Indian Institute of Technology Bombay

CS 684 Project Report

Team 9

DATA LOGGER AND ANALYTICS

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Contents

List of Figures

1 Introduction

A greenhouse is a building in which plants are grown. These structures range in size from small sheds to industrial-sized buildings. Greenhouses are used extensively by botanists, commercial plant growers, and dedicated gardeners. Particularly in cool climates, greenhouses are useful for growing and propagating plants because they both allow sunlight to enter and prevent heat from escaping. The transparent covering of the greenhouse allows visible light to enter unhindered, where it warms the interior as it is absorbed by the material within. The transparent covering also prevents the heat from leaving by reflecting the energy back into the interior and preventing outside winds from carrying it away.

One of the major tasks is to optimize the conditions for plant development in greenhouse. The greenhouse climate factors on which optimal plant development depends are as follows :

- Light : Light is the most significant parameter for the plant development and life. All the active life process in it can be achieved only in the presence and active influence of light.
- Temperature : Air temperature influences the energy balance of the plant canopy through the convective heat transfer to the plant leaves and bodies. Depending on the character of the air movement in the greenhouse, it is more or less near the temperature of the plant itself.
- Humidity : Air humidity directly influences transpiration of the plant leaves. Lower humidity means drying of the plant and reduced production. Higher humidity produces more leaves, lower quality of fruits and sensitive to a number of plant diseases.
- Pressure : Air pressure controls the atmosphere's circulation, and therefore influences how moisture moves.

2 Problem Statement

The goal of the project is to accurately measure the Greenhouse Temperature, Pressure, Humidity and Luminosity using sensors and analyze the readings obtained so that optimal greenhouse environment is maintained for plant development. Project includes analyzing the data in meaningful ways by drawing charts and graphs to identify the effect of each parameter on greenhouse climate. Data obtained is logged into the database for performing analysis. Hence project aims at designing integrated database.

The project includes generating real time graphs for the continuous sensor readings which helps in continuous monitoring of greenhouse. Developing highly interactive and user friendly GUI is the vital task of the project.

3 Requirements

3.1 Functional Requirements

- Accurately measuring the environments temperature, humidity, pressure and luminosity.
- Getting the data, consolidating and saving them to database.
- Functional requirements related to developing web application :
  - Showing list of greenhouses to user.
  - Showing the instant and past measurements and their comparisons.
  - Sending an alert message whenever instant measurements exceeds threshold.
  - Showing real time graphs based on streaming data received from sensors.

3.2 NonFunctional Requirements

- Reliability : in terms of data accuracy. Data accuracy is checked to make sure sensors do not send wrong data.
- Availability : Web interface will always be available.
- High speed Internet connection
- Robustness and fault tolerance.

3.3 Hardware Requirements

- RadioSonde FT232 Kit with RS92-SGP and XT09-SI-NA
- CC430F6137 with MSP430 microcontroller

3.4 Software Requirements

- NetBeans IDE for developing web application
- Tera Term and X-CTU terminals
- Code Composer Studio 5.3.0
- MySql server 5.1.49
- JDK 6 and Apache Tomcat Server 7.0
- Languages : Java, JSP, HTML, Javascript, J2ME, SQL and HTML
- Operating System : Windows 7 and 8
- Libraries : MySql connector(JDBC), RXTXcomm.jar

4 Design and Implementation

4.1 Project Overview

The whole project is divided into three modules, which are detailed in the following sections.

1. **Application Module :** The basic idea behind this module, is creation of graphical based interface which is easy to use. This is integrated with all other modules i.e database and analysis module providing full featured support for monitoring greenhouse appropriately without any unnecessary overhead.

2. **Backend Module :** This module implements a wrapper around the database. It creates the database design, and APIs for accessing the data. Certain constraints and checks are performed on the data that is accessed by the front end and it is dynamically updated whenever data arrives. This also includes parsing the data received via serial communication before updating it into database.

