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CC4003NI Introduction to Robotics and IoT

IoT-based smart farming System

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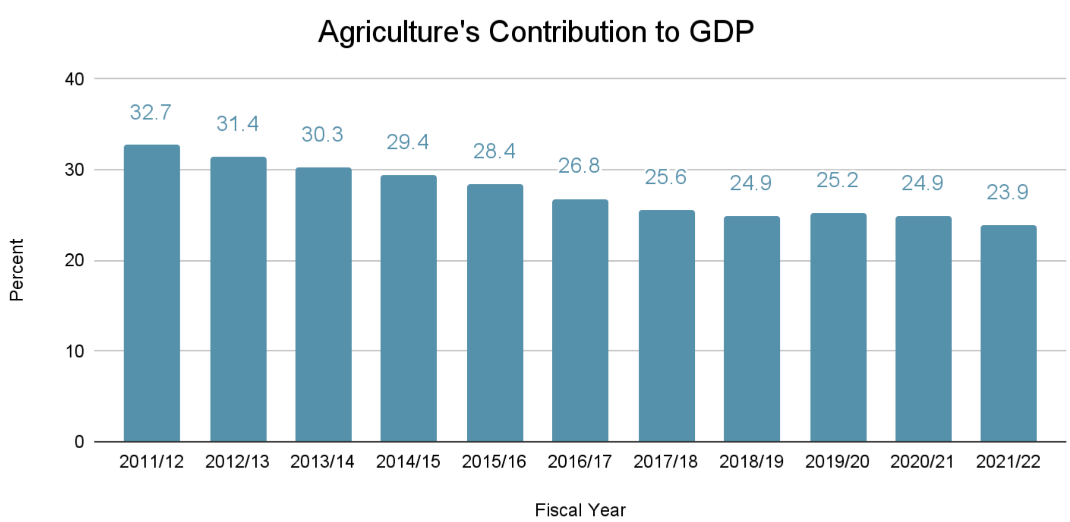
1 Introduction

Internet of Things (IoT) is a network of sensor-enabled devices interlinked through the internet that operates to bridge the physical and digital worlds. The devices linked in the network transform ordinary objects into smart systems that automatically execute tasks, irrespective of any human intervention, and that provide real-time information. IoT improves efficiency and decision making in various faculties based on cloud and edge computing such as healthcare, smart cities, agriculture, and industry, among others. IoT combines hardware, software, and connectivity to enable machines to user interaction that adapt to the dynamic ecosystems that change depending on the real-world circumstances.

The project is centered on leveraging IoT principle with the primary goal of modernizing agriculture in Nepal, aiming to enhance efficiency and optimize crop production. The main components used in this project are Ultrasonic Sensor, Soil Moisture Sensor, DHT11, ESP32, LCD, Breadboard, and Water pump.

1.1 Current Scenario

Nepalese agriculture is an important sector with over 60% of the Nepalese population involved and accounting for approximately 23% of GDP. Nevertheless, the sector faces several problems such as unpredictable rainfall, land fragmentation, and departures of young population in seek of foreign employment put the country back. At the same time, Nepal has many different agricultural climate zones, which can potentially cultivate many crops, and efforts are being made to digitize agriculture, starting from IoT based smart farming to agriculture policy. The future of agriculture in Nepal depends on coping with the problems and use opportunities for sustainable growth and commercialization.



The graph shows the dependence of the Nepalese economy on agriculture throughout the course of a decade with almost one by fourth of the total GDP supported by agriculture showing its importance to the country.

1.2 Problem Statement and Project as a Solution

Nepalese agriculture, despite being vital for livelihood and economy, faces a range of difficulties such as, over-reliance on conventional farming, low levels of mechanization, vulnerability to climate, and weak access to improved inputs and technology. These limit crop yield, food security, and capacity to transition towards commercial agriculture. Land fragmentation, limited labor due to out-migration to urban areas, and weak market linkages also limit development. The project aims at the rejuvenation of agriculture work in Nepal by using an intelligent farm system on the principles of IoT for crop production optimization. The system of smart farming comprises the following: the first is a water level control sensor for a storage tank of, the second is a control sensor for humidity in the soil, the third is the DHT11 sensor, which monitors the temperature and humidity in the surrounding environment. The data acquired by the sensors is interpreted by the ESP32 microcontroller, which controls the water pump for irrigation of crops, and the system information is displayed on the LCD screen. Thus, in short, the project makes sure that water consumption for irrigation is minimized, and the crops are grown in proper conditions, which ensures that the yield of the crops is increased, and sustainable agriculture is promoted.

