Mabelle Planting Rover

Agriculture Technology IoT

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Overview

- Introduction
  - System requirements
  - Functionalities
  - Hardware Components
- **Modules**
  - **M1:** Balancing Platform
  - **M2:** Planting and Sensing Mechanism - *NPK Sensor*
  - **M3:** Data-driven decision making
  - **M4:** IoT Dashboard
- Conclusion and References

Introduction

- Develop **innovative** agricultural robot
- **Automate** planting, fertilizing, watering
- **Sensors** measure soil moisture, nutrients
- Data **transmitted** to server
- User-friendly **dashboard** for monitoring
- Enhance crop **cultivation efficiency**

System Requirements

1. Self-leveling base
2. Plant seeds using a designed gripper.
3. Collect from the soil the needed data.
4. Transmit the data needed from the robot to the main server through wireless connection.
5. From the data received and relative data from APIs, the robot should make a decision about the amount of water to be supplied and fertilizer using neural networks.

System Requirements

6. The data received, in addition to the results analyzed, will be displayed on a user-friendly dashboard.
7. Controlled amounts of water and fertilizer will be supplied to the seeds based on the results found.
8. Obstacle avoidance mechanism

Modern Control Techniques

- Balance control on uneven surfaces:
  - Mechanism, motors, sensors, controller
- Precise, fast planting:
  - Needle-like gripper inserts seed at specific depth
  - Drops seed without soil distortion
- Control water, fertilizer based on received data

But how does it all ***actually*** happen?

Core Functionalities [1]

Self-Leveling Base

- **Fragile components** on self-balancing platform
- **Linkage** system with 3 points of contact
- **Three servo** motors tilt **upper** base
- **Controller**: **Fuzzy** inference system

Core Functionalities [2]

Planting seeds

- **Container, gripper** designed on **SOLIDWORKS**
- Seed pushed into tube using **gravity**
- Water mixed with **20-20-20 NPK pumps seed**
- **Gripper tip opens hole** in soil for seed

Core Functionalities [3]

Collect NPK (Nitrogen–Potassium–Phosphorus) Data

- **Gripping mechanism for** NPK sensor designed on **SOLIDWORKS**
- Holds NPK sensor **fixed** in ground for measurement
- Values **logged on Arduino** for later action

NPK sensor communication protocol explained later (M2)

Core Functionalities [4]

Sending the Data and Data Display

- Arduino R4 with **built-in Wi-Fi** sends NPK values **via Arduino cloud**
- Values fetched from **Python for NPK determination**
- Combined with **temperature, humidity sensor outputs**
- Displayed on **user-friendly interface** with **predicted values**
- User can **upload data**, collected for **research purposes**

Core Functionalities [5]

Data-Driven Decision Making

- Gather the values of the **NPK, temperature, humidity**
- In addition to **rain intensity from an API**
- **Deep Learning Techniques:** Neural Network **fine-tuned on our preprocessed data**
- Predict the needed values of **water and NPK levels** that should be **added** to the soil for an **optimal growth**

Core Functionalities

Our Building Blocks

Self-Leveling Base

Collecting NPK Data

Decision Making (ANN)

Data Sending and Display

Planting Seeds Mechanism

Hardware Components

Sensors

- MPU 6050
- Soil Sensors (3 in 1 NPK sensor)
- MAX485 TTL to RS-485 Module
- Humidity and Temperature Sensor (DHT11)

Mechanical Components

- 3D printed balancing mechanism
- Ready-made rover model
- 3D printed Gripper, robotic arm
- Seed , Fertilizer and Water Containers

