**Crop Recommendation for Precision Agriculture**

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**ABSTRACT**

Agriculture in every country plays a prominent role in its economy and employment. Canada is one of the largest agricultural producers and exporters in the world. But it is noticed that there is a common problem faced amongst the farmers while farming, that they don't choose the right crop based on their soil requirements and location. Due to this they face a serious setback in productivity. This problem of the farmers has been addressed through precision agriculture. Precision agriculture is a modern farming technique that uses research data of soil characteristics, soil types, crop yield data collection, and suggests the farmers the right crop based on their site-specific parameters.

Our website will help the farmers by recommending them an appropriate crop based on their soil type and location and assists them on making better decisions regarding farming. This increases the rate of accuracy in making the correct choice while selecting the crop and thus proliferate the productivity. A unique feature is also provided in the website for the farmers to find out the cause of a crop disease and to get its detailed description by just uploading the picture of the infected plant.

**1.INTRODUCTION**

Canadian agriculture has evolved over time in response to challenges, opportunities and market developments however the contribution of agriculture to the Canadian economy has grown and is likely to continue increasing. In agriculture it is important that the recommendations made are accurate and precise because in case of errors it may lead to heavy material and capital loss. The motivation for implementing the website was primarily of interest to help the farmers in selecting their crop based on their soil type and location.

This website not only helps the farmers to choose the appropriate crop for their farm but also helps those who are trying to learn more about farming and agriculture through various videos. There is a detailed description of crops so that the farmers get information of the crops that they are planning to cultivate.

In addition to this, our website takes feedbacks from the users and in turn we can reply to their feedback through emails. If the farmers have any query related to our website, they can contact us through email.

Moreover, we are providing a feature of recognition, description and cause of a crop diseases based upon the photo provided by the user. This Image Recognition of crop disease implements a module of IBM Watson Image Recognition in which a classifier is defined which has various classes of different crop diseases. In each of these classes there are around 200-300 images of plant related diseases.

The rest of the paper is organized as follows. In the next section, related work is discussed. We present problem statement in Section 3. In Section 4, we propose our project details and design. In Section 5, a comprehensive set of experiments over a real dataset, our findings and the challenges in the project are presented. Finally, we conclude and propose ideas about future scope in Section 6.

**2. RELATED WORK**

“Crop Recommendation System to Maximize Crop Yield using Machine Learning Technique”- this project does the work related to our project. In this project they use precision agriculture method. This method is characterized by a soil database collected from the farm, crop provided by agricultural experts, achievement of parameters such as soil through soil testing lab dataset. The data from soil testing lab given to recommendation system will use the collected data and do ensemble model with majority voting technique using support vector machine (SVM) and ANN as learners to recommend a crop for site specific parameter with high accuracy and efficiency.

So, from this project, we got the idea to alleviate farmers by suggesting them the suitable crop for their farm. Moreover, we are also providing them guidance regarding farming through video tutorials. Also, a unique feature is included in our website which helps farmers to identify crop disease and gives them the detailed description and cause of the disease so that they can improve the crop productivity and soil fertility.

**3.PROBLEM STATEMENT**

Agriculture is a diverse and exciting industry.

The urbanization of Canada will have an impact on the farming practices. With the advancement of the technologies more and more improved techniques and methods are being used by the farmers. One of the method is precision agriculture. Precision agriculture is the technology of “site-specific” farming. It has provided us with the advantage of efficient input, output and better decisions regarding farming.

*PROBLEM 1: There are some websites which recommends crops based on the farm’s soil type and does not concern about the climatic conditions of the location and thus it doesn’t yield the crop productivity.*

*PROBLEM 2: Sometimes it happens that farmers cannot recognize the crop disease and tend to buy the pesticide which does not cure the disease and thus spends the money in buying irrelevant pesticide.*

*PROBLEM 3: If the farmers want to learn new farming techniques and methods through videos, they need to browse different websites.*

After finding out this problem, we decided to try and overcome these problems through our project. The idea for solving this problem is as follow.

This website is helping farmers by providing multiple functionality on the same platform. For solving all these three problems, in this project we are is recommending the farmers, the crop which is suitable for their farm based on the climatic conditions and type of soil. Also, we are providing a platform where a farmer can get detailed description of the disease which affected the crop, just by uploading a picture. Moreover, they can also learn new farming techniques and methods by browsing the list of training videos which are provided by this website with an ease without going to another website to learn new techniques.

**4.PROJECT DETAILS AND METHODOLOGY**

**4.1 DEFINITIONS**

**On Assignments/Stories:**

Assignments/Stories that are currently underway.