1.3 Aim and Objectives

Aim is to develop an Internet of Things (IoT) based agricultural monitoring system to promote crop yield increases and decrease challenges associated with traditional farming practices prevalent in Nepal.

Objective

1. Ensure real-time monitoring of environmental parameters such as soil moisture, temperature, and humidity.

2. Integrating the IoT system with web and mobile applications for ease of use and faster adoption among farmers.

3. Design the IoT system to be affordable and accessible to farmers in rural or underprivileged areas of Nepal.

4. Enhance agricultural efficiency with the use of IoT technologies.

2 Background

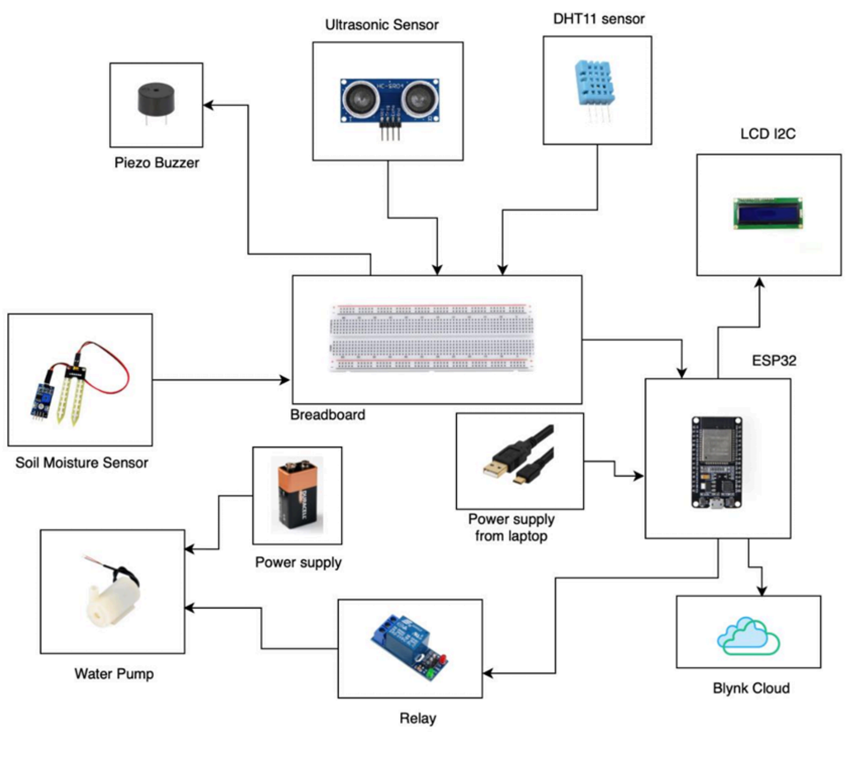
2.1 System Overview

The agricultural monitoring system is an IoT-based hardware solution designed to optimize crop growth by monitoring key environmental parameters such as temperature, humidity, soil moisture, and water levels. The system consists of interconnected sensors, actuators, and an ESP32 development board that processes real-time data and triggers appropriate actions based on predefined thresholds.

The system includes a DHT11 sensor to measure temperature and humidity, ensuring optimal environmental conditions for crops. A soil moisture sensor (FC-28 with HW-100 comparator module) detects moisture levels in the soil, and based on the readings, the ESP32 activates or deactivates a water pump via a 5V relay module, ensuring efficient irrigation. Additionally, an ultrasonic sensor (HC-SR04) monitors water levels, and when necessary, the system alerts farmers by activating a buzzer (TMB12A05). For real-time data display, an I2C LCD screen presents temperature, humidity, and soil moisture readings. The system is powered by AA batteries, with a switch included for manual power control. This setup provides an automated approach to agricultural monitoring, helping farmers efficiently manage resources while maintaining optimal growing conditions.