Actuators

- Servo Motors (DS3218, MG996)
- DC Motors
- Pump

Controllers

- Arduino UNO R4 Wi-Fi
- Arduino UNO R3
- L298n Motor driver

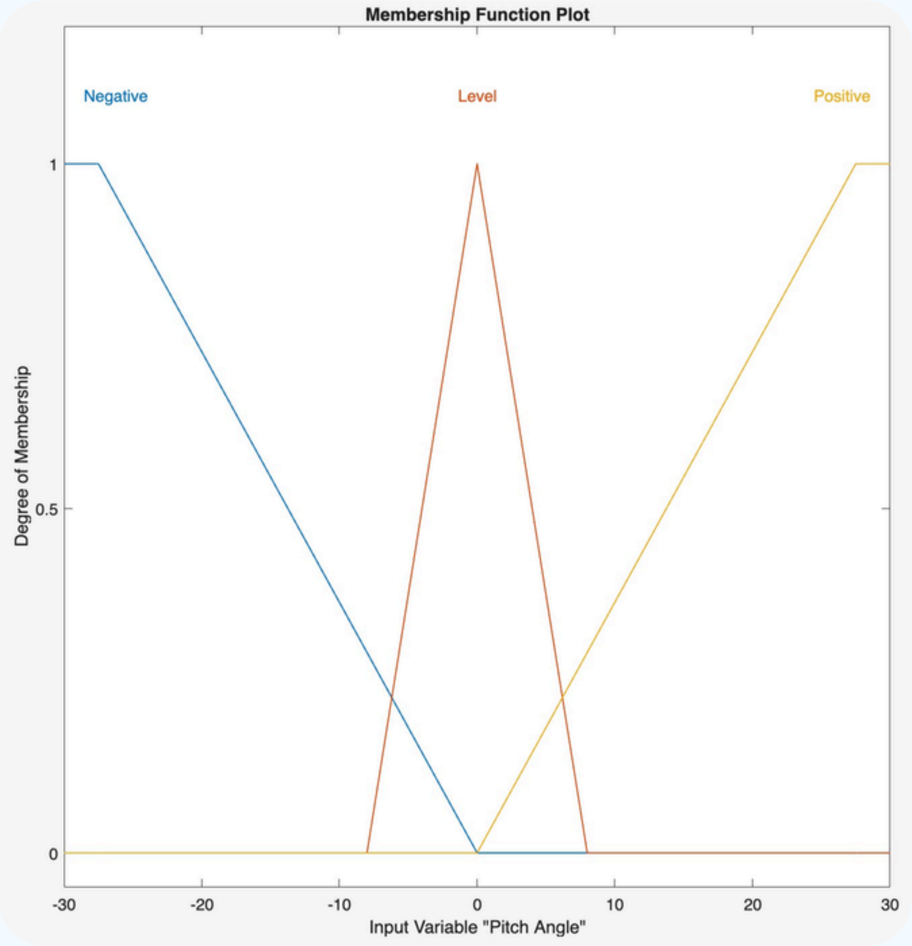
M1: Balancing Platform

A Delicate Fuzzy Balance

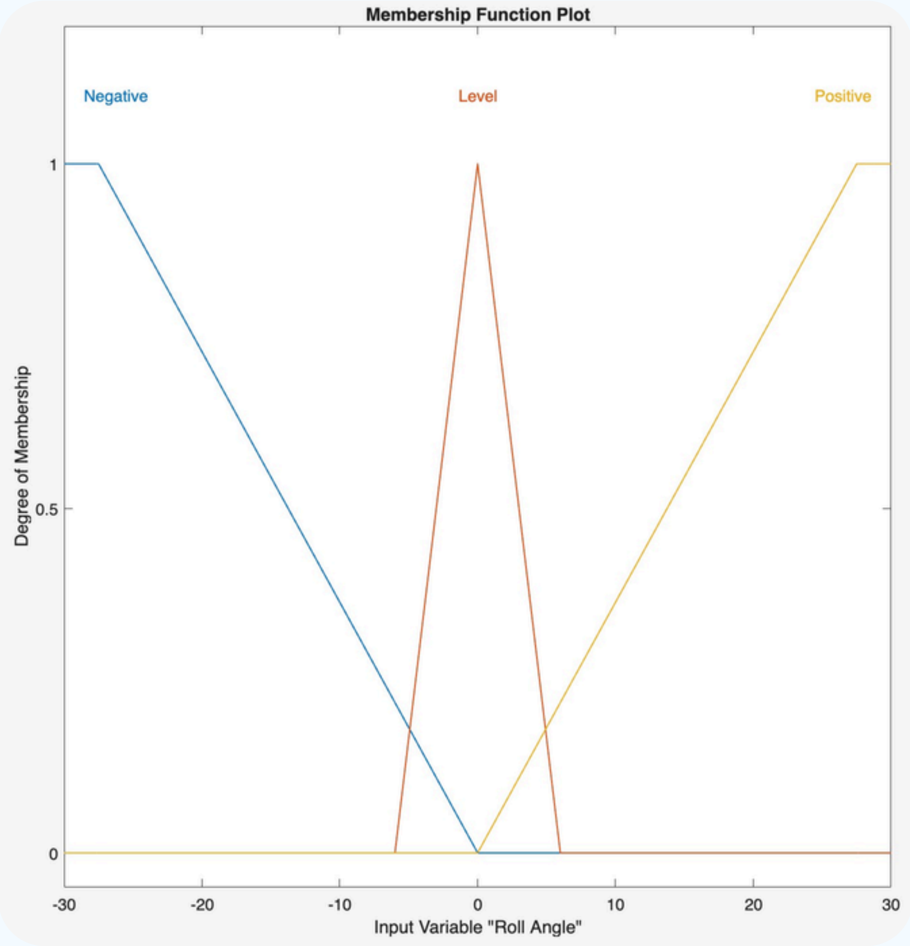
- Robot maintains **balance on uneven surfaces** to prevent spills
- Mechanism comprises **three servo motors** with **120-degree** displacement
- **SolidWorks**-designed links connect servos to **upper platform**
- **Mamdani Fuzzy** IS uses **MPU6050** data (roll and pitch)
- System dictates **servo rotation** angles to maintain platform level
- **MATLAB**-designed inference system tested with dummy values
- **.fis** file imported as **C++ Arduino code**

