

# AN ADAPTIVE USER INTERFACE FOR SATELLITE IMAGERY AND DATA CLASSIFICATION

By

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A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE  
In  
COMPUTER ENGINEERING

UNIVERSITY OF PUERTO RICO  
MAYAGÜEZ CAMPUS  
2009

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## **ABSTRACT**

This work presents the development of a new web application called Terrexplorer. Terrexplorer is a web application that handles different types of information as satellite images, boundaries, metadata and related data, and displays them according to the users needs. An adaptive user interface is used to display all this information, to accommodate the diversity of users, and to provide more usable interactions. A usability evaluation was conducted to identify usability deficiencies and to determine the user satisfaction. The usability evaluation identified some minor deficiencies. However, the users were able to complete all the task of the usability test and were satisfied with the application.

## RESUMEN

Este trabajo presenta el desarrollo de una nueva aplicación por web llamado Terrexplorer. Terrexplorer es una aplicación web que maneja diferentes tipos de información como imágenes de satélite, contornos, meta data e información relacionada y la despliega de acuerdo a las necesidades de los usuarios. Una interfase adaptiva es usada para desplegar toda esta información, para acomodar la diversidad de usuarios y proveer más interacciones utilizables. Una evaluación de usabilidad fue llevada a cabo para identificar las deficiencias de usabilidad y para determinar la satisfacción del usuario. La evaluación de usabilidad identificó mínimas deficiencias. No obstante, los usuarios fueron capaces de completar todas las tareas de la prueba de usabilidad y se mostraron satisfechos con la aplicación.

To my family . . .

## ACKNOWLEDGEMENTS

I would like to thank my chairman and advisor Dr. José Borges for his guidance and patience in the development of Terrexplorer. I also would like to thank my graduate committee formed by Dr. Néstor Rodríguez and Dr. Domingo Rodríguez for their advice, help and contribution in my work. I would like to thank Prof. Linda Vélez and Prof. Ismael Pagán Trinidad for their help and technical advice on GIS applications.

I would also like to thanks Omar Valenzuela who has been working with me integrating Terrexplorer with the Walsaip Boundary Tool and my fellow students Juddy Gómez, Verónica L. Acaba, Mariana Mendoza, John Sanabria, David Ortiz, Ricardo Veguilla, and Angel Villalain that have given me tips and suggestions on improving my work.

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## **List of Terms & Abbreviations**

PHP = A scripting language developed to provide dynamic web pages

URL = Universal Resource Locator

AJAX = Asynchronous Javascript and Xml

HTML = Hyper Text Markup Language

WALSAIP= Wide Area Large Scale Automated Information Processing

USGS= United States Geological Survey

GIS = Geographic Information System

NAD83 = North American Datum 1983

# 1 INTRODUCTION

With the availability of satellite images and geographical information on the internet, researchers have found an enormous wealth of data. These satellite images and geographic information are used by civil engineers, geologists, city planners, researchers, and businesses to make decisions and create plans. In order for this wealth of data to be effective, it must be easily accessible and the information presented to the users must be reliable and extensive. Currently, to access and find these data in the internet is a challenge due to the different sources available. The researcher would have to access several databases and web sites to obtain the information necessary, obligating the user to use a different user interface and match the information obtained to make an informed decision.

There are several GIS web applications as Google Maps, Yahoo Maps, Microsoft Virtual Earth, Geo Mac, among others, that provide such type of information. Each application may be dedicated to different types of data as roads, places, and geological data [1]. However, as more geographic data is displayed in the user interface, more complicated, complex and difficult to use is the GIS application [10]. In addition, it requires time and training for the user to use a complex interface [4, 8]. There have been different studies trying to simplify GIS user interfaces by including user customization and active customization [10]. User customization is limited by the application options and in the majority of the cases does not cover individual needs. Active customization helps to display a user interface that changes

depending on the data but it gets complicated when different types of data are displayed at the same time.

An adaptive user interface in a web application would help eliminate the information overload, reduce the time required to search and display the geographical information, and help the user concentrate on the actual research instead of the user interface. An adaptive user interface relies on a user profile which makes assumptions about the user needs [3]. The user interface will be able to anticipate the users' requirements and display the information in which the user is interested to avoid information overload [4].

The main objective of this research is to develop a web application that can work with different types of information as satellite images, boundaries, metadata, and related data. This application will be called Terrexplorer, meaning earth explorer. It should display the information or data according to the users' requirements and should have the ability to search different databases and web sites using one user interface. This will reduce the time of searching in different websites and helps the user concentrate on their work by using one interface to search multiple databases.

The research and development of Terrexplorer has been conducted as part of the WALSAIP project. This is a project focused on water-related ecological and environmental applications. WALSAIP is being funded and supported by the National Science Foundation, the National Oceanic and Atmospheric Administration, the University of Puerto Rico at Mayagüez, and

the Department of Natural Resources of Puerto Rico. As part of this initiative, another important objective of this work is to be able to integrate Terrexplorer with other developments and projects in WALSAIP. At the present, Terrexplorer will be integrated with the WALSAIP Boundary Tool. This tool is being developed by Omar Valenzuela and its main function is to use images and maps to create, edit, and view boundaries. Terrexplorer will share the information from the local database with the WALSAIP Boundary tool. Both of these applications will be multi-platform, meaning that they will run in different environments. They require a web browser such as Firefox, Opera, or Safari.

In an application with the capabilities to anticipate the user's needs and display relevant information to the user, the usability of the user interface is critical. Thus, usability principles, guidelines, and evaluations will be applied throughout the lifecycle of the project. In addition, a usability test with participants performing different tasks with Terrexplorer will be conducted. The usability test will help evaluate the user's satisfaction with the system and uncover any usability deficiencies in Terrexplorer.

The second chapter of this thesis presents the literature review of related research. It also describes other applications or systems with aspects similar to Terrexplorer. Chapter 3 exposes the implementation of Terrexplorer from its file structure, system architecture, database design, metadata format, and coordinate system. Chapter 4 presents an overview of the user interface of Terrexplorer and its functionality. The usability test conducted with

Terrexplorer and the results are described in Chapter 5. Finally, Chapter 6 contains the conclusions of this research and recommendations for future work.

## **2 LITERATURE REVIEW**

### **2.1 Introduction**

Terrexplorer is a web application that allows the users to use a single user interface to search data from different databases. The adaptive user interface in Terrexplorer displays the data depending on the user profile and importance. It organizes the data and displays it in order, from most important to least important. There are several web applications that have some of the features of Terrexplorer and the WALSAIP Boundary tool, like the capability to manage geographical information and geographical images; but none integrate the information in one interface. The following section will describe several of these existing web applications and their use.

### **2.2 Web Applications**

In the last several years some Web applications with GIS capabilities have surfaced on the internet. Some of these web applications are mostly used for finding locations. The best known applications of this type are: Google Map ([maps.google.com](http://maps.google.com)), Microsoft Virtual Earth ([www.microsoft.com/virtualearth/](http://www.microsoft.com/virtualearth/)), Mapquest ([www.mapquest.com/](http://www.mapquest.com/)) and Yahoo Maps ([maps.yahoo.com/](http://maps.yahoo.com/)) [1]. There other web applications that contain geographical, political, and ecological information. Examples of these are the National Geographic Map Machine ([plasma.nationalgeographic.com/mapmachine/](http://plasma.nationalgeographic.com/mapmachine/)), GIS Data Studio ([gisdata.usgs.gov](http://gisdata.usgs.gov)), and National Atlas of the USA ([www.nationalatlas.gov](http://www.nationalatlas.gov)) [1]. Each one of these web applications

manages different types of information as roads, businesses, entertainment centers, geological factors, and other features. It is a challenge to display all this information at once and for the user to be able to interpret it clearly. Some works have applied human factors techniques to make it easier for the researcher to use these GIS applications. An example of this is a prototype called Luigi developed by Ramesh Jain from the University of California and T. Todd Elvins from San Diego Supercomputer Center [11]. This prototype use objects to represent real world concepts.

## **2.3 User Interfaces**

There have been several different approaches to the problem of displaying different types of data in the user interface. A work realized by John Grundy and John Hosking of the University of Auckland [7] consisted of creating a component-based system using the JViews framework. This framework allows the creation of user interface components in java that are reconfigurable and reusable. Each component has an identification of the area that will be modified depending on the data type providing the ability to modify menu bars, buttons and forms [7]. The JViews framework allows users to change the user interface options depending on the data type. The objective of this approach was to provide a simpler interface that only displays the necessary options. The problem with this approach is that the interface constantly changes the location of the buttons and fields. This affects the usability

of the system and the users may need to search the display to locate the data and controls. This would require more effort from the users to use the application.

The work developed by a group at the University of California [11] takes another approach to the problem of displaying different types of data in the user interface. Their approach was to apply a real world concept model in the user interface of a GIS application. This resulted in the implementation of an application called “Luigi” that relies on the direct manipulation of layers that represent the mapping data and satellite images. As the different types of mapping data are displayed, more options are available on the user interface. This represents a high learning curve to the user and requires the user to concentrate more on the interface than on the task at work.

## **2.4 Adaptive User Interface**

The model employed for displaying the information on the interface of Terrexplorer was the use of an adaptive user interface. In the context of this work, an adaptive user interface means an interface that can order and display information based on certain rules. Terrexplorer changes the order of relevance of some of the information displayed and of the initial search window to be displayed. The buttons and form fields are always displayed in the same area, giving the user a consistent interface.

Adaptive user interfaces have been used in different types of applications to present the user with an interface that is easy and efficient to use. For example, one application used an adaptive user interface to implement an e-Learning System. The study is described in a paper by Andrina Granic and Jelena Nakic of the University of Split in Croatia titled “Meeting User Individual Characteristics through Adaptive Interface of an e-Learning System: An Empirical Study Design” [3]. This study concentrates on testing a diversity of users from different backgrounds and knowledge and on how to proceed and measure the results. The preliminary results were favorable and indicated that the e-learning system helped the students to learn basic programming concepts by using an adaptive user interface.

The research paper from Adrina Granic and Vlado Glavinic titled “Functionality Specification for Adaptive User Interfaces” [4] presents the specification required for an Intelligent Tutoring System and describes an application developed, called Tex-Sys (Tutor-Expert System). The Tex-Sys application changes its menu depending on the action of the user and proposes the use of an adaptable menu to cover different needs.

The research paper from Jon Davis, Andrew Tierney and Elizabeth Chang titled “A User Adaptable User Interface model to support Ubiquitous User Access to EIS Style Applications” [6] describes a system that decouples the user interface from the application main logic layer. This decoupling presents the advantage of being able to create and adapt several user interfaces to several devices and users. This was created by using a web based services and xml (extensive markup language) based user interface to adapt to the different

kind of users and devices. In Terrexplorer the interface adapts itself using the adaptive algorithm to determine the data that is most valuable to the user. This enables the user to concentrate on the information that the user needs and avoids unnecessary interactions.

The work presented by Jimin Liu [5] from the Hong Kong Baptist University, implements an adaptive user interface based on episodes identification and association. The user interface was implemented based on the following approach:

1. Build a user profile that will help determine a personalized interaction.
2. Observe and record the user interactions.
3. Recognize the user interaction patterns.
4. Adaptively help user based on their recognized patterns.

Terrexplorer follows several of these approaches by building a user profile that will determine a personalized interaction. The algorithm implemented in Terrexplorer recognizes the user interaction patterns and creates a user profile. Based on this profile, Terrexplorer determines the order of the information to be displayed and the default type of search mechanism.

## **2.5 Web Search Engine**

An important feature of Terrexplorer is the ability to search multiple databases using one interface. There are other web applications in the internet with the capability to search for

any type of data, such as: Yahoo, Google, and Altavista [15]. The difference between each search engine is how they process the data retrieved from the website. Each search engine considers the metadata, links related to that metadata, the time it's been online, and other characteristics with a combination of data mining techniques and filters to display the most accurate results possible. This allows the results from each search engine to have different rankings for the searched information. A study by Amanda Spink, Bernard J. Jansend, Chris Blakely, and Sherry Koshman [14] compared three different search engines results from Google, Yahoo, and Ask Jeeves. The purpose was to find how much overlap there was between the results of each search engine. The results found an overlap between all three search engines of 50,671 (11.9%). This means that Google, Yahoo, and Ask Jeeves have unique search results and that several search are required to obtain information not contained in the other search engine databases.

In comparison, Terrexplorer connects to a local database and the USGS Database to retrieve the results. This allows the user to search multiple databases without having to search each one of them individually. Due to the nature of the data that can be searched in the internet, the results can vary and will not always return the information desired by the user. Terrexplorer provides the advantage of searching for a specific type of data as geographical images and boundaries. This provides the user the benefit of a more accurate search results for these two types of data.

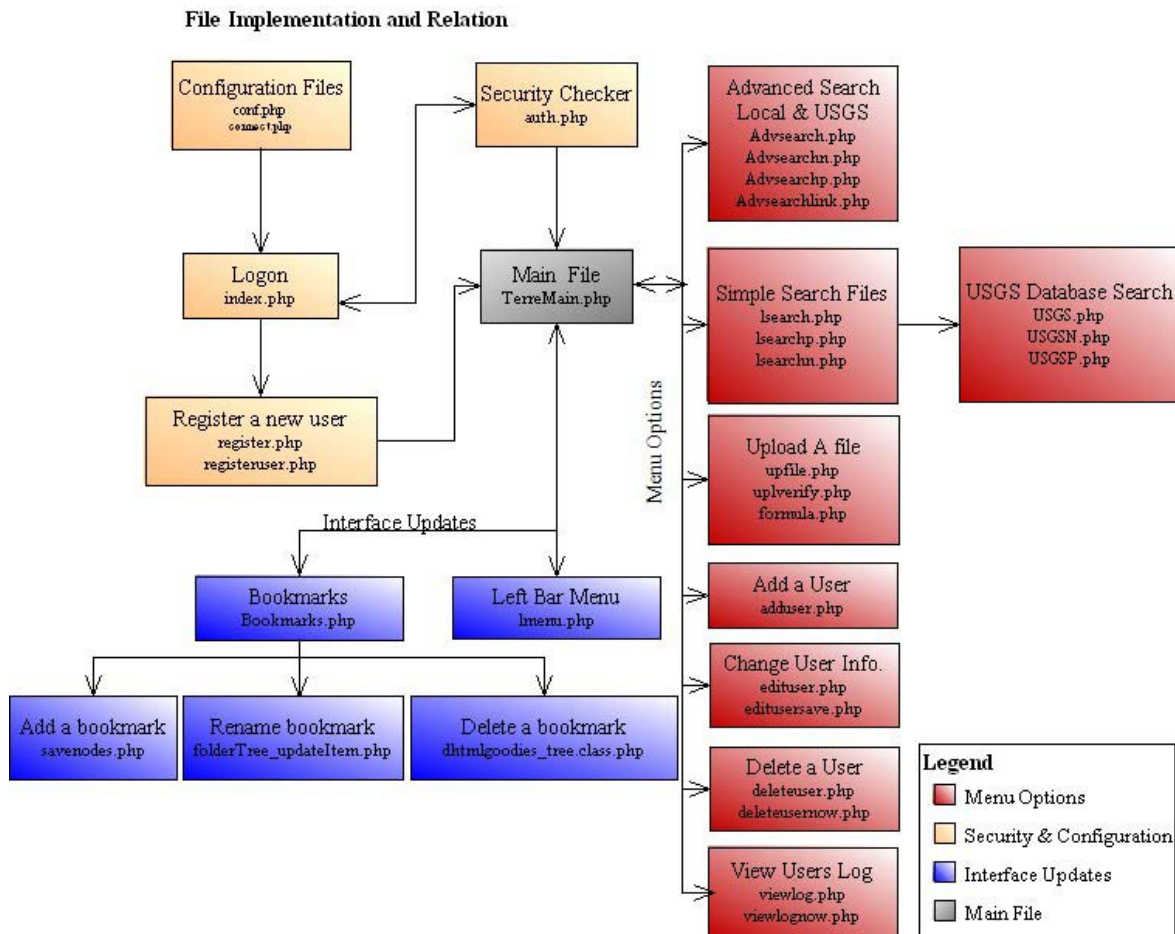
Some web search engines, like the Monduo search engine developed in the University of Kyoto by Hiroyuki Kawano [15], use data mining, association rules, and keywords to find the information in the Internet. In comparison, Terrexplorer uses the metadata available to search for the information with the difference that it does not use association rules to determine the value of the information presented. This allows the search engine to get more search results and simplifies the search implementation. The next chapter will describe the implementation of Terrexplorer.

