First Interim Report

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First Interim Report

I. Objective

This is the first interim report that describes the progress of my research until Sunday 9Th of March 2019. The report will cover an introduction about the project, Literature Review, Research and Development Methodology, Senors and Actuators used in the first prototype of the robot, Design process of the robotic system, schematic of the electrical system of the first prototype, Performance Discussion and Conclusion.

II. Introduction

Many years ago computer scientists and engineers started making devices that send notifications to the users and gives the users the ability to take action whenever they need and wherever they are using mobile apps and connected devices. The interaction between humans and robots evolved over the years as humans wanted to deal with more interactive systems, systems that can understand and handle their needs instead of waiting for human influence. In this thesis, a system is to be implemented to enable plants in offices to satisfy their own needs using Humanoid Plants Systems. A Humanoid Plant System is a system that is aware of the environmental changes around it and satisfies its own needs based on its own knowledge.

III. Literature Review

Indoor planting has been technologically mutated by making use of automation which led to significant improvements in the past few years. Those systems are studied and classified into four main types as follows: systems that only send notification and the user should handle the issue, systems that make use of sensors data by forecasting the needs of the soil which can be used to handle the problem autonomously, robotic-based autonomous systems and user interactive systems.

Many systems were implemented to help plants get their needs including water and light. Some systems acted as reminder systems that send notifications to the user in critical conditions. For instance, in this paper [1] a system was implemented to notify users to water their plants by measuring the moisture in the soil in the plant pot, Other systems send notifications and wait for the user to control the flow of water remotely. For example, a system was implemented [2] to irrigate the plant manually using a solenoid valve according to the readings from some sensors including soil moisture, light, and ultrasonic sensors. In those systems, users are notified via email to activate the watering activity manually using an android app.

Many systems made advantage of the data collected using multi-sensors to minimize human influence. For instance, the plant watering process may be automated using future expectation of the soil moisture content that is based on moisture content data that can be collected from moisture sensors in real time[3]. Another system was introduced to rotate the plant in order to redistribute light over the unreachable hidden parts of the plant, besides autonomously watering the plant using a water tank that is designed to be put in the plant pot [4]. Handling the incoming sensor data in real time makes the systems more efficient and less prone to human errors.

Technological progress in the fields of Robotics and Computer Vision produced some fully autonomous robotic systems that are capable of monitoring and satisfying plants needs. One of the systems[5] implemented a gardening robotic system with multiple robots acting as gardeners providing static plant pots with the needed water on demand, it also locates the plants in the garden and grasps cherry fruit using Computer Vision. The plants used in their prototype were potted cherry tomatoes where they monitored its humidity and the state of the fruit. The advancement in the Computer Vision field made it possible to detect plant wilt using feature extraction from images. For instance, a system was developed[6] to pour water to wilting plants automatically. The welting plant is detected by measuring the areas and degrees of the leaves parts in the image taken by a camera

Living plants were also used in the Human-Robot interaction field. Sensors and Actuators were used with plants to make them interact with the environment and the users around them. For instance, a plant was augmented with light sensors to make it lean towards some direction triggered by human actions[7]. Another system[8] made the plant responsive to touch using non-invasive techniques alongside with machine learning to differentiate between different hand gestures which can make the plant a musical instrument. The plant was treated as an electric circuit that can be represented using electronic components. Living plants have also been given some cyborg capabilities. For example[9], Ag/AgCl electrodes were used to measure the extracellular potential of the plants. The extracellular potentials measured were used to determine from which direction the light is coming as the plants are bio-electrochemically excited in response to light changes. The plant then moves towards the light source to get the greatest amount of light needed to survive.

IV. Research and Development Methodology

As this project is aimed to make a system that senses plants' needs and makes it act independently like human beings, many sensors were used in parallel to identify plants needs and to try to fulfill those needs. The project consists of two main components: the robot that carries and monitors the plant and the feeding base from which the robot can request a certain amount of water or light. The process consists of three main sub-processes as Follows:

- The data collection process
- The data analysis process

- The decision-making process

The three sub-processes are simultaneous and happen in order. First, the robot starts by collecting the data. Then, the collected data is analyzed and this leads to an action taken by the robot as going to the base to get some certain amount of water that lasts for a few hours. The amount of water is based on many factors. For example, the user can state that the plant shouldn't move around for a specific amount of time. Based on the amount of time that the user states, the robot analyzes the data and estimates the amount of water needed to keep healthy during the stated time. The project is implemented in 7 phases as follows:

- Exploration phase: in this phase, a study of the literature was made to see the solutions and applications that other researchers implemented to tackle similar problems. At the end of the exploration phase, an idea was formulated to handle the problem with some improvements that made a significant difference between the system that would be implemented in this thesis and the other systems explored in the literature review.
- Plant-monitoring robot design: the plant monitoring robot is designed based on the idea formulated in the previous phase. In this phase a schematic diagram was made for the whole electrical system of the robot, the microcontroller code was implemented for each sensor and the sensors were tested separately according to the schematic diagram.
- Plant-monitoring robot implementation: the first prototype is implemented according to the design from the previous phase and the plant-monitoring robot is assembled and all the sensors are integrated.
- Feeding station design phase the design of the base is to be made using the same steps stated before in the second phase. Feeding station.
- implementation phase: the feeding station would be implemented using the same steps in the Plant-monitoring robot implementation phase.
- Testing the system after integration: the whole system would be tested and evaluated. The evaluation metric would be defined based on the error from the sensors and the behavior of the whole system.
- The system optimization phase: In this phase, the system would be optimized based on the evaluation from the previous phase. The optimization of the system would be divided into code optimization and electrical system optimization. After finishing this phase the system needs to be tested again searching for further points that could be made.

Fig.1 explains the inputs and outputs of each phase.

V. Robot Sensors and Actuators

The robot is constructed and designed to navigate through tough indoor environments. A mount is laser cut to enable the robot to carry the plant pot. The robot mainly consists of two parts as follows:

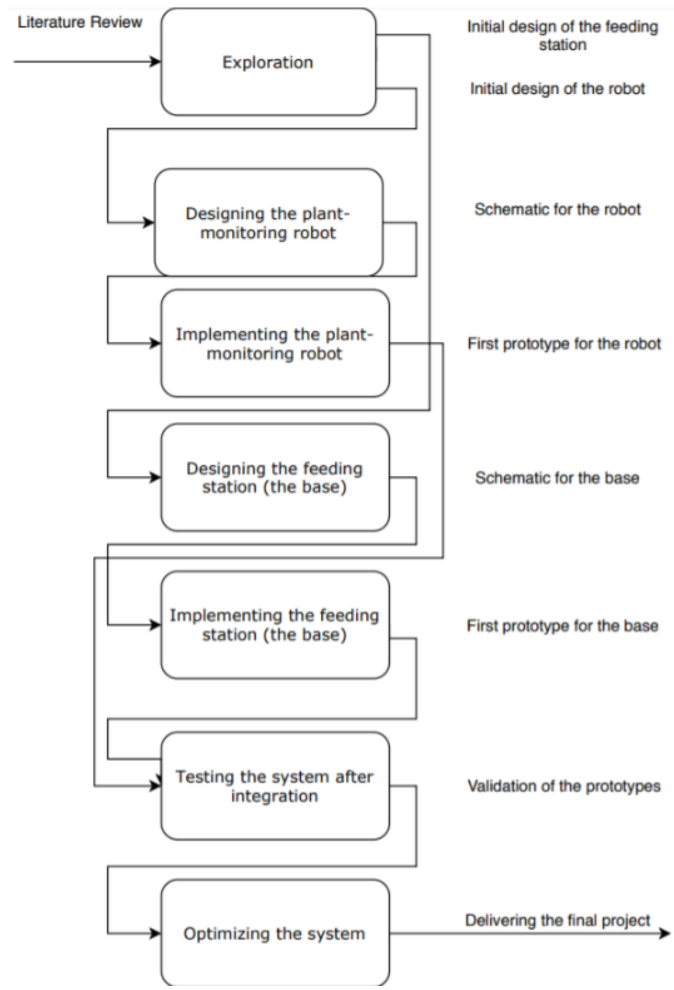

Fig. 1. Phases of the methodology of the research

A. Motors

four DC geared motors were used with the following technical specifications:

DC motor (GR 42x25)	Unit of measurement	
Nominal voltage	VDC	24
Nominal speed	RPM	3600
Nominal torque	Ncm	3.8
Nominal current	A	0.9
Starting torque	Ncm	20
Starting current	A	4
Demagnetisation current	A	6.5
Mass moment of inertia	gcm2	71
No-load speed	RPM	4200
No-load current	A	0.17
Motor weight	gr	390

B. Sensors and Controllers

Many sensors and actuators are used to control the robot according to the plant needs:

- Motor Drivers: two motor Cytron MD10C motor drivers were used. The motor drivers can drive high current brushed DC motor up to 10A peak current continuously.
- Arduino Mega chip to receive the sensors values and take a decision whether to move the robot or not.
- Lidar lite sensor with a range of 40 meters.
- Moisture sensor to measure the moisture content of the soil.
- Humidity and temperature sensor (DHT22) to measure the humidity and temperature of the surroundings that might affect the plant.
- Waterproof temperature sensor to measure the temperature of the soil.

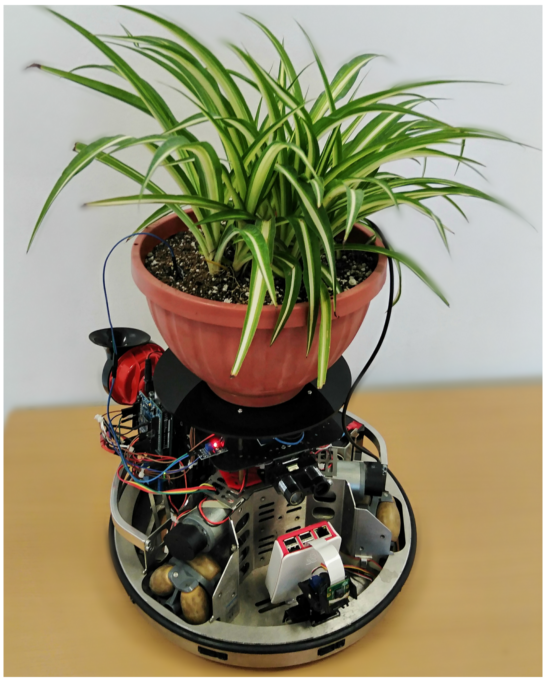

Fig. 2. Robot Image

VI. Design and Implementation Progress

The whole electrical system was finely checked after designing the schematic diagram of the system. The electrical system was implemented and tested many times before delivering the first prototype of the robot. The programming and integration part of the prototype came after many trials and experiments to overcome electrical and control faults and the code was written to fulfill the Arduino conventions and to avoid keeping it idle at any point of time. The Robot is provided with moisture, humidity, air temperature sensor, and soil temperature sensor. The sensors collect data from the environment then a decision is made by the robot whether to move to the base or stay in its place. Then the amount of water needed would be sent to the base which provides the plant system with the needed amount of water. The communication between the base and the robot is done wirelessly using two Xbee modules which provide a wireless communication range of 1500 meters of eyesight.

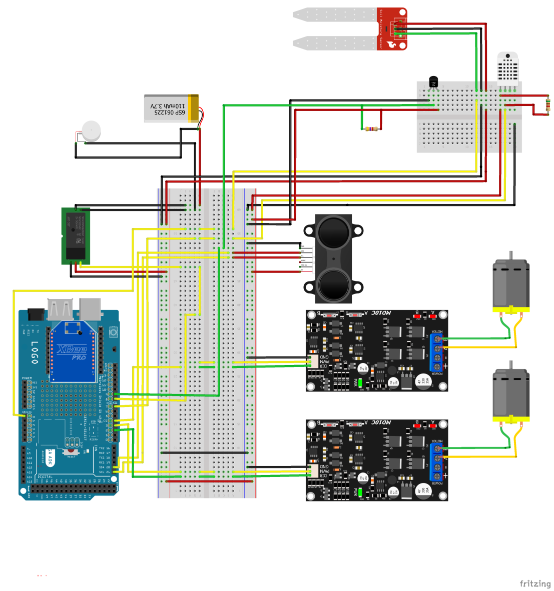

Fig. 3. Schematic diagram

VII. Performance Results and Discussion

It is noticed and recorded that the robot performs well during test trials with some challenges and limitations in the mechanical and control systems as the system is relatively large which makes it hard for the robot to navigate in tight areas of the environment. The code for the moving plant system was tested more than 10 times and ensured to give precise and reasonable non-contradicting sensor values. The wireless communication between the two Xbee modules was tested many times for delays or data corruption and the data from wireless transmission was compared with the data from a wired connection and the almost the same with no significant errors.

VIII. Conclusion

The first prototype for the robot was implemented and the sensors were integrated and tested many times to ensure the stability of the system. The base is to be implemented and integrated to communicate with the robot and provide the needed care for the plant. The first three phases were finished and all the modules were tested carefully. The next two phases are expected to be finished by Sunday 7Th of April as stated in the previous strategy. The last two phases would be finished by the 4th of May.

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