



A Prototype for Designing Plant Care System

Using Machine Learning and Mechatronics

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Abstract: We propose an automated device based on machine learning and mechatronics to facilitate proper care and optimal conditions for plants within the community. This innovation enables individuals to tend to their plants effectively, even when time is scarce. Our current focus addresses the issue of automated plant watering through the design of a circuit controlled by a program, utilizing insights from experimental outcomes. The program operates on machine learning principles, while the machine control mechanism is rooted in mechatronics. This prototype's advancement leverages cutting-edge technologies to establish a fully automated plant watering system. We anticipate that this innovation will inspire increased plant cultivation among individuals, thereby making a substantial contribution to a greener planet. Furthermore, this proposal holds the potential for wider-scale implementation within agricultural practices, aiming to enhance water efficiency.

Index Terms – Machine learning, Plant care system, Sensors, Mechatronics.

I. INTRODUCTION

We have noticed that a lot of people and in fact, even nature-lovers, are afraid to buy and keep plants with them because they think that they can't take proper care of them. This problem is the most common in the age group of 25 to 60 years. Moreover, on a larger scale, significant challenges arise due to water wastage and droughts, leading to the demise of numerous plants. Implementation of this approach could contribute significantly to optimizing agricultural practices. We worked on this project by applying mechatronics and machine learning. Mechatronics is very intriguing and it can change the technology in the world to solve numerous problems. Our project will take into consideration all the aspects of the environment and ecosystem to obtain a better way to take care of plants. It will also help people to take care of plants with minimal efforts, especially for people when travelling and for the elderly. In this prototype we apply machine learning to learn the characteristics and requirement of the plant, further by applying these learning, water can be provided to the plants using automatic motor movement based on mechatronics. Sensors can be used to learn the current requirement and also while learning phase and type of the plant. Based on the above discussion following are the requirements and advantages of the proposed system.

Design requirements of the proposed system:

- ✓ Automatically determine the watering needs of plants
- ✓ No need of manual work
- ✓ The user does not need to fill the water as it is directly taken from pipes
- ✓ When checking the plant, system will lower its sensor into the soil next to the plant
- ✓ Sensor probe can move from side-to-side and up and down using software control
- ✓ Based of level of moisture in the soil and plant needs, the system will release adequate quantity of water

Advantages of the proposed system:

- No need of manual work
- Monitors plant health
- Saves time
- Easy to use
- Will work long term

- Optimize water usage
- Improved yield

II. BASICS OF MECHATRONICS AND MACHINE LEARNING

In this section, we explain basic principle of applying Mechatronics and machine learning concepts with the help of some real-life examples.

2.1 Mechatronics, its examples and its application in our proposed system: Most of the mechanical systems work on analog signals and these analog signals need to be converted into digital signals [1]. As microprocessors can mostly work only using digital inputs. Hence to make a control system using microprocessors, requires changing analog to digital and digital to analog to apply control signal to mechanical system. Mechatronics is combination of Mechanics and electronics, where mechanics consists of actual sensors or mechanical devices which works with controlling object. Electronic is the combination of hardware and software designed to control mechanics part [2]. Main components of a mechatronics system are (as shown in **Figure 1(a)**): Mechanical units attached to the object, sensing unit (sensors and signal processing) to get inputs from the object through mechanical components, Control system to work on the received inputs from the sensor, then feedback unit (actuators and signal processing) to provide feedback the control signal to mechanical unit as shown in the Figure and detailed in [3]. It's a closed loop system to control environment parameters or objects using controlled mechanical unit using feedback.