## 3 Implementation

Terrexplorer was developed using a combination of technologies such as Html, Ajax, and Php [2]. Each language has its uses in the implementation. Html is used to present the user interfaces to the browser; Ajax is used to update the data and the interface in real time; and Php is used to connect to the Mysql database and to search thru several databases. Terrexplorer generates a lot of database transactions to identify the user profile and to search the database for images and boundaries. This requires a dedicated server with a large disk space and x86 CPU. Terrexplorer requires the following: Apache Server 2.0, Php version 5, and Mysql server 5.0. The implementation of Terrexplorer will be described in the following sections.

### 3.1 File Structure

Figure 3.1 presents the file structure of Terrexplorer. This structure does not include the Javascript files and image files, it only includes the relation between each Php file and the order in which they are executed when a users logs into the system. The files are divided and represented in four group or areas: the security and configuration file, the interface updates files, the menu options file, and the main file.



### 3.1.1 Security and Configuration Files

The configuration files, shown in Table 3.1, contain the settings for Terrexplorer and the local database. The *conf.php* file contains the settings of Terrexplorer as the location of the application, the location of the WALSAIP boundary application, and the option to allow registration of new users. The *connect.php* file contains the location of the local database and the database account to add, edit and delete data.

**Table 3.1 Configuration Files Description**

<b>Files</b>	<b>Description</b>
<i>conf.php</i>	Contains the settings for Terrexplorer
<i>connect.php</i>	Contains the settings of the local database

The security files are the files that implement the security in Terrexplorer as shown in Table 3.2. They contain the security algorithm to identify and assign different user access. The *index.php* file contains the specification of the Log On screen which is the first file that is shown to the users when they enter the system. Users will have to enter their name and password to access the system or they must register as a new user by submitting the user registration form (*register.php*).

**Table 3.2 Security Files Description**

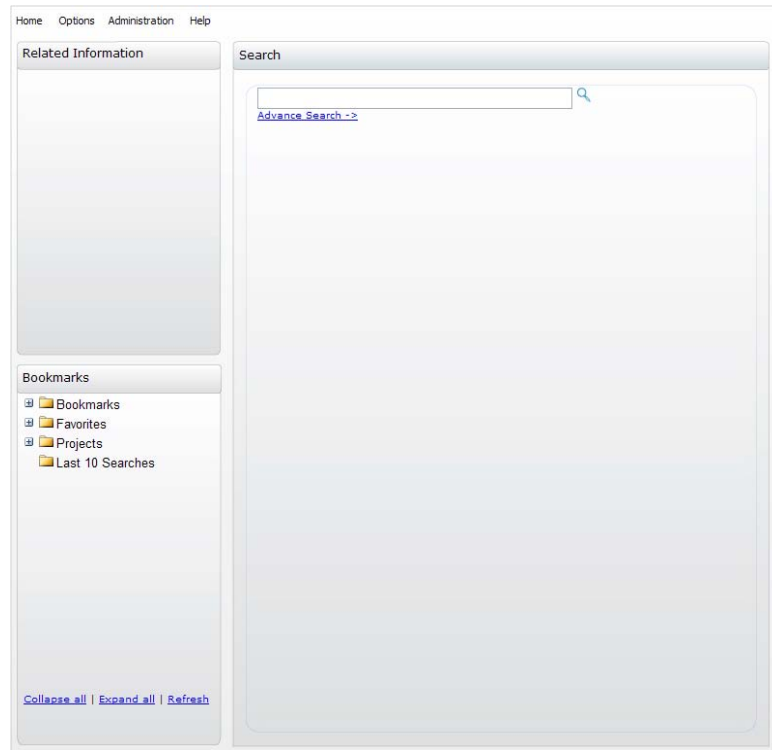
<b>Files</b>	<b>Description</b>
<i>index.php</i>	Displays the Log On screen for the user
<i>register.php</i>	Displays the register form and checks the information entered.
<i>registeruser.php</i>	Registers the new user in the system
<i>auth.php</i>	Checks if the user has authorization and his access level

Once users enter their login information, then the *auth.php* file is in charge of checking if the users have access to the system and the type of access. Currently, there are three types of

access or users: regular user, uploader, and administrator. The regular user can search different databases, view satellite images and boundaries, make bookmarks, create boundaries, and change their personal settings. The uploader can realize all operations of a regular user and in addition they can upload files. The administrator can realize all the operation of the uploader and is also allowed to add, edit and remove users, and to access or view the user's logs. After the user passes the security checks, the system opens the *terremain.php* file that is the main file of the web application.

### 3.1.2 Main File

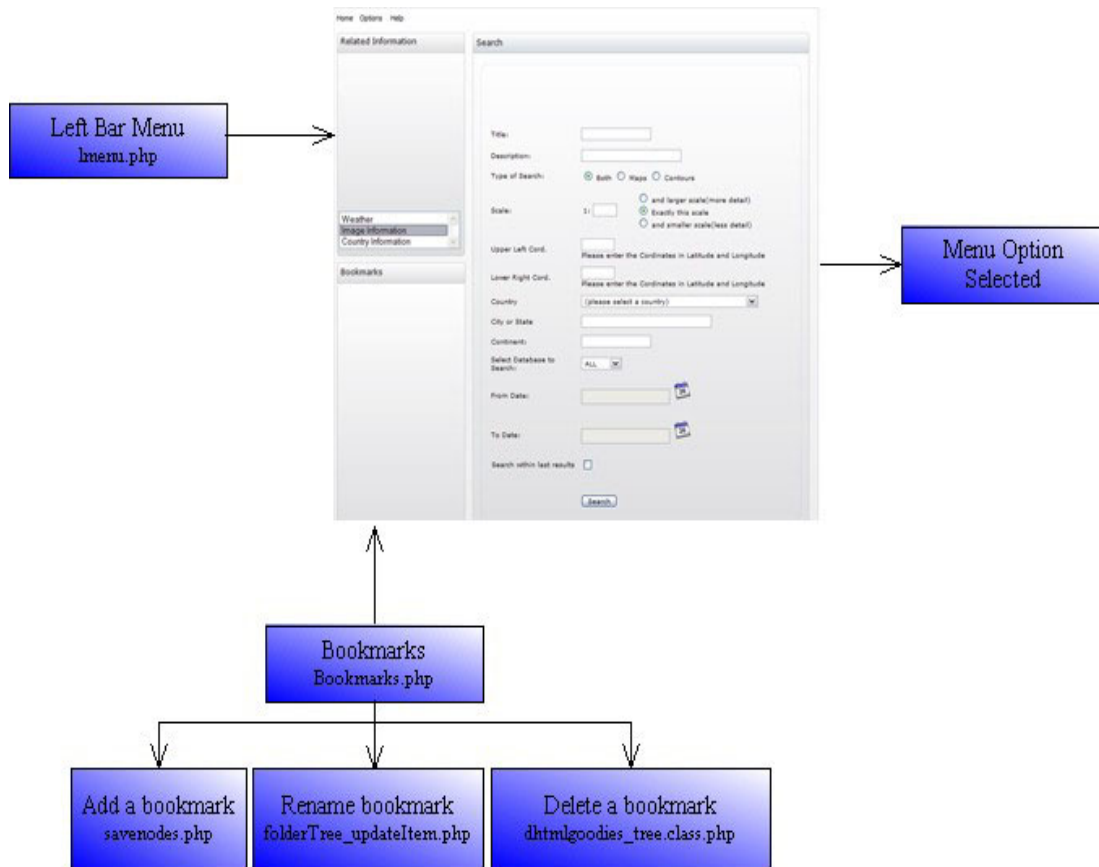
The main file, called *terremenu.php*, contains the template of the application, the user profiling algorithms, and the adaptive user interface code. As shown in Figure 3.2, the template of Terrexplorer is divided into four sections. These are the Menu Bar, the Related Information panel, the Bookmarks Panel, and the Search Panel. All these section or panels are updated on real time with Ajax by calling different files. When the user first logs into the system and reaches the main file, the system will display different menu options depending on the user's type (see section 4.4 for menu options).



**Figure 3.2 Terrexplorer Template**

### 3.1.3 Interface Updates Files

The interface of Terrexplorer is built mainly by using Ajax to update the different panels of the screen. Figure 3.3 presents a diagram representing the relations between the files and the interface. Depending on the user's action, the interface updates itself by calling the corresponding files shown in the rectangles.



**Figure 3.3 Terrexplorer Interface File**

Table 3.3 shows a description of the files called by Terrexplorer that update the user interface.

These files are called to display the different forms in the user interface.

**Table 3.3 Description of Areas the Interface Files**

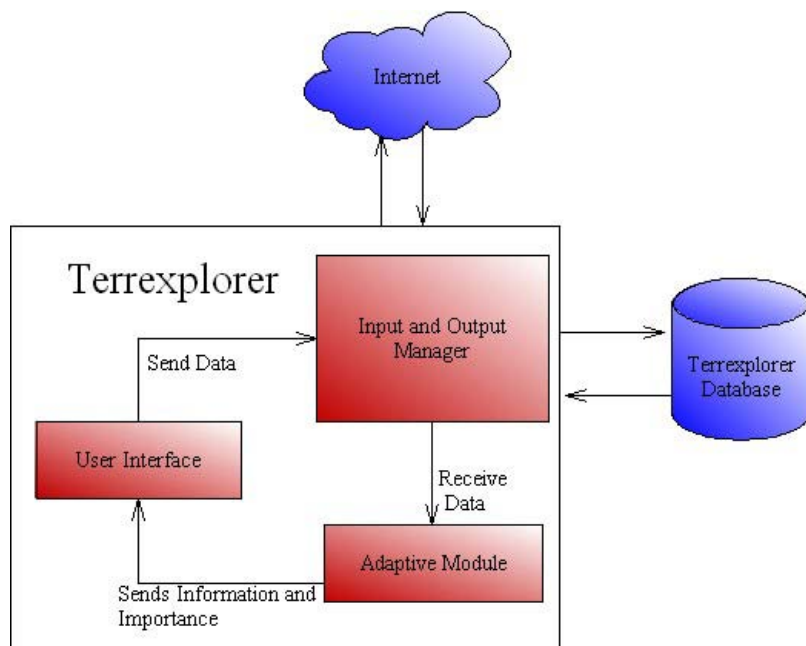
<b>Area</b>	<b>Files</b>	<b>Description</b>
Related Information	<i>lmenu.php</i>	Display the related information of a satellite image as the image information, country information and temperatures
Bookmark	<i>bookmarks.php</i>	Display the bookmarks and give the user the ability to change, delete and move bookmarks.
Menu Options	<i>advsearch.php</i>	Display the advance search form
	<i>lsearch.php</i>	Display the simple search form
	<i>uplfile.php</i>	Displays the upload form
	<i>adduser.php</i>	Add a user to Terrexplorer
	<i>edituser.php</i>	Edit a user to Terrexplorer
	<i>deleteuser.php</i>	Delete a user to Terrexplorer
	<i>viewlog.php</i>	View the users log

The Related Information panel in the main template is activated when a user selects an image. It displays information related to the image selected such as weather, country information, and image information. The Bookmark panel displays a folder structure and updates itself every time there is a change in the bookmarks. The Menu Bar is used to display several options to the users. The options included for the Menu Bar are: advance search, simple search, and change settings. The Menu Bar options will be discussed in more detail in Chapter 4.

## 3.2 System Architecture

Terrexplorer was designed by taking into consideration the huge quantity of data available from different sources and databases. To display and process the data there must be an infrastructure to support different types of data as images, boundaries, metadata, and web information.

Figure 3.5 shows the architecture of Terrexplorer which consists of three subsystems or modules: the Input and Output Manager (I/O Manager), the User Interface (UI), and the Adaptive Module (AM).



**Figure 3.4 Terrexplorer Architecture**

The I/O Manager is in charge of connecting the databases, web services, and websites that are found in the internet and intranet. It receives the request for data by the actions of the user in the interface. In addition, it manages the connection to the local database and the National Geologic Map database (U.S.G.S) in order to conduct a search for satellite images and boundaries.

The interaction between the Adaptive Module and the I/O Manager depends on the type of data received and sent from the I/O Manager. The Adaptive Module contains the algorithm that determines the position and the value of the data it receives from I/O Manager. The User Interface module displays and organizes all the data depending on what is sent from the Adaptive Module.

### 3.2.1 Adaptive Module

The Adaptive Module in Terrexplorer is used to identify what type of information has more value to the user. The Adaptive Module changes the value of the information depending on the user's history and this value changes while the user is using Terrexplorer. The adaptive module algorithm used does not depend on the user providing a selection preference. Classic adaptive algorithms modify their value to adjust to the user predefined preferences. The adaptive module uses a classification table instead of the user predefined preferences. This

minimizes the user's interaction necessary to be able to use Terrexplorer. Table 3.4 shows an example of a user profile that contains a list of the actions realized by a user and the number of times that each action was done.

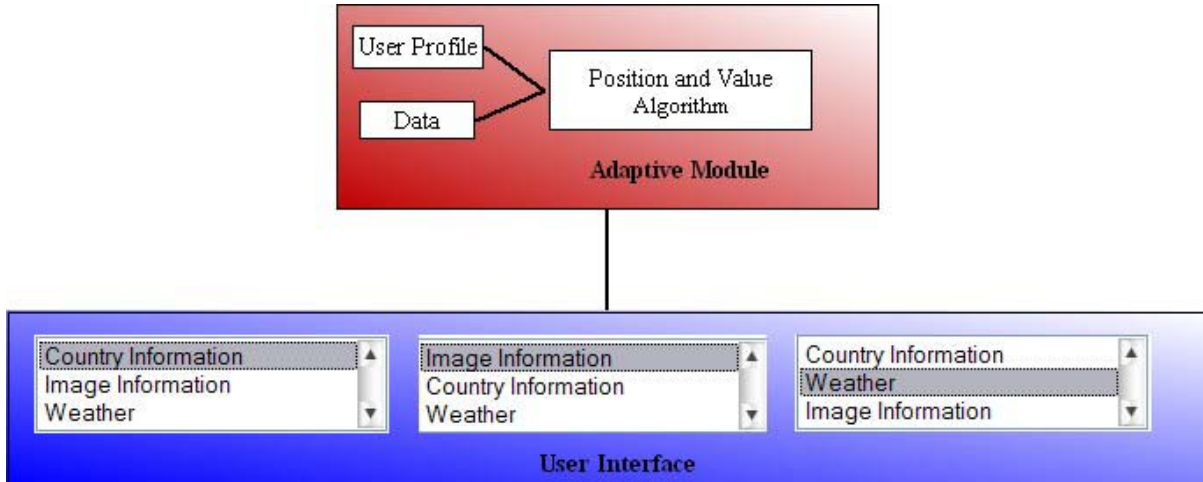
**Table 3.4 User Profile**

<b>Action</b>	<b>Quantity</b>
Selected Weather	8
Selected Country Information	10
Selected Image Information	20
Simple Search	7
Advanced Search	15

The user profile is used to identify the user's preference for certain types of data and actions. Primarily, the Adaptive Module algorithm is applied in the following events: when the user logs into the system, and when the user selects a satellite image to be displayed.

When the user logs into the system, the Adaptive Module decides which type of search has more value to the user. Based on the frequency and type of previous actions, it determines which search page will be displayed initially: the simple search page or the advanced search page. The other events in which the Adaptive Module selects the information to be displayed, is when a user selects a satellite image from the local database. In this case, the Adaptive Module determines which information related to the image selected will be displayed and organizes or sorts the list of related information options displayed in the user interface.

Figure 3.5 shows an example of the information being represented in different positions based on the profile of the users.



**Figure 3.5 Adaptive Module and the User Interface**

The Adaptive Module constructs the User Profile (Table 3.4) and receives the event type from the I/O Manager. The information of the user profile and event type is sent to the position and value algorithm. The computed value from the position and value algorithm rates the importance of certain type of data for the user. Higher numbers means more importance.

The steps taken by position and value algorithm are:

1. Receive the User Profile and Data (Event type)
2. Multiply the frequency of the users actions by the value of the classification table (Table 3.5)
3. Order the results in descending order by event type

4. Send the information and its position to the user interface
5. Display the information in the user interface

The data classification table contains a value for each type of event and an event type identifier (Table 3.5). The value used in the classification table was assigned by the developer based on the relation between the information and the image. For example, Image information was assigned a value of 80 because it has a direct relationship with the image. The other types of related information, Country and Weather, were assigned a value of 50. As shown in the table, the value assigned for the two types of search events is the same. Therefore, the type of search page to be displayed initially is determined by the quantity of those events found on the user profile table.