3. **Analysis Module :** This module generates real time graphs based on the data in the database. This module is responsible for analyzing the greenhouse parameters and alerting whenever values cross the predefined threshold.

4.2 Application Module

This basically carries out the job of creating a front end(GUI) for the central server, which can be operated by greenhouse administrator.

Design Objectives : To develop an intuitive, feasible and user friendly front end (web interface) for greenhouse supervisor. Providing facility of publishing current temperature, humidity, pressure and luminosity values of the greenhouse. It should also display real time graphs depicting changes in the greenhouse environment.

Review of the work done : A completely functional front end has been developed, with all relevant features. Features have been added in the interface to make it more intuitive to the user. Efforts have been put to make the interface easily usable even by a layman person.

Functionality : The following section gives a detailed description of the work done under this module. The various functions of this module can be divided into the following parts:

- Supervisor Login : Greenhouse supervisor has to first login into the front end using username and password in order to monitor greenhouse.
- Publishing current values of greenhouse parameters : Front end is responsible for showing the latest values of temperature, humidity, pressure and luminosity as it is updated in database.
- Showing real time graph : As data keeps on coming continuously at interval of 3 seconds, it gets updated in database and real time graph shits as per the latest value received. Web interface shows this dynamic graph and provides features for scaling and selecting values as per required.

The following are the few snapshots of the developed user interface :
Technical Description : We developed two interfaces. Initially created user interface had 6 jsp/html files. As it was less user friendly then we created new interface in which the number of jsp/html files created were 7, each having a css file associated with it.

- For designing purpose, a set of forms have the same css (Cascading Style Sheets).
- Pages have jsp coding embedded within html lines.

