Graduate Directed Project

User Requirements Document

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Farming UAV Image Analysis

And Robotics

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Abstract

This document contains the user requirements for the Farming UAV Image Analysis and Robotics system. This is a graduate directed project (44-696) at Northwest Missouri State University.

These user requirements were established according to requests formulated by the Client Dale Dickkut. The document complies with the User Requirements Document (URD) from the Software Engineering Standards.

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**Chapter 1**

# Introduction

## 1.1 Purpose

The purpose of this document is to specify the requirements of Farming UAV image analysis and robotics in a clear and consistent manner.

## 1.2 Scope

This is a stand-alone application which intakes the scanned farm image as input and does the job of analyzing the picture to provide the details related to crop health at a particular location in the crop. This application would be of useful for farmers who cultivate in large fields. Usability is also increased by offering a front-end for users to access the system.

## 1.3 Product Context

At present the farms are scanned using a drone machine which takes multiple NIR images of the crop. These obtained images from the drone are stitched together to provide in one piece image (Figure 1) of the farm. Later using the NDVI values upon image the health information of the farm on whole is obtained as in figure 2. Our goal in this project is to use the NIR image (figure 1), NDVI range and position coordinates of the image to obtain the health of crop as explained in section 2.3.

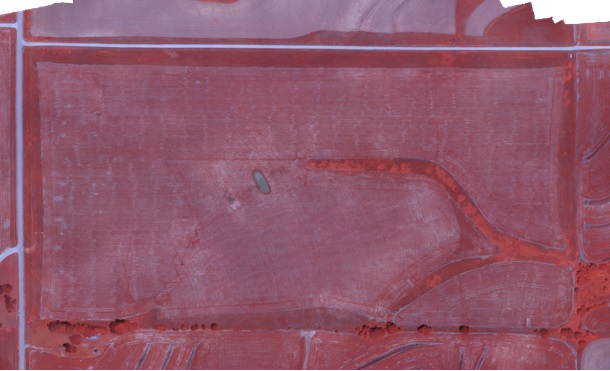


Figure 1 NIR Image of Farm

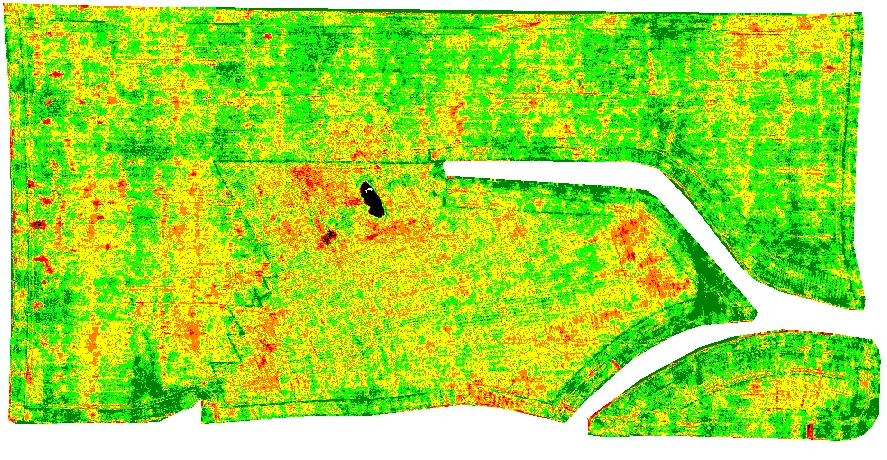


Figure 2 NDVI Image of Farm

## 1.4 List of definitions and abbreviations

## 1.4.1 Definitions

|  |  |
| --- | --- |
| Application | A non-interactive data processing application consisting of executables, scripts and/or auxiliary data files that reads one or more input data files and writes one or more output files. |
| Job | Computation of location coordinates, determining the crop health by dividing the picture into several blocks and finding the average of particular color pixels in each block. |
| Image Analysis | Process of extracting meaningful information from images; mainly from digital images by means of digital image processing techniques. |

### 1.4.2 Abbreviations

|  |  |
| --- | --- |
| UAV | Unmanned Aerial Vehicle |
| URD | User Requirements Document |
| GPS | Global Positioning System |
| NIR | Near Infrared Reflectance |
| NDVI | Normalized Difference Vegetation Index |

**1.5 References**

**RD1** E-mail from Monismith David “Farming UAV image analysis and robotics” August 21 2014

**RD2** Client meeting, September 3 2014

**RD3** E-mail from Dale Dickutt “Coordinates of GPS drawings”, September 12 2014

**RD4** Client meeting, September 26 2014

**RD5** Client meeting, October 24 2014

**RD6** Client meeting October 31 2014

**RD6**  Client meeting November 7 2014 “Usability testing”

**1.6 Overview**

This document is structured from the requirements gathered during in [RD 1] [RD 2] [RD 4][RD 5][RD 6].

Chapter 2 gives the description of functional requirements of the application. It describes the product, the capabilities and the characteristics of the users and the environments it is going to operate in.

Chapter 3 describes a set of use cases.

Chapter 4 describes about the database which includes information related to ER diagrams.

Chapter 5 presents the description of user interface through prototypes.

Chapter 6 describes the scope for future enhancements.

**Chapter 2**

# Functional Requirements

## 2.1 Application Security:

The application verifies the authenticity of the user by providing login and password fields. User would be able to use the application only when the login details are valid. There is also an option to change the existing password of the user which would be done by answering the security questions.

## 2.2 Inputting Image:

The application allows the user to submit one image at a time for analysis.

User has to provide the image information which includes:

**Name of the image:** name of the input image will be typed in this field by user

**Image URL:** the user provides the link of the image which he can browse from the desktop

**Total Area:** Inputs the total area of the field

**Width in Feets:** Inputs the breadth of the field

**Height in Feets:** Inputs the height of the field

**Longitude:** User inputs the longitude position of any four corners of the overall field

**Latitude:** User inputs the latitude position of any four corners of the overall field

**Split:** Clicking on this button will perform the image analysis.

## 2.3 Image analysis:

Upon taking the UAV drone farm image as input the application performs image analysis to provide the health of crop by dividing the picture into several blocks and finding the average of particular color pixels in each block. This is done as shown in figure below. The original image will be divided into several blocks each sized to a scale of one acre (scale can be variable). Upon hovering or clicking onto a particular grid the application should be able to give crop information which consists the information related to the percentage of a particular color in that block and also the location details through which the health of crop can be known in detail at any block



Grid

Figure 3 Image when divided into several grids

.