**Table 3.5 Data Classification Table**

<b>Data</b>	<b>Value</b>	<b>Event Type</b>
Country Information	50	A
Image Information	80	A
Weather	50	A
Simple Search	1	B
Advanced Search	1	B

The two events referred in Table 3.5 are:

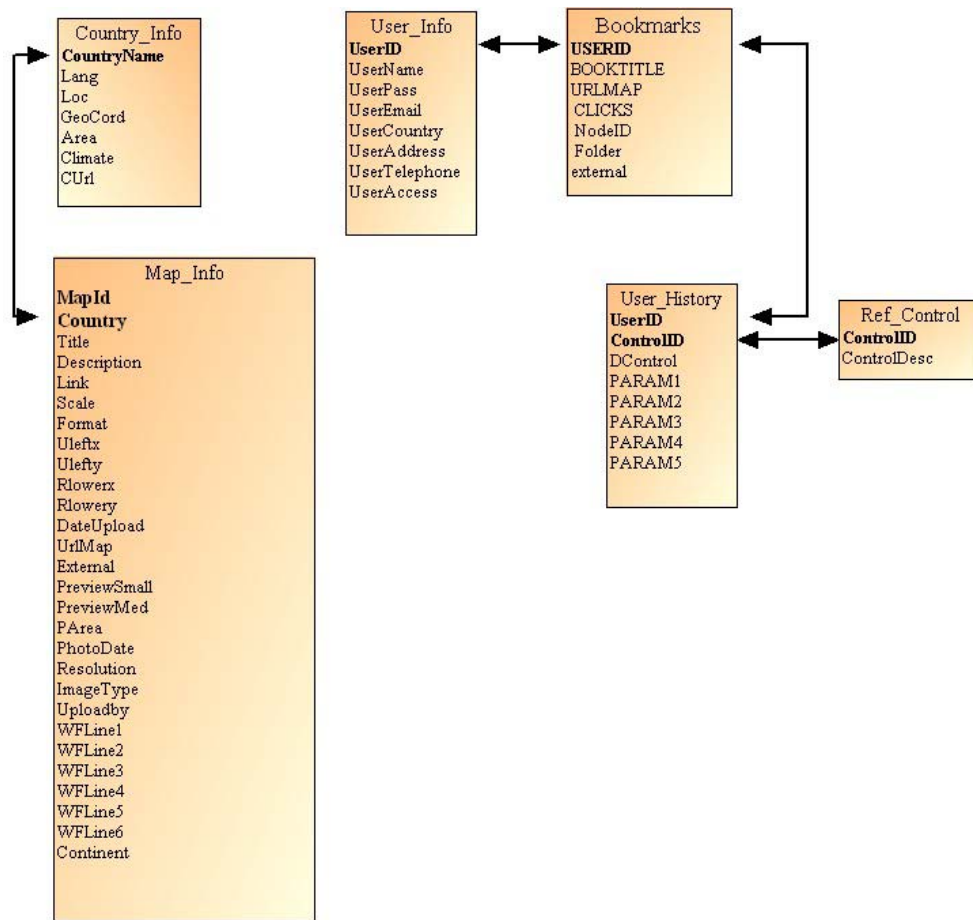
- A. User is going to view a satellite image (Event Type A)
- B. User logs into Terrexplorer (Event Type B)

Future versions of Terrexplorer could extend the adaptive algorithm to other parts of the user interface and to different types of events and menu options. This will change extensively the user interaction with Terrexplorer and make it more adaptable to the user's needs.

### **3.3 Database Design**

The database consists of two table sets. Parts of the database were designed for Terrexplorer and other parts for the WALSAIP Boundary tool. This allows the integration between WALSAIP Boundary tool and Terrexplorer. The WALSAIP Boundary tool, developed by Omar Valenzuela as part of the WALSAIP project, contains all the database tables related to boundaries.

As shown in Figure 3.7, the first set of tables in the database consists of six tables related to satellite image and users profiles. The tables related to satellite images are Map\_Info and Country\_Info. The Map\_Info table contains all the data related to the satellite image such as title, description, format, scale and also if it is geo-referenced or not. The Country\_Info table contains information regarding the country associated with the image. The fields include the name, language, area, coordinates, and a related URL that can be used to access more information about the country, if desired. The other four tables shown in the figure, User\_Info, User\_History, Ref\_Control, and Bookmark, contain all the data related to the users.

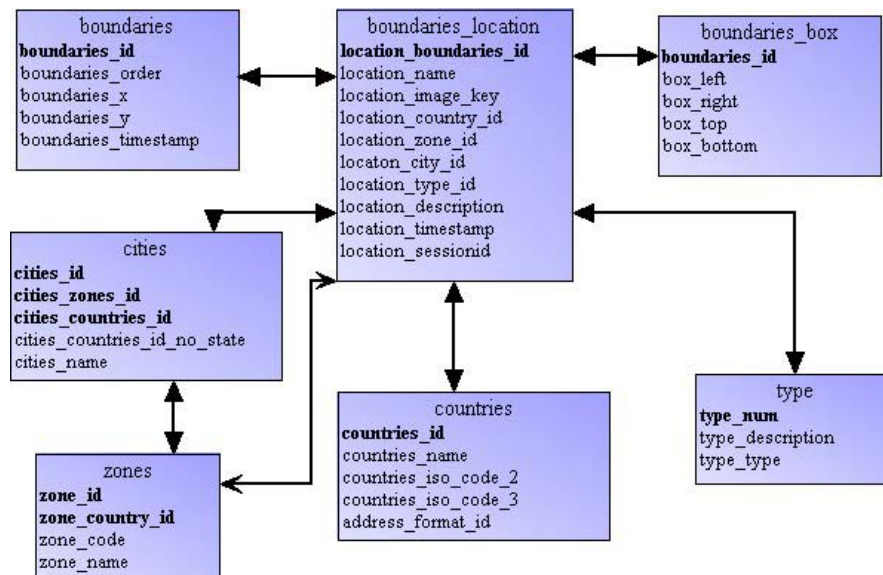


**Figure 3.6 Terrexplorer Table Set**

The User\_Info table contains the name, password, address, telephone, email, country, and user access. The User\_History table contains the user id, user actions, and the date, and time when the actions occurred. This table is used in conjunction with the Ref\_Control table to know what kind of actions the user realizes. The table is used also by the Adaptive Module to keep count of the types of user actions and to classify them according to frequency, type of actions, and types of parameters. The Bookmarks table contains the name of the link, the

URL, the containing folder, and the number of times it has been called. This table is used by the interface to make external and internal bookmarks.

The other set of tables in the system are from WALSAIP Boundary tool and are used to search for boundaries in Terrexplorer. Figure 3.8 shows seven tables that contain the information about boundaries. The boundaries\_location table contains several keys representing the relations to the other tables. These keys are the name, location, country, city, and type.



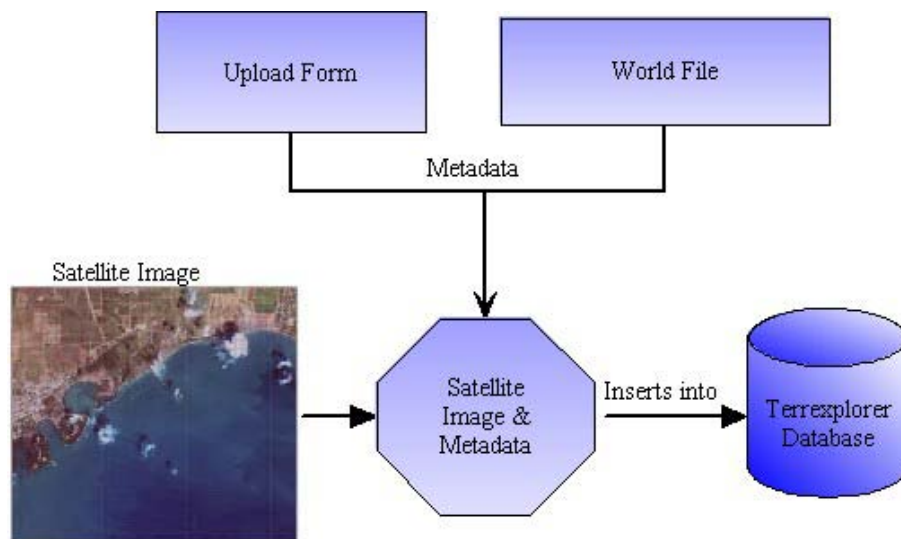
**Figure 3.7 WALSAIP BOUNDARY Tables**

The Boundary Tables contains all the geographic points for the boundary. The boundaries\_box contain upper the left point and lower right point of the boundary. This

information represents the limits of the boundary and is used to determine if a specific satellite image contains or intersects a boundary. All the coordinates on the table are saved as latitude and longitude to make them compatible with any geo-referenced satellite image.

### 3.4 Metadata

Metadata are data that describes the specifications of the data itself, in this case data that describes an image. There are two main sources for these metadata: a World file and the Upload Form file (Figure 3.9).



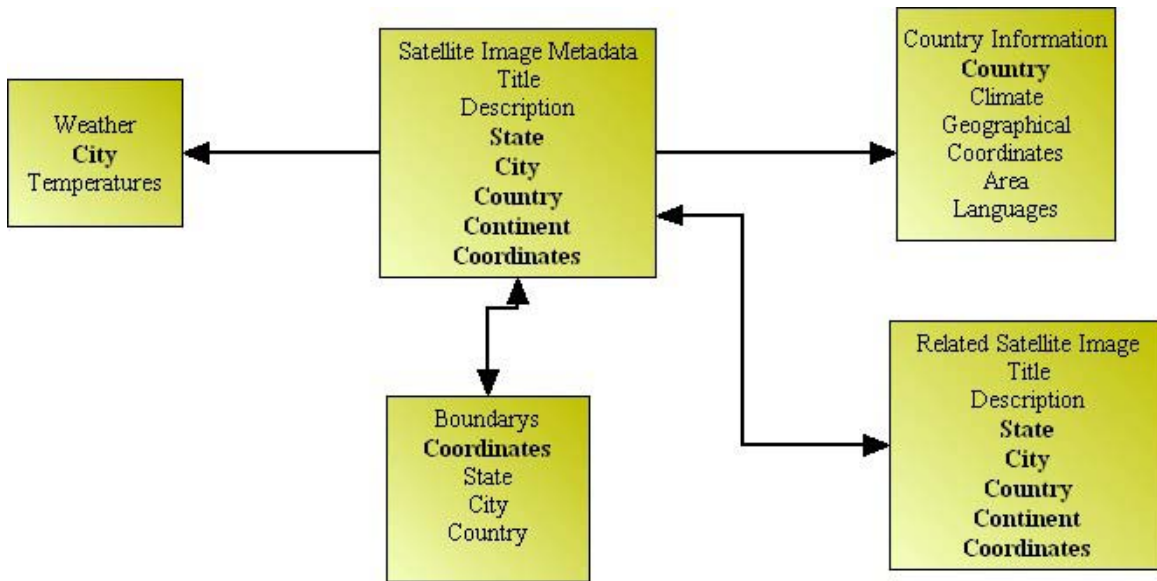
**Figure 3.8 Metadata Sources**

When a satellite image is geo referenced, the metadata will come from the Upload Form file and the World file. In the case of non geo referenced data, then the only source would be from the Upload Form file. The Upload Form file contains the title, description, type of map,

coordinate system, image type, image date, city, state, country, and continent. The World file is basically a file that contains six lines which are used by a process to extract the upper left coordinate, lower right coordinate, scale, and resolution. The metadata are used to associate the image with additional data from other sources such as: country information, weather, related images, and available boundaries.

The metadata received from the Upload Form are mainly used to connect to an external site to access information from the internet. The weather information is obtained from the Weather Underground site ([www.wunderground.com](http://www.wunderground.com)) and the country information from the C.I.A World Factbook ([www.cia.gov/library/publications/the-world-factbook/index.html](http://www.cia.gov/library/publications/the-world-factbook/index.html)).

The image information, boundaries, and satellite images are accessed from the Terrexplorer database. Figure 3.10 shows the relationship of the metadata with the external sources and the fields which identifies how the data are related to the image selected.



**Figure 3.9 Metadata Relationships with External Data**

### 3.5 Image Coordinates and Geo-reference

Terrexplorer supports geo-referenced images and different coordinate formats as latitude, longitude and NAD83 [12]. The images geo-reference is read from the World File. The file contains the following six lines:

First line: dimensions of a pixel in a map unit. (A),

Second line: rotation parameter (D),

Third line: rotation parameter (B),

Fourth line: Negative of the y dimension (E),

Fifth line: Translation parameters of x coordinate (C),

Sixth line: Translation parameters of y coordinate (F),

The formula used to translate from pixel to location coordinate are:

$$X = Au + Bv + C ,$$

$$Y = Du + Ev + F ,$$

Where:

X = calculated x coordinate of the pixel on the map,

Y = calculated y coordinate of the pixel on the map,

u = column number of a pixel in the image, and

v = row number of a pixel in the image.

The coefficients A, B, C, D, E and F are from the World file. An example of a World file can be found at Appendix B: World File Example

This formula can be used with any type of coordinate system to transform from image pixel to coordinate location [13]. The satellite images from the satellite Ikonos are usually in NAD83 coordinate format [12] and must be converted when uploaded to latitude and longitude.

### **3.6 Installation**

Terrexplorer is a server based application and its uses several software packages: Apache (Web Server), Php (Scripting Language) and Mysql (database software). The operating system of the server must support these software applications to be able to install

Terrexplorer. Terrexplorer has been hosted on Linux, Unix, and windows operating systems

using the software applications mentioned above. If Apache, Php and Mysql are not configured correctly to interact with each other, Terrexplorer will not be able to work.

To install Terrexplorer the server administrator must:

1. Copy Terrexplorer to the public Html directory,
2. Download Phpmyadmin at [http://www.phpmyadmin.net/home\\_page/downloads.php](http://www.phpmyadmin.net/home_page/downloads.php),
3. Unzip Phpmyadmin in a separate directory in the public Html directory,
4. Enter in your web browser to the location of Phpmyadmin,
5. Enter your username and password (must have administrator access in MySQL),
6. Select the option of import,
7. Select Browse in the location of text file
8. Select and open terredb.sql
9. Press the button Go

When Terrexplorer is finished with the installation, the system administrator must configure the application. This process is described in the next section.

### **3.7 Configuration**

The configuration of Terrexplorer is mainly done by editing two files *conf.php* and *connect.php*. The *conf.php* file contains the location of Terrexplorer, the location of the WALSAIP Boundary application, and the option to allow new users. Below is an example of the configuration process (*conf.php*).

```

<?php
$homebase = "https://hcisrv.ece.uprm.edu/~william";
// contains the main address of the web application
$boundaryapp = "https://hcisrv.ece.uprm.edu/~omar";
//contains the boundary app web address
$allowregister="y";
// Allow new users to register
?>

```

To configure Terrexplorer the user must edit `conf.php` as follows:

1. Change the first line in the file and between the brackets with the location of Terrexplorer for your website for example
 

```
$homebase = "http://yourwebsite.com";
```
2. Change the third line and put between the brackets the location of WALSAIP Boundary application for example
 

```
$boundaryapp = "http://boundaryappexample.com";
```
3. To allow or deny new users to Terrexplorer, the administrator must change the fifth line of the file, inserting in the brackets a “y” or “n”. For example:
 

```
$allowregister="y";
```

The other file, `connect.php`, contains the information related to the database connection.

Below is an example of the file.

```
<?php
// contains the sql account and database
// note: The user needs access to insert, modify and delete
$conn_string = mysql_connect("localhost", "terreuser", "terreuser");
mysql_select_db("hcidb", $conn_string);
?>
```

The fourth and fifth lines of the *connect.php* file contain the information about the server, database, the username, and password. To change this information, the user must modify the fourth line (`$conn_string = mysql_connect("server_name", "username", "password");`) and substitute the `server_name`, `username` and `password` with their own server name and user name and password. This account must have administration privileges in MySQL to insert and delete information.

After the modification, the file must be saved and closed. To verify the configuration the administrator must logon into Terrexplorer using “Administrator” as username and “terreadmin” as password. If the system allows this logon, then Terrexplorer is correctly configured. Once configured, the administrator must change the password to avoid unauthorized access.

Once the installation and configuration is finished, the users can begin using Terrexplorer. The next chapter will describe in detail the functionality, options, and user interface of Terrexplorer.

## 4 User Interface

This chapter will present the different aspects of the user interface of Terrexplorer. The user interface was designed using the feedback from several professors and students from the University of Puerto Rico, Mayaguez Campus. Unlike traditional applications, Terrexplorer uses an adaptive user interface. The goal of a user interface is to be clear, efficient and easy to use [9]. Adaptive user interfaces makes assumptions about the user's needs and makes changes depending on the user's profile [4]. In case of Terrexplorer the interfaces make changes on the information displayed depending on the user's profile and data value. This is done to prevent the overload of information displayed on the user interface.

Terrexplorer is designed for a resolution of 1280 x 1024 and should be viewed using one of the following web browsers: Firefox 2 ([www.firefox.com](http://www.firefox.com)), Opera 8 ([www.opera.com](http://www.opera.com)), or Safari 3 ([www.apple.com](http://www.apple.com)). The following sections will present the different parts of the user interface of Terrexplorer and their functionality.