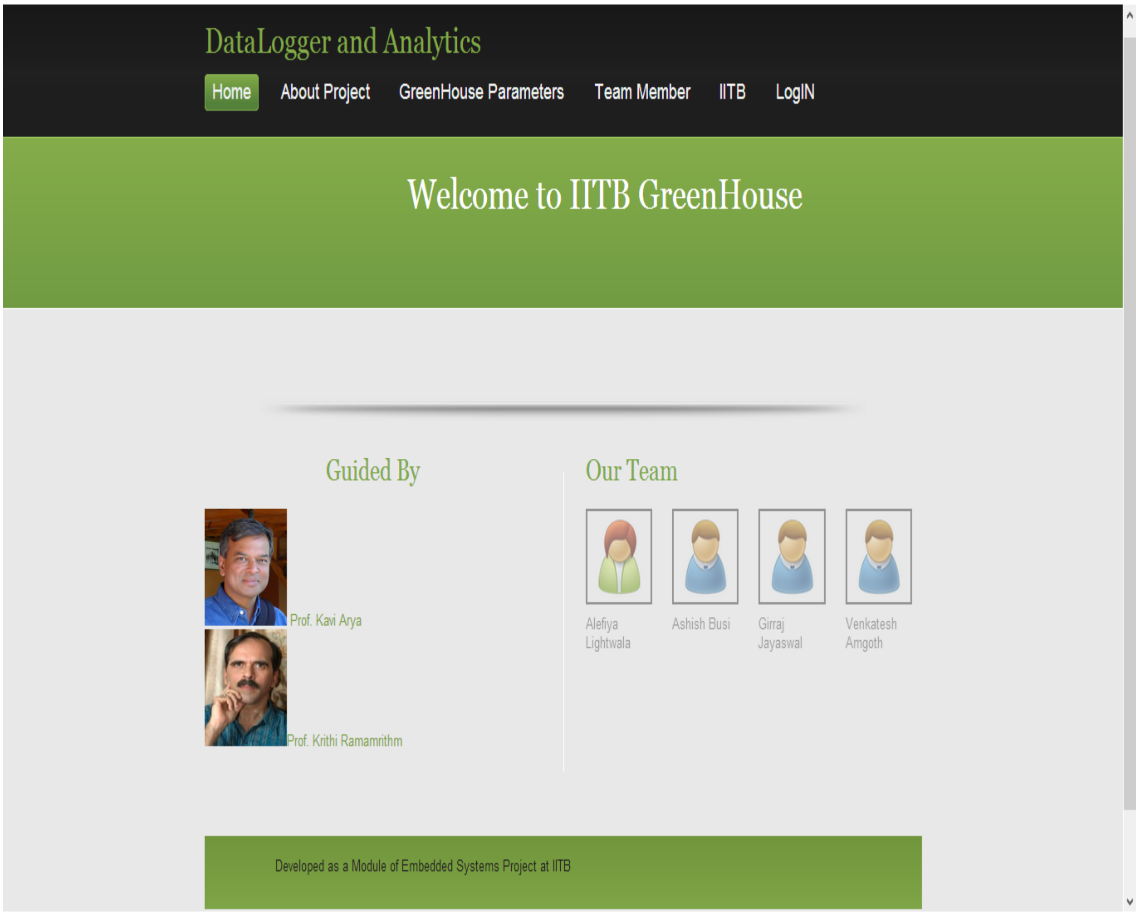

Figure 1: Home screen before login

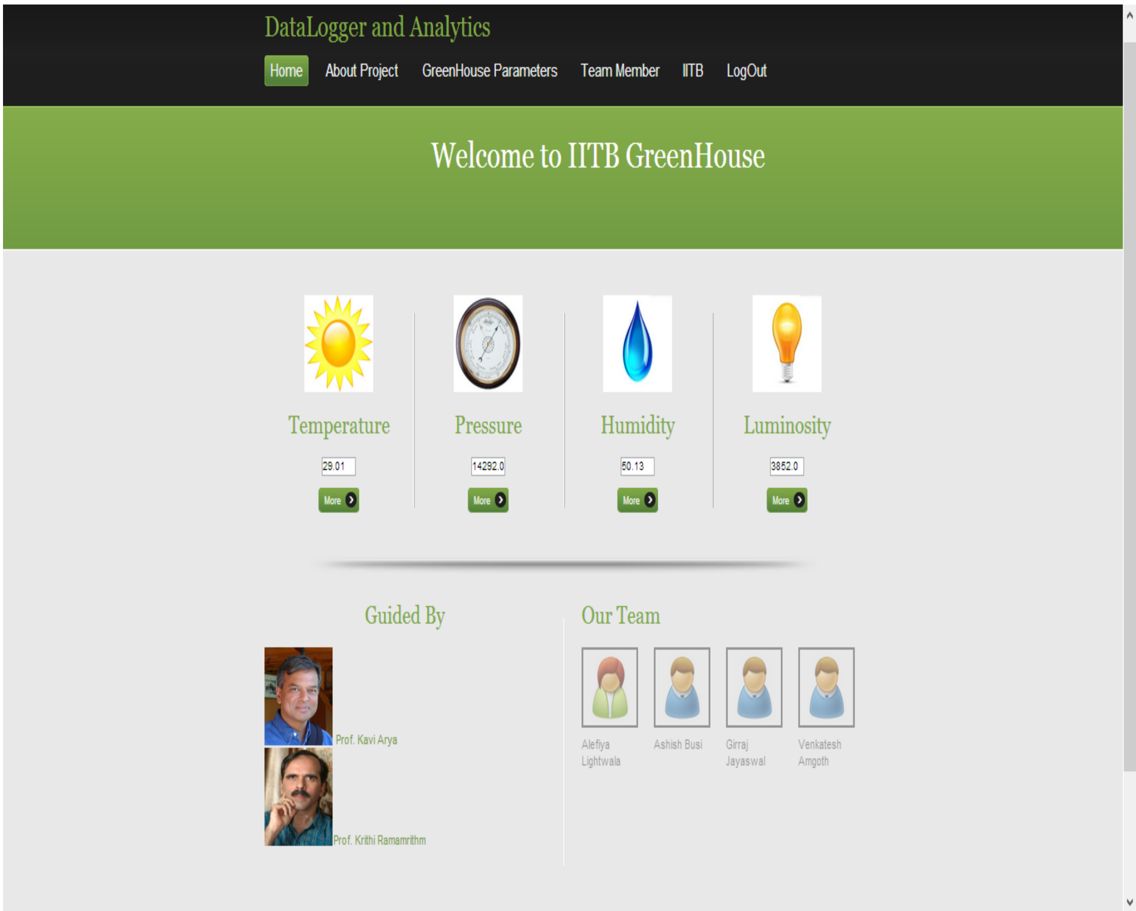

Figure 2: Home screen after login

- Commonly used objects within forms are text fields, labels, text area and buttons.
- We have also implemented a login table to monitor access to the database.
- fonts.css and default.css is created for styling purpose.
- We generated real time graphs using available APIs.
- In initial design we implemented a tree for implementing a hierarchy of links to different pages for enhanced usability. The tree is implemented using JavaScript, which generates the tree at run-time using cookies.

Quality Aspects :

- Usability : The interface helps the user perform all the required tasks (viewing graphs, latest data etc) with ease and is also very intuitive.
- Reliability : The performance of module is very consistent.
- Interoperability : The module is tested on different browsers (Firefox, Google Chrome and IE6) and is found to be working properly.

4.3 Backend Module

The Data Access Objects(DAO) are used which implements a wrapper around the database. This prevents access to tables from any outside application code and limit impact of any modification of data. These results in achieving higher security of data. This also included interfacing with serially arriving data using serial communication API. The data arriving is stored in database dynamically.