## 2.4 General Constraints

The accuracy in calculating the geographic location at a pixel depends upon the scale to which the area has to be considered.

**Chapter 3**

# Use Cases

In this Chapter we discuss on how the user interacts with the application. The use case is explained by dividing into three main categories login, Analyzing New Image, Previous results.

The relationship between the user and application with various actions to be performed is shown in below use case diagram



Figure 4 Use Case Diagram

### Login

This Use Case describes the process by which users log into the application. It also allows the user to change password or retrieve password if forgotten.

**Actors**

* User

**Use Cases**

* Change password
* Forgot password
* Analyze new Image
* Previous search

**Flow of Events**

1. The Use Case starts when the user starts the application.
2. The system will display the login screen.
3. The user enters a username and password.
4. If user selects change password
   1. User has to enter username.
   2. User has to answer security questions.
   3. User has to enter the new password.
5. If the user selects the Forgot Password
   1. User has to enter username.
   2. User has to answer security questions.
   3. System displays the password
6. The system will verify information.
7. If the user selects Analyze new Image
   1. Use Analyze new Image
8. Else if user select Previous Results
   1. Use Previous Results

**Analyze** **New** **Image**

This Use Case describes the process by which user does Analyze New Image.

**Actors**

* User

**Use Cases**

* None

**Flow of Events**

1. The Use case starts with selection of Analyze New Image button after login.
2. User has to enter all details of the crop including image.
3. User has to submit image for analyze.
4. User views the analyzed image.
5. If user selects save.
   1. Saves the image to database with details.
6. If user selects split.
   1. User views the split image.
   2. User selects save.

### Use Previous Results

This use case describes the process by which the user search the previously analyzed images from database.

**Actors**

* User

**Use Cases**

* None

**Flow of Events**

1. This use case starts with the selection of Previous Results Button after login.
2. User has to select/search the previously analyzed image from the table.
3. User views the analyzed image provided from the database.

**Chapter 4**

# Data Management

**4.1ERDiagram**

Figure 5 ER Diagram for database

**Entity: User**

The User entity has two attributes username and password. The username is the primary key of the table which is unique and not null.

**Entity: Security**

The Security entity has three attributes securityQuestion, securityAnswer and username. The securityQuestion is the primary key in the table which is unique and not null. The username is the foreign key from User table. The relationship between user User and Security entities is one to many relationship for example one user can have many security questions. Each security question has an associated security answer.

**Entity: Image\_Details**

The attributes present in the Image\_Details are imageName, image, Area, stageOfGrowth, width, height, longitude, latitude, variety, sourceOfImage, state, county, range/township/section, typeOfCrop, pictureDate, imageUploadedDate and userName. The imageName is the primary key in this table which is unique and not null. The userName is the foreign key from User table. The relationship between User and Image\_Details is one to many relationship for example a user can upload many images whereas image can be uploaded by only one user. The area attribute stores the total area of the field. The stageOfGrowth attribute stores the stage of the crop. The length and width attributes stores the length and width of the field respectively. The latitude and longitude stores the bottom left latitude and longitude values. gridArea stores the number by which the field should be divided. The typeOfCrop stores the type of the crop. Source of Image attribute stores the type of source through which the image has been taken. State, County and range/township/section stores the details of the field location.

**Entity: Color**

The attributes present in the Color entity are colorId, colorName, minimum\_NDVI and maximum\_NDVI. The colorId is the primary key in the table. The minimum\_NDVI and maximum\_NDVI stores the minimum and maximum NDVI values of the color.

**Entity: OutputImage\_Details**

The attributes present in this table are outputImageName, image, toprightLatitude, topLeftLatitude, bottomLeftLatitude, bottomRightLatitude, toprightLongitude, topleftLongitude, bottomLeftLongitude, bottomRightLongitude, fieldDescription, notes, imageName and colorId. The outputImageName is the primary key in this table. The imageName is one of the foreign key from Image\_Details entity and colorId is the foreign key from Color entity. The relationship between Image\_Details and Dimension table is one to one relationship for example each inputImage has exactly one and only one outputImage. The relationship between Color and Dimension entities is one to many relationship for example an output image has many colors. The fieldDescription attributes stores the amount of the each color present in the field in acres. The notes attribute stores the notes related to the field entered by the user.

**Entity Name: OutputImageGrid\_Details**

The attributes present in this table are gridId, sizeOfGrid, outputImageName, topLeftLatitude, topRightLatitude, bottomLeftLatitude, bottomRightLatitude, topLeftLongitude, topRightLongitude, bottomLeftLongitude, bottomRightLongitude, gridArea and colorId. The gridId, sizeOfGrid and outputImageName together form the composite primary key. The colorId is the foreign key from Color entity. The relationship between Dimension and Dimension Grid is one to many relationship for example each output image has many grids. The relationship between color and Dimension Grid is one to many relationship.

