Abdullah Gul University

Department of Computer Engineering

Internet of Things Project Report

Autonomous Greenhouse System

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Introduction

In the realm of Internet of Things (IoT), our project, titled "Autonomous Greenhouse System" endeavors to create an intelligent greenhouse that seamlessly integrates various sensors and actuators to meticulously monitor and control the greenhouse environment. The amalgamation of Arduino and Raspberry Pi 4 forms the backbone of our comprehensive solution. The project encompasses a multitude of features designed to enhance agricultural practices and optimize plant growth conditions:

- Light Control: The system dynamically adjusts internal lighting based on real-time environmental parameters, ensuring an optimal light regime for plant growth.

- Soil Moisture Regulation: Leveraging advanced sensor technology, our greenhouse intelligently manages soil moisture levels, activating irrigation systems precisely when needed.

- Water Reservoir Monitoring: Continuous tracking of water levels in the reservoir ensures that the system can promptly alert users with a buzzer in the event of water scarcity.

- Temperature and Humidity Control: The internal temperature and humidity conditions are meticulously regulated using fans and other mechanisms, fostering an environment conducive to plant health.

- Enables the establishment of a Wi-Fi connection for efficient data transmission. Facilitates the upload of sensor data to a dedicated server, providing users with real-time insights.

- Disease Status Monitoring: A Raspberry Pi 4, coupled with a camera, captures plant images for a comprehensive assessment of plant health. Machine learning models provide valuable insights into the disease status of the plants, with findings communicated to users via email.

System Model

- **Hardware Design**

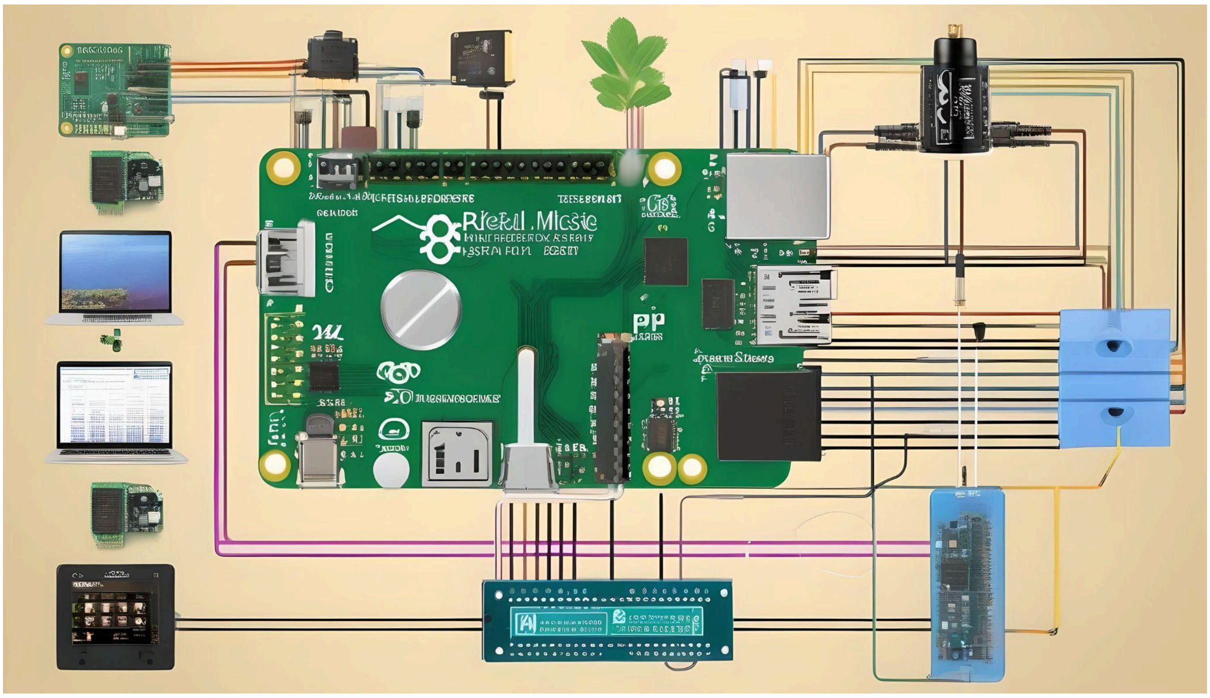
Our smart greenhouse system is meticulously designed, encompassing a sophisticated array of hardware components:

- Arduino Board:
  - Manages a plethora of sensors including light, soil moisture, temperature, and humidity.
  - Controls various actuators to regulate greenhouse conditions.