**Assignment Organizers:** The group of people who make all the arrangements for the assignments.

**Web-based System:** Information system that uses internet web-technologies to deliver information and services to users.

**Target Customers:** The group of people for whom the application is being made for.

**Methodology:** The specific process used for the project.

**Iterative Process Model:** Methodology to implement the application.

**Project timeline:** Time in which the application must be completed.

**Functional goals:** A functional goal defines functions of the system and its components. It is a set of inputs, behavior, and outputs.

**Strategic goals:** Goals which tell us about which software implementation technique we are going to use in our software and what plans/techniques we should use to make our software successful.

**Business goals:** Business goals tell us how minimum cost can produce the maximum and best output, how the software is to advertise in a way that it gives maximum profit.

**Technological goals:** Technological goals outline the best and up-to-date technologies available for software implementation.

**Quality goals:** Quality goals ensures the quality of an implemented software based on different parameters i.e. interface quality, performance, usability etc.

**4.2 SPECIFICATION**

**Functional Requirements:**

• The web application shall allow admin to log in with their user id and password.

• The web application shall allow users to log in with their user id and password.

• The web application shall allow users retrieve their password if they forgot their password.

• The web application shall allow users to request to change password.

• The web application shall allow admin to add new crop and its description.

• The web application shall allow admin to add new training videos related to farming.

• The web application shall allow users to get appropriate recommendation of crop by entering their soil type and location as an input.

• The web application shall allow users to give feedback through emails.

• The web application shall allow users to view various training videos related to farming.

• The web application shall allow users to upload the picture of the infected crop and get detailed description of the crop disease.

**Non-Functional Requirements:**

• The web application shall be user-friendly. • The web application shall be reliable and bugs free.

• The web application’s response time shall be based on the speed of user’s local internet connection e.g.

• The web application shall be portable and have good security also.

**4.3 ARCHITECTURE**

We are using a 3- Tier architecture for our web-based application. It consists of 3 different layers as described below.

• **Presentation Layer:** Front-end of the application. It displays information related to services available on the website.

• **Business Layer:** It controls application functionality by performing detailed functionality. It makes a call to the domain and decides what to show to the users.

• **Data Layer:** It stores the information in the database.

**4.4 PLATFORM**

• For back-end, we are using MS SQL Server 2012

• We are using ASP .Net MVC 4.0 framework and Xcode 9.0 with IBM Watson Image recognition service in frontend.

**4.5 DESIGN**

**Use Case(s)**

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| **Use Case UC1** | **Farmer Login** |
| **Actors:** | Primary: Farmer  Secondary: System  Database |
| **Description:** | Farmer needs to login with their username and password to use various website features. |
| **Pre-conditions:** | Farmer should be a registered user |
| **Post-conditions:** | The user is successfully logged in |
| **Normal Flow** | User clicks on login button.  User enters their account credentials.  If credentials are correct, user successfully access the website. |

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| **Use Case UC2** | **Admin Login** |
| **Actors:** | Primary: Admin  Secondary: System  Database |
| **Description:** | Admin needs to login with their username and password to access the backend. |
| **Pre-conditions:** | Admin should be a registered user |
| **Post-conditions:** | The user is successfully logged in |
| **Normal Flow** | User clicks on login button.  User enters their account credentials.  If credentials are correct, user successfully access the backend data. |

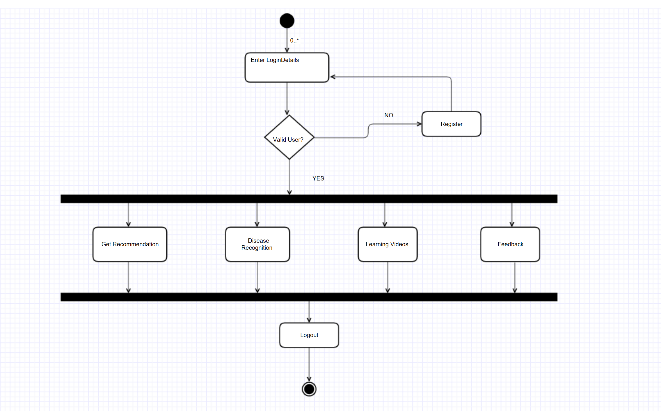
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| **Use Case UC3** | **Crop Configuration** |
| **Actors:** | Primary: Admin  Secondary: System  Database |
| **Description:** | Admin will enter the detailed description of the new crop to the database. |
| **Pre-conditions:** | Only if the user is the registered admin then he can have access to the backend. |
| **Post-conditions:** | New crop details will get added to the database. |
| **Normal Flow** | Admin will get a page where he will fill the details of the crop and then will click add button through which that crop will get added to the database. |

