INTI JOURNAL | eISSN:2600-7320
Vol.2019:36

# Study and Implementation of Data Mining in Urban Gardening

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## Abstract

The system is essentially a three-part development, utilising Android, Java Servlets, and Arduino platforms to create an optimised and automated urban-gardening system. Linking of these platforms are through a five-step process – monitoring, recording, processing, optimising, and reporting. The process begins through the monitoring of plants using sensors connected to the Arduino device. Attached sensors generate data and send these data to the Java Servlet application through a WIFI module. These data are processed and stored in appropriate formats in a MySQL server database. Using the J48 tree algorithm implemented through WEKA API on a Java Servlet, data provided is processed to derive a health index of the plant, with the possible outcomes set to "Good," "Okay", or "Bad". This information is then utilised to optimise the automated plant-caregiving features that the system contains, which are irrigation and sunlight through LED grow lights. Feedback given to the user to inform them of methods by which they can improve their plant's health condition, derived through the information generated from the data-mining module. A user can then remotely monitor and care for their plants. The major caregiving tasks of the plants in this system is automated and its users are equipped with a powerful tool that informs and educates them on the conditions of their plant, providing them with information that aids with improvement of the plants' health conditions.

## Keywords

Urban gardening, data mining, learned irrigation

## Introduction

Plants are an essential element to life on earth providing food, shelter, and a habitable environment to terrestrial organisms (Clark, 2018). The exponential urbanisation of planet earth and constant change in environmental conditions require a means by which plants grow in a home with its environment conditioned to its needs. There are several climate and environmental factors critical for plants to grow and thrive, among which are water (Iannoti, 2017) or irrigation (Monica et al., 2017), light (Gillespie, 2018), soil conditions, and temperature (Bareja, 2011; Hopper, 2017).

The lack of such factors is not the only a threat to the health of a plant as the presence of pests and herbivores should also be taken into consideration. Keeping a plant healthy in an urban

International Conference on Innovation and Technopreneurship 2019
Submission: 1 June 2019; Acceptance: 20 June 2019

environment is a challenge by itself given the absence of natural sunlight and water to nourish the plant.

The challenges faced when managing an urban garden (or home garden) can be mystifying to its owners as the cause of a plants degrading health may not be immediately apparent (Dyer, 2018). Furthermore, home-gardeners are often not experts in the field and may require external guidance and advice on how to successfully run and manage an urban garden. Home users sometimes intentionally or unintentionally neglect their plants due to lack of time, being away from home, or simply forgetting their caregiving responsibilities. Solutions include automatically caring for the plants at home while its owner is out or busy. More than just assistance in caring for their plants, urban gardeners will also benefit from useful information and recommendations regarding their plants. Such information assists owners in making decisions on how to manage their plants, as well as to present insights on the plants themselves such as their health statuses. As mentioned before, home-gardeners are often not experts in botany and thus the information provided to them should be in a useful manner.

This paper's goal is to discuss features to deal with and overcome the common challenges and problems that urban gardeners face. The first feature is to create a smart flowerpot that monitors, analyses, and optimises the environmental conditions of plants automatically. The "smart" flowerpot will contain sensors to read the conditions of a plant and determine its needs. The pot will also contain actuators to care for the plant by optimising its environmental conditions to that which has been determined to be appropriate. The second feature is to be able to control, manage, and generate useful reports from the smart flowerpot through a mobile application developed. A mobile application will grant users full control over the functions of the "smart" flowerpot. The application will also be equipped with reports presented appropriately to equip users with necessary information to make appropriate decisions. Finally, a third feature would be to analyse data derived from the system and build data models that will optimally improve the plant's condition. Data collected by sensors and from user input will be stored in a database where data mining techniques will be utilised to derive insights to build data models carrying solutions to aid in the optimisation of the plant's environmental conditions through the "smart" flowerpot.

## Methods

Interview and observation were the main forms of data collection on requirements. The authors interviewed and observed three owners of gardens, two of whom had relatively large gardens and one had a small condominium and has had unsuccessful experience with indoor plants.

Based on the data collected, the functional requirements include automatic watering of plants, detection of when a plant needs watering based on data collected from appropriate sensors. Other than that, there is a requirement to have reports on the health of the potted plant, detection of the conditions of the plant and possible causes of degradation of its health if any. The third requirement is to have suggestions on solutions to aid in caregiving and maintenance of plants, based on readings from the system's sensors and analysis of previous data.

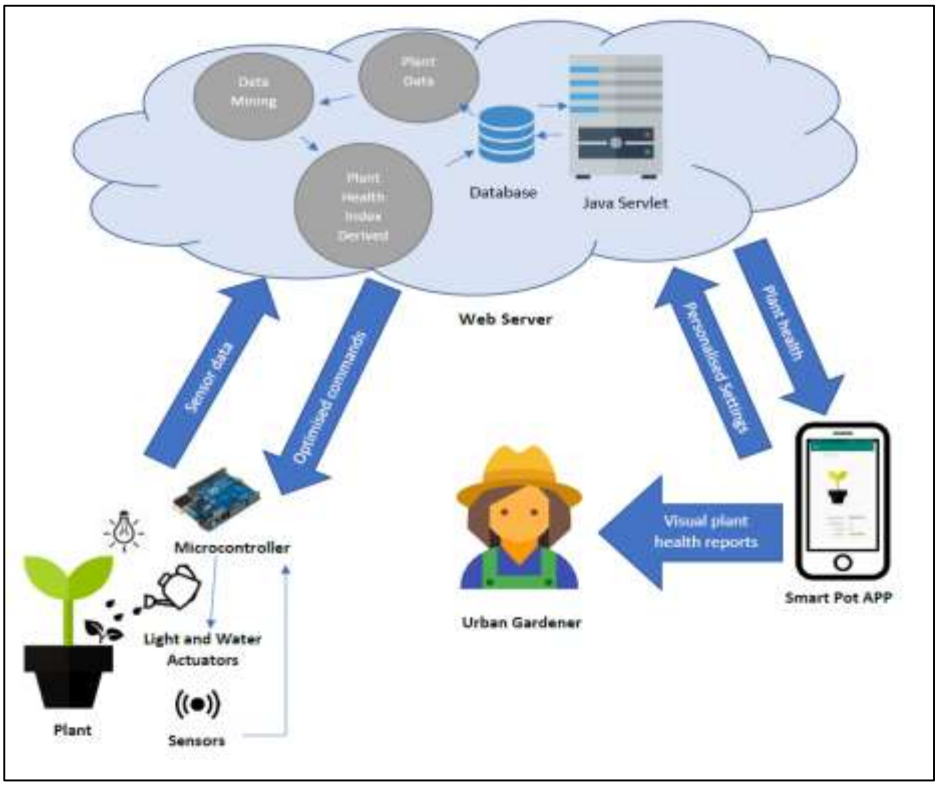

Figure 1. Architectural Design of Smart POT System

Figure 1 shows the architectural design that involves the use of a web server, a mobile app and sensors for a flower pot. The sensors use light and water actuators to detect moisture and light needs of the plant. The sensors have microcontrollers that sends data to the web server. The web server also receives and sends data to the urban gardener. The web server uses data mining to optimise the plants health.

Various sensors used in the system for tracking and recording environmental conditions of the plant subjected for testing. An ESP8266 WIFI module was also utilised and configured on the Arduino to connect to a home network where it will communicate with the web application deployed. Table 4.1 presents the list of hardware components used.

| # | |
|---|---|
| 1 | Arduino UNO R3 |
| 2 | ESP8266 ESP-01 WIFI Transceiver Wireless Module |
| 3 | BH1750FVI Digital Light Intensity Sensor Module |
| 4 | AM2302 DHT22 Temperature and Humidity Sensor Module |
| 5 | Soil Moisture Sensor Module |
| 6 | Ultrasonic Module HC-SR04 Distance Measuring |

Table 1. Arduino and Modules Utilised

The HTTP Post function used in the Arduino program iterates until a POST is successful. This is done by checking a Boolean value that states whether a connection to the server has been established. The web application records data sent by the Arduino, filtering appropriate and valid data, and processing these data to produce useful information to convey to the user through an Android application. The web acts as the middle-man for the Android application and the Arduino device. Users do not directly interact with the web application and thus it contains no user interface.

Data retrieved from the Arduino through HTTP doPost function on the JSP Web Application is sent to the MySQL database. A function is used to retrieve plant sensor data from the last 5 days to correlate the data with the number of times it was watered and the health appearance index that the user has provided. These data and their correlations will be determined.

The activation of the self-watering feature is schedule-based and relies on Boolean checks retrieved from the database. Alternatively, the frequency of watering the plant can also be set in the Android application. In addition, there is another function used to classify plant's health based on the sensor data retrieved from database.

The authors used WEKA to implement Data Mining onto the web application using its JAVA API. WEKA also has an application interface to test the various data mining techniques to identify which one is most suitable for the project. The J48 Decision Tree Algorithm determines by attributes provided, whether a plant is healthy or not. The web application retrieves data from the MySQL server database and plugs the data into the function built using the WEKA API. There, the function will determine if the plant is healthy or not and its results recorded into the database.

A set of training data generates a classification model for the data mining process. These training data is on average readings and randomised values based on the collected readings. The generated data was loaded onto the WEKA GUI Chooser to view the classification tree derived. The following are the attributes provided for the classification model to determine the health of the plant.

| **No** | **Attributes** | **DataType** |
|---|---|---|
| 1 | Times Watered | numeric |
| 2 | Average Soil Moisture | Numeric |
| 3 | Average Temperature | Numeric |
| 4 | Average Humidity | Numeric |
| 5 | Hours of Sunlight | Numeric |
| 6 | Health Appearance Index | Numeric |
| 7 | Health Index | class (Good, Okay, Bad) |

Table 2. Attributes for Classification Tree

Using the provided attributes, the J48 Decision Tree Algorithm determines the overall health of the plant. Using the training set data provided, the data model built was able to predict the health index of the plant accurately.

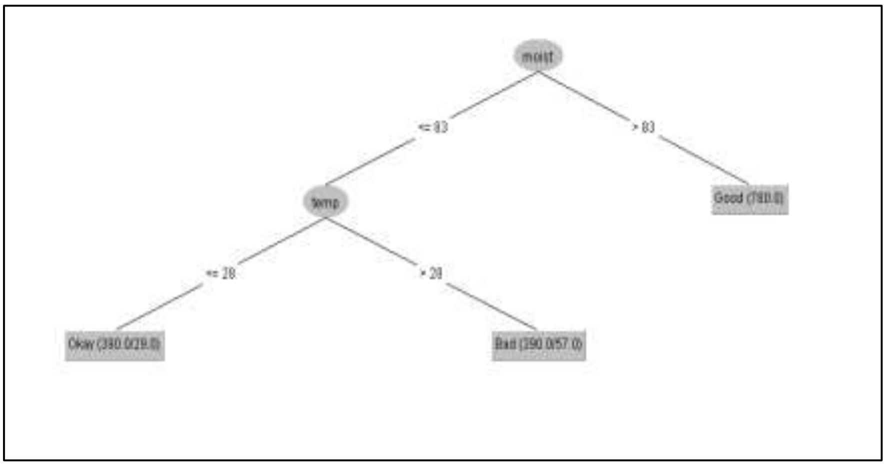


Figure 2. Generated Visualisation of Tree

Figure 2 demonstrates the generated visualisation of the J48 Decision Tree derived from the training set inputted. There are three possibilities of classification, namely, Good, Okay, and Bad. The three demonstrates that if the average soil moisture of a plant is above 83%, a plant is generally healthy. If soil moisture is below 83%, then the temperature of the plant is checked. Generally, an average temperature above 28 degrees Celsius will result in a “Bad” health index, whereas average temperatures equating or less than 28 degrees Celsius results in an “Okay” (average) health index rating.

## Results and Discussion

| | |
|---|---|
| Automated Management | Users can leave their plants to be automatically watered by the system |
| Intelligent Configuration | The system automatically sets the frequency of watering and data collection without the need for user intervention |
| Efficient Management Interface | Simple and efficient user interface for viewing and management of smart plant system |

Table 3. Results

Even though this system is able to support automated caregiving, the caregiving itself is limited to watering only. Apart from that, this application is run on a localhost and not on the Internet with proper web hosting. Battery consumption for the artificial light source is also high due to the bulky hardware.

## Conclusions

Automation of plant conditioning is possible in this project with features meeting its caregiving needs. The developed prototype equips its users with information that aids in identifying problems in urban gardening and recommends user actions. It even automates the most basic caregiving needs of gardening, which is irrigation and sunlight.

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