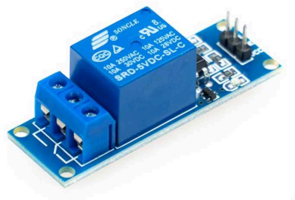
- Raspberry Pi 4:
  - Employs a camera to capture images of plants within the greenhouse.
  - Utilizes machine learning models for the detailed analysis of plant disease status.
  - Acts as the communication hub, providing Wi-Fi connectivity for data transmission.
  - Facilitates the upload of sensor data to a remote server, enabling real-time monitoring.

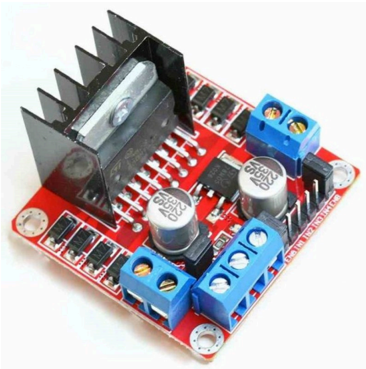
- Actuators:
  - A Servo motor intricately controls the greenhouse window, optimizing ventilation.
  - A Water motor and sprinkler system ensure precise and efficient soil irrigation.
  - A Fan is employed for the nuanced regulation of temperature and humidity.
  - A Buzzer serves as an audible alert for low water levels in the reservoir.

- Sensors:
  - The system incorporates a diverse range of sensors including light, soil moisture, air humidity, temperature, and water level sensors, collectively ensuring comprehensive data collection.



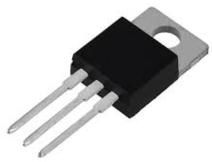
A heater-coupled relay is an electrical device that functions to turn a heater on or off, usually based on a signal provided by a control system. This type of relay is used to control the heater and turn the heater on or off when certain temperature conditions are reached.

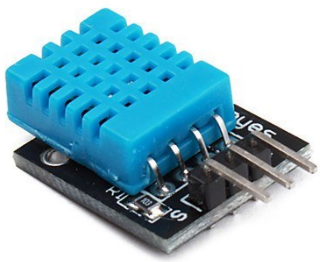




A motor driver is an electronic device used to control and manage an electric motor. Motor drivers are used in ventilation systems.

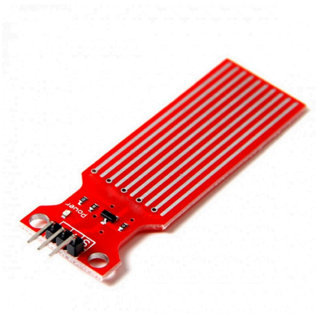
Transistors are electronic components used to operate water engines. In this application, transistors take on the task of powering and controlling water motors.





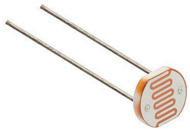
DHT11 is a sensor used to measure temperature and humidity. This sensor is used to collect temperature and humidity information in weather stations, climate control systems, home automation projects, and similar applications.

Water level sensor is a sensor used to measure water level. This sensor is usually designed to detect the water level in a particular environment and transmit this information to a control system or a microcontroller via digital or analog signals.



The term "mini diver pump" is generally understood as "mini submersible pump", and this type of pump is a type of small-scale pump that can operate by submersion in water. It is used for water drainage.

LDR (Light-Dependent Resistor) is a resistor that is sensitive to light intensity. This sensor is used to detect and measure environmental light levels.



- **Software Design**

The software architecture is a critical aspect of our project, where meticulous coding ensures the seamless interaction and control of various hardware components:

- Arduino Code:
  - Orchestrates the collection of sensor data and the activation of actuators.
  - Manages the dynamic control of light, irrigation, and environmental conditions within the greenhouse.

- Raspberry Pi 4:
  - Utilizes machine learning algorithms to analyze images captured by the camera.
  - Sends informative alerts regarding plant disease status to users via the website.
  - Enables the establishment of a Wi-Fi connection for efficient data transmission.
  - Facilitates the upload of sensor data to a dedicated server, providing users with real-time insights.

Disease Prediction (Machine Learning)

The application detects diseases in potato plants with using FastAPI, a modern web framework, and TensorFlow.

FastAPI Setup:

- We created a FastAPI application and set up Cross-Origin Resource Sharing (CORS) middleware. This allows our app to handle requests from different origins, making it versatile for web or mobile applications.