2.2 Design Diagram

2.2.2 Hardware Architecture



2.2.2 Flow Chart

2.2.3 Circuit Diagram

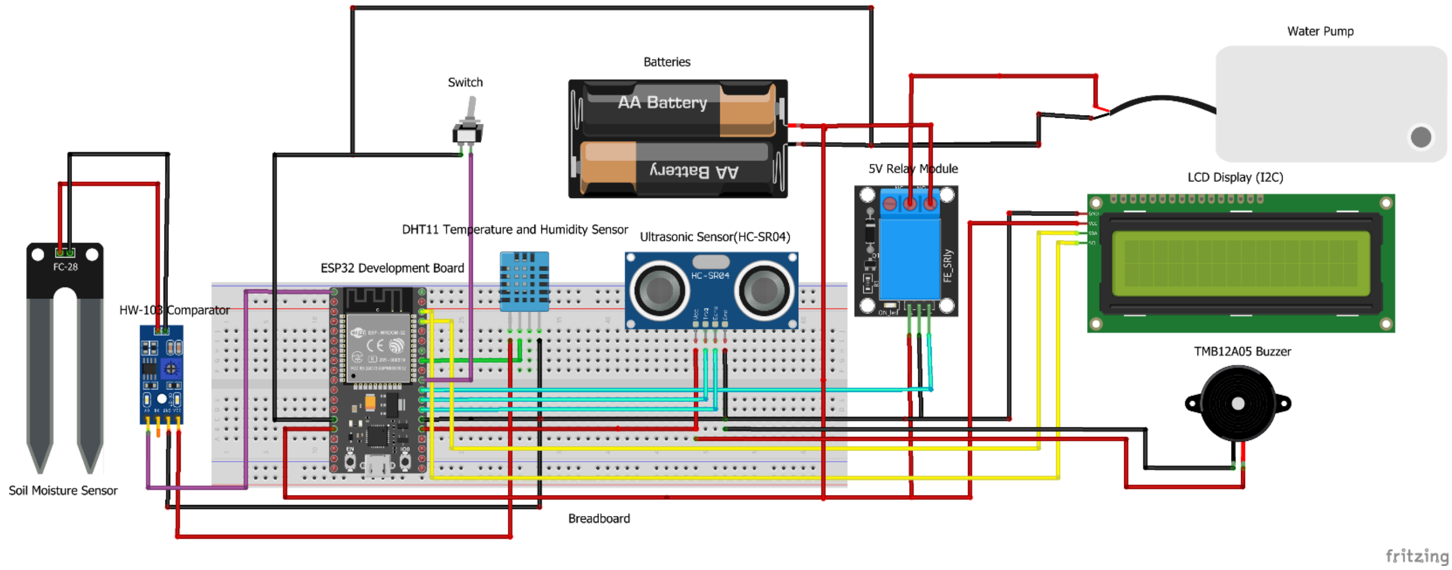


Figure 4: Circuit Diagram

2.3 Requirement Analysis

2.3.1 Hardware Requirement

1) **ESP32 Development Board:**

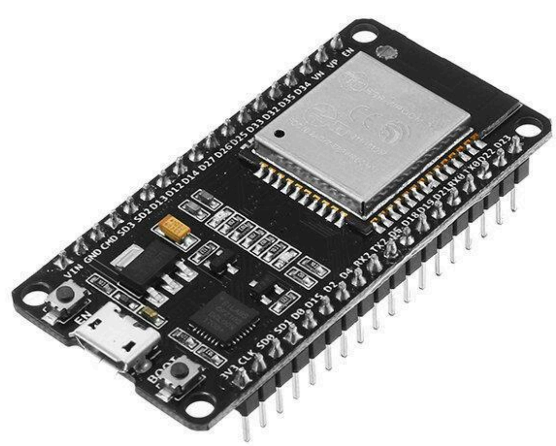


Figure 5: ESP32 Development Board

The ESP32 development board is a low-cost microcontroller with Wi-Fi, Bluetooth, and multiple GPIOs, ideal for IoT and automation. It offers high performance, low power consumption, and real-time data processing

2) Ultrasonic Sensor:

Figure 6: Ultrasonic Sensor

An **ultrasonic sensor** is a device that measures distance by emitting **high-frequency sound waves** and detecting their reflection from an object. It calculates distance based on the time taken for the sound waves to return. Commonly used in **automation, robotics, and water level monitoring**, it provides accurate, non-contact measurement.

3) Buzzer (TMB12A05)

Figure 7: Buzzer (TMB12A05)

The Buzzer TMB12A05 is a compact, high-performance electronic buzzer designed for various applications such as alarms, notifications, and signaling. It operates on a low voltage, typically 12V DC, and produces a loud sound when activated. This type of buzzer is commonly used in consumer electronics, automotive systems, and industrial equipment for indicating status or alerts.