## 4.1 Terrexplorer Login

When a user enters into Terrexplorer, the first screen that is displayed is the logon screen. This interface, shown in Figure 4.1, includes the Log In button and a New User button. The New User button only appears if the system administrator has configured Terrexplorer to accept new users. If the Username and Password entered by the user in the text boxes shown is correct, then the system opens Terrexplorer's main user interface. If the New User button is selected, then the system redirects the user to the registration interface. The next section describes the User Registration interface.



Figure 4.1 Terrexplorer Logon

## 4.2 User Registration Interface

When a user presses the New User button in the login screen, Terrexplorer automatically redirects the user to the User Registration interface shown in Figure 4.2. In order to be registered in the system, a new user will have to fill the seven fields shown in the registration. The seven fields are: name, password, password confirmation, email, telephone, address, and country. The Password field needs to have more than six characters and must be repeated in the Password Confirmation to allow the new user to register. Once the user is registered, the system will open the Log In screen so users can enter their username and password.

Register a New User

Please complete all the fields.

Name:

Password:

Password Confirmation:

Email:

Telephone:

Address:

Country:

To increase your security access please leave an email to Administrator

**Figure 4.2 Register a New User**

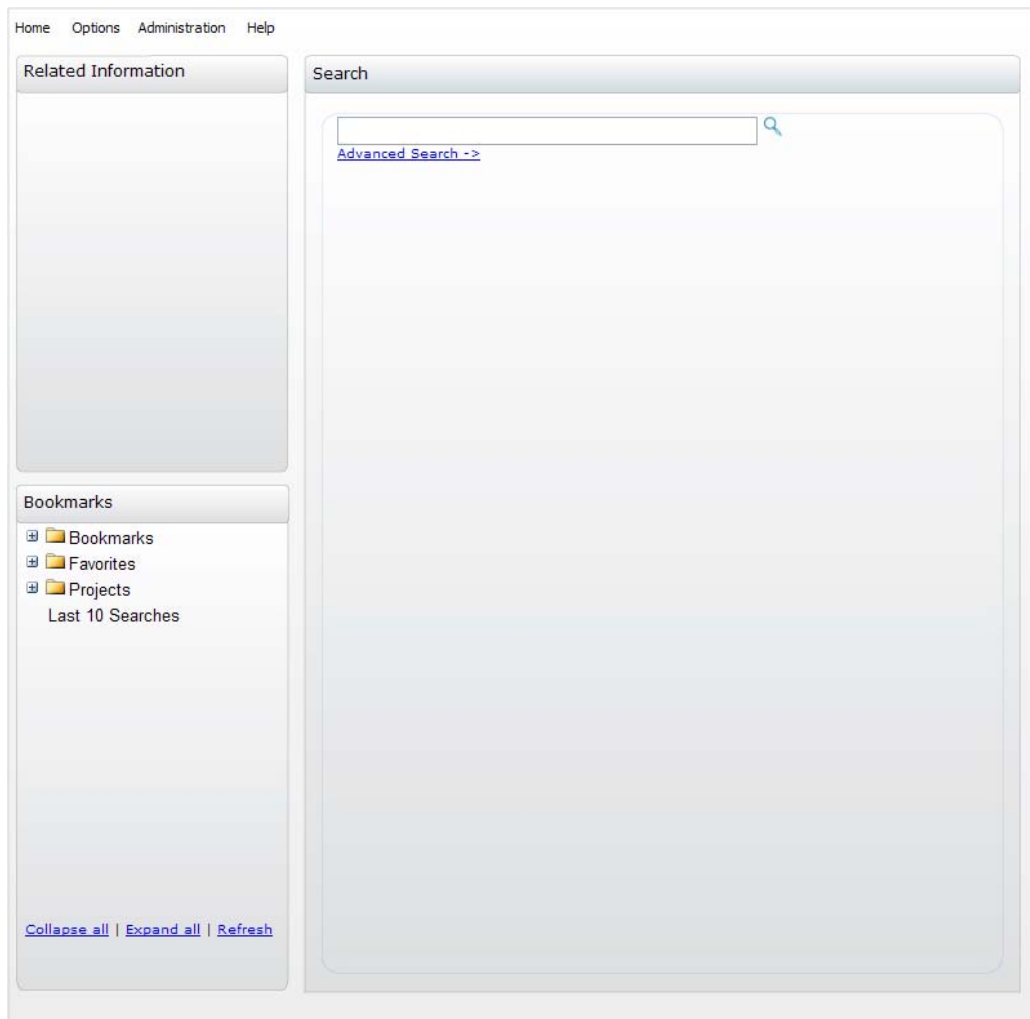
## 4.3 Terrexplorer Main Interface

While using the application, users will spend the majority of the time in the main interface of Terrexplorer. When the main interface is loaded, the system automatically decides which type of search to display. This decision is based on the quantity of simple search and advanced search the user has done previously. Figure 4.3 shows the Main interface consisting of a Simple Search Panel, Menu Bar, and Bookmarks Panel.

The main interface is divided into four sections:

1. Menu Bar – Located on top
2. The Search Panel – Located on the upper right
3. Related Information – Located at the upper left
4. Bookmarks Panel– Located at the bottom left

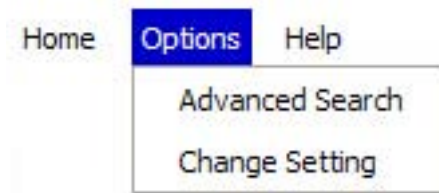
The options in the Menu Bar change according to the access level of the user. As described in Chapter 3, a user can be a regular user, an uploader, or an administrator. The Search Panel, Related Information, and Bookmarks change according to the user actions. The areas that are modified by the different user options will be presented in the next sections.



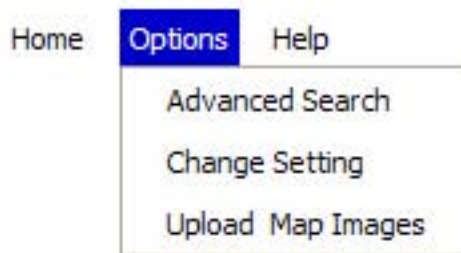
**Figure 4.3 Terrexplorer Main Template**

## **4.4 Terrexplorer Menu Options**

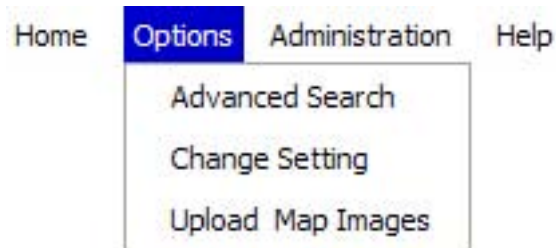
When a user logs into Terrexplorer, the system determines the security access of the user in order to determine which options to display in the Menu Bar. Figure 4.4 illustrates the three types of menu options that will be displayed according to the user's access type.



**a. Regular User Access**



**b. Uploader User Access**

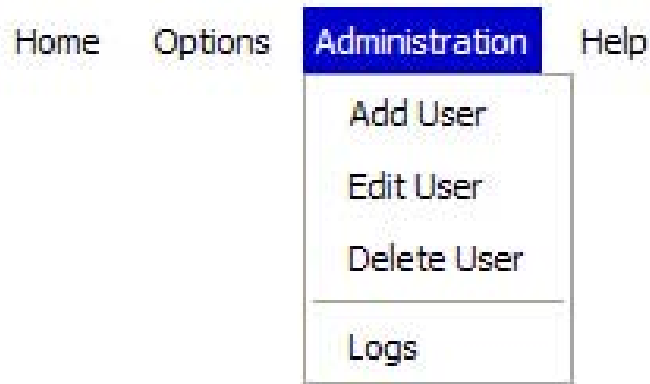


**c. Administrator User Access**

**Figure 4.4 Terrexplorer Different Menu Options**

The first Menu Bar and options shown are those available to regular users. The options menu contains the advanced search and the change settings options. The Help option is available in the Menu Bar for all types of users. The second menu shown, the Uploader menu, has the same options as the regular user with the additional option to upload map images.

The Administrative user menu, shown last, includes the same options available to the Uploader, but it also has an Administration option in the Menu Bar. Figure 4.5 shows a list of actions or functionality that can be selected in the Administration option. It includes the options: Add User, Edit User, Delete User, and Logs. The last option will display the history logs (a list of past actions) of the users on the system.



**Figure 4.5 Terrexplorer Administration Options**

## **4.5 Terrexplorer Advanced Search**

The Advanced Search Panel allows the user to be more specific while conducting a search for different types of data. The panel contains the following fields: title, description, types of search, types of maps, image type, scale, coordinates, continent, image date, city, state, country and which database to search. Table 4.1 includes a description of each of these fields and the type of data they expect.

**Table 4.1 Advanced Search User Fields**

<b>Field Name</b>	<b>Description</b>	<b>Required Action</b>
Title	Title of the Satellite image	The users fill in the blank.
Description	Description of the satellite image	The users fill in the blank with keywords or description.
Type of Search	Indicate the type of data searched: boundaries, maps or both	The users select which type of search from the options.
Type of Maps	Indicate the type of maps to search: all, geo-referenced, not geo-referenced	The users select which type of map from the options.
Scale	Indicates the scale of the image	The users fill in the blank. The field only accepts numbers.
Scale Options	The scale option indicate if the number of the scale: is larger, equal or smaller	The users select which type of scale from the options
Upper Left Coordinate	Represents the upper left coordinate from the image	The users fill in the blank. The field only accepts numbers.
Lower Right Coordinate	Represents the lower right coordinate from the image	The users fill in the blank. The fields only accepts numbers
Continent	The continent from which the image proceeds.	The users fill in the blank.
From Date	The image earliest date in which the user wants to search	A calendar pop up and the users select the date.
To Date	The image latest date in which the user wants to search	A calendar pop up and the users select the date.
City or State	The city or state from which the image proceeds.	The users fill in the blank.
Country	The country from which the image proceeds.	The users select from a list of countries.
Database:	The database in which the user wants to search for the information	The users select from a list of databases.

The Advanced Search Panel requires users to specify at least one field in order to conduct a search. When the user selects a field that requires a date the web application opens a window with a calendar. Figure 4.6 shows an example of an Advanced Search and a calendar. The Advanced Search Panel also includes an option to allow users change to a simple search.

Advanced Search

[Simple Search ->](#)

Please specify at least one of the fields.

Title:

Description:

Type of Search:  Both  Maps  Boundaries

Maps:  All  Geo Referenced  Not Geo Referenced


Image Type:


Scale: 1:   and larger scale(more detail)  
 Exactly this scale  
 and smaller scale(less detail)

Upper Left Cord. Latitude  Longitude

Lower Right Cord. Latitude  Longitude

Continent:

From Date:  

To Date:  

City or State

Country

Select Database to Search:

« « October 2007 » »						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			
[close] [clear]						

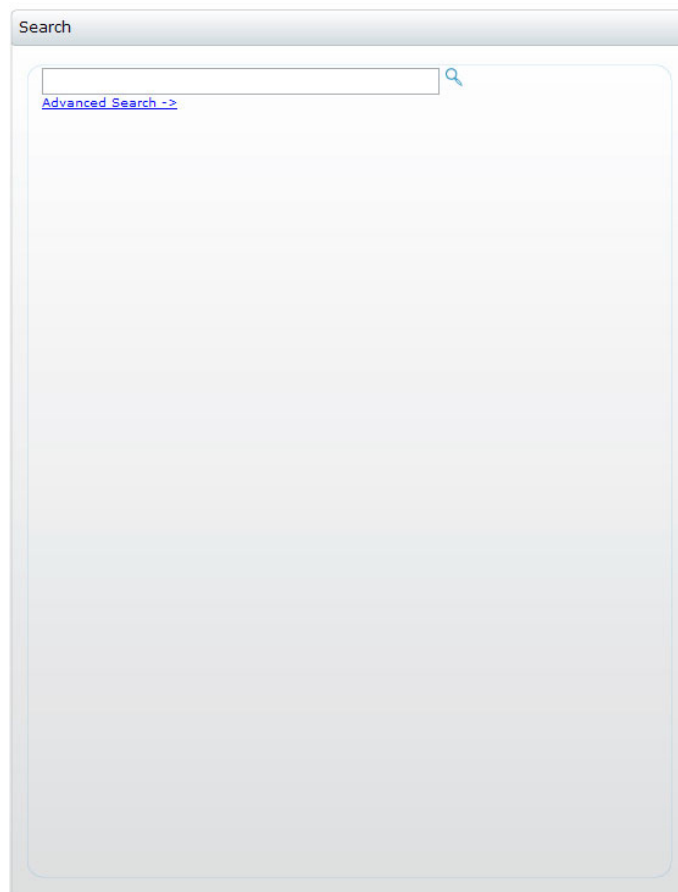
a. Advanced search template

b. Calendar

Figure 4.6 Advanced Search and Calendar

## 4.6 Terrexplorer Simple Search

Contrary to the advanced search that has many options, there is the simple search that consists only of a blank text field. The user fills the text field and Terrexplorer conducts a search thru different fields as maps, image type, scale, coordinates, continent, image date, city, state and country. This search is conducted within all the databases that are connected to Terrexplorer. Figure 4.7 shows the Simple Search Panel which also includes an option to move to the Advance Search Panel.



**Figure 4.7 Simple Search**

## 4.7 Terrexplorer Search Results

Once the user submits an advanced search or a simple search, the search results are displayed in the same section of the user interface. Figure 4.8 shows a search result that includes three satellite images and three boundaries. If a search results item includes a “Preview” link, then the user can select this link to view a small preview of the image. This allows users to save time by avoiding having to select each result item to determine the contents of the image. When the user selects the magnifier glass icon shown below a search result item, Terrexplorer automatically opens an advanced search form that includes the coordinates of that image or boundary. This helps the user to search for another image or boundaries that have the same coordinates without having to enter the coordinates manually.

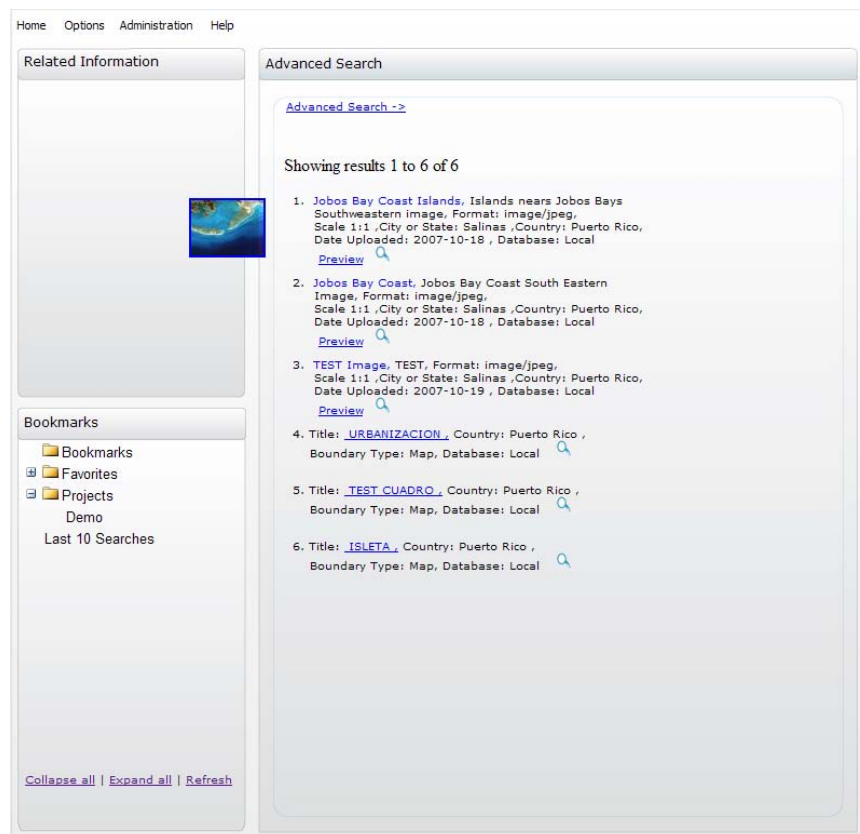
Each search result item includes the metadata of the image or boundary and indicates from which database is that search result item. For example, if the search result represents an image map it will also display the following information associated with the resulting item: the title, description, image format, scale, city or state, country, date uploaded and from which database comes from. Next is an example of a search result representing an image map.

*1. Salinas Coast, Salinas Southwest Coast, Format: image/jpeg, Scale 1:1, City or State: Salinas, Country: Puerto Rico, Date Uploaded: 2007-11-08, Database: Local*

The search results that represent boundaries display the following metadata: the title, country, boundary type and the database. Next is an example of a boundary search result.