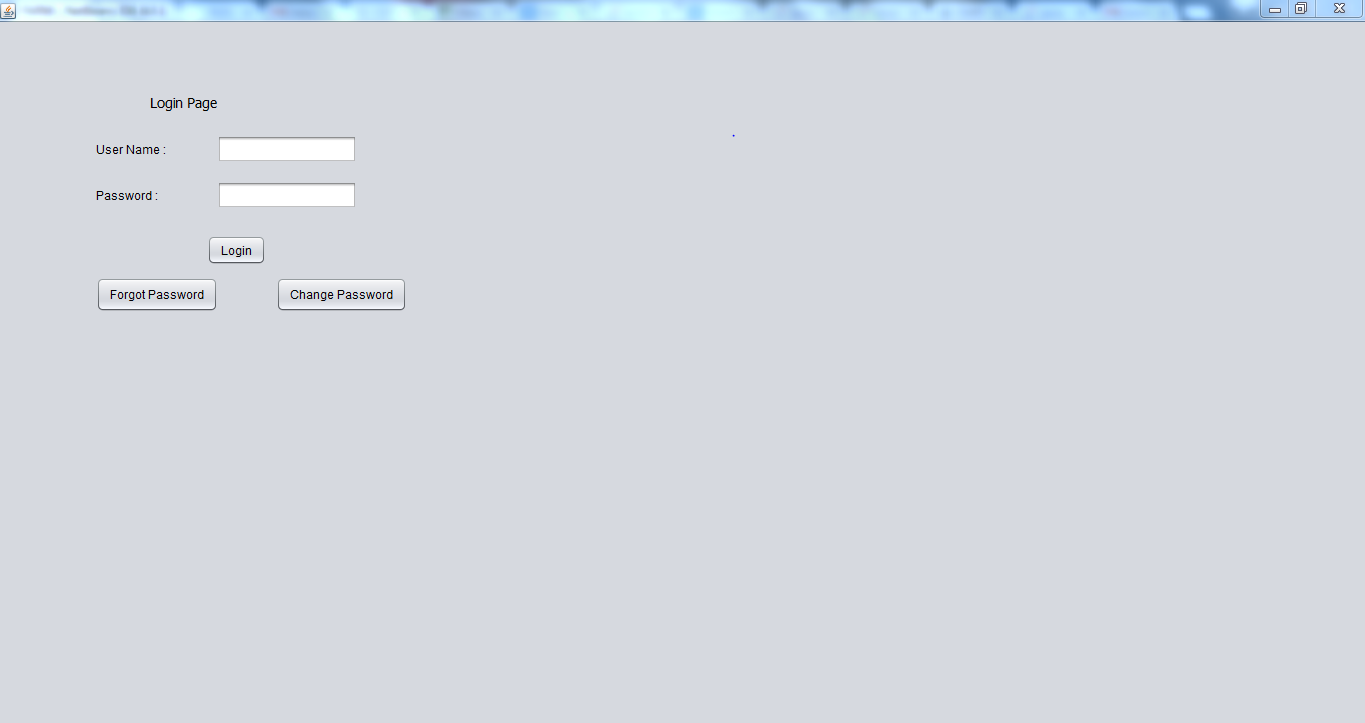
**Chapter 5**

**Prototypes**

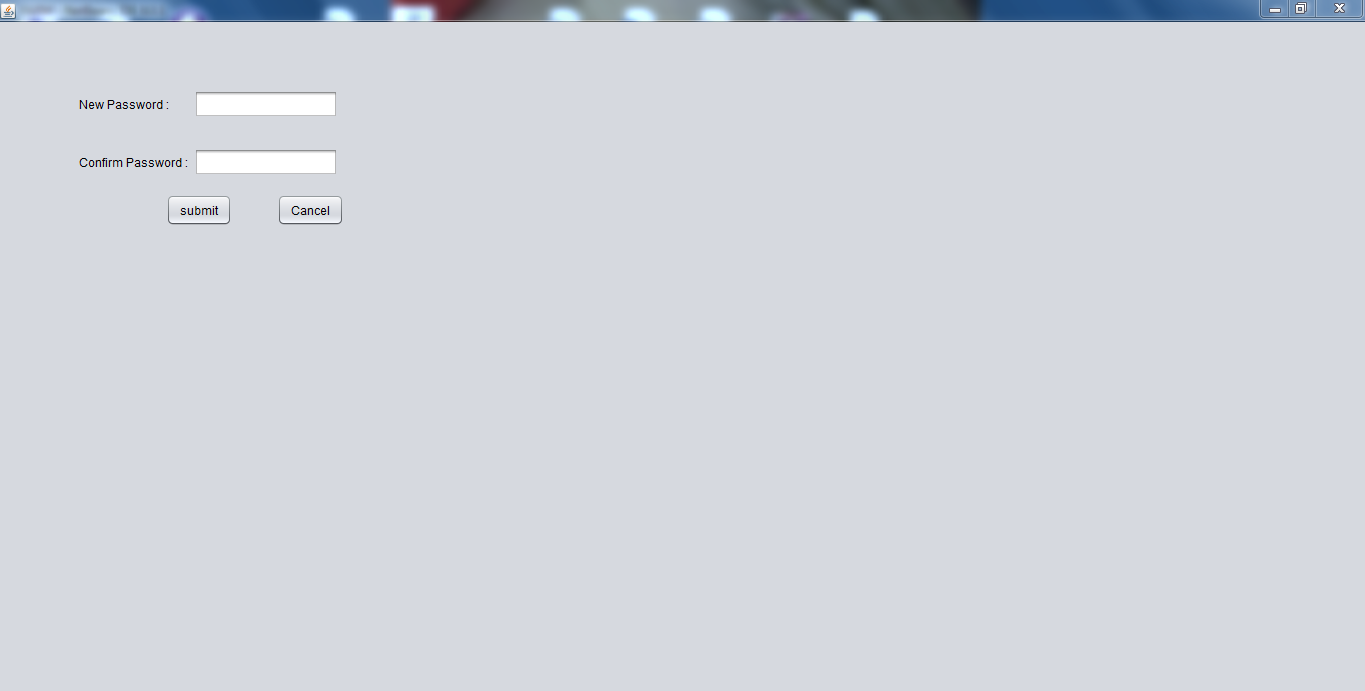
Below are the various tool drawn prototypes showing the user interface of the application

**Login Screens:**

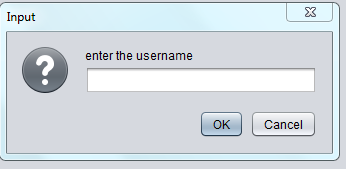
* This is an initial screen for the application where user enters his username and password for the application and clicks on ‘Log In’ button to enter into the application.
* Upon clicking ‘login’ user will be directed to screen 2.
* Upon clicking ‘forgot password’ user can change the password by entering old password and new password fields.
* User has to answer the security questions either in case of Change Password or Forgot Password.
* Security questions will be popped up in the form of dialogue screens.