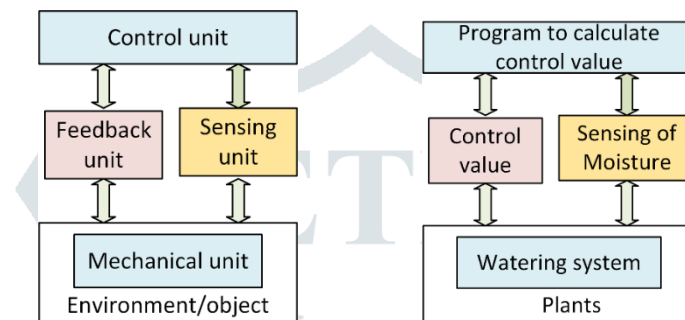


Figure 1(a): Basic Mechatronics based system, 1(b): Application of Mechatronics in our proposed system

Few of real-life examples for mechatronics are as follows [4,5]: Anti-lock brakes and air bag inflation in the vehicles, Robotic surgical arm in healthcare, unmanned Aerial vehicles and automatic manufacturing in industries. In our proposed system, we have used mechatronics concept in the following way as shown in **Figure 1(b)**: Plants are the objects to be taken care of, watering system will provide water according to the requirements. Sensors shall provide moisture status in terms of some signals to the program. Program will calculate the need of water and accordingly generate the control value and apply to the watering system.

2.2 Machine learning, its examples and its application in our proposed system

Machine learning is a technique to get intuitive decisions from a machine by applying algorithms. It can be said that Machine learning is making the machine so efficient so it can work without human involvement or it facilitates the machine to program themselves. It can have any one of following three types of algorithms [6]:

- Supervised learning:** In this type of algorithm, firstly input data and expected output is provided as training signals and once training phase is over, algorithm can work on input in same manner. For example, for filtering spam mails. Initially spam mails data is provided to the algorithm and it understand the attributes of the spam mail, then it can filter out spam mails based on that.
- Un-supervised learning:** In such algorithm, no training data is provided, algorithm has to work based on probabilistic approaches and hidden attributes in the input data to provide outputs.
- Reinforcement learning:** In this approach, algorithm continuously receives feedback and changes its response to achieve accuracy. In this approach, algorithm reaches to desired output using hit and trial approach because of getting feedback on its every output.

Few real-life examples of machine learning are: A few basic applications of machine learning are Spam Filter, Sentiment Analysis, Voice Chat-Bot, Image Classifier, Stock Market Prediction [6]. In our proposed system we suggest to apply reinforcement learning based machine learning approach to understand plant requirements and accordingly analyze output signals to control movement and volume from mechanical unit to provide water to plant as shown in the following **Figure 2**.

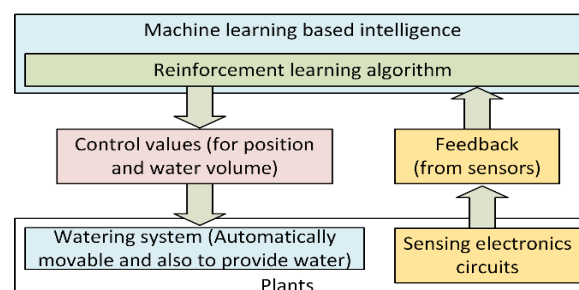


Figure 2: Application of machine learning and mechatronics in the proposed system

III. BROAD LEVEL VIEW AND WORKING PRINCIPLE OF THE PROPOSED PLANT CARE SYSTEM

In this work, we would like to address the need for caring plants and would like to make a solution which is fully automatic and remove the need for any manual care. This can be achieved by combining two advance technologies Mechatronics and machine learning. A broad level view of the proposed system is shown in the diagram below (**Figure 3**). The main components in the proposed system are: sensors/scanner to examine the soil and to examine the plant position and type, a motor to move the sensor and scanner/sensors up and down to determine the needs of the plant, a dome to hold the water, a water sprinkler with control system to control volume of the water, a pipe connecting to the source of water, a waterproof screen displaying information about the plant.

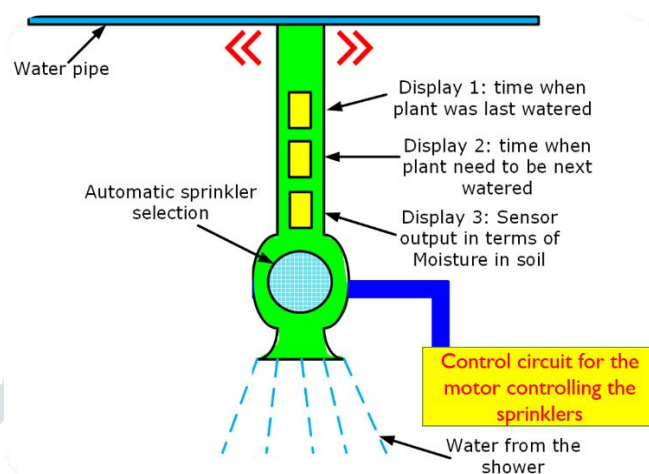


Figure 2: Broad level view for the proposed plant care system

3.1 Working principle

The working of the system is as following:

There are sensors to examine moisture level in the plant (Further we plan to add cameras to recognize the type of the plant too). Also, if we consider many plants to be taken care of, the mechanical system needs to be moved according to the position of every plant. Hence, we need scanner-based sensing system to get knowledge of the position of the plant with the aim that the mechanical system can be moved as per the need of every plant accordingly. The mechanical part consists of a motor to provide speed as per the output of the control circuit, to control the sprinkler. There shall be threshold values in the control circuit based on the learning of machine learning algorithm for every type of plant. Accordingly, the sprinkler shall move to a spot over the plant after a threshold value corresponding to that plant, enabling control of the amount of water provided to the plant according to the moisture sensor output for that plant. There shall be a control unit consisting of a machine learning-based algorithm to calculate the required amount of water for any particular plant, since various plants have differing needs in distinct weather conditions. There shall be a display unit with LCD displays to indicate the status of plant care system. Additionally, specific lights will switch on in case of a short circuit or water overflow in the system.

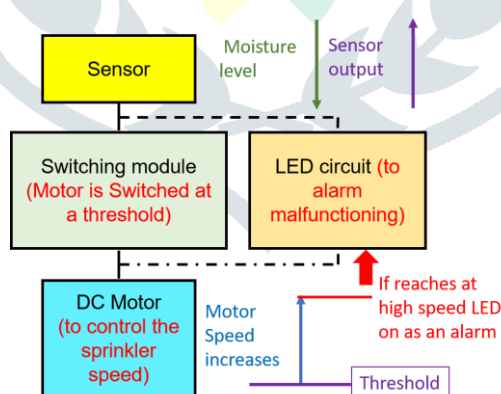


Figure 3: Working of the proposed system

IV. PROTOTYPE FOR THE PROPOSED PLANT CARE SYSTEM TO VALIDATE THE WORKING OF THE SYSTEM

Prototype of the proposed system is implemented in two parts (block diagram is shown in Figure 4). An experiment is conducted using a moisture sensor circuit and its outcome is applied to a program which is written in python to control the sprinklers.

4.1 Electronic circuit implemented for the prototype

Role of the circuit: To design a circuit to automatically control the amount of water discharged by the sprinkler as per the need of the plant and to give an alarm in case of malfunctioning.

The main features in product will be:

- A sensor to examine the moisture level of the soil.

- A motor to provide speed as per moisture sensor output to control the sprinkler. It starts after a threshold value and speed is controlled according to the moisture sensor output
- LED switches ON when some short circuit occurs in the sensor path

The block diagram of the prototype implemented and the resulting output at various stages in the project are shown in the following figure:

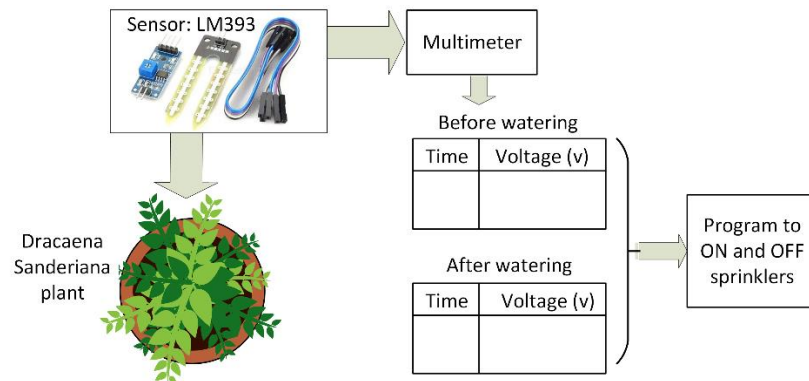


Figure 4: Prototype implementation of the proposed system

A moisture sensor LM393 is used to conduct the experiment on a Dracaena Sanderiana plant. Sensor was kept in the plant for three days and voltage was measured using Multimeter at various time instances. These voltages were used for deciding input ranges for the program. Features of the used sensors are as below:

- Operates within a voltage range of 3.3V to 5V
- The module has 2 probes used to measure volume of water present.
- The two probes help the sensor assesses soil moisture by analyzing resistance after passing a current through the soil.
- Also known as a soil hygrometer, this module is designed to effortlessly be integrated with various microcontrollers.
- Equipped with an onboard LM393 comparator and featuring a power LED indicator.

