INSTITUTO POLITÉCNICO DE BRAGANÇA
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Development of an historical landscape photography database to support landscape change analysis in the Northeast of Portugal

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Dissertation presented to the School of Agriculture of Bragança in partial fulfillment of the requirements for the degree of Master of Science in Forest Resources Management

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Bragança
July 2016

بِسْمِ اللهِ الرَّحْمنِ الرَّحِيم

"قُلْ إِنَّ صَلاتِي وَنُسُكِي وَمَحْيَايَ وَمَمَاتِي لِلَّهِ رَبِّ الْعَالَمِينَ, لا شَرِيكَ لَهُ وَبِذَلِكَ أُمِرْتُ وَأَنَا أَوَّلُ الْمُسْلِمِينَ"

In the name of Allah, most gracious, most merciful

"Say, Indeed, my prayer, my rites of sacrifice, my living and my dying are for Allah, Lord of the worlds"

Acknowledgments

First I would like to thank my thesis advisor **Sérgio Deusdado**, Professor in the Escola Superior Agraria at the Instituto Politécnico de Bragança. His office door was always open whenever I need help about my research or writing. He consistently allowed this paper to be my own work, but steered me in the right direction whenever he thought I needed it.

I would like also to thank my co-advisors who were involved in the supervision of this research project: **João Azevedo** professor in the Escola Superior Agraria at the Instituto Politécnico de Bragança and **El Ayachi Sehhar** Professor in the Agronomy Department of Agronomy and Veterinary Institute HASSAN II. Without their passionate participation and input, the validation survey could not have been successfully conducted.

I would also like to acknowledge **Nuno Carvalho**, technician in the Escola Superior Agrária at the Instituto Politécnico de Bragança, I am gratefully indebted for his very valuable comments and help during the practical phase of the project.

I am deeply grateful to all members of the jury, **Amílcar Teixeira** and **josé exposto,** for agreeing to read the manuscript and to participate in the defense of this thesis.

My sincere thanks to the Faculty and administrative body of the **Instituto Politécnico de Bragança** and **Agronomy and Veterinary Institute HASSAN II** for giving me all the necessary knowledge during my studies in Rabat and Bragança.

Finally, I must express my very profound gratitude to my parents, my sister **Khadija**, my brother **Ahmed** and my friends for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of research and writing of this thesis. This accomplishment would not have been possible without them. Thank you.

Abstract

Repeat photography is an efficient, effective and useful method to identify trends of changes in the landscapes. It was used to illustrate long-term changes occurring in the landscapes. In the Northeast of Portugal, landscapes changes is currently driven mostly by agriculture abandonment and agriculture and energy policy. However, there is a need to monitoring changes in the region using a multitemporal and multiscale approach.

This project aimed to establish an online repository of oblique digital photography from the region to be used to register the condition of the landscape as recorded in historical and contemporary photography over time as well as to support qualitative and quantitative assessment of change in the landscape using repeat photography techniques and methods.

It involved the development of a relational database and a series of web-based services using PHP: Hypertext Preprocessor language, and the development of an interface, with Joomla, of pictures uploading and downloading by users. The repository will make possible to upload, store, search by location, theme, or date, display, and download pictures for Northeastern Portugal. The website service is devoted to help researchers to obtain quickly the photographs needed to apply RP through a developed search engine. It can be accessed at: http://esa.ipb.pt/digitalandscape/.

Keywords: Repeat photography, landscape change, PHP/MySQL, online database, Relational database.

Resumo

A fotografia histórica é um método útil e eficiente para realizar estudos comparativos e evolutivos das alterações da paisagem e, em geral, da geografia. Tem sido amplamente usado para ilustrar as alterações mais importantes ocorridas cronologicamente nas paisagens. No Nordeste de Portugal, as alterações da paisagem devem-se, sobretudo, ao abandono da exploração agrícola que teve como consequência a florestação de novas áreas, bem como pelas construções para aproveitamento da energia hidráulica ou eólica. Em súmula, é evidente a necessidade de monitorizar as alterações da geografia da região usando uma abordagem multi-temporal e multi-escala.

Este trabalho teve por objetivo principal a implementação de um repositório digital para registos fotográficos históricos da paisagem da região de Trás-os-Montes, com o intuito de disponibilizar serviços web que permitem o armazenamento e o acesso aos registos fotográficos históricos e contemporâneos das paisagens da região, permitindo assim uma análise quantitativa e qualitativa da evolução dessas paisagens.

Em termos práticos, envolveu a criação de uma base de dados relacional e uma pletora de serviços web usando recursos de programação para a web, nomeadamente PHP e Javascript. Requereu igualmente a criação de um website para a centralização e disponibilização dos serviços, este foi elaborado com base em Joomla. Assim, disponibiliza-se à comunidade académica, e não só, um conjunto de serviços digitais para o estudo, com base em fotografia, das alterações na paisagem em Trás-os-Montes. O website pode ser acedido em http://esa.ipb.pt/digitalandscape/.

Palavras-chave: Fotografia histórica da paisagem, alterações da paisagem, PHP/MySQL, bases de dados online, base de dados relacional.

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1. Introduction

Monitoring landscapes becomes today necessary, especially in the context of climate change, agriculture abandonment and energy policy. A subject that interests several areas, but it is not within the reach of everyone to optimize the solutions aiming to resolve their problems.

Many different tools were developed to acquire information on changes in the environment, such as remote sensing, geographic information system, cartography etc. but most of them were limited because of the use of the large scales, and also because they are based on knowledge and techniques to analyze and to interpret the results which are not always mastered by most of the users.

For these reasons, we must think of an alternative approaches to track and assess landscapes at different scales, and that can be used for different purposes and in many different fields.

In the face of such challenges, the development of repeat photography (RP) occurs as one of the best solutions, but it requires the involvement of new technology to manage information and to ensure interactivity among users.

The present work was developed from this perspective. It aims to establish an online repository of oblique photography in the North-eastern region of Portugal, to register the condition of the landscapes as recorded in historical and contemporary photography over time as well as to support qualitative and quantitative assessment of change in the landscape using RP techniques and methods.

Such systems require a prior analysis of needs in order to make decisions on technology and tools to use in their development and implementation. The web is becoming a privileged channel of communication between individuals, as it can provide a level of availability that cannot be obtained with the applications considered traditional.

The development of the system must keep in mind the ease of use and availability of information, ensuring their security and the possibility of future updates.

1.1. Problem

To assess landscapes using an approach based on repeat photography, we need a set of historical images taken over several years. This problem claims the collection, organization, cataloguing, retrieval and backup of large amounts of diverse types of oblique images.

We needed to establish a database that can support the huge number of information used in repeat photography application. For this reason, we had to choose the adequate tools and adopt the right methods to meet the objectives of the work, taken into