****

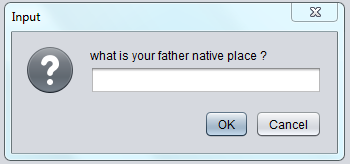
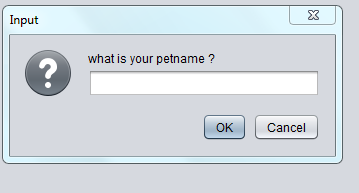
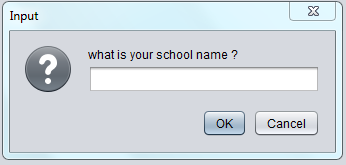
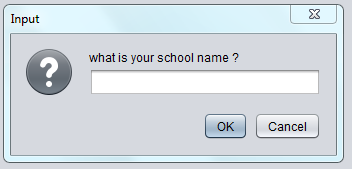
Screen 1: Login Screen

****

Screen 2: Change Password

****

**Security questions**

****

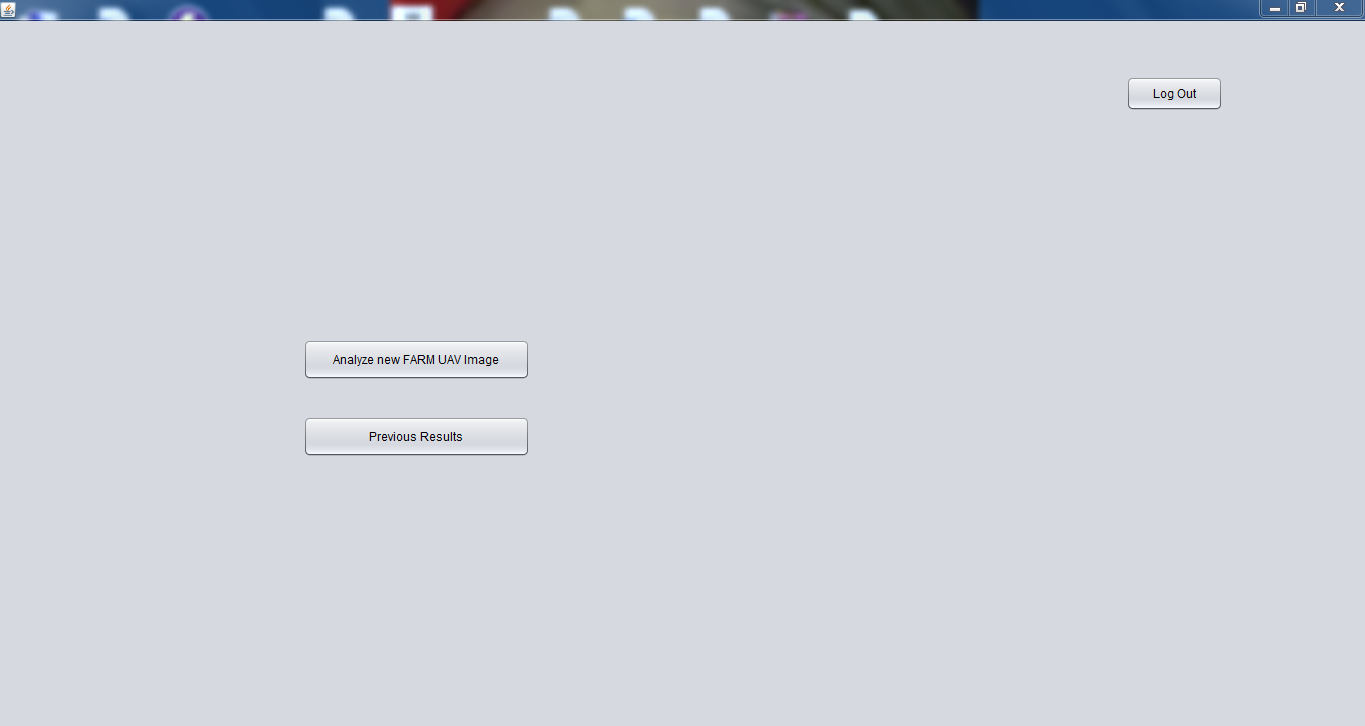
Dialogue box 1: Security questions

### Analyze and Search Image screen:

This screen involves two operations

a) Analyze FARM UAV Image

b) Previous Results

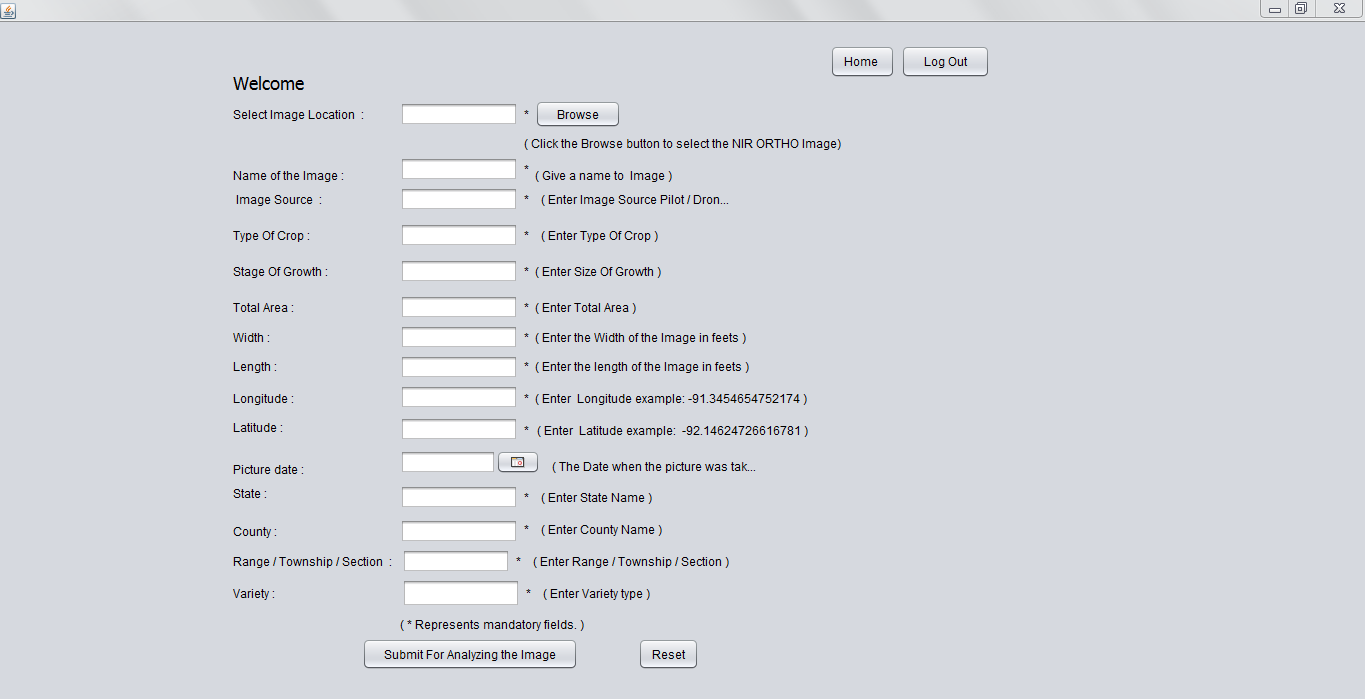


Screen 3: Analyze/search image

**a) Analyze new FARM UAV Image**

This operation is redirected to the screen where user gives the image as input by clicking on browse button and chooses the file from his desktop.

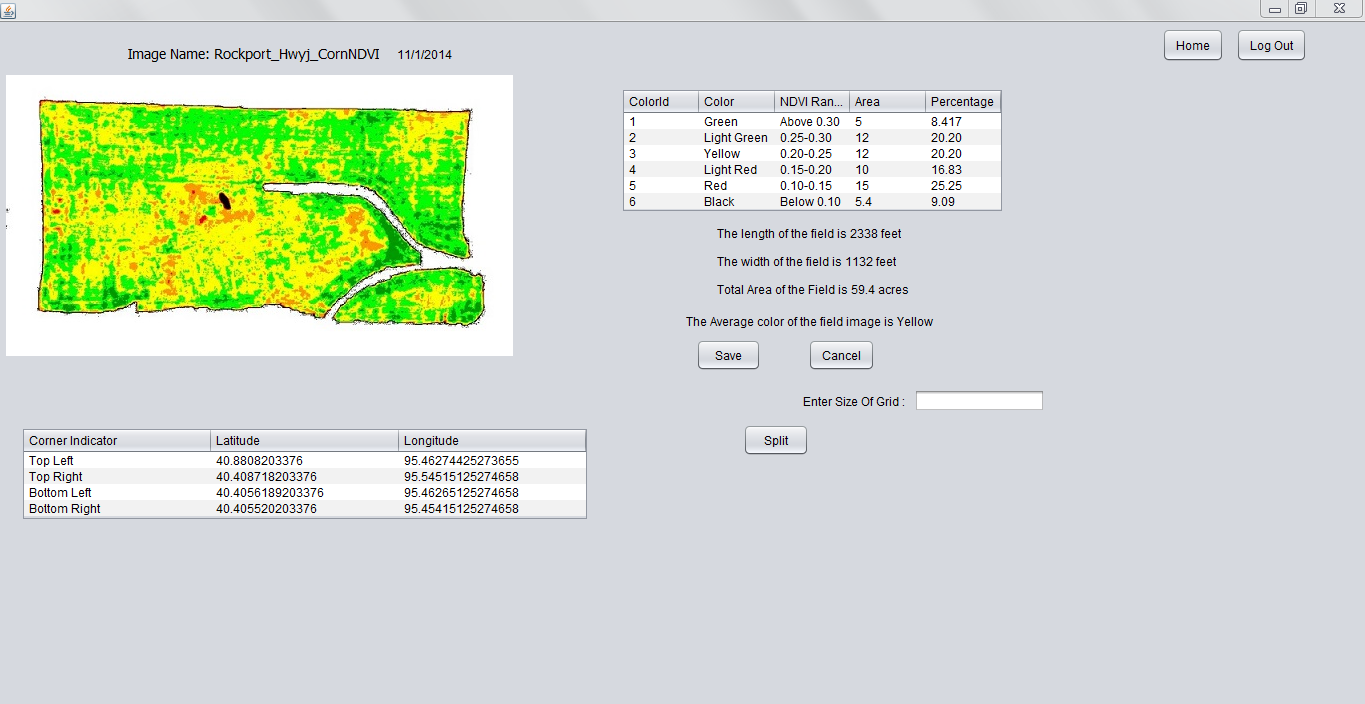
* **Name of the Image**: User can enter name of the image for future reference.
* **Select Image Location**: User has to use the ‘Browse’ button to select the image from his desktop.
* **Type Of Crop**: In this text field user has to enter the crop type for e.g.: maze, corn etc.,
* **Stage Of Growth**:
* **Total Area**: The total field area will be entered into the text field.
* **Width**: User enters the width of the field in feet.
* **Length**: The user enters the height of the field in feet.
* **Longitude**: This field has to be provided with the longitude information of any four corners of the total scanned field.
* **Latitude**: This field has to be provided with the longitude information of any four corners of the total scanned field.
* **Picture Date**: This field should include the date on which the image is taken.
* **State**: This field should have the territory information of crop. E.g.: Missouri, Alabama etc.,
* **County**: This should include the territory information.
* **Range/Township/Section**: This should include the territory information.
* **Submit for Analyzing image**: Upon clicking submit user will be directed to screen 5.



Screen 4: Input Image and Attributes

The screen 5 shows the information obtained after performing the image analysis by application.