2. Title: *AGUIRRE POWER PLANT* , Country: *Puerto Rico* ,  
Boundary Type: *Map*, Database: *Local*

The maximum number of search results that can be displayed at once in Terrexplorer are eight. Terrexplorer displays the number of results found and automatically provides the options of previous and next at the bottom of the result page when there are more results available.



**Figure 4.8 Search Results**

## 4.8 Satellite Image

When a satellite image is selected from the search results or a bookmark, the user interface displays a picture of the satellite image. As shown in Figure 4.9, the Related Information Panel automatically displays new options and the Search Results Panel is replaced with the Satellite Image Panel that includes the selected image.

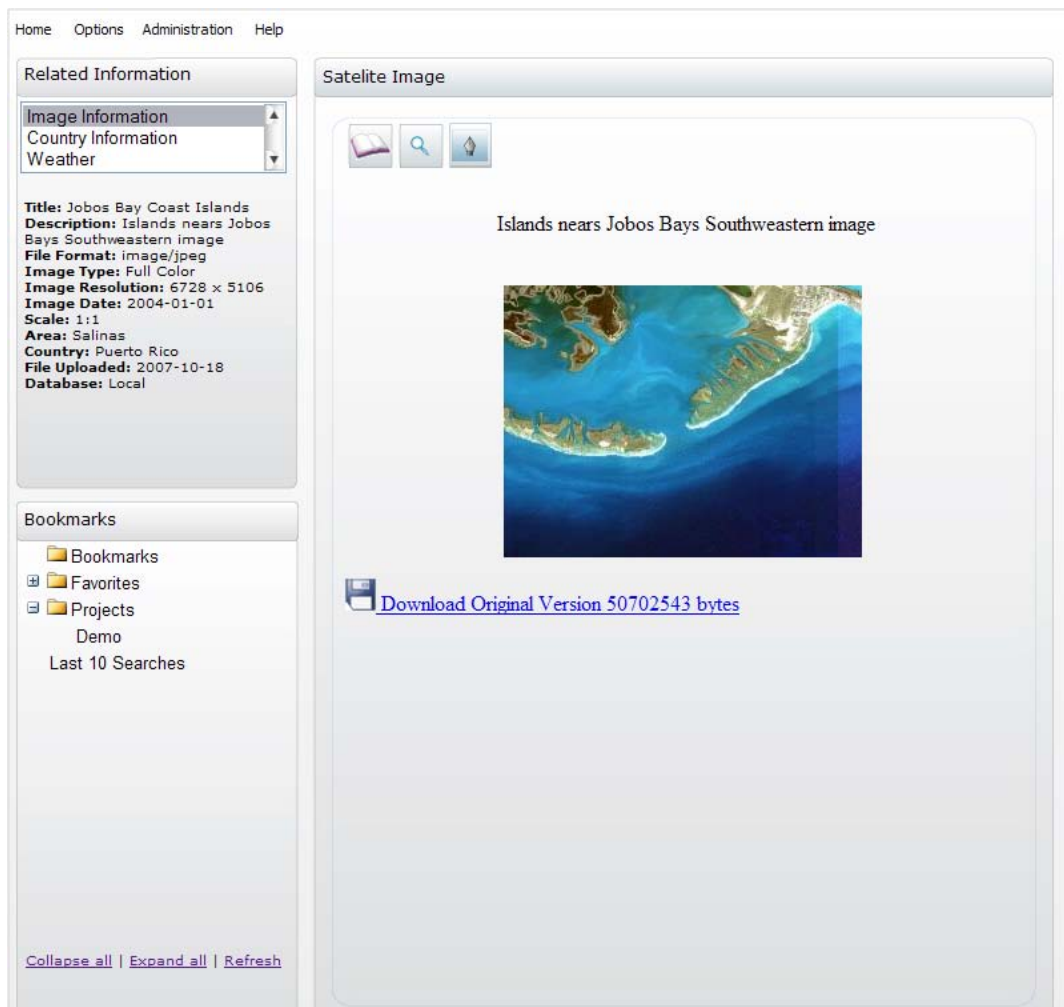


Figure 4.9 Satellite Image

The Satellite Image Panel contains three icons that are used to select different actions that can be taken in relation to the image displayed. The first option, represented by an icon that contains an open book, allows users to create a bookmark. When a user selects the bookmark icon, the system displays the bookmark options which are described in another section. The second option is represented by a magnifier glass icon. When this icon is selected, an Advanced Search Panel is opened. This search form includes the coordinates of the image under question and allows the user to search for other images or boundaries that has related coordinates. The third option is the pen icon that allows the user to open the WALSAIP Boundary application to create a boundary within the displayed image. The link “Download Original Version” permits the user to download the image with the original resolution that it was uploaded to the system. This provides the user with a high resolution images to use with different GIS applications. The Related Information Panel will be discussed in the next section.

#### 4.8.1 The Related Information Panel

The Related Information Panel includes a menu that provides access to three types of information related to the satellite image selected. The Image Information option in the menu is used to display all the metadata related to that image. As seen in Figure 4.10, this includes the following information: title, description, file format, image type, image resolution, image date, scale, area, country, upload date and database of origin.

The Country Information option displays some basic information of the country associated with the image metadata. This option includes a link at the bottom of the panel to access additional information. When a user selects the link the application opens a window to the C.I.A World Fact Book with more information about the country.

The Weather Information option displays the temperature in Celsius and Fahrenheit, the type of weather, and the time in which the temperature was measured for the city in the image metadata. If the user clicks on the link “click to forecast” it connects to the weather underground website (<http://www.wunderground.com>) to access and display a forecast for that area.

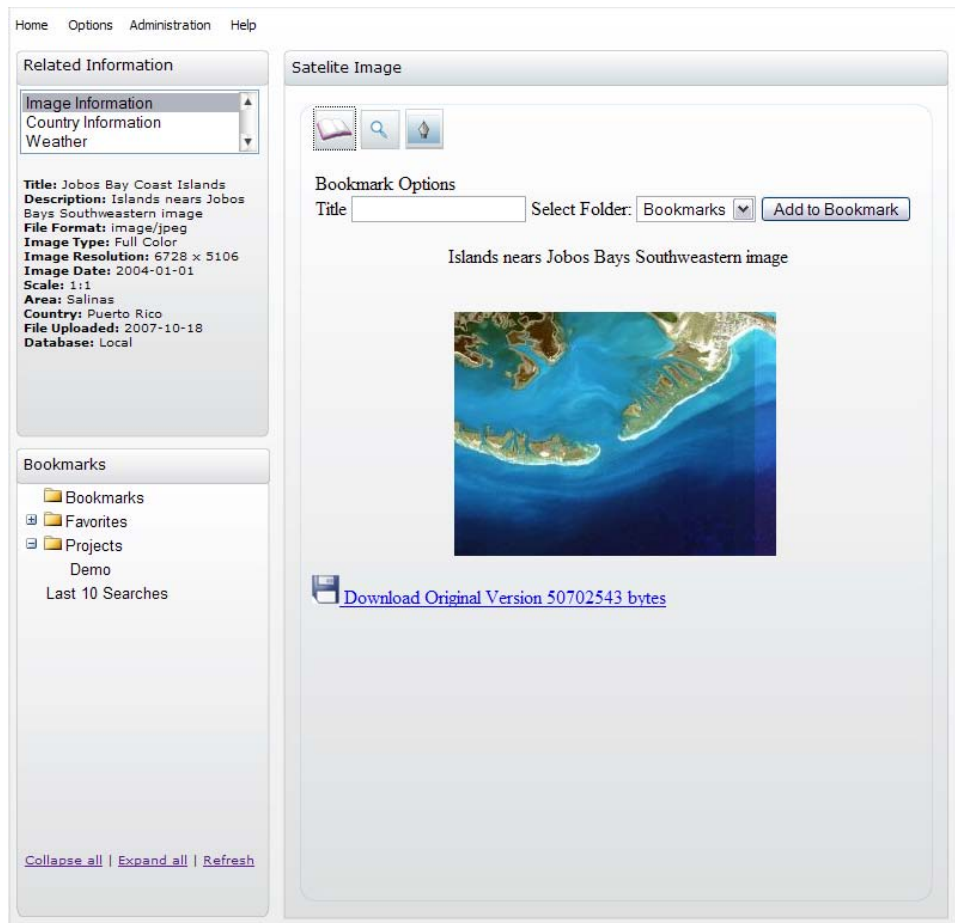
The order in which the system displays the data in the Related Information Panel is dynamic and depends on the adaptive module discussed previously in chapter 3. Figure 4.10 shows the Related Information Panel with the Image Information, Weather, and Country Information in different order.



**Figure 4.10 The Related Information Panel**

## 4.8.2 The Bookmark Form

When a user selects the bookmark icon in the Search Results Panel, the application displays the bookmark options. Figure 4.11 shows the options displayed on top of the image. It contains the title, a combo box to select the folder for the bookmark, and an Add To Bookmark button. When the user enters the title, selects a folder from the combo box and clicks the button, the application will add the bookmark to the folder selected.



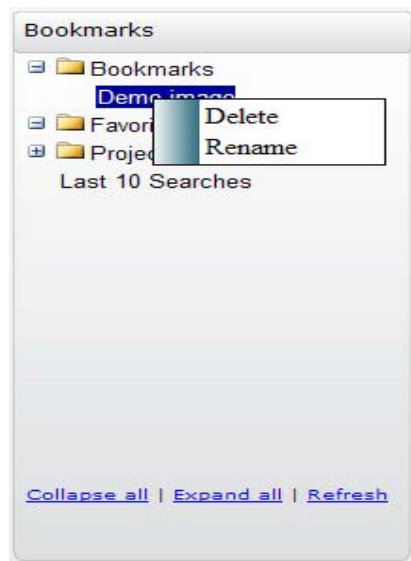
**Figure 4.11 The Bookmark Options**

The bookmark links that are saved and included in the Bookmark Panel will be described in the next section.

## 4.9 Bookmark Panel

The Bookmark Panel contains the bookmarks that the user has created. The main purpose of this panel is to provide shortcuts to the links of interest and access to the previous search results. As shown in Figure 4.12 the Bookmark Panel contains three folders: Bookmarks,

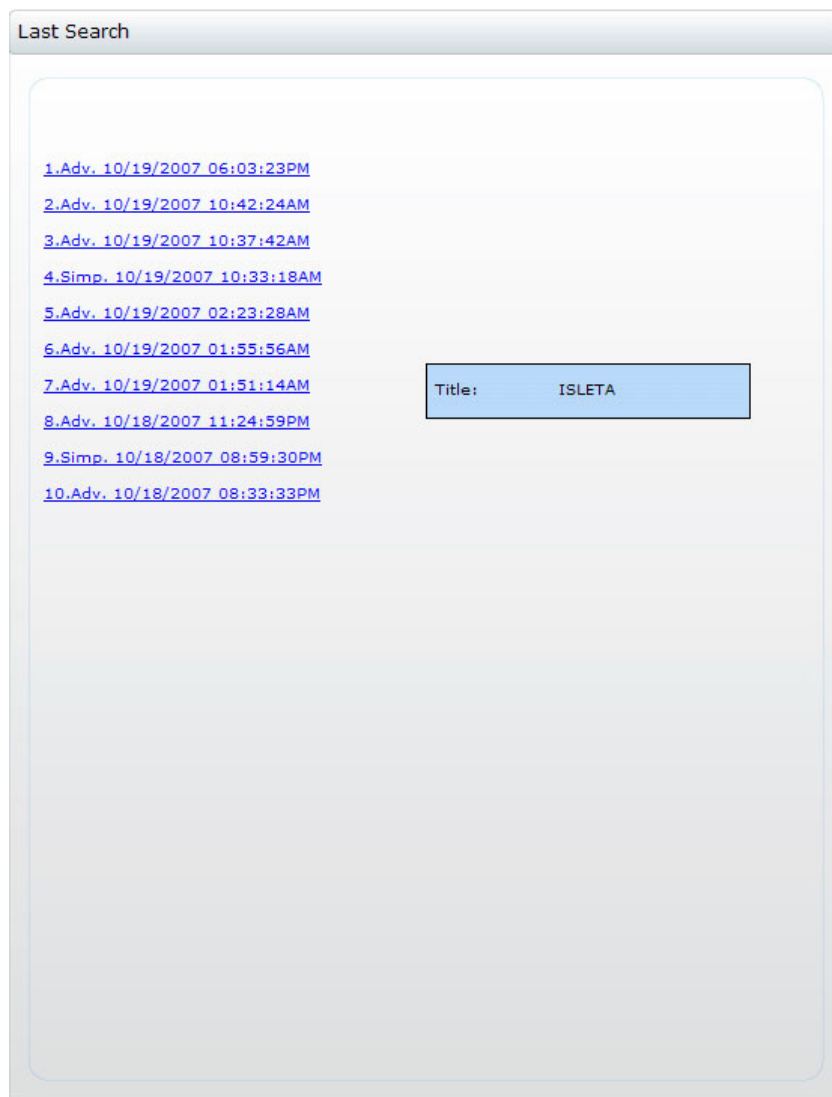
Favorites and Projects. Each folder may contain none to several links. The user has the option to delete, rename and move existing links. To delete and rename a link the user selects the link and then a right click of the mouse will display a menu with the available options. To move a link the user drags and drops the link to the folder desired. The Bookmark panel also includes a link that provides access to the last ten searches realized by the user. This link is static and cannot be deleted or renamed.



**Figure 4.12 Bookmark Panel**

#### 4.9.1 Last 10 Searches

When a user selects the Last 10 Searches link from the Bookmark Panel the system will display a list in the upper right panel representing the last ten searches. Figure 4.13 shows an example of a list of the last ten searches. Each link has the date, time and type of search. If the user hovers the mouse over a link, then a description of the search will displayed, as shown in the figure.

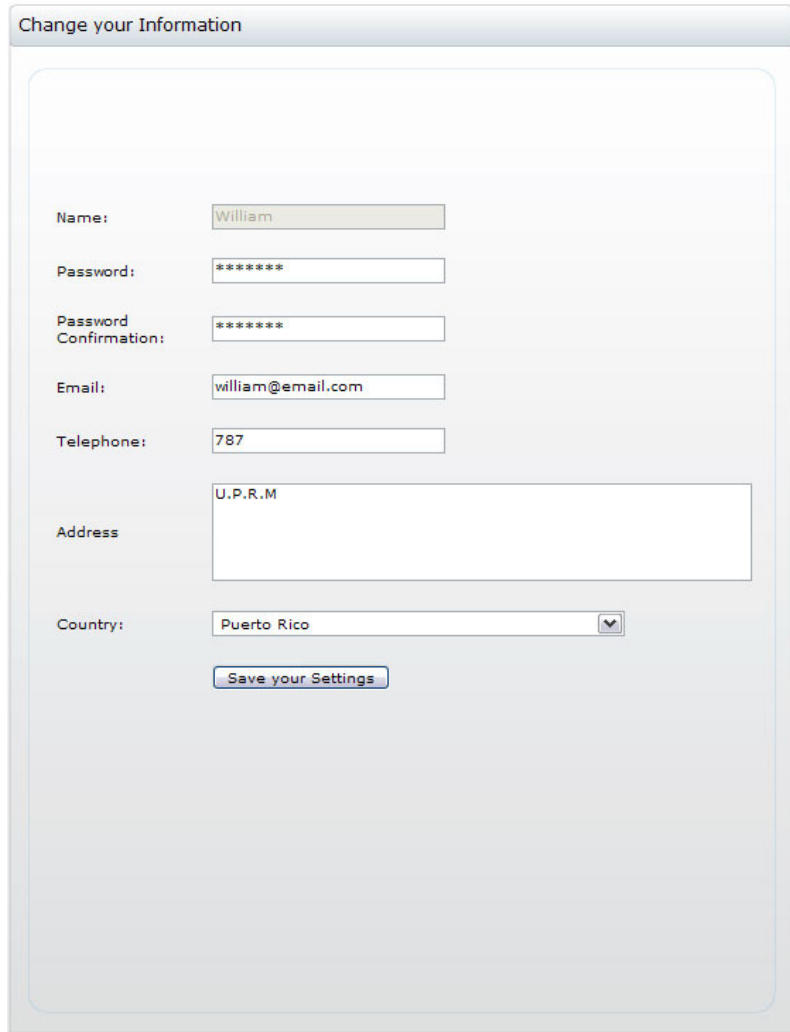


**Figure 4.13 Last 10 Searches Template**

## 4.10 Changing Personal Settings

One of the options in that is available in the Menu Bar is the “Change Settings” option. This option allows users to change their password, email, telephone, address and country. Figure

4.14 shows an example of the template to change user settings. All the fields must be filled to be able to process the changes. The user name is not changeable.