Functionality and Technical Description :

- A Java wrapper class surrounding each database table is made. A JAVA object is made for each table. The fields are accessed through set and get methods of the JAVA classes associated with their corresponding object. A single database object is implemented which has methods to insert/delete/update different database tables. A search method according to given criteria which is select-where query is implemented.
- Tables are populated through serial communication. The data received through serial communication is string having defined format. New data arriving at intervals of 3 seconds begins with $ symbol followed

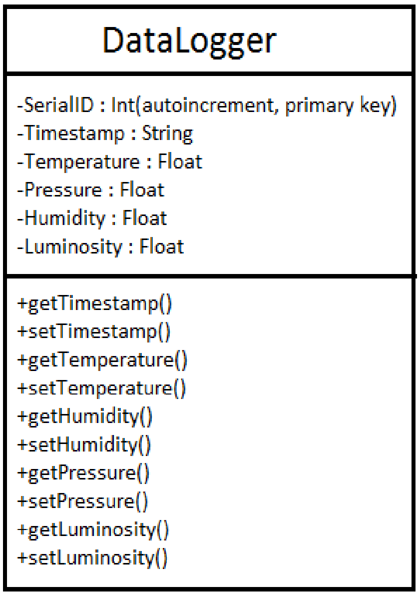

Figure 3: Class Description

by temperature value then pressure and then humidity. Luminosity readings are achieved from MSP430 in the same format. We parse these data using scripts and populate them into database. We use two way serial communication for the same.

- We programmed MSP430 using UART. Luminosity readings are obtained on PIN 2.4 of CC430F6137 board which was thereby configured as input pin. Moreover maximum voltage supported by CC430F6137 is 2.5V but in order to obtain accurate luminosity values we provided external voltage of 3V.

4.4 Analysis Module

This module is responsible of generating real time graphs. GreenHouse data at morning, afternoon and evening of 5 days was collected for the purpose of anlysis.