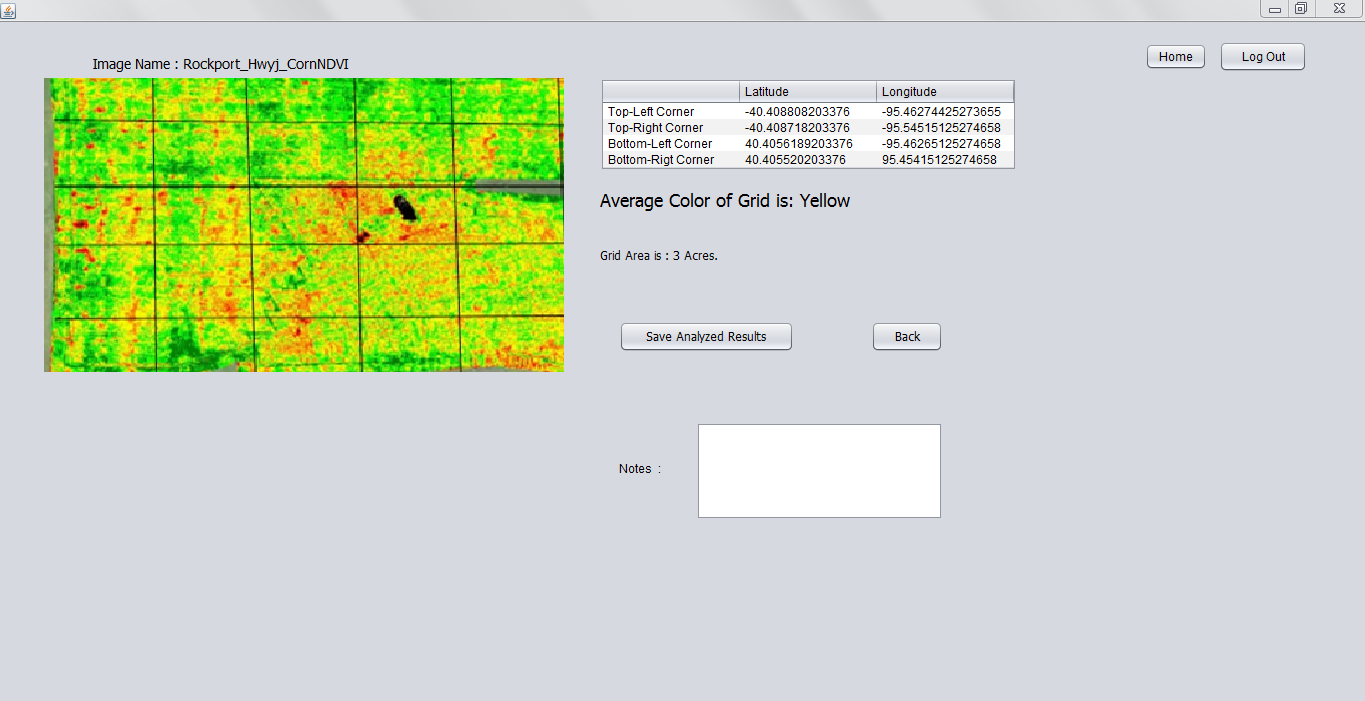
* The image is displayed at the top left and a table below that shows the latitude/longitude information of four corners of the whole field.
* Table at the right top corner has the summary of color and its respective NDVI Range, occupied area in acres, percentage of color in overall field. The information can be used to obtain the amount of a particular color in the total field.
* User will be able to save the above tabular data in a file by clicking on ‘Save’ button**.**
* If user wants to get a detailed information at any block he can click on the ‘split’ button. To perform the split operation user has to enter the size of grid in the text field after which clicking on split will direct the user to screen 6



Screen 5 Summary of Crop

Below screen shows the image divided into several grids when hovered onto a particular grid the application will be able to provide the details related to average color and positioning information.

User can take notes in the text area which can help him to note details about the crop and his/her findings.