The image shows a web form titled "Change your Information". The form contains the following fields and values:

- Name: William
- Password: \*\*\*\*\*
- Password Confirmation: \*\*\*\*\*
- Email: william@email.com
- Telephone: 787
- Address: U.P.R.M
- Country: Puerto Rico (selected from a dropdown menu)

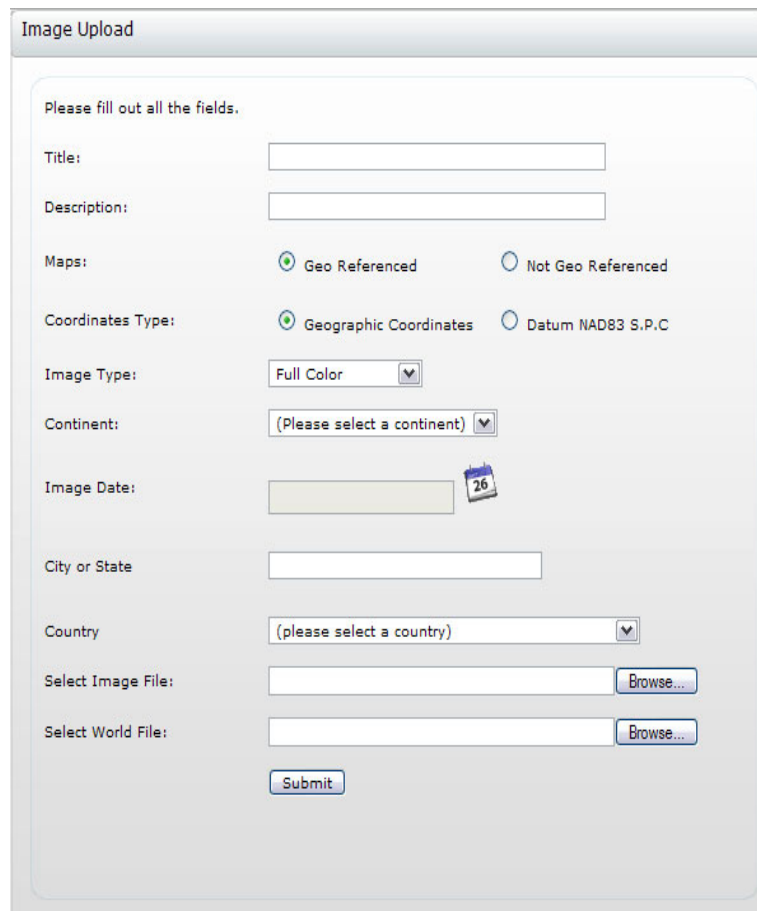
At the bottom of the form is a button labeled "Save your Settings".

**Figure 4.14 Change Users settings**

## 4.11 Upload Form

As shown previously in the Menu Options sections, if the user's security type is Uploader or Administrator, then the Upload Image map option will be available in the Menu Bar.

Figure 4.15 shows an example of the upload form. It contains the following fields: title, description, type of map, coordinate type, image type, continent, image date, city or state, image file location, and world file location. All the fields in the Upload form are required. When the Upload form is submitted, the image is added to the Terrexplorer local database.



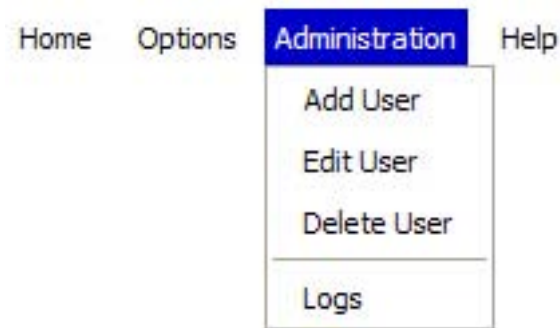
The screenshot shows a web form titled "Image Upload". At the top, it says "Please fill out all the fields." The form contains the following elements:

- Title:** A text input field.
- Description:** A text input field.
- Maps:** Two radio buttons: "Geo Referenced" (selected) and "Not Geo Referenced".
- Coordinates Type:** Two radio buttons: "Geographic Coordinates" (selected) and "Datum NAD83 S.P.C".
- Image Type:** A dropdown menu with "Full Color" selected.
- Continent:** A dropdown menu with "(Please select a continent)" selected.
- Image Date:** A date input field with a calendar icon showing the number "26".
- City or State:** A text input field.
- Country:** A dropdown menu with "(please select a country)" selected.
- Select Image File:** A text input field followed by a "Browse..." button.
- Select World File:** A text input field followed by a "Browse..." button.
- Submit:** A "Submit" button at the bottom.

**Figure 4.15 Upload File Form**

## 4.12 Administration Options

The Administration menu options are displayed in the Menu Bar when the user's security access is of type Administrator. It contains the following options: Add User, Edit User, Delete User and Logs. Figure 4.17 shows the Menu Bar with the Administration Options. The next subsections will describe the different options.



**Figure 4.16 Terrexplorer Administration Options**

### 4.12.1 Add User Form

Figure 4.17 shows an example of the Add User Form. This option is selected from the administrator menu. The administrator can add the name, password, email, telephone, address, country, and user access. The system requires the administrator to fill out all the fields. If the system determines that the selected user name already exists, then it will ask the administrator to specify a different user name.

**Add a User**

Please complete all the fields.

Name:

Password:

Password Confirmation:

Email:

Telephone:

Address:

Country:

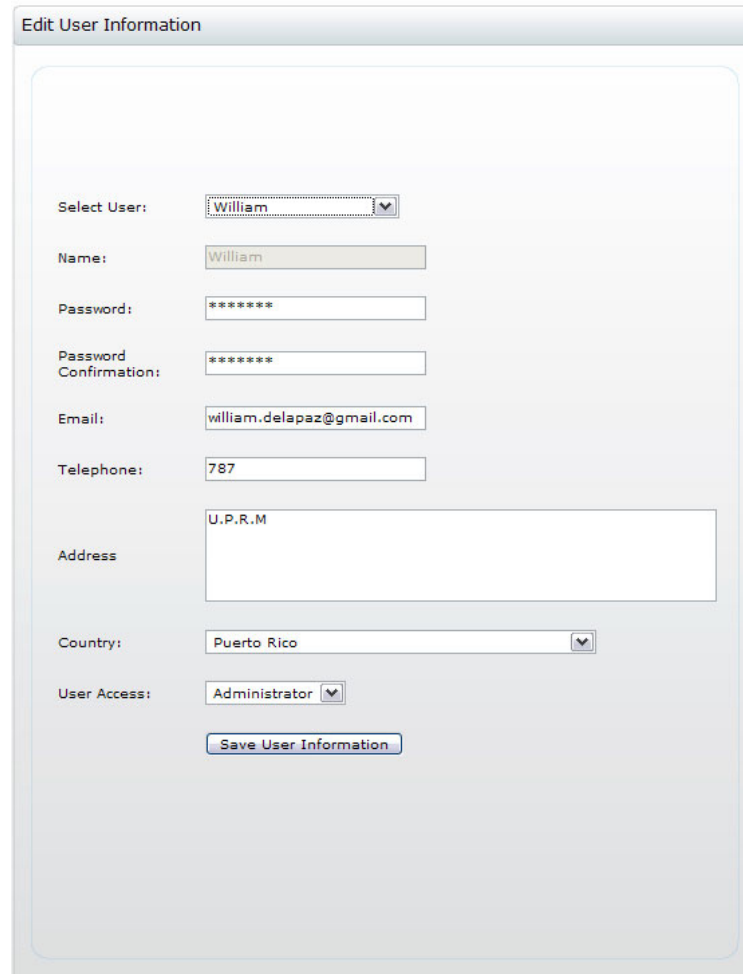
User Access:

**Figure 4.17 Add a User Template**

#### 4.12.2 Edit User Form

Another option in the administrative menu is used to open the Edit User Form. The administrator must first select a user from a combo box and then the system will display the information of the user selected. The fields in the Edit User Form are: select user, name, password, password confirmation, email, telephone, address, country, and user access. The

administrator can change any user field except the name of the user. All the fields must be filled to be able to accept the changes. Figure 4.18 shows the template of the Edit User Form.



The image shows a web form titled "Edit User Information". The form contains the following fields and controls:

- Select User:** A dropdown menu with "William" selected.
- Name:** A text input field containing "William".
- Password:** A text input field containing "\*\*\*\*\*".
- Password Confirmation:** A text input field containing "\*\*\*\*\*".
- Email:** A text input field containing "william.delapaz@gmail.com".
- Telephone:** A text input field containing "787".
- Address:** A large text input field containing "U.P.R.M".
- Country:** A dropdown menu with "Puerto Rico" selected.
- User Access:** A dropdown menu with "Administrator" selected.
- Save User Information:** A button at the bottom of the form.

**Figure 4.18 Edit User Form**

### 4.12.3 Delete User Form

The Delete User Form is accessed by selecting the Delete User option in the administration menu. Figure 4.19 shows example of the Delete User Form. The fields in this form are: select user, name, password, password confirmation, email, telephone, address, country, and user access. When the administrator selects the Delete User button, the system will display a

dialog to confirm deletion. If it is confirmed, then the user information is deleted from Terrexplorer.

The screenshot shows a web form titled "Delete User". It contains the following fields and values:

- Select User: William (dropdown menu)
- Name: William (text input)
- Password: \*\*\*\*\* (password input)
- Password Confirmation: \*\*\*\*\* (password input)
- Email: william.delapaz@gmail.com (text input)
- Telephone: 787 (text input)
- Address: U.P.R.M (text input)
- Country: Puerto Rico (dropdown menu)
- User Access: Administrator (dropdown menu)
- Delete User (button)

**Figure 4.19 Delete User Form**

#### 4.12.4 Logs Form

Access to Logs is another option in the administration Menu Bar. This option permits the administrator to view the history of a user's actions in the system. Figure 4.20 shows an

example of the Log form that is used to specify the logs to be displayed. There four fields in the Log form are defined in Table 4.2.

The screenshot shows a web form titled "View users Log". The form is contained within a light gray border. At the top left of the form area, the text "View users Log" is displayed. Below this, there are four rows of controls:

- Select User:** A dropdown menu with "All Users" selected and a downward arrow.
- View Log:** Two radio buttons. The first is labeled "New Window" and is selected (indicated by a green dot). The second is labeled "Excel" and is unselected.
- From Date:** A text input field containing "10/20/2007" and a calendar icon to its right showing the number "26".
- To Date:** An empty text input field and a calendar icon to its right showing the number "26".

Below the "To Date" field, there is a blue button labeled "View".

**Figure 4.20 Log Form**

**Table 4.2 Log Form Fields**

<b>Field Name</b>	<b>Description</b>	<b>Required Action</b>
Select User	A list of user names	A selection from the list
View Log	Specifies how the log information will be displayed. The options are: Excel and New Window	The user selects one option
From Date	The earliest date in which the user wants to display information in the user Log	A calendar pops up and the user selects the date
To Date	The latest date in which the user wants to display information in the user Log	A calendar pops up and the user selects the date

The administrator can select to view the history form of all users or from a specific user. The “From Date” and “To Date” fields allow the administrator to specify the time frame to be used to access the information. If the user selects those fields, then a calendar will open in a window similar to the advance search calendar. The system also provides the option to select where to display the information. The choices are a web browser or an Excel spreadsheet.

Figure 4.21 shows an example of the user log displayed in a web browser. The first column contains the date and time of the users action, the second column contains the user name, the third column contains the type of action, and the fourth contains the details about that action of the third column. This information can also be displayed in Microsoft Excel ®. Figure 4.22 contains an example of the user log in Microsoft Excel ®.

Date	Username	Description	Parameter
10/20/2007 08:53:49PM	William	Logged On	William
10/20/2007 08:47:17PM	William	The user selected the option	Weather
10/20/2007 08:31:28PM	William	The user selected the option	Weather
10/20/2007 08:29:54PM	William	The user selected the option	Country Information
10/20/2007 08:19:34PM	William	The user selected the option	Image Information
10/20/2007 08:19:34PM	William	The user selected the option	Country Information
10/20/2007 08:19:33PM	William	The user selected the option	Weather
10/20/2007 08:19:33PM	William	The user selected the option	Country Information
10/20/2007 07:58:18PM	William	Logged On	William
10/20/2007 06:27:27PM	William	Logged On	William
10/20/2007 06:27:14PM	William	Logged On	William
10/20/2007 04:56:37PM	William	Logged On	William
10/20/2007 12:57:55AM	William	The user selected the option	Weather
10/20/2007 12:57:55AM	William	The user selected the option	Image Information
10/20/2007 12:57:53AM	William	The user selected the option	Country Information
10/20/2007 12:57:52AM	William	The user selected the option	Image Information
10/20/2007 12:57:51AM	William	The user selected the option	Country Information
10/20/2007 12:57:49AM	William	The user selected the option	Image Information
10/20/2007 12:57:29AM	William	Logged On	William
10/19/2007 06:03:23PM	William	Advance Search	Map_Info.Title Like "%ISLETA%"

Figure 4.21 Example of the User Log in New Window

The screenshot shows a Microsoft Excel window titled "Microsoft Excel - viewlognow.php-5.xls". The spreadsheet contains a table with the following data:

	A	B	C	D	E
1	Date	Username	Description	Parameter	
2	11/19/2007 09:24:33PM	Upl	Logged On	Upl	
3	9/19/2007 10:22:34AM	Upl	The user selected the option	Image Information	
4	9/19/2007 10:22:33AM	Upl	The user selected the option	Weather	
5	9/19/2007 10:22:33AM	Upl	The user selected the option	Country Information	
6	9/19/2007 10:19:05AM	Upl	The user selected the option	Country Information	
7	9/19/2007 10:19:05AM	Upl	The user selected the option	Weather	
8	9/19/2007 10:18:58AM	Upl	Advance Search	Map_Info.Title Like "%Coast%"	
9	9/19/2007 10:17:16AM	Upl	Logged On	Upl	
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Figure 4.22 Example of the User Log in Microsoft Excel

The next chapter will describe the usability test conducted to evaluate the user interface of Terrexplorer. It will explain the methodology and results of the usability test.

## 5 USABILITY TEST

### 5.1 Introduction

The user interface is one of the most important aspects of an application. It will influence the user and determine their perception of an application. A usability test is used to evaluate the usability of an application. The results of a usability test consist of the identification of usability problems in the user interface, the participants' quantitative data, and the participants' satisfaction of the application. The results are obtained by assigning task to the end users and observing their interaction with the application. This provides us with useful and relevant information about the usability of the user interface. Terrexplorer was designed taking into consideration the usability of the user interface in the development stages by the feedback provided by professors and students of the University of Puerto Rico, Mayagüez Campus.

This chapter presents the test goals, methodology, task list, test condition, and the results of the test. The following section will present the test goals and how they were determined for the usability test.

## 5.2 Test Goals

The system goals are a list of the main functionality of Terrexplorer. These goals were used to establish the test goals.

The goals for Terrexplorer are to:

1. Provide the ability to search for images and boundaries from several database using one user interface
2. Allow the user to view images and information related to an image.
3. Allow the users to have quick access to the image of interest.
4. Allow the user to navigate between the WALSAIP Boundary tool and Terrexplorer
5. Allow the user to add images into Terrexplorer's local database.

The test goal for Terrexplorer are to:

1. Determine the user's impression and understanding of the icons, menus, options, navigation scheme, and functionality of Terrexplorer (System Goals 1, 2, 3, 4).
2. Test the usability of the search options and displayed results (System Goals 1, 4).
3. Test the usability of the option to upload map images (System Goal 5).
4. Test the usability of the bookmark options and the search history option (System Goal 1,3).

From the test goals the task list for the usability test was created. The next section will present the methodology used for the usability test.

## 5.3 Methodology

The purpose of this test was to get quantitative and qualitative information about the participant's interaction with Terrexplorer. In specific, the test was conducted to measure the participants' satisfaction and find usability deficiencies in Terrexplorer. The test measured the time taken by the participants to complete each task. In addition, the user interaction with Terrexplorer was recorded with Camtasia (<http://www.techsmith.com>). Camtasia is an application designed to record the interaction between the participants and the application. There were a total of six participants for the usability test. The six participants were students from the University of Puerto Rico, Mayagüez Campus.

The usability test consisted of the following phases:

1. General orientation about the test
2. Pre test questionnaire
3. Brief description of Terrexplorer and the WALSAIP Boundary Tool,
4. Execution of tasks
5. Post test questionnaire.

As listed above, the first step of the usability test was to give the participants a general orientation. The objective of this orientation was to welcome the participant and to explain the purpose and procedure of the test.

The purpose of the pretest questionnaire was to obtain background information of the participants. This includes information such as the participant's age, sex, education, computer literacy and experience with similar systems. The information from the pretest questionnaire was used to determine the participant's knowledge and demographic. A copy of the pretest questionnaire form is included in Appendix B. After the participant completed the pretest questionnaire they were given a brief description of Terrexplorer and the WALSAIP Boundary Tool. This consisted of an overview of the user interface, components and functionality of these applications. The average time it took to brief the participants was 4 minutes. Once the participant's received the brief description they began performing the 13 tasks assigned in the usability test. The last task asked the participants to create a boundary in an image. This task would move the participants WALSAIP Boundary Tool where they would continue the usability test. This was done to test the user interaction between Terrexplorer and the WALSAIP Boundary tool.