4) **DHT11 Sensor**

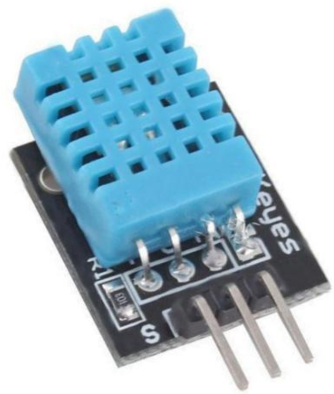


Figure 8: DHT11 Sensor

The DHT11 is an affordable and simple digital sensor that measures temperature and humidity. It offers accurate measurements within a temperature range of 0-50°C and a humidity range of 20-90% RH. The sensor communicates with microcontrollers, such as Arduino, via a digital signal and is commonly used in weather stations, home automation, and environmental monitoring applications due to its ease of use and reliability.

5) **I2C LCD Display**

Figure 9: I2C LCD Display

The 16x2 I2C LCD display is a compact screen that can display 16 characters per line and has two lines. It uses the I2C protocol for communication, allowing it to connect to microcontrollers like Arduino with only two data wires, simplifying wiring and saving pins. It’s commonly used in projects requiring a small display for status information or text output.

6) Breadboard

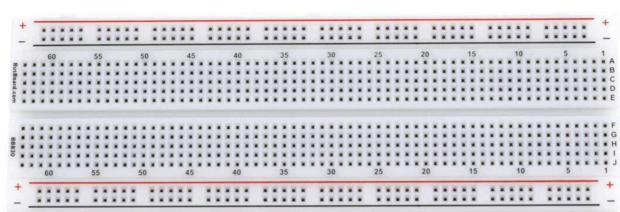


Figure 10: Breadboard

A breadboard is a tool used for prototyping electronic circuits without the need for soldering. It has a grid of holes where electronic components, such as resistors, capacitors, and ICs, can be inserted and connected using jumper wires. Breadboards are commonly used in the early stages of circuit design for testing and modifying designs.

7) **Soil Moisture Sensor (FC-28 with HW 100 Comparator Module)**

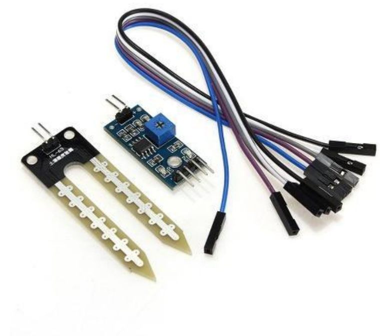


Figure 11: Soil Moisture Sensor (FC-28 with HW 100 Comparator Module)

The FC-28 Soil Moisture Sensor with HW 100 Comparator Module is a device used to measure the moisture level in soil. It consists of two parts: the sensor probe, which detects soil moisture, and the HW 100 comparator module, which processes the sensor's output and converts it into a usable signal for microcontrollers. This sensor is commonly used in gardening and agricultural projects to automate irrigation systems.

8) **Water Pump**

Figure 12: Water Pump

A DC water pump is an electric pump powered by direct current (DC) to move water. It is commonly used in small-scale applications such as aquariums, irrigation systems, and cooling systems. These pumps are efficient, compact, and easy to control with microcontrollers, making them ideal for automated water flow control in various DIY and hobbyist projects.

9) 5V Relay Module

Figure 13: 5V Relay Module

A 5V Relay Module is an electronic component that allows low-voltage circuits (like microcontrollers) to control higher-voltage devices, such as motors or lights. It consists of a relay switch, which is triggered by a 5V signal, and it can handle higher current and voltage, providing isolation between the low-voltage control circuit and the high-voltage load. It’s commonly used in automation and control systems.

10) Jumper Wires

Figure 14: Jumper Wires

Jumper wires are flexible electrical wires used to make connections between different components on a breadboard or circuit. They come with pre-attached connectors at both ends, allowing for easy and quick connections without soldering. Jumper wires are essential for prototyping, testing, and building circuits in electronics projects.

2.3.2 Software Requirements:

1) **Arduino IDE**

Figure 15: Arduino IDE

The Arduino IDE (Integrated Development Environment) is a software platform used to write, compile, and upload code to Arduino microcontrollers. It provides a user-friendly interface with support for various programming languages, primarily C/C++. The IDE allows users to develop and test code for a wide range of Arduino boards and peripherals, making it essential for creating and debugging projects.