M1: Balancing Platform

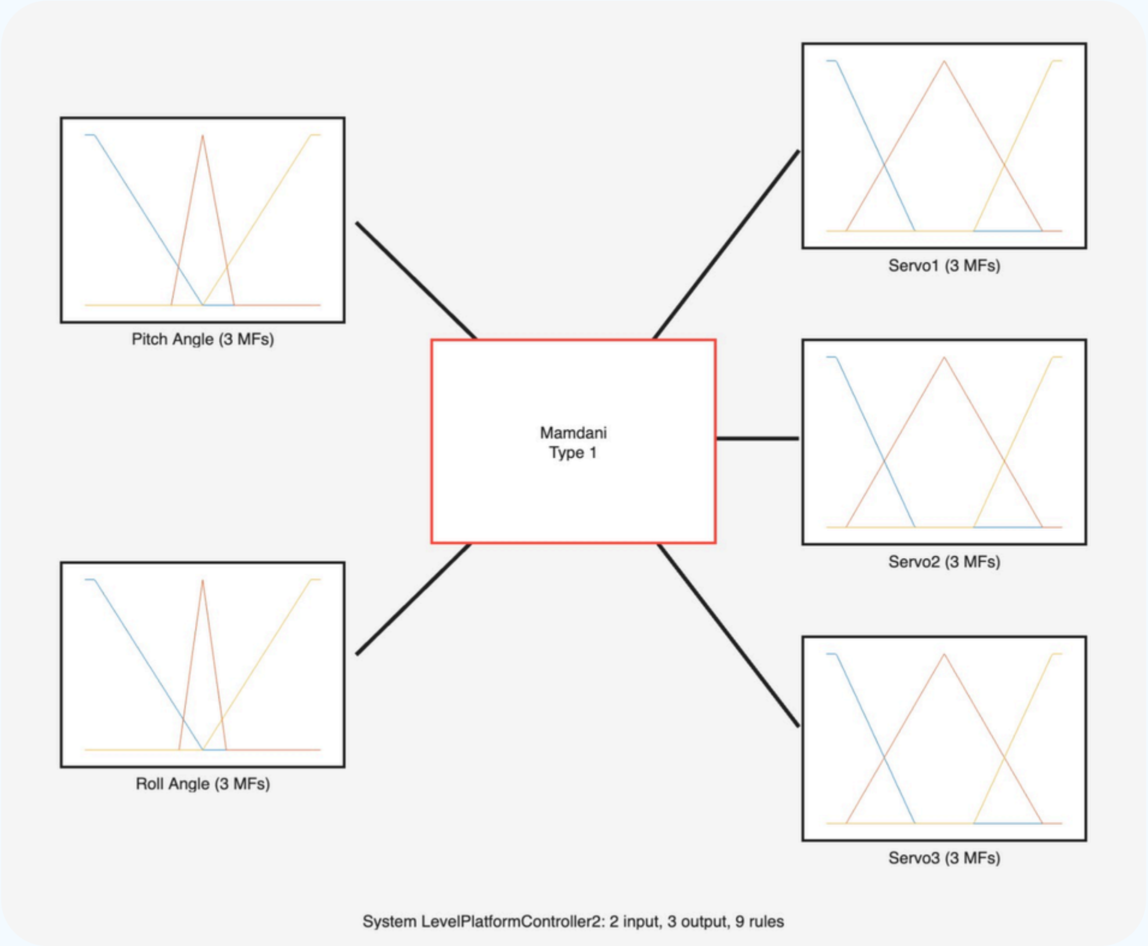
A Delicate Fuzzy Balance



Input 1 - Pitch



Input 2 - Roll



Overall View + Outputs

M2: Planting and Sensing Mechanism

A Full Circle of Efficiency

# of planting positions within distance
# of seeds

Dashboard

Calculates time between seeds positions based on distance

Arduino

Arm opens seed box, pumps seeds and fertilized water.

Pump, Tanks, Robotic Arms

Info Logged onto dashboard for User to evaluate.

Dashboard

Notes:

- NPK sensor deployed every 3 seeds for analysis
- Rover returns when seeds planted match requirement
- Fertilizer: 20-20-20 NPK fertilizer used, pump adds as needed..