The tasks assigned were the following:

1. Do a search for Salinas (Test Goal 1,2)
2. Select the Image where you can see the islands (Test Goal 1,2)
3. What is the resolution of that image (Test Goal 1,2)
4. Bookmark the selected image (Test Goal 1,4).
5. Go back to your last search results. (Test Goal 1,2,4).
6. Select the image where you see the coast (Test Goal 1,2).

7. Select the bookmark you created initially (Test Goal 1,4).
8. Move the bookmark to Favorites (Test Goal 1,4).
9. Upload the selected image and specify the following information (Test Goal 3)
  - Title: Test Image
  - Description: Test image for student
  - Maps: Geo Referenced
  - Coordinates Type: Datum NAD83 S.P.C
  - Image Type: FULL COLOR
  - Continent: North America
  - Image Date: 01/01/2004
  - City or State: Salinas
  - Country: Puerto Rico
  - Select Image File: C:\test\test.jpg
  - Select World File: C:\test\test.jgw
10. Do a Search with the following specifications (Test Goal 1,2)
  - Find a map of Jobos that is located in Puerto Rico in the City of Salinas.
11. Select the image where you can see map description Jobos (Test Goal 2).
12. What is the temperature of that City? (Test Goal 2).
13. Create a boundary (Test Goal 1).

After the completing the tasks, the participants were asked to fill out the post test questionnaire. The post test questionnaire was used to determine the user satisfaction. It asked the participants to rate the different areas of the application. The questionnaire used a 5 point scale system for the participants to rate the ease of use, terminology, user interface, and satisfaction. The post test questionnaire consisted of five rating questions and five open ended questions. A copy of the post test questionnaire used for Terrexplorer is in Appendix B. Usability Testing Documents.

The test conditions of the usability test are presented in the next section.

## 5.4 Test Conditions

This section describes the initial conditions of the system at the beginning of each test.

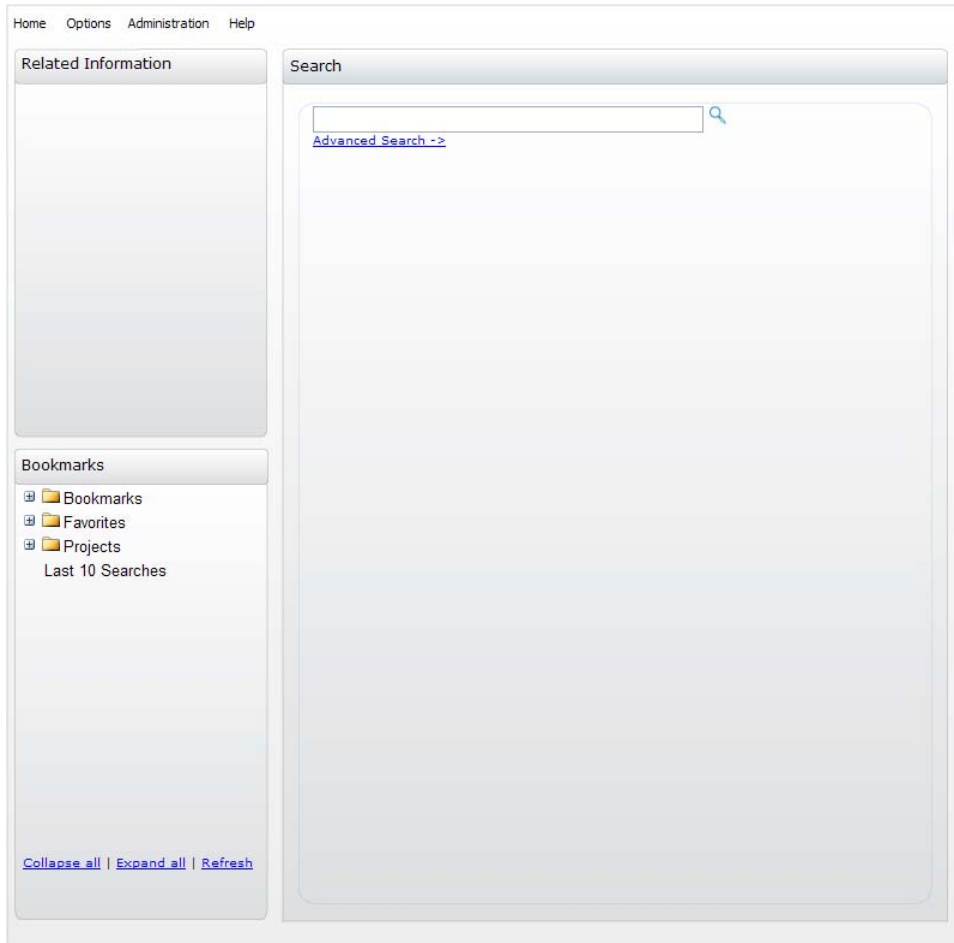
Terrexplorer contained 4 satellite images and 3 boundaries in the local database (Table 5.1).

After each participant finished the usability test, the satellite image and boundaries created during the test were eliminated from the database to offer each user the same initial conditions.

**Table 5.1 Terrexplorer Database Content**

<b>Database Content</b>
1. Salinas Coast, Salinas Southwest Coast, Format: image/jpeg, Scale 1:1 ,City or State: Salinas ,Country: Puerto Rico, Date Uploaded: 2007-11-08 , Database: Local
2. Topographic PR, Topographic map of Puerto Rico, Format: image/jpeg, Scale 1:0 ,City or State: Salinas ,Country: Puerto Rico, Date Uploaded: 2007-11-08 , Database: Local
3. Salinas Coast, Salinas Southeast Coast, Format: image/jpeg, Scale 1:1 ,City or State: Salinas ,Country: Puerto Rico, Date Uploaded: 2007-11-08 , Database: Local
4. Salinas Jobos Coast, Salinas Northwest Jobos Coast, Format: image/jpeg, Scale 1:1 ,City or State: Salinas ,Country: Puerto Rico, Date Uploaded: 2007-11-08 , Database: Local
5. Title: AGUIRRE POWER PLANT , Country: Puerto Rico , Boundary Type: Map, Database: Local
6. Title: ROAD TEST , Country: Puerto Rico , Boundary Type: Map, Database: Local
7. Title: CIRCLE , Country: Puerto Rico , Boundary Type: Map, Database: Local

At the beginning of the test each participant was presented with the user interface for a simple search (Figure 5.1). Each participant used the same computer for the test. The web browser used for the usability test was Firefox 2 (www.firefox.com).



**Figure 5.1 Terrexplorer Simple Search**

## 5.5 Results

Table 5.2 shows a summary of the participant's profile obtained from the pre test questionnaire. The participants of the usability test were between 24 to 32 years old and the

group was composed by 4 males and 2 females. The participants had between 9 to 14 years of experience using computers and 6 to 12 years using the internet. Thus, all of the participants were knowledgeable in computers and had experience using a web browser.

**Table 5.2 Pre-Test Questionnaire Results**

<b>User Profiles</b>	
Age:	24 - 32
Sex:	4 Males, 2 Females
How many years using computer :	9 – 14 Years
How many years using the Internet:	6 – 12 Years
Have used GIS:	5 No, 1 Yes

Table 5.3 shows a summary per task of the minimum time, the maximum time, average time, and the standard deviation for all participants. All the participants in the usability test were able to complete the task list. The high standard deviation presented in some tasks means that a larger sample of participants is required to have trustworthy results. Even with the high standard deviation presented in these results, it can be used to obtain an idea of the average time required to complete a task. The times and averages obtained from the six participants are not statistically significant to be used as a reference of time. Table 5.4 shows the minimum, maximum and average time for all participants to complete the task list.

**Table 5.3 Minimum, Maximum and Average Time by Task**

<b>Task</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Average</b>	<b>Standard Deviation</b>
1	17 sec	26 sec	21 sec	3.54
2	18 sec	112 sec	43 sec	36.39
3	2 sec	28 sec	13 sec	8.69
4	11 sec	122 sec	51 sec	40.33
5	24 sec	93 sec	47 sec	25.39
6	9 sec	46 sec	20 sec	13.47
7	7 sec	34 sec	17 sec	9.50
8	3 sec	97 sec	25 sec	35.94
9	79 sec	144 sec	121 sec	22.65
10	55 sec	291 sec	135 sec	88.89
11	6 sec	52 sec	16 sec	18.17
12	5 sec	24 sec	15 sec	7.34
13	7 sec	91 sec	29 sec	33.18

**Table 5.4 Minimum, Maximum and Average Time of Completing the Task List**

<b>Minimum Time</b>	<b>Maximum Time</b>	<b>Average Time</b>
4 minutes 11 seconds	13 minutes 30 seconds	9 minutes 8 seconds

Even though all participants were able to complete the tasks, several participants had problems with some specific tasks. Table 5.5 has a summary of the observations recorded during the test and some of the problems encountered by the participants. These observations and problems represent potential usability problems in the system.

**Table 5.5 Usability Problems and Observations**

<b>Observations</b>	<b>Participants</b>
1. In the simple search the users press the Enter key after entering the search parameter, but were supposed to click on magnifying glass to get search results	4
2. The user confused the magnify glass of the coordinate search with advanced search option	4
3. The users confused the bookmark icons with the browsers bookmark options	3
4. If the user wanted to go back they pressed the back button of the browser. This would return them back to the login page.	2
5. The user confused the meaning of the icons	3
6. Used the icons tooltips	1
7. Did a simple search in a advance search task	3
8. Did an advance search in a simple search task	2

Table 5.6 summarizes the post test questionnaire results that measured the user’s satisfaction with the application. As seen in the table, the participants found the application easy to use and useful for searching and obtaining information about satellite images.

**Table 5.6 Post Test Questionnaire Results**

<b>Questions</b>	<b>Meaning “1”</b>	<b>Meaning “5”</b>	<b>Average</b>
<b>1. Did you find the interface of the web application easy to understand?</b>	Did not understand	Understand Completely	4.33
<b>2. Do you find that the advanced search form is clear and concise?</b>	Not clear	Completely Clear	4.50
<b>3. How useful are the search options?</b>	Not useful	Very useful	4.83
<b>4. Did you understand what each icon represents?</b>	Did not understand	Understand Completely	4.50
<b>5. Did you find the navigation of the web application?</b>	Complicated	Very easy	4.00

### 5.5.1 Results Discussion

The first task of the test asked the participants to realize a simple search. The majority of the participants (66%) pressed the Enter key of the keyboard to initialize the search after filling out the search text field. However, the search is executed by pressing the magnifying glass icon next to the search text field (Figure 5.1). When the participants figured out that pressing Enter did not return the search results, they clicked the magnifying glass icon to display the search results. This indicates the need for the system to recognize when the users press Enter in the text box of the simple search and to initialize a search by such action.

As can be observed from Table 5.3 the average time it took the participants to complete the task number 6 was much less than the average time taken for task number 2. Both of these tasks required the participants to use the preview option to find a specific image. The participant was able to do the similar task more rapidly the second time. This denotes that the participants understood the option to preview the images in the search results more quickly.

There were certain situations in which some participants wanted to go back to the search results. Many would press the Back button available in the browser and the browser would display the login page. However, after the participants realized that the Back button from the web browser was not working as intended, they pressed the Forward button and continued with the task. This behavior occurred when the participants were trying to complete the task number 5, which asked them to go back to the last search results. Apparently some participants were confused with the terminology of the task description and they responded pressing the Back button of the browser. Even with this problem, the participants eventually realized what the task required and completed the task successfully by selecting the “Last 10 Searches” link in the Bookmark panel of Terrexplorer.

Another observation was that some participants realized a simple search in task number 10 which required an advanced search. Similarly, some participants realized an advanced search in task number 1, even though it only required a simple search. None of the task descriptions stated specifically what type of search to use. The search results returned were the same. In the cases when an advanced search was done instead of a simple search, the participants typed in the text field the description specified in task number 10. Since the content of the local database contained only seven entries, the results from the simple search returned the same as the advanced search. The participants were able to continue with the task and did not notice the difference.

Four participants had trouble identifying some of the icons in Terrexplorer. The most frequent was the coordinate search icon. The majority of the users tried to do an advanced search by pressing this icon and later discovered that it was a coordinate search. This occurred when the participant changed from the upload form tab to the main user interface of Terrexplorer, to complete task number 10.

The bookmark icon and the boundary icon were also confused momentarily by three participants. However, the participants were able to determine the meaning of the icons when they selected the icon or saw the tool tip of the icon. This behavior was observed while the participant was doing the task number 4, 5, and 13. The task related to those icons were completed successfully in spite of the difficulty of figuring out the meaning of the icons.

Task number 7 asked the participants to select a bookmark that was created previously in task number 4. Three participants selected the Bookmark option of the web browser instead of using the Bookmark Panel in Terrexplorer. However, after finding out that no bookmark was available in the web browser they proceeded to the Bookmark Panel in Terrexplorer and completed the task successfully.

The participants had several minor problems with the user interface but in no moment it impeded the completion of the tasks assigned. All the participants were able to complete the tasks in the task list. Table 5.4 indicates that the majority of the tasks had an average completion time of less than one minute. The only tasks that took more time were task

number 9 (uploading an image), and task number 10 (advanced search). The longer time taken to complete task number 9 (uploading an image) was due to all the fields that the participants had to specify and the time required to upload a file into the system. Similarly, the time for task number 10 was affected by the time it required to enter the search specification and time consumed by the system to conduct a search and display the search results.

In the last phase of the usability test the users were given a post-test questionnaire. As shown in the summary of the result from this questionnaire (Table 5.6), the participants rated Terrexplorer very highly. The participants found the system to be very useful for searching images and boundaries and in general found the interface to be straight forward and easy to understand.

The open ended questions resulted in the following recommendations:

1. To add more databases to the search option of Terrexplorer.
2. To add the ability to submit a search by pressing Enter in the simple search form.

The next chapter will discuss the conclusions and recommendations for future work.

## 6 CONCLUSIONS

The main objective of this research was to develop a web application that could work with different types of geographical information and that could search different databases and web sites using one user interface. This was accomplished with the creation of a web application tool called Terrexplorer, which manages different types of information such as: boundaries, satellite images, metadata, and information related to the images. As explained previously, the application also allows users to search multiple databases within a single user interface.

Terrexplorer is a unique application tool in the way that it manages data from several different sources and incorporates them in one user interface. This helps distinguish Terrexplorer from other web application tools in the internet. Users can access information by using an advanced search, simple search, last search, and bookmarks. Another feature of the interface is the ability to view information related to the images selected or displayed. This includes different type of data such as: present weather data associated with the image's location, information about the country represented by the image, and technical information about the image itself.

Another objective of this research was to reduce information overload. This objective was accomplish by implementing an adaptive user interface that displays the information

necessary in the related information panel and by selecting the type of search the user requires when he logs on Terrexplorer.

In any application with the capabilities to anticipate the user's needs and display relevant information to the user, the usability of the user interface is critical. Therefore, another of the objectives of this research was to apply usability principles, guidelines, and evaluations throughout the development of the project. In order to evaluate the results of this objective, a usability evaluation was conducted to determine if there were any major usability deficiencies in Terrexplorer. The evaluation also was used to determine the user's impression after using the system and their satisfaction with the system. The impact of incorporating usability principles and guidelines throughout the development of Terrexplorer was demonstrated with the results of the usability test. The results indicate that the usability deficiencies were minimal and that all the participants were able to complete the tasks given.

The results of the usability test suggested that there must be a redesign of some icons to make them more intuitive and that the word "bookmark" used in the application must be changed to avoid confusion with the bookmarks in the web browser. The participants in the post test questionnaire rated Terrexplorer very high in user satisfaction.

A new usability test with more participants is required in order to have statistically significant data from the evaluation. However, even with six participants only, the results

collected and observations were of value. The usability test showed that the majority of the tasks assigned to the users took in average less than two minutes to complete, indicating that the user interface in Terrexplorer is easy to use.

The other important objective of this research was to integrate Terrexplorer with the WALSAIP Boundary. The interaction between Terrexplorer and the WALSAIP Boundary Tool allow users to access the tool in order to create, edit, and view boundaries and to search for them using Terrexplorer. The usability test showed that participants were able to interact or transition easily between Terrexplorer and the WALSAIP Boundary tool as if they were using only a single web application.

The objectives of this research were all accomplished. The results of these objectives are the creation of a web application, a usability evaluation, and the integration of Terrexplorer and WALSAIP Boundary Tool. The following section will discuss the future work and the overall recommendations to improve and expand Terrexplorer.