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| **Use Case UC4** | **Crop Suggestion Tool** |
| **Actors:** | Primary: Farmer  Secondary: System  Database |
| **Description:** | The system will find all the crops which are suitable for the particular soil type. |
| **Pre-conditions:** | Farmers must enter the valid soil type. |
| **Post-conditions:** | There should be a suitable crop relevant to that soil type. |
| **Normal Flow** | Farmer will enter their farm’s soil type and location as input and based on that system will find the crops from the database which grows in that soil and display the result to the farmer. |

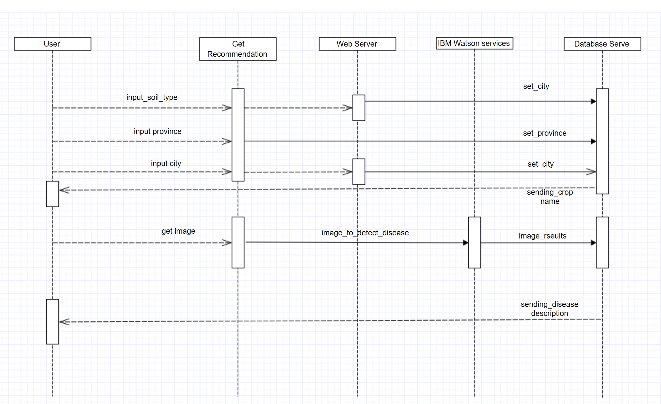
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| **Use Case UC5** | **Training Videos Configuration** |
| **Actors:** | Primary: Admin  Secondary: System  Database |
| **Description:** | Admin will add the Farming training videos to the database. |
| **Pre-conditions:** | Only if the user is the registered admin then he can have access to the backend. |
| **Post-conditions:** | Training videos will get added to the database. |
| **Normal Flow** | Admin will get a page where he will fill the details of the videos and then will click add button through which that Training video will get added to the database. |

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| **Use Case UC6** | **Training Videos** |
| **Actors:** | Primary: Farmer  Secondary: System  Database |
| **Description:** | System will display all the training videos to the farmer. |
| **Pre-conditions:** | Farmer must be logged in first to be benefited to watch the training video. |
| **Post-conditions:** | Each video must run smoothly, and it must satisfy the user’s requirement to the fullest. |
| **Normal Flow** | Farmers needs to go to the page where he will get the list of the videos.  Then he will click on the video he likes to watch.  Video will get fetched from the YouTube and buffered onto the page itself. |

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| **Use Case UC7** | **Disease Recognition** |
| **Actors:** | Primary: Farmer  Secondary: System  Database |
| **Description:** | The system will recognize the disease and will give detailed description of the disease. |
| **Pre-conditions:** | User must have the picture of the infected crop to upload. |
| **Post-conditions:** | Based on the picture, the system will find the disease from the library. |
| **Normal Flow** | Farmers need to click the picture of the infected crop.  Then he must upload the picture.  After recognizing the disease, the system will provide its detailed description. |



**Fig 1. Activity Diagram**



**Fig 2. Sequence Diagram**

**5. EXPERIMENTAL SETUP**

**5.1 IMPLEMENTATION DETAILS:**

Taking crop production in Ontario province as an example, the paper collected information of 6 soil monitoring points at all orientations in 22 cities and built crop fertility database. The Crop Recommendation for Precision Agriculture were designed by using OO and UML2.0. Crop decision-making system was implemented by using C #, ASP.NET MVC and MS SQL Server 2012. The recognition of diseases is based upon the picture provided by user which is implemented using a ios application made in Xcode 9.0 and IBM Watson swift framework. It has a user interface to capture photograph, this image is then sent to the IBM Watson Image Recognition service where it is identified and categorized based on classifiers and classes.

System may be installed in Windows 8/10 or more on PC or touch screen system. First, farmer may select and query the crop information based on soil type and location. Second, System buffers the training videos from You Tube. Third, farmers can get to know the details of the crop disease. Finally, the system gave formula for crop decision and crop harvesting technology decision according to soil monitoring point information, crop target output and local production level.