M2: Planting and Sensing Mechanism

A Full Circle of Efficiency

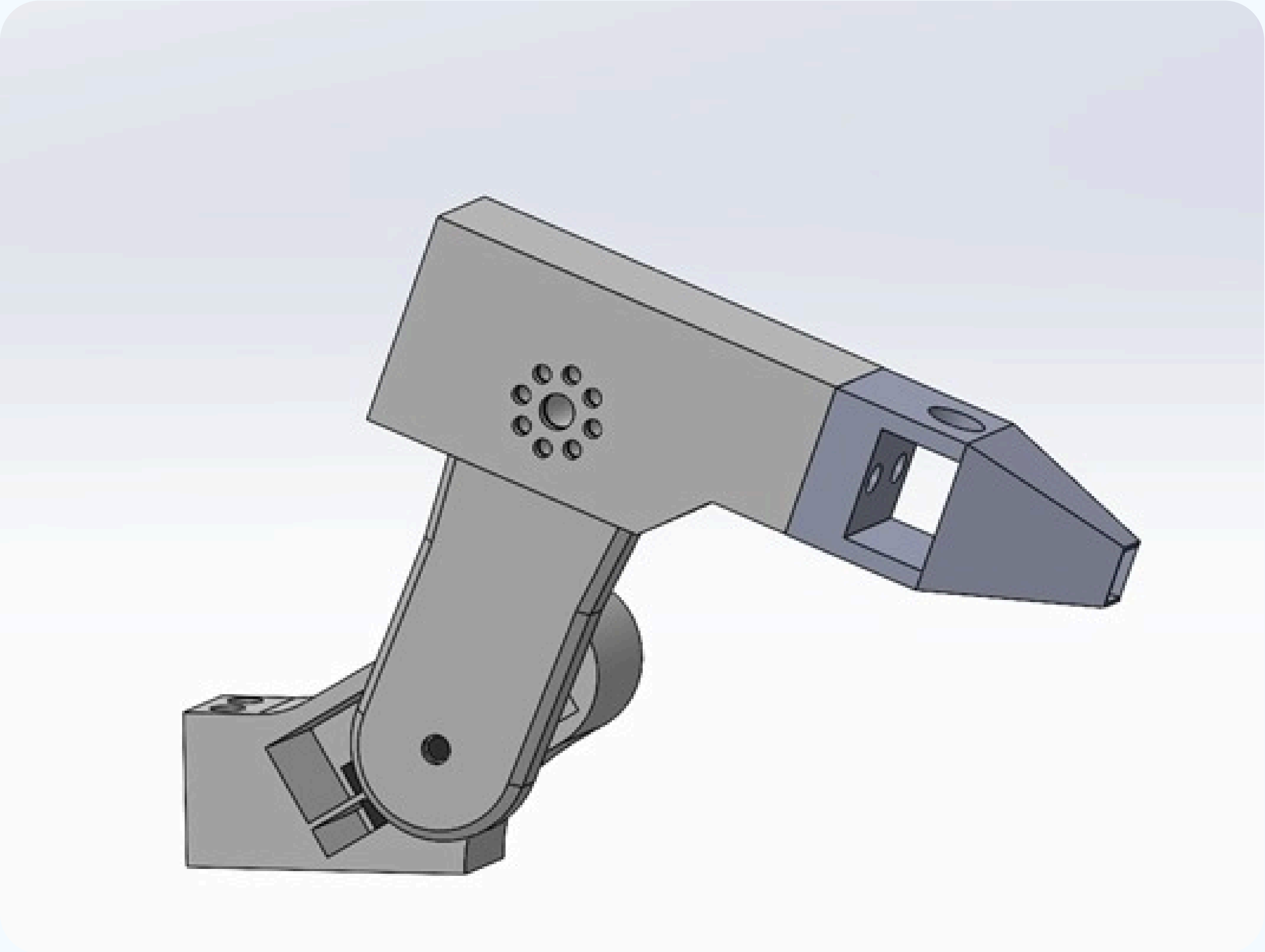


Figure 1: Planting Arm

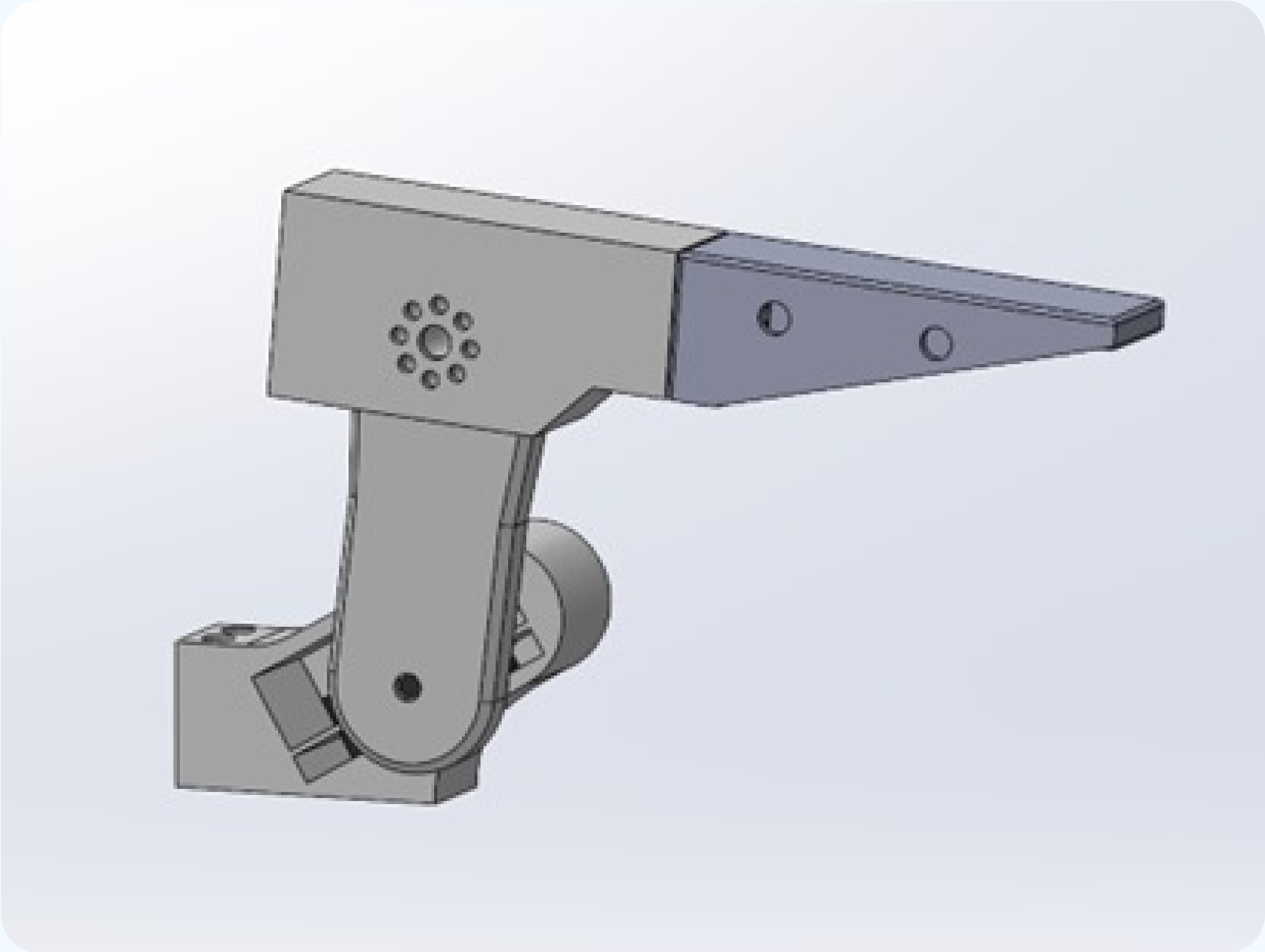


Figure 2: Sensing Arm

M3: Data-Driven Decision Making

A Lot of Neurons Were Involved

Synthetic Data Generation

- **600 initial** NPK data points (No T, H)
- Generated to **replicate real-world conditions**