2) Fritzing

Figure 16: Fritzing

Fritzing is an open-source electronics design tool that allows users to create circuit diagrams and designs. It provides a user-friendly interface for laying out components on a virtual breadboard, creating schematic diagrams, and designing PCB (Printed Circuit Board) layouts. Fritzing is commonly used by hobbyists and engineers to visually represent and prototype electronic projects.

3) Blynk

Figure 17: Blynk

Blynk is a mobile app and IoT platform that allows users to easily build and control smart devices through smartphones. It provides a simple interface to create custom dashboards with widgets for controlling sensors, relays, and other connected devices. Blynk supports various hardware platforms like Arduino, Raspberry Pi, and ESP8266, making it popular for home automation and remote monitoring projects.

3 Case Study

3.1Introduction

Students of the Asian Journal of Applied Science and Technology (AJAST) conducted IoT based smart agriculture monitoring system project for Nepal's agriculture to address its farming issues. Agriculture in Nepal, which supports over 60% of the country's population, has problems such as scarcity of water, complex geographical land structure, and dependence on monsoon rains for irrigation. In cases where irrigation is needed as traditional methods overly depend on monsoon rains and human interventions, the project aims to automate the irrigation process, save water, and monitor environmental parameters in real-time using IoT sensors. The project uses Arduino based system with integrated soil moisture, temperature, humidity, and ultrasonic sensors to save labor, conserve water, and increase yields. Finally, the sensor data is transmitted to the ThingSpeak platform for processing and thus, farmers will be able to make remote evidence-based decisions.

3.2 Problem Statement

- Ineffective Water Use & Scarcity:
  A mere 40% of Nepal's cultivable lands are under irrigation, resulting in the over utilization water resources and dependence on whimsical monsoon.

- Lack of Monitoring:
  Soil and climatic conditions are not measured accurately in traditional practices. Therefore, there are late responses to the changing conditions in the field.

- Technical Issues:
  Ensuring that hardware malfunctions, programming errors, and component compatibility issues did not occur during the development and implementation stages was a major concern.

- Budget Constraints:
  The consolidation of IoT components poses a notable possibility of going beyond the budget provided. Therefore, great care was taken to avoid budget overruns and create a system that is cost effective to farmers.

- User Accessibility:
  The most important thing was making it user-friendly so that it helped farmers who may not have much technological knowledge.

3.3 **System Analysis**

1. **Arduino UNO:** A microcontroller, the Arduino Uno has both digital and analog (I/O) pins. These pins control the sensors and the device.
2. **Soil Moisture Sensor**: It is a sensor which is used to check the moisture in the soil. It detects the water in the soil and sends the Analog signals which are shown digitally.
3. **Ultrasonic Sensor**: Sensing probe element is provided with unique wire cable that can accurately measure the surface level of almost any liquid, like water, salt water, and oils. The sensor element is electrically insulated and isolated from the liquid it is inserted into and will not rust after some time.
4. **DHT11 Sensor**: DHT11 sensor is a humidity and temperature sensor. It uses a capacitive sensor to measure humidity and a thermistor to measure the air temperature.
5. **Water Pump**: Motor Pump is a need for remote-control irrigation system. The water pump works on sensor inputs.
6. **ThingSpeak Dashboard**: It is used to visualize real time data such as soil moisture level, humidity, and temperature and make remote evidence-based decisions.

3.4 Recommendation

The system can be enhanced further by incorporating a few additional features, improving functionality and usability. For instance, incorporating an audible warning buzzer that beeps when the water tank is low, encouraging refills on time and preventing the possibility of running out of water. Additionally, a switch to an ESP32 development board from an Arduino UNO would be highly beneficial. The ESP32 has built-in Wi-Fi and Bluetooth capability, eliminating the requirement for internet integration to be carried out manually. This would permit real-time data transfer, with ongoing monitoring and more immediate control of the system. The motor pump can be adapted to serve other purposes such as spraying pesticides and transmitting liquid fertilizer, streamlining operations and becoming more efficient. Another method of controlling the water pump might be made available to the farmer so that they could start or stop irrigation from afar without being at the farm. Farmers would be able to prepare and anticipate bad weather with this option.

3.5 Conclusion

The deployment of an IoT-based Farm Monitoring system using IoT devices and software can significantly alleviate the burden of labor for farmers, all at minimal expense. If adopted, the suggested alternatives and recommendations will improve the opportunity for long-term success and allow the farmers to manage the system in a more efficient and productive way