**5.2 TESTING:**

**Test Case(s)**

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| Test Case TC1 | Login with user id and password |
| Description | A registered user should able to successfully add credentials |
| Preconditions | The user must already be registered with a e-mail address and password. |
| Assumption | A supported browser is being  used. |
| Test steps | Click the login/Sign up button. In the ‘Username’ field, enter  the user id of the registered user.  Enter the password of the registered user.  Then click the Login button |
| Expected Results | A page will redirect the user to the home page with the username in the header and with the option of other  features like message and  notifications |
| Unexpected Results | If the user enters invalid user id or password, Application  displays message “invalid  login details “ |

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| **Test Case 2** | Check whether all parameters are entered |
| **Description** | The registered user should be able to enter city name, soil type. |
| **Preconditions** | The user should able to select values from dropdown list. |
| **Assumption** | A supported browser is being  used. |
| **Test steps** | Click recommendation menu and select soil type and city from list and click “get recommendation” button. |
| **Expected Results** | A page will redirect the user to the recommendation page and the city and soil type values should be entered by user. |
| Unexpected Results | If user will not choose any city name and soil type |

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| **Test Case 3** | Navigation to different tabs. |
| **Description** | When user clicks on any tabs of navigation menu he/she should be redirected to particular page. |
| **Preconditions** | None |
| **Assumption** | A supported browser is being  used. |
| **Test steps** | Select any tab from navigation menu other than current page. |
| **Expected Results** | The user should be redirected to selected tab by him/her from current page. |
| **Unexpected Results** | None |

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| **Test Case 4** | Learning Videos are working properly or not |
| **Description** | When user navigates to Learning Videos tab the videos should play properly. |
| **Preconditions** | None |
| **Assumption** | A supported browser is being  used. |
| **Test steps** | Select Learning Videos tab from navigation menu other than current page. |
| **Expected Results** | The user should be redirected to selected tab by him/her from current page and videos from current page should work properly. |
| **Unexpected Results** | None |

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| **Test Case 5** | Image Detection |
| **Description** | Image uploaded by the user is detected in application or not. |
| **Preconditions** | Image should be uploaded. |
| **Assumption** | Devices should have camera |
| **Test steps** | The user should upload image from his/her device then click upload button |
| **Expected Results** | The message window will pop up that supported image is uploaded. |
| **Unexpected Results** | The image format is not valid or image is not uploaded. |

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| **Test Case 6** | Disease results should be displayed. |
| **Description** | The user should able to see name of disease to crop and its cause. |
| **Preconditions** | Image should be uploaded |
| **Assumption** | Devices with camera should be used. |
| **Test steps** | The user should upload image from his/her device then click upload button |
| **Expected Results** | The user should be redirected to new view controller which can display results. |
| **Unexpected Results** | Internet is not working. |

**5.3 DISCUSSION OF FINDING AND CHALLENGES:**

**5.3.1 CHALLENGES:**

1. We implemented module of crop recommendation based on selected crop type which shows all the crops which can be grown in that particular type of soil. It was difficult to find all crops based on particular soil type.

2. Data collection for plantation of a crop was challenging as we had to gather data for humidity and temperature for each crop.

3. There are around 550-700 different types of plant diseases in each category of bacterial and fungal infections. Getting a dataset for all diseases with training images was difficult. In end we gathered a dataset with around 15 different classes, each class having at least 200 training images for IBM Watson.

4. We were able to show learning/recommended videos to users from YouTube. But loading video from YouTube takes a bit of time.

* + 1. **FINDINGS:**

1. In this website we found how to use MVC with ASP.net framework.

2. In this website we learned <https://plantix.net/>

-we found similar project to ours. We were able to gather and implement few new modules from the project like image detection.

3. In this website <https://github.com/watson-developer-cloud/swift-sdk> <https://www.ibm.com/watson/services/visual-recognition/>

- we learned how to implement IBM Watson Image recognition service on mobile application(IOS)

- how to send JSON from Watson visual recognition service and gathering the data in websites and mobile application

- how to define different classifiers, classes and how to upload training Images.

**6. CONCLUSION:**

In conclusion, the analysis of the existing systems was done; to identify its problems and its features. The solution to the problems that was intended to be solved was carefully analyzed, evaluated, treated and addressed by the proposed system.

* 1. **FUTURE WORKS**

• By using machine learning we will train data as it variably changes nowadays due to change in weather.

• We will make UI friendlier as if users have to just search by Postal Code and will give more precise information regarding suggesting right choice of crop according to their soil characteristics and climate.

• We would like to add more feature of soil balancing in which farmers can know which fertilizer they have to use and in how much quantity.

• We would like to use Support Vector Machine(SVMs) to achieve more accuracy.

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