- **Augmented, Balanced, Binned** (3.55k entries)
- **Developed guidelines** based on available experiments and **discussion with experts**

Building the ANN

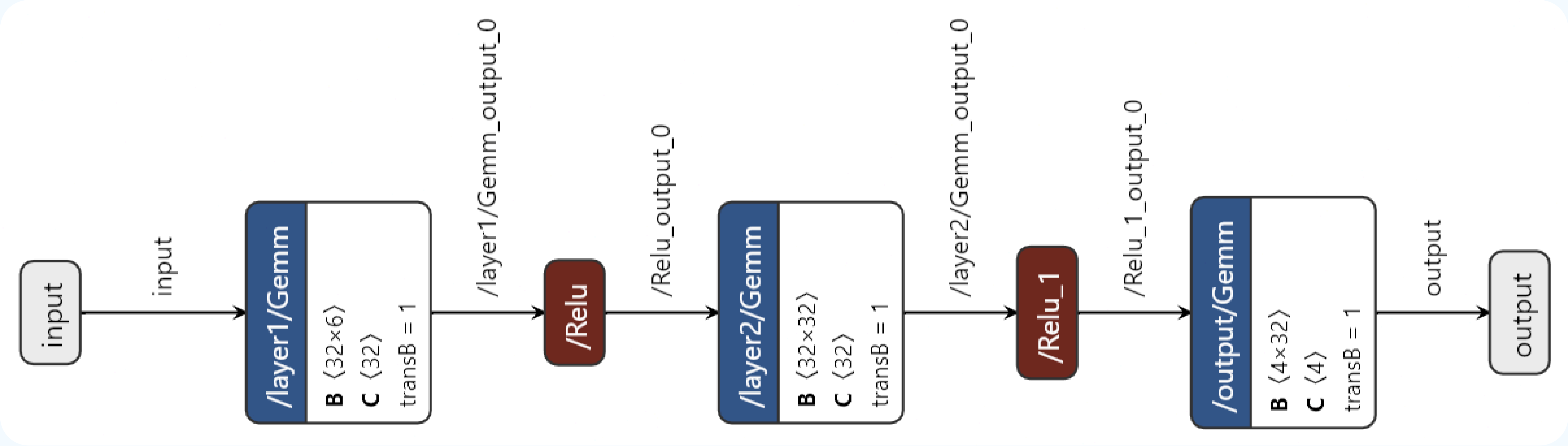
- **Visualized and Preprocessed** Synthetic Data (pandas, Tensorboard)
- Constructed and trained NN model, **monitored Loss and Accuracy**
- Model exported to **ONNX for quick inference**

Wireless Synchronized Communication

- Rover sends NPK, temperature, humidity to server via **Arduino Cloud IoT**
- Values fetched from cloud, classified, processed by ANN, **outputs sent back to cloud and rover**

M3: Data-Driven Decision Making

A Lot of Neurons Were Involved



Inputs:

- NPK (Sensor, Encoded)
- W, H

Outputs:

- NPKW (To be Added)

M4: IoT User Dashboard

Monitoring Success

User Input:

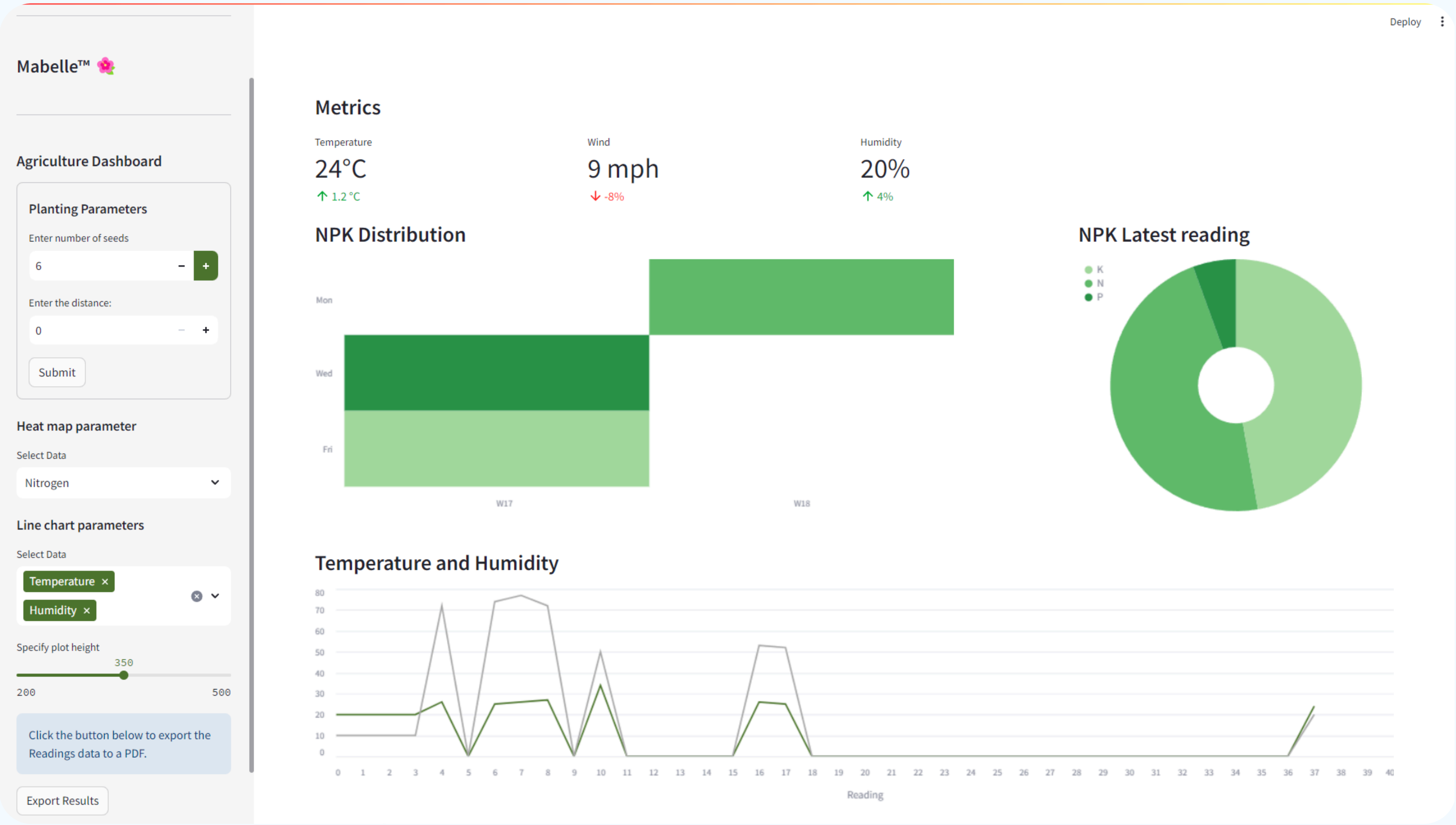
- Number of planting positions
- Distance to be planted
- Ability to export the historical data
- Turns on Rover remotely

Monitoring:

- Current NPK logs
- Temperature and Humidity with respect to time
- Weather Forecast
- Heatmap of each nutrient with respect to the distance

M4: IoT User Dashboard

Monitoring Success



Conclusion

Discovering New fields

- IoT application and data communication
- Decision making and data generation
- Agriculture perspective and applications

Areas of Improvement

- More compact design with less wires prone to damage
- Adding the type of seeds as an option in the decision making
- More efficient planting mechanism
- More accurate sensors
- Experimentally proven data

References

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