database

Sample result received in the app after result analysis

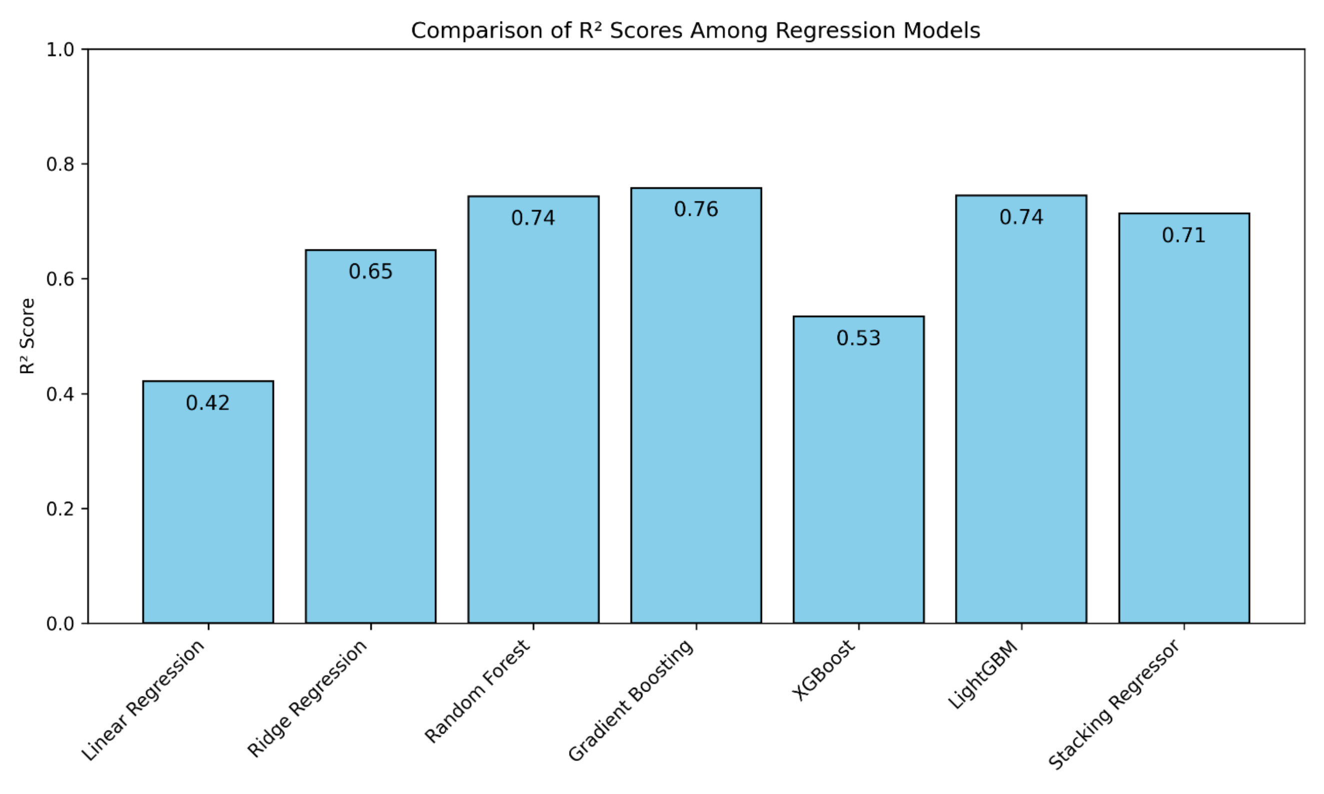
OUTPUT: FEATURE EXTRACTION



	Temp (F)	Humidity (%)	Moisture	Nitrogen	Phosphorus	Potassium
Temp (F)	1.00	0.20	-0.12	0.14	-0.11	0.12
Humidity (%)	0.20	1.00	-0.85	0.09	-0.30	0.01
Moisture	-0.12	-0.85	1.00	-0.04	0.04	0.03
Nitrogen	0.14	0.09	-0.04	1.00	0.05	0.00
Phosphorus	-0.11	-0.30	0.04	0.05	1.00	0.02
Potassium	0.12	0.01	0.03	0.00	0.02	1.00

Correlation plot with the soil features

Comparison of correlation values among different regression models



APPLICATIONS

- ✓ Precision agriculture
- ✓ Real-time soil data (moisture, temperature, pH, nutrients)
- ✓ Optimized irrigation and fertilization
- ✓ Improved crop yields
- ✓ Sustainable land management
- ✓ Long-term soil health monitoring
- ✓ Erosion control
- ✓ Biodiversity enhancement
- ✓ Prevention of soil degradation
- ✓ Drought and climate adaptation
- ✓ Efficient water use
- ✓ Support in water-scarce regions
- ✓ Climate-resilient farming practices
- ✓ Soil behavior analysis
- ✓ Support for crop breeding programs
- ✓ Study of environmental impact on soil
- ✓ Community and cooperative farming
- ✓ Shared low-cost open-source system
- ✓ Rural productivity improvement
- ✓ Research and development etc.

FUTURE SCOPE

- **Use of advanced technologies:**
  - ✓ AI and machine learning for predictive insights
  - ✓ IoT and wireless sensor networks for real-time monitoring
  - ✓ Drones and satellite imaging for large-scale analysis

- **Sustainable agriculture and climate resilience:**
  - ✓ Climate-smart farming adaptation
  - ✓ Efficient resource use and reduced carbon footprint

- **Farmer empowerment and decision support:**
  - ✓ Mobile apps with real-time alerts and recommendations
  - ✓ Decision support for both smallholders and large farms

- **Big data and cloud-based platforms:**
  - ✓ Regional soil data aggregation
  - ✓ Policy planning, crop insurance, market forecasting

- **Integration with smart farming systems:**
  - ✓ Automated smart irrigation
  - ✓ Contribution to Internet of Agri-Things (IoAT) ecosystem

RESEARCH PUBLICATION

- *Subhrajyoti Mandal, Shibam Mishra, Arpan Biswas, Subhojit Malik; "**A Comprehensive Review on Soil Fertility Management Using Machine Learning Tools**" In Intelligent Systems in Solid State Electronics and Communication Engineering (Book Chapter, provisionally accepted), CRC Press, Scopus indexed, accepted on 30.04.2025.*

CONCLUSION

- ✓ Promotes sustainable and data-driven agriculture
- ✓ Uses affordable IoT-enabled sensors for real-time soil monitoring
- ✓ Empowers farmers, researchers and environmentalists
- ✓ Supports resilient and productive farming practices
- ✓ Addresses challenges of climate change and population growth
- ✓ Future scope includes advanced sensors, machine learning and satellite integration
- ✓ Provides a scalable and sustainable solution for future agriculture

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THANK YOU