Functionality and Technical Description :

- FT232 and CC430F6137 are programmed to measure greenhouse pa-

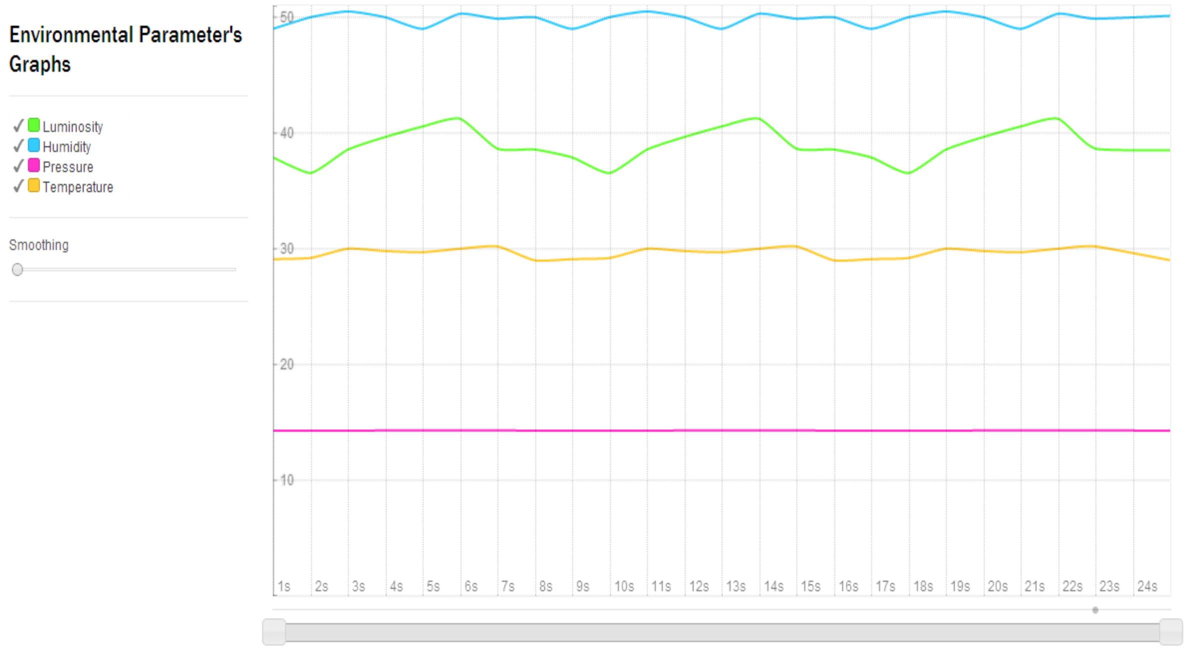

Figure 4: Real Time Graph

rameters through sensors at interval of 3 seconds. So whenever readings are obtained they are serially transmitted to the server machine and thereby using two serial communication written in Java database is updated. Hence database is always up to date.

- The real time graph generation code is written using javascript embedded within JSP which continously reads data from database and updates the graph. Graph shifts itself whenever new entry arrives in the database.
- The graph is highly interactive as we have provided legend for selecting required data to be viewed. Four checkboxes for tempertaure, humidity, pressure and luminosity values are present for selection purpose. The graph can also be scaled to certain amount.