FastAPI

Machine Learning Model:

- We load a pre-trained machine-learning
- model using tensorflow for potato disease detection. This model has been trained to recognize diseases based on images of potato plant leaves.

TensorFlow

Image Processing Functions:

- We defined a function to process the uploaded image. It takes raw image data, converts it to a manageable format, and resizes it to ensure uniformity for our model.

Prediction Endpoint:

- The main feature is the /predict endpoint. It's a POST request where you can upload an image of a potato leaf. The uploaded image is processed, and our pre-trained model predicts if the leaf is healthy or affected by early or late blight.

Web

We have clients and a server. Web frontend and Arduino are our clients. The server has two layers. The first one is in charge of saving sensor data, responding to fetch requests for sensor data, creating authorization tokens, and finally conveying image files to the second layer. The second layer runs a machine learning model and predicts the input file if the plant is healthy or ill. In this way, we can accept images for prediction from different sources like a mobile phone, Raspberry, web frontend, or any client capable of sending images to the API.

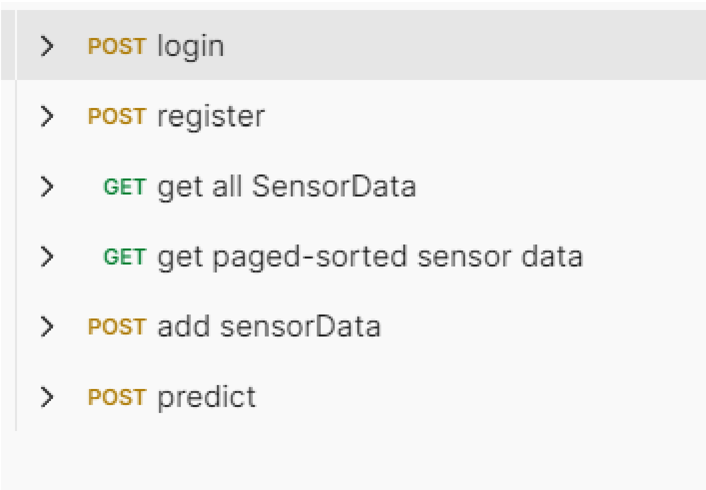
API-1 is written in Java/Spring. API-2 is written in Python/fastAPI.

Web frontend is written in React.js

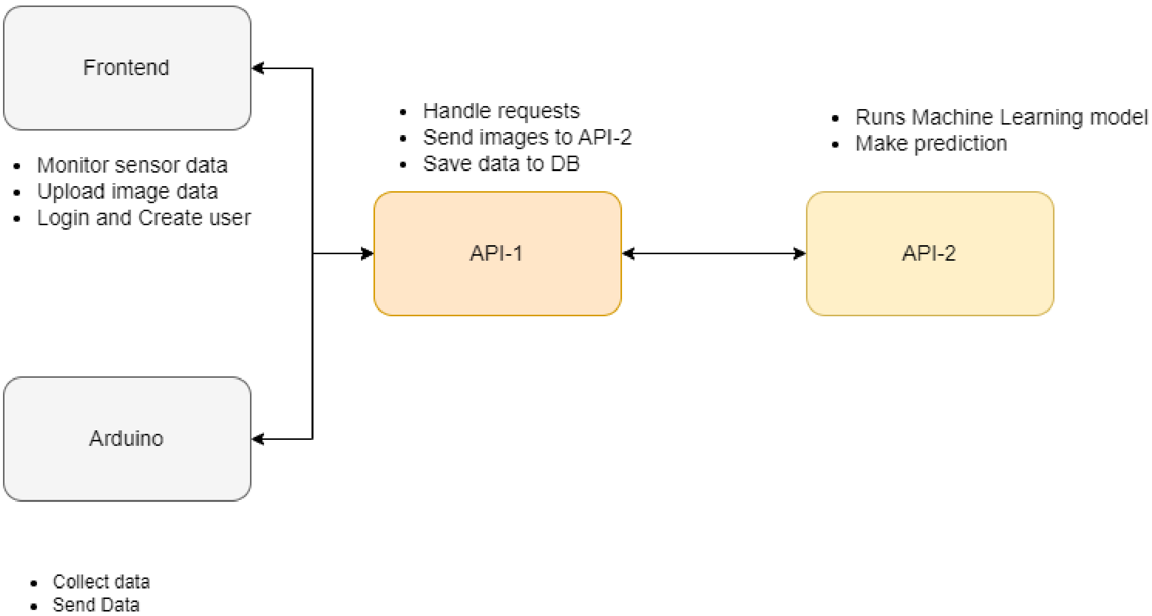
In our IoT project, an Arduino UNO efficiently collects data at regular intervals. The Arduino UNO periodically sends the gathered data to the server using HTTP requests, where the backend requires a JWT token for access control. This token is generated upon client login, providing a secure means of data access. The received data is then stored in the database.