4.2 Programming used in the prototype

Following programming is done in Python to control ON/OFF of the sprinklers based on the input received from the sensor. When voltage is less than “0”, it indicates that plant water level is lower than expected level. Hence sprinkler should be “ON” and if voltage is greater than “0”, there is no need to give more water. Hence there is no need to “ON” water sprinklers. It can be an automatic control in the real system. For prototype implementation, range of input is applied based on voltages received from the experiment. Following is the program for the prototype implementation which has been executed using the PYTHON language.

Python program:

```

import pygame
import random

# Initialize Pygame
pygame.init()

# Set up screen dimensions
screen_width, screen_height = 400, 400
screen = pygame.display.set_mode((screen_width, screen_height))
pygame.display.set_caption("Voltage Control")

# Define colors
CYAN = (0, 255, 255)
GREEN = (0, 255, 0)
RED = (255, 0, 0)

# Create sprites
sprinkler1 = pygame.Rect(100, 150, 40, 40) # Adjusted position
sprinkler2 = pygame.Rect(250, 150, 40, 40) # Adjusted position
sprinkler1_visible = False
sprinkler2_visible = False

# Initial voltage values

```

```

voltage1 = random.uniform(-5, 5)
voltage2 = random.uniform(-5, 5)
voltage = 0

def voltage_val():
    global sprinkler1_visible, sprinkler2_visible
    sprinkler1_visible = bool(voltage < 0)
    sprinkler2_visible = bool(voltage > 0)

clock = pygame.time.Clock()
running = True

while running:
    screen.fill(CYAN)
    voltage1 = random.uniform(-5, 5)
    voltage2 = random.uniform(-5, 5)
    voltage = (voltage1 + voltage2) / 5
    print(voltage)
    voltage_val()

    for event in pygame.event.get():
        if event.type == pygame.QUIT:
            running = False

    pygame.draw.rect(screen, GREEN if sprinkler1_visible else CYAN, sprinkler1)
    pygame.draw.rect(screen, RED if sprinkler2_visible else CYAN, sprinkler2)

    font = pygame.font.Font(None, 25)
    text = font.render("The water sprinklers should be on."
    if sprinkler1_visible
    else "The water sprinklers should be off.", True, GREEN if sprinkler1_visible else
    RED)
    screen.blit(text, (5, 315)) # Render status text separately

    pygame.display.flip()
    clock.tick(60)

pygame.quit()

```

V. RESULTS AND DISCUSSION

Figure 5 shows the screenshot of the experiment displaying the multimeter readings of -1.99 V and -0.10 at different time instances. In such way reading have been noted down for three days at different time before and after giving water. Based on those readings a graph is shown in Figure 6 between time and voltage values. It is notable that the plant is in dry state at the late afternoon time instances and watering is required after a certain threshold, which can be decided for each plant based on its type in the real system.

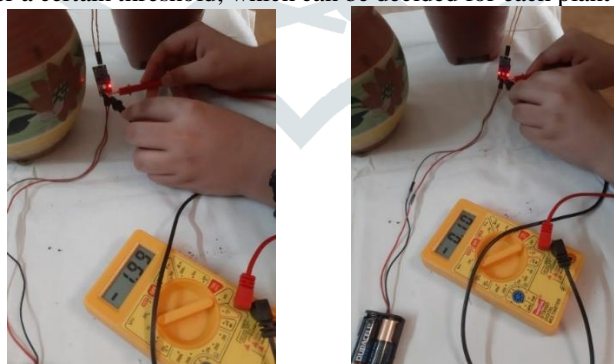


Figure 5: Experiment showing different reading in Multimeter based on water level

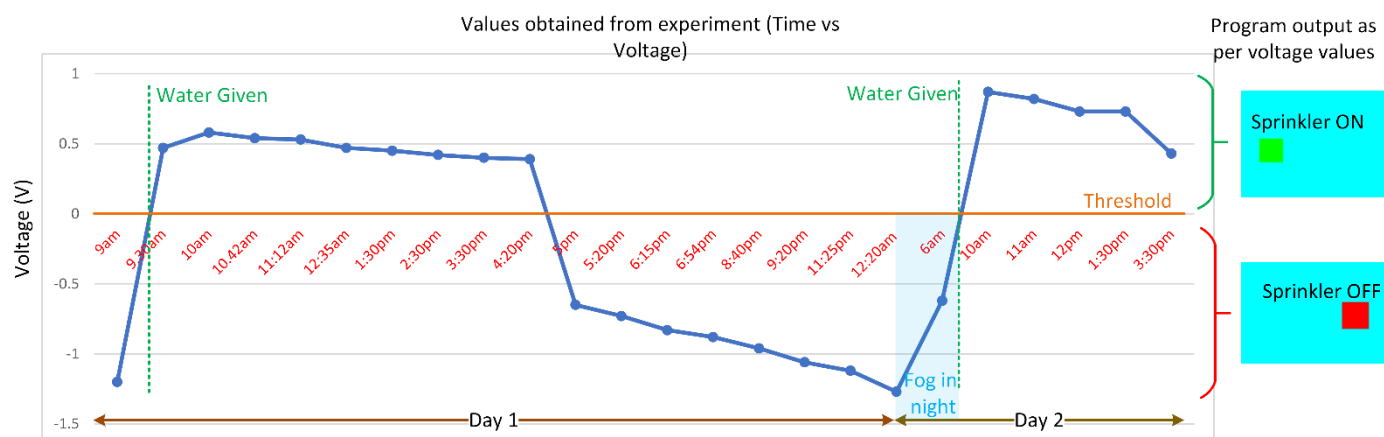


Figure 6: Results

The provided voltage data, measured at specific time intervals, likely reflects fluctuations in moisture levels within a plant or soil. Initially, sudden spike of increase in voltage over the first day suggests an extremely adequate moisture content due to watering of the plant. Further, the voltage remains nearly constant, with an extremely small decrease, until a swift and significant negative voltage change, indicating an impressive decrease in the plant's moisture content. This trend continues into the second day until the plant is exposed to the atmospheric dew overnight and during the early morning hours, which is seen by the increase in the voltage. Then, there is an instantaneous increase in the voltage on day 2, denoting the watering of the plant. These voltage shifts may signify corresponding changes in the plant's moisture content, where negative voltages could indicate dryness or decreased moisture, while positive values post-watering could signify increased hydration levels. These findings strongly imply a potential link between voltage changes and the plant's watering regimen, emphasizing the importance of consistent moisture maintenance for optimal plant health. Further investigation and correlation with specific plant conditions or watering routines would yield deeper insights into these voltage variations and their direct association with plant hydration levels.

VI. CONCLUSION AND FUTURE WORK

We presented some results from the prototype implementation of the proposed plant care system. Through the creation of a moisture-monitoring device tailored for plants, we strive to enhance overall plant well-being. Incorporating mechatronics, we aim to simplify plant care for all, alleviating the worry of plant dehydration. Recognizing the unique moisture requirements of each plant for optimal growth, our innovation involves an integrated image recognition system which we plan on integrating within our device. This technology enables precise watering adjusted to individual plants, preventing soil dryness while avoiding excessive watering at any point of time. Not only does this innovation encourage more people to engage in gardening, but it also holds the potential to significantly impact broader contexts, such as reducing agricultural labor and optimizing water resources. Moreover, this product is a sustainable solution for water and electricity conservation, which are essential matters worldwide. Advancement into the future allows us to promote increasingly specialized features for diverse types of plants, including determining plant type using machine learning and image recognition software, large-scale product usage over areas like farms and orchards, and, most importantly, the automatic functioning of the watering system through multiple sensors.

Acknowledgment

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