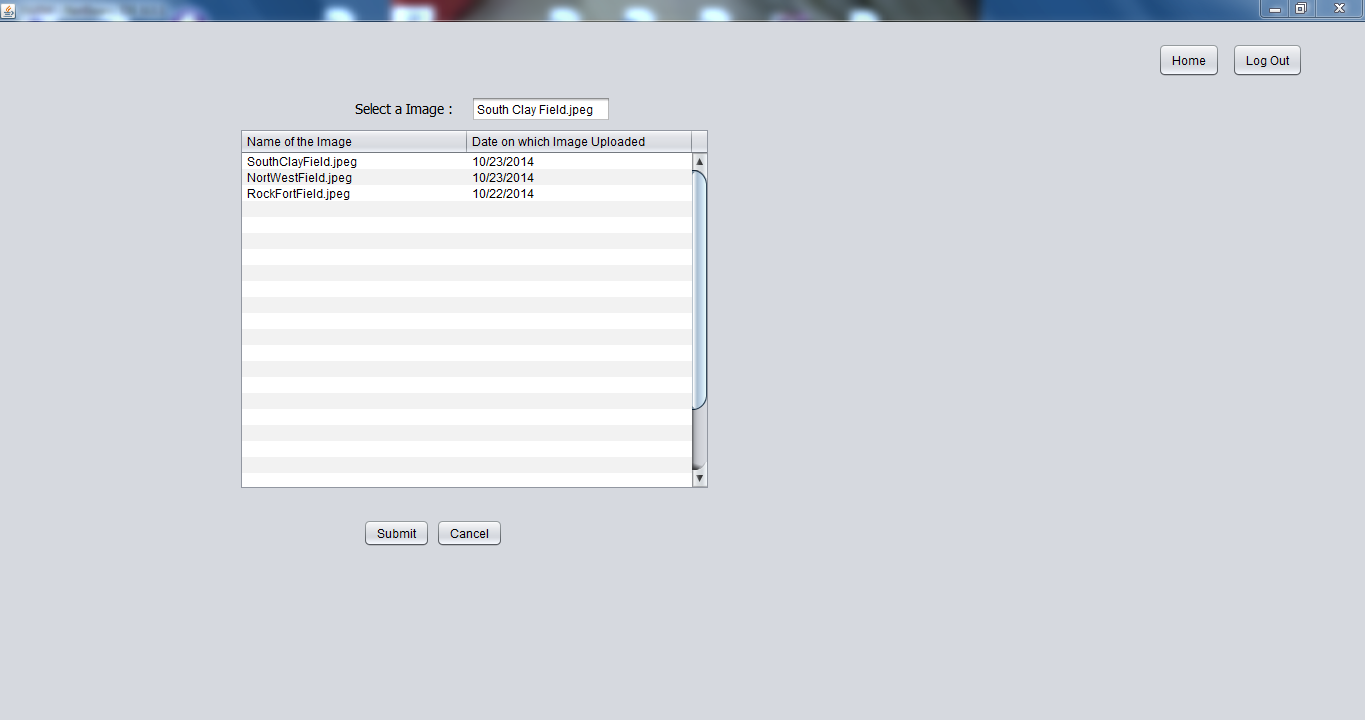
Screen 6: Grid results of the Image

**b) Previous Results Screen:**

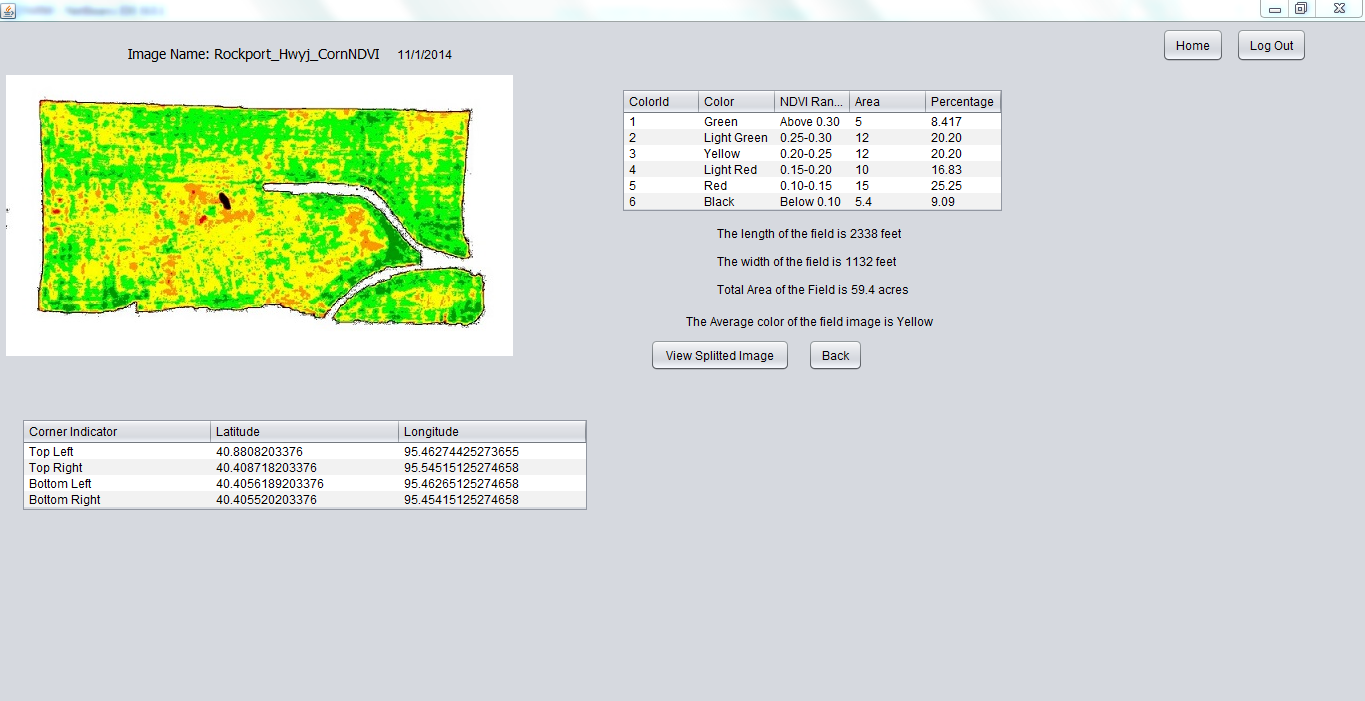
The screen7 will allow the user to browse previously analyzed images from the database. Information of the previous analyzed images will be shown in form table.