## **6.1 Future Work**

Terrexplorer is a web application tool that still has much room for improvement. There are certain features or recommendations that would make the application more useful and resourceful for the researcher. Some of these are:

1. A framework to add new functionality to Terrexplorer
2. A mechanism to allow the easy connection to new databases and data sources from the internet
3. Integration with other WALSAIP projects
4. Redesign of icons in Terrexplorer
5. Usability evaluation with a significant number of participants

With these features or recommendations implemented, Terrexplorer will greatly improve. The first feature will help to develop extension and features without the need to touch the main code of Terrexplorer. For example, the ability to add new data types by using a plug-in to customize the functionality of Terrexplorer.

The second recommendation will help expand the information available in satellite images and boundaries giving the user more search results. The third will integrate other WALSAIP projects, as image operators and sensors information to provide a common user interface for the users. WALSAIP projects are environmental applications that have been implemented and designed by students and faculty of the University of Puerto Rico, Mayagüez Campus. This would allow the researchers to see the information related with the sensors and image operators in Terrexplorer without the need to access other sources of information. Finally, the redesign of icons will help clarify the meaning of the icons to the users.

## References

- [1] Geller, T, “Imaging the World: The State of Online Mapping ” *Computer Graphics and Applications, IEEE*, Volume 27, Issue 2, March-April 2007 Page(s):8 – 13 Digital Object Identifier 10.1109/MCG.2007.39
- [2] Serrano, Nicolóys; Aroztegi and Juan Pablo ,”Ajax Frameworks in Interactive Web Apps” *Software, IEEE* Volume 24, Issue 5, Sept.-Oct. 2007 Page(s): 12–14 Digital Object Identifier 10.1109/MS.2007.132
- [3] Granic, Andrina; Nakic, Jelena; “Meeting User Individual Characteristics through Adaptive Interface of an e-Learning System: An Empirical Study Design”, *Information Technology Interfaces, 2007. ITI 2007. 29th International Conference on 25-28 June 2007* Page(s):333 - 338
- [4] Granic, A.; Glavinic, V.; “Functionality specification for adaptive user interfaces”, *Electrotechnical Conference, 2000. MELECON 2000. 10th Mediterranean Volume 1, 29-31 May 2000* Page(s):123 - 126 vol.1
- [5] Jiming Liu; Chi Kuen Wong; Ka Keung Hui; “An adaptive user interface based on personalized learning”, *Intelligent Systems, Volume 18, Issue 2, Mar-Apr 2003* Page(s):52 – 57
- [6] Davis, J.; Tierney, A.; Chang, E.; “A user adaptable user interface model to support ubiquitous user access to EIS style applications” , *Computer Software and Applications Conference, 2005. COMPSAC 2005. 29th Annual International Volume 1, 26-28 July 2005* Page(s):351 - 358 Vol. 2
- [7] Grundy, J.; Hosking, J.; “Developing adaptable user interfaces for component-based systems”, *User Interface Conference, 2000. AUIC 2000. First Australasian 31 Jan.-3 Feb. 2000* Page(s): 17 – 25
- [8] Cudd, P.A.; Oskouie, R.; “Combining HCI techniques for better user interfacing”, *IEE Colloquium on Interfaces - The Leading Edge (Digest No.1996/126) 3 April 1996* Page(s): 11/1 - 11/9

- [9] Wills, C.E.; “User interface design for the engineer”, Electro/94 International. Conference Proceedings. Combined Volumes. 10-12 May 1994 Page(s):415 – 419
- [10] Lopes de Oliveira, J.; Mederiso, C.B.; Cilia, M.A.; “Active customization of GIS user interfaces”, Data Engineering, 1997. Proceedings. 13th International Conference on 7-11 April 1997 Page(s): 487 – 496
- [11] Elvins, T.T.; Jain, R.; “Engineering a human factor-based geographic user interface”, Computer Graphics and Applications, IEEE, Volume 18, Issue 3, May-June 1998 Page(s):66 - 77
- [12] James E. Stern; “NOAA Manual NOS NGS5 State Coordinate System of 1983”, U.S Department of Commerce National Oceanic and Atmospheric Administration, September 1995
- [13] North Carolina Department of Environment and Natural Resources, [http://gis.enr.state.nc.us/sid/bin/zhelpworld\\_nofrm.htm](http://gis.enr.state.nc.us/sid/bin/zhelpworld_nofrm.htm), 2007
- [14] Spink, A.; Jansen, B.J.; Blakely, C.; Koshman, S.; “Overlap Among Major Web Search Engines”, Information Technology: New Generations, 2006. ITNG 2006. Third International Conference on\_10-12 April 2006 Page(s): 370 – 374
- [15] Kawano, H.,” Overview of Mondou Web search engine using text mining and information visualizing technologies” Digital Libraries: Research and Practice, 2000 Kyoto, International Conference on 13-16 Nov. 2000 Page(s): 234 - 244

# Appendix A: Usability Testing Documents

## Pre-Test Questionnaire

The purpose of the questionnaire is to obtain an idea about your experience and knowledge.

1. Age: \_\_\_\_\_
2. Academic Preparation:  Associate  Bachelor  Master  Doctorate  
Concentration: \_\_\_\_\_
3. Area of Investigation or interest  
\_\_\_\_\_
4. Sex:  Male  Female
5. How many years of experience you have with computers?  
\_\_\_\_\_
6. How many hours daily do you use the computer?  
\_\_\_\_\_
7. How many years have you used the Internet?  
\_\_\_\_\_
8. Have you used a G.I.S (geographic information system) application?  
 Yes  No (if your answer is no pass to question number #11)
9. What is the name of the GIS application used?  
\_\_\_\_\_
10. What are the limitations of the existing system that you used?  
\_\_\_\_\_
11. Have you used a web based map application as Google Maps, Terraserver ?  
 Yes  No (if your answer is no skip question number #12)
12. Please insert in the table the web applications you have used.

Web application name	Times used
1. Google Maps	
2. Map Quest	
3.	

Post-Test Questionnaire

The following questionnaire is to extract information from the user in which can not be reflected by the usability test alone. This is done to determine which are the areas of the interface which needs to be modify to suit the needs of the typical user.

6. Did you find the interface of the web application easy to understand?  
(*Did not understand*) 1 2 3 4 5 (*Understand completely*)

7. Do you find that the advanced search form is clear and concise?  
(*Not clear*) 1 2 3 4 5 (*Completely clear*)

8. How useful are the search options ?  
(*Not useful*) 1 2 3 4 5 (*Very useful*)

9. Did you understand what each icon represents?  
(*Did not understand*) 1 2 3 4 5 (*Understand completely*)

10. Did you find the navigation of the web application?  
(*Complicated*) 1 2 3 4 5 (*Very easy*)

11. Did Terrexplorer seem useful to your needs?

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---

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12. What improvements do you see as necessary?

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13. Any comment about the application?

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---

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14. Did the search options provided are useful?

---

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---

---

15. Would you use this application for your everyday work?

---

---

---

## Task List

1. Do a search for Salinas
2. Select the Image where you can see the islands
3. What is the resolution of that image
4. Bookmark the selected image
5. Go back to your last search results.
6. Select the image where you see the coast
7. Select the bookmark you created initially
8. Move the bookmark to Favorites
9. Upload the selected image and specify the following information  
Title: Test Image  
Description: Test image for student  
Maps: Geo Referenced  
Coordinates Type: Datum NAD83 S.P.C  
Image Type: FULL COLOR  
Continent: North America  
Image Date: 01/01/2004  
City or State: Salinas  
Country: Puerto Rico  
Select Image File: C:\test\test.jpg  
Select World File: C:\test\test.jgw
10. Do a Search with the following specifications  
Find a map of Jobos that is located in Puerto Rico in the City of Salinas
11. Select the image where you can see map description Jobos
12. What is the temperature of that City?
13. Create a boundary

## Appendix B. World File Example

0.00756992686878552

0.000000

0.000000

-0.00756992686878552

-68.3461954775724

20.1959449559992

## Appendix C. User Guide

This section presents the steps to allow the user to search and to download and image in Terrexplorer.

- Enter in the web browser <https://hcisrv.ece.uprm.edu/~william/>
- The user must enter the username and password to access the main user interface.
- On the menu bar select the options Advanced Search. (see Figure C.1)

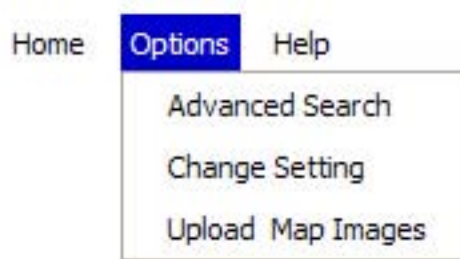


Figure C.1 Menu Options

- Enter the fields required for your search (see Figure C.2).
- Once the fields for your search are filled press the search button.

Home Options Help

**Related Information**

---

**Bookmarks**

- Bookmarks
- Favorites
- Projects
- Last 10 Searches

[Collapse all](#) | [Expand all](#) | [Refresh](#)

**Advanced Search**

[Simple Search ->](#)

Please specify at least one of the fields.

Title:

Description:

Type of Search:  Both  Maps  Boundaries

Maps:  All  Geo Referenced  Not Geo Referenced

Image Type:

Scale: 1:   and larger scale(more detail)  
 Exactly this scale  
 and smaller scale(less detail)

Upper Left Cord. Latitude  Longitude

Lower Right Cord. Latitude  Longitude

Continent:

From Date:

To Date:

City or State:

Country:

Select Database to Search:

Figure C.2 Advanced Search Selection

- The search results will be displayed (see figure C.3)
- The user can select the results by clicking on the title or the preview link

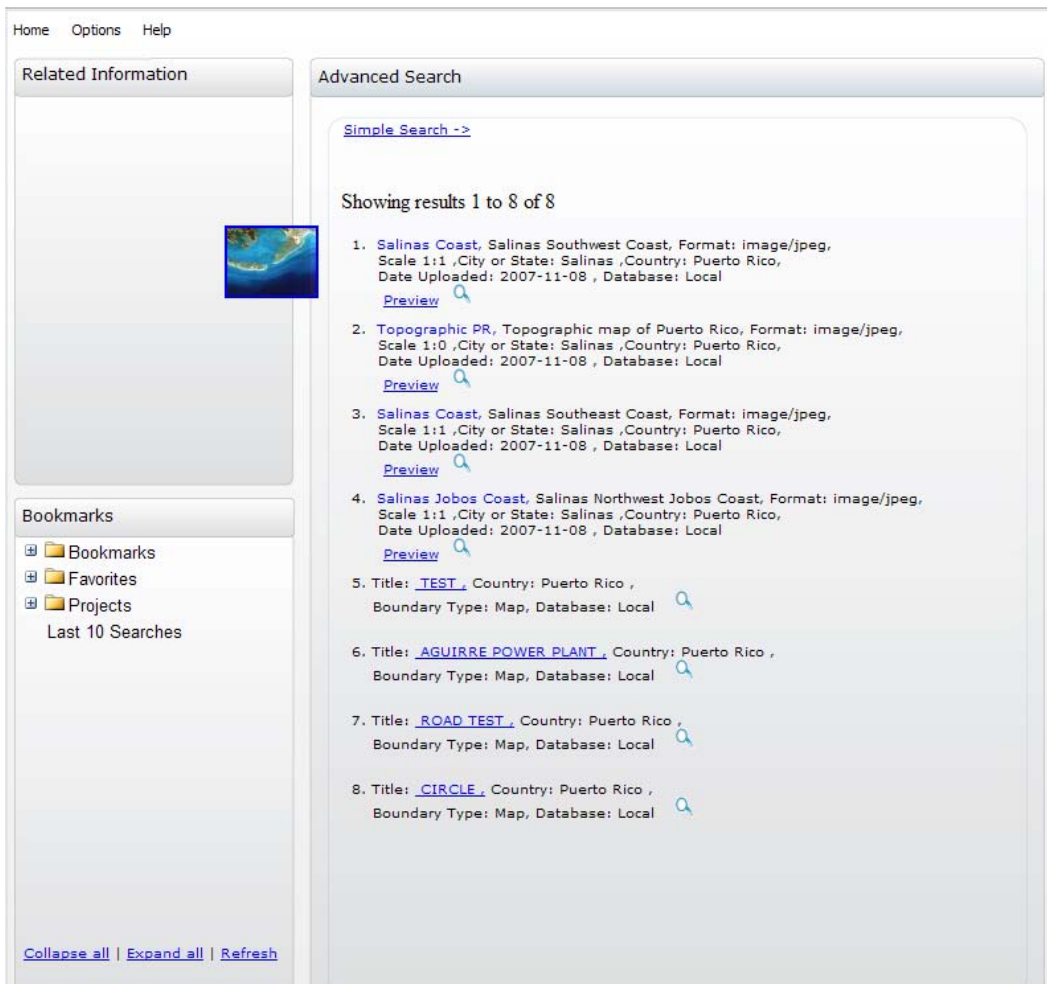


Figure C.3 Advanced Search Selection

- Once the user selects and image the several new options will be displayed (see Figure C.4)
- If the user selects a boundary Terrexplorer will automatically open the WALSAIP Boundary Tool

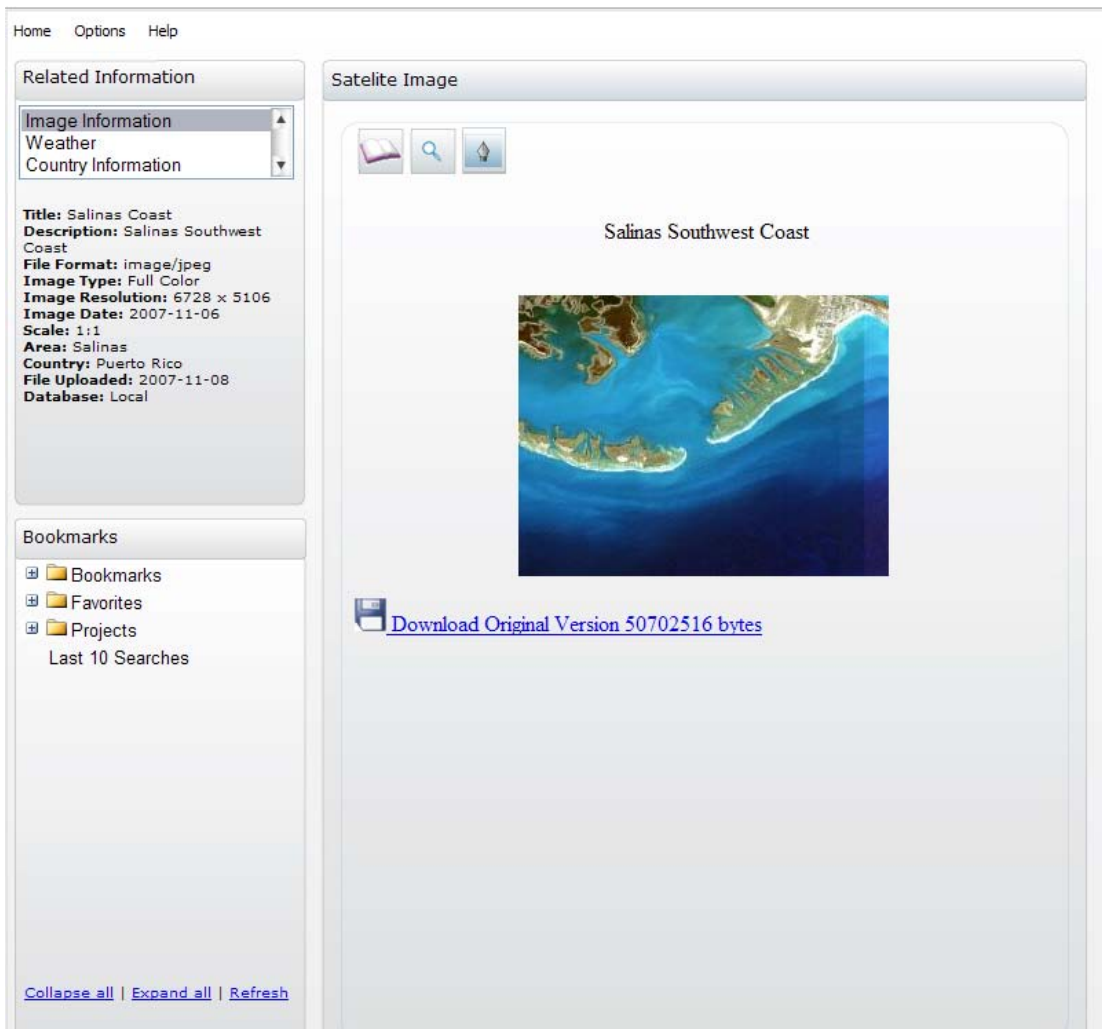


Figure C.3 Satellite Image Options

- To download an image click on the link “Download Original Version”
- The web browser will ask to save or open the selected file.