When the frontend web application needs access to this data, it utilizes the API. Additionally, we've implemented another API that facilitates the execution of a machine-learning model. In this process, an image uploaded via the web frontend is transmitted to the backend. The backend, in turn, forwards the image data to a FastAPI, developed by our team. This FastAPI runs the machine learning model, classifies the image, and returns the prediction result to the backend, which is relayed to the client. This seamless interaction between the frontend and backend components ensures a reliable and secure flow of information in our IoT system.

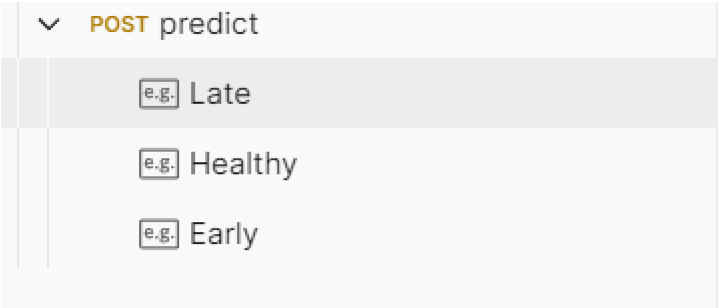
The operations held by API-1.



API-1 acts as a gateway for API-2 where the machine learning operations are done.

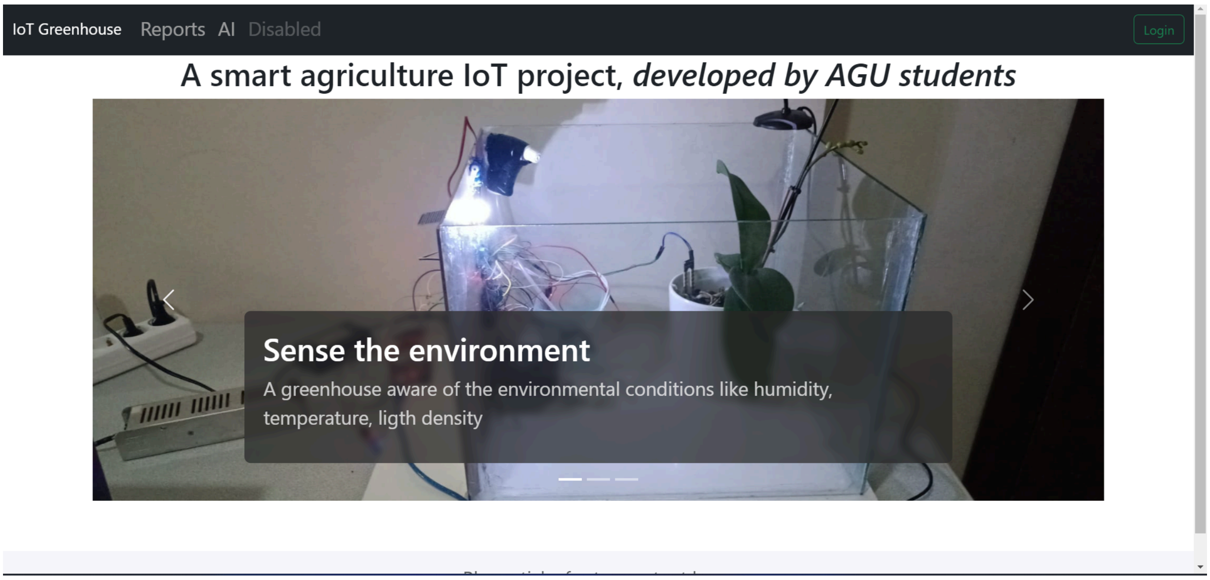


The prediction result coming from the fastAPI can be one of the three: healthy, early blight, and late blight.


POST predict
e.g. Late
e.g. Healthy
e.g. Early


IoT Greenhouse
Reports
AI
Disabled
Login
A smart agriculture IoT project, developed by AGU students
ML keeps track of health
Our Machine Learning model keeps track of the health condition of the plants for a specific disease.


IoT Greenhouse
Reports
AI
Disabled
Login
A smart agriculture IoT project, developed by AGU students
Take immediate action
Based on the optimal conditions, it takes the required actions automatically.