User can enter name of the analyzed image in search field and click on

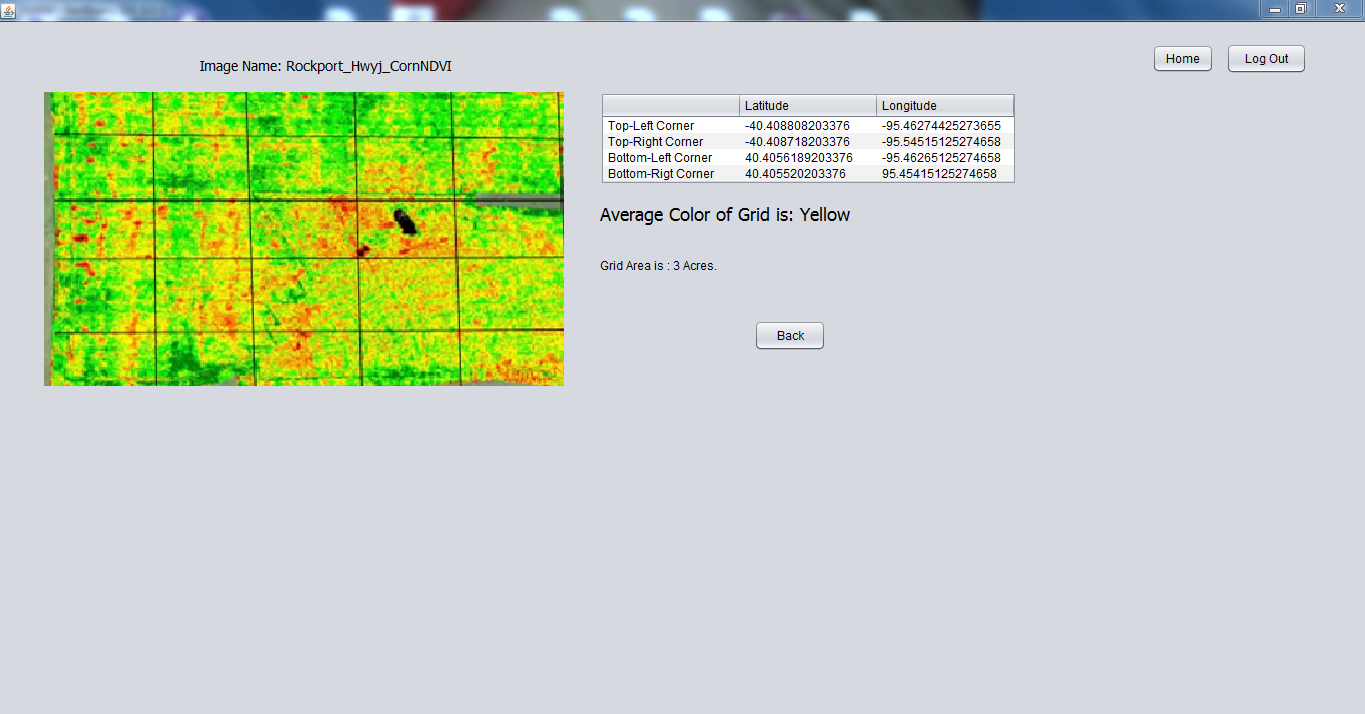
‘Submit’ button which directs to screen 8 and screen 9.



Screen 7: Previous results



Screen 8: Crop summary from database



Screen 9: Grid information from database

**Chapter 5**

**Usability Test**

**5.1 Test Plan**

|  |
| --- |
| Users: First: Praveen , Computer Science Major  Second: , Computer Science Major  Domain Knowledge: Web browsing  IT Knowledge: Basic Computer knowledge  Finding test users: Students at Northwest Missouri State University &  Farmer |
| Test site: B.D. Owens Library & Meeting Room |
| Facilitator: Harshavardhan Naidu    “Computer”: Priyanka Peddi  Log Keeper: Naveen Poreddy |
| Test Tasks: 1. Find the average color of the entire field  2. Find the average color of a grid in a field  3. View the analyzed results of RockFortField  Presenting Tasks: By welcoming the test users and giving brief  explanation about the tasks  Start-up state: Home Screen  User Instruction: Oral Presentation |

|  |
| --- |
| Test Method: Observing and think aloud test, one user at a  Time  Data Collection: Written notes |
| Debriefing: Explained below |
| Planning the time:  User1: Welcome and intro: 5 mins  Test tasks: 12 mins  Debriefing: 2 mins  Reporting the problems: 60 mins  Total: 79 mins    User2: Welcome and intro: 5 mins  Test tasks: 23 mins  Debriefing: 2 mins  Reporting the problems: 60 mins  Total: 90 mins |
|  |
|  |

**5.2 Test Logs**

**5.2.1 Welcome and introduction**

Hello, we are team of 10 people from Applied Computer Science department. We are going to develop a desktop application that emphasizes on creating an interface for analyzing the field image which helps the farmer’s to determine the amount of fertilizer the crop needs. We have created a prototype to test the usability features of an application. So, we want you to perform the usability test on the application.

There are four tasks to be performed on the prototype. You need to think it as a screen on the computer and click the thing you want to look into and enter the data on the screen via data on a sheet of paper. The most important of all, we want you to think aloud. That is, you need to speak out loud, while performing the usability test.

**5.2.2 Tasks**

* **Task 1:** Find the average color of the entire field.
* **Task 2:** Find the average color of a grid in a field.
* **Task 3:** View the analyzed results of RockFortField image on 10/22/2014.
* **Task 4:** Change the password.

**5.2.3 Debriefing**

|  |  |  |
| --- | --- | --- |
| Question | Test User 1 Response | Test User 2 Response |
| Do you think this application is interactive | Yes | Yes |
| Is the navigation system in this website proper or not | Yes | Yes |
| Any Suggestions | Need to have a drop down list for the type of crop.  Highlight the average color of field when compared to other.  Buttons for splitting the image should be placed under the image. | Need to have a label for variety of crop.  Need to have percent of area in green, black, etc.  Source of image (pilot/drone).  Didn’t find address field in new image analyze screen. |

**5.3 Test Report**

**5.3.1 Objective Measures**

**5.3.1.1. Task Time Results**

|  |  |  |
| --- | --- | --- |
| Task | User 1 | User 2 |
| Task 1 | 3:50 s | 10:50 s |
| Task 2 | 4:28 s | 7:40 s |
| Task 3 | 1:48 s | 2:30 s |
| Task 4 | 1:15 s | 1:30 s |

**5.3.2 Subjective Measures**

**5.3.2.1. Opinion poll – Questionnaire**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| QUESTIONS | Praveen | | | Xyz | | |
| Agree | Neutral | Disagree | Agree | Neutral | Disagree |
| The Application is interactive | **AQiAC** |  |  | **AQiAC** |  |  |
| Navigation is proper |  | **AQiAC** |  |  | **AQiAC** |  |
| Website maintains consistency | **AQiAC** |  |  |  | **AQiAC** |  |

**5.3.2.2. Score for understanding**

|  |  |  |
| --- | --- | --- |
| Questions | Scale A-D | |
| Praveen | xyz |
| Please fill the required fields | **A** | **A** |
| Mismatch of password and confirm password | **B** | **B** |
| Feedback messages | **A** | **A** |

**Chapter 6**

**Future Enhancements:**

This application is robust and allows to make changes related to the user interface and the format in which the output is requested. For example, the user can have an output as shown in the above screen or document in a tabular form with each grid information.