4.5 Design Diagrams

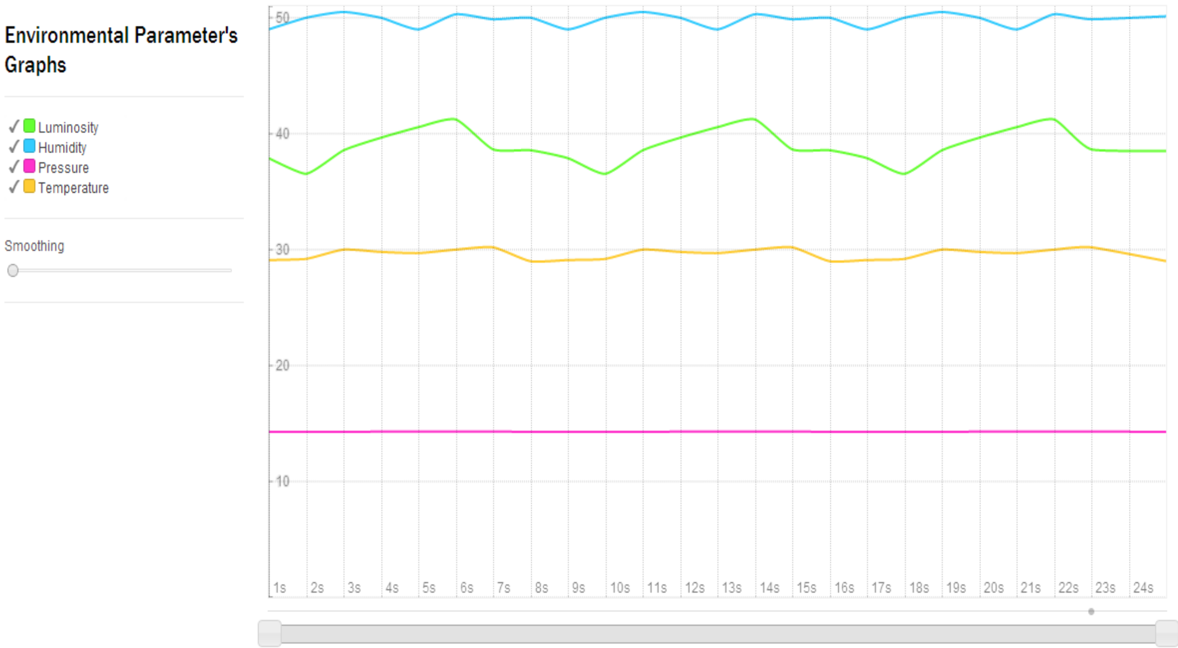

Figure 5: Finite State Machine

5 Design Challenges and Open Issues

Following are the major challenges which we faced :

- Difficulty in serial interfacing : Serial interfacing requires a standardized API with platform-specific implementation. Java being platform independent language faced problem with interfacing. So we used RxTx API for serial communication.
- Programming MSP430 : This was another major challenge as it required thorough knowledge of MSP430. Read the complete

datasheet for the same and understanding it consumed the major amount of time.

- Another major issue was of supplied voltage. MSP430 supported maximum voltage of 2.5V but inorder to get accurate luminosity values we needed voltage above 3 V. Interfacing with external voltage supply was another issue.
- Another difficulty was generating real time graphs for streaming data which arrived at interval of 3s.
- Maintaining database updated was one of the major challenge. Dynamically updating database with latest data was major challenge which we did using two way serial communication.
- During designing interface phase we faced difficulty of making our design compatible to commonly used browser. We regularly updated css in order to overcome this problem. Another major task was integration of all modules to provide complete functionality.

6 Future Work

Future works includes implementing the alerting system. Whenever any greenhouse parameter value crosses predefined threshold value an alert message must be sent to the responsible person either in form of SMS or e-mail. Also improving user interface to incorporate features like manual or automatic actuation is another step. The application currently developed manages single greenhouse, hence future work will be to extend this application to manage large number of greenhouses.

7 Conclusions

Analyzing the greenhouse parameters we devised that temperature of greenhouse is quite higher then the optimal range required for plant growth. Also we found large deviation in pressure values and investigating in the matter we found that this was because of the fan running in the greenhouse. Moreover major learning which we achieved through project includes serial communication in Java and programming MSP430. Another major conclusion drawn is that there is not major change in the values of temperature, humidity and luminosity which indicates that almost constant environment is maintained for plant growth. Real time graphs which we generated helps in visualization of the current situation in greenhouse. Also database developed is real time and dynamically updates itself with the values obtained from sensors at the interval of 3 seconds. Finally the project helped in understanding the effect of measured parameters on the greenhouse environment.

References

[1] *GREENHOUSE CLIMATE FACTORS* by Kiril Popovski, Faculty of Technical Sciences, Bitola University, Bitola, Macedonia

[2] E-yantra website.*http://www.e-yantra.org.*

[3] CC430F6137 Datasheet. *http://www.ti.com/lit/ds/symlink/cc430f6137.pdf*