IoT Greenhouse
Reports
AI
Disabled
Login
A smart agriculture IoT project, *developed by AGU students*
Sense the environment
A greenhouse aware of the environmental conditions like humidity, temperature, ligth density


IoT Greenhouse
Reports
AI
Disabled
Reports
Sensor Data
Light Density
Water Level
Temperature
Humidity Soil
Humidity Weather
Place sticky footer content here.

How Our Project Related SDG

SDG 9 - Industry, Innovation, and Infrastructure:

The project significantly aligns with SDG 9 by leveraging advanced technologies and innovative solutions in the agricultural sector. Components such as Arduino, NodeMcu, and Raspberry Pi are integrated to form a comprehensive smart greenhouse system. This integration not only represents advancements in agricultural infrastructure but also promotes innovation in farming practices. The use of IoT technologies enhances efficiency, automation, and data-driven decision-making, contributing to the goal of building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation.

SDG 12 - Responsible Consumption and Production:

The project addresses aspects of SDG 12 by incorporating responsible consumption and production practices. Through precise monitoring and control of environmental parameters, such as soil moisture and water levels, the system optimizes resource utilization. The intelligent irrigation system, activated based on soil moisture data, reflects a commitment to efficient water usage in agriculture. By promoting sustainable farming practices and minimizing resource waste, the project aligns with the broader objective of responsible consumption and production patterns.

SDG 13 - Climate Action:

The project significantly contributes to SDG 13 by actively promoting climate action in agriculture. The smart greenhouse system dynamically regulates internal environmental conditions, including temperature, humidity, and light, to create an optimal growing environment for plants. This not only enhances agricultural productivity but also reduces the environmental impact of farming. By fostering climate-friendly agricultural practices, the project aligns with the goal of taking urgent action to combat climate change and its impacts.

In summary, the project aligns with SDG 9 through technological innovation, SDG 12 through responsible consumption and production practices, and SDG 13 by actively promoting climate-friendly agricultural initiatives.

Results and Discussion:

Results:

Our endeavor to create the "Autonomous Greenhouse System" has yielded significant outcomes across various facets of agricultural management.

Light Control: The real-time adjustment of internal lighting based on environmental parameters has fostered optimal plant growth, providing a tangible boost to photosynthesis and overall plant health.

Soil Moisture Regulation: Leveraging advanced sensor technology, the system's intelligent management of soil moisture levels has led to precise irrigation, contributing to enhanced plant development without unnecessary water usage.

Water Reservoir Monitoring: Continuous tracking of water levels has proven effective in preventing water scarcity. Timely alerts through the buzzer system have empowered users to take swift action, ensuring a consistent and reliable water supply.

Temperature and Humidity Control: Meticulous regulation of internal conditions has created an environment conducive to optimal plant growth. The nuanced control of temperature and humidity using fans has mitigated risks associated with extreme conditions.

Disease Status Monitoring: The integration of Raspberry Pi with a camera and machine learning models has facilitated early disease detection. Email alerts provide users with timely insights, enabling proactive measures to prevent disease spread and minimize crop losses.

Discussion:

The success of our project is a result of the harmonious interaction between hardware and software components, showcasing a responsive and intelligent greenhouse environment.

Hardware Design: The integration of diverse sensors, actuators, and control systems, including Arduino, Raspberry Pi 4, and various actuators and sensors, has created a responsive and intelligent greenhouse environment. This integration ensures precise control over environmental parameters, crucial for effective plant management.

Software Design: The robust software architecture, incorporating Arduino code, Raspberry Pi functionalities, and machine learning algorithms, forms a foundation for effective data collection, analysis, and decision-making. The utilization of FastAPI and TensorFlow for disease prediction underscores the potential of advanced technologies in agriculture.

Web Integration: The seamless integration of web frontend, Arduino, and backend components through APIs illustrates a holistic approach to data flow and analysis. The secure transmission of data and images between components ensures the reliability and confidentiality of information.

Conclusion:

In conclusion, the "Autonomous Greenhouse System" stands as a testament to the efficacy of IoT technologies in transforming agricultural practices. The positive results obtained in light control, soil moisture regulation, water monitoring, temperature and humidity control, and disease monitoring collectively highlight the system's potential for sustainable and efficient farming.

Furthermore, the alignment with Sustainable Development Goals (SDGs) 9, 12, and 13 underscores the project's contribution to technological innovation, responsible consumption and production, and climate action in agriculture. As we reflect on the achievements and lessons learned, the Autonomous Greenhouse System paves the way for future advancements in smart agriculture, offering a blueprint for integrating technology into sustainable farming practices.