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# Smart Desktop Plant Watering System

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Report submitted in partial fulfilment of the requirements of the module  
Project (E) 448 for the degree Baccalaureus in Engineering in the Department of  
Electrical and Electronic Engineering at Stellenbosch University.

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# Acknowledgements

I would like to thank my chair, for always having by back. I also would like to thank my coffe machine, for being there for me during the late nights. Finally, I would like to thank Dr Herman Kamper and Dr Rensu Theart for this amazing report template.



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# Abstract

## English

Design and develop a smart desktop plant watering and monitoring system to provide ideal growing conditions for a few pot plants. The system must be able to measure soil moisture levels and include a watering system to every appropriate plant as needed. The real-time system information must be able to be observed via an app or website, with accompanying historical data. The watering system must be able to be remotely accessed through the app. A camera must be included in the watering system, having view of all the plants, and should store the historical photos to create a timelapse. Periodical photos can be accessed on the app.

## Afrikaans

Ontwerp en ontwikkel 'n slim water- en moniteringstelsel vir tafelplante om ideale groei toestande vir 'n paar potplante te bied. Die stelsel moet grondvogvlakke kan meet en 'n besproeiingstelsel by elke toepaslike plant insluit, indien nodig. Die intydse stelsel inligting moet waargeneem kan word via 'n toep of webwerf, met gepaardgaande historiese data. Die waterstelsel moet op afstand via die app beheer kan word. 'n Kamera moet in die besproeiingstelsel ingesluit word, met uitsig op al die plante, en moet die historiese foto's stoor om 'n tydsverloop te skep. Periodiese foto's kan op die app verkry word.

# Contents

<b>Declaration</b>	<b>ii</b>
<b>Abstract</b>	<b>iii</b>
<b>List of Figures</b>	<b>v</b>
<b>List of Tables</b>	<b>vi</b>
<b>Nomenclature</b>	<b>vii</b>
<b>1. Introduction</b>	<b>1</b>
1.1. Background . . . . .	1
1.2. Problem Statement . . . . .	1
1.3. Project Objective . . . . .	1
1.4. Summary . . . . .	2
1.5. Scope . . . . .	2
1.6. Layout of this report . . . . .	2
<b>2. Literature review</b>	<b>3</b>
2.1. Related Work . . . . .	3
2.1.1. This cool Project . . . . .	3
2.2. Background concepts . . . . .	5
2.2.1. Soil moisture sensors . . . . .	5
2.2.2. Water irrigation techniques . . . . .	5
2.2.3. Plant health indication using camera . . . . .	6
2.2.4. Progressive Web Apps . . . . .	6
<b>3. System design, hardware and software choices</b>	<b>7</b>
<b>4. Summary and Conclusion</b>	<b>8</b>
<b>Bibliography</b>	<b>9</b>
<b>A. Project Planning Schedule</b>	<b>10</b>
<b>B. Outcomes Compliance</b>	<b>11</b>

# List of Figures

# List of Tables

# Nomenclature

## Variables and functions

$p(x)$	Probability density function with respect to variable $x$ .
$P(A)$	Probability of event $A$ occurring.
$\varepsilon$	The Bayes error.
$\varepsilon_u$	The Bhattacharyya bound.
$B$	The Bhattacharyya distance.
$s$	An HMM state. A subscript is used to refer to a particular state, e.g. $s_i$ refers to the $i^{\text{th}}$ state of an HMM.
$\mathbf{S}$	A set of HMM states.
$\mathbf{F}$	A set of frames.
$\mathbf{o}_f$	Observation (feature) vector associated with frame $f$ .
$\gamma_s(\mathbf{o}_f)$	A posteriori probability of the observation vector $\mathbf{o}_f$ being generated by HMM state $s$ .
$\mu$	Statistical mean vector.
$\Sigma$	Statistical covariance matrix.
$L(\mathbf{S})$	Log likelihood of the set of HMM states $\mathbf{S}$ generating the training set observation vectors assigned to the states in that set.
$\mathcal{N}(\mathbf{x} \mu, \Sigma)$	Multivariate Gaussian PDF with mean $\mu$ and covariance matrix $\Sigma$ .
$a_{ij}$	The probability of a transition from HMM state $s_i$ to state $s_j$ .
$N$	Total number of frames or number of tokens, depending on the context.
$D$	Number of deletion errors.
$I$	Number of insertion errors.
$S$	Number of substitution errors.



## **Acronyms and abbreviations**

AE	Afrikaans English
AID	accent identification
ASR	automatic speech recognition
AST	African Speech Technology
CE	Cape Flats English
DCD	dialect-context-dependent
DNN	deep neural network
G2P	grapheme-to-phoneme
GMM	Gaussian mixture model
HMM	hidden Markov model
HTK	Hidden Markov Model Toolkit
IE	Indian South African English
IPA	International Phonetic Alphabet
LM	language model
LMS	language model scaling factor
MFCC	Mel-frequency cepstral coefficient
MLLR	maximum likelihood linear regression
OOV	out-of-vocabulary
PD	pronunciation dictionary
PDF	probability density function
SAE	South African English
SAMPA	Speech Assessment Methods Phonetic Alphabet

# Chapter 1

## Introduction

### 1.1. Background

In the current climate of technology, systems and devices centred around the Internet of Things concept is on the rise. There are more and more consumer and commercial products that are connected to the internet in some way or another, and most of these devices are controlled via an accompanying website or mobile phone application. This is a very effective and comfortable way of always being on control of your devices and environment, and almost everything in a consumer home can now be connected to the internet, from your fridge to your lightbulbs to your water-meter.

One aspect of a consumer's home that hasn't received an all-inclusive IoT upgrade is houseplants. Houseplants and desktop plants are arguably the easier plants to grow, but there is still a need to monitor them to ensure they can grow healthy. Most houseplants do require a lot of water and can sometimes be forgotten about and are difficult to get healthy again. There are numerous methods to provide solutions, but none have been comprehensively explored and put to market.

### 1.2. Problem Statement

The aim is to design a smart desktop plant watering system to monitor a couple of plants' health and report it to a website or app. The system must also document the growth of the plants via a camera

### 1.3. Project Objective

The project sets out to fulfil the following objectives. The system must:

- measure the soil moisture content of the plant soil, with the possibility of viewing the plant health using a camera system.
- be able to activate a watering system that is able to water each plant individually.

- display this information via a website or app, allowing the user to activate the watering for each individual plant from the website.
- store camera photos of the plants in order to create a time-lapse video of the plants' growth.

## **1.4. Summary**

## **1.5. Scope**

The project sets out to solve the problem in the most comprehensive way possible while also allowing for a user-friendly experience. There are some solutions that, although possible, would not make sense to implement.

One such a solution is to not only monitor the soil moisture content, but also the pH levels of the soil. This allows for comprehensive data of the plants' health and soil mixture, but it is very difficult to implement in a digital system in a way that makes sense and would be useful to the user. A simpler approach to this would be to use pH and nutrient sticks purchased from a local plant nursery.

The project also does not aim to adhere to a specific cost cap, but materials and components are chosen in such a way that they try to find the middle-ground between value and cost. The components are also limited to a pool that is available at time of writing. Prices are subject to change as water pumps improve and as microcontrollers and camera modules become more affordable.

## **1.6. Layout of this report**

# Chapter 2

## Literature review

### 2.1. Related Work

#### 2.1.1. This cool Project

##### Objectives

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##### Methods

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## Results

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## Shortcomings

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## **2.2. Background concepts**

### **2.2.1. Soil moisture sensors**

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### **2.2.2. Water irrigation techniques**

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### **2.2.3. Plant health indication using camera**

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### **2.2.4. Progressive Web Apps**

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# **Chapter 3**

## **System design, hardware and software choices**



## **Chapter 4**

### **Summary and Conclusion**

# Bibliography

# **Appendix A**

## **Project Planning Schedule**

This is an appendix.

# **Appendix B**

## **Outcomes Compliance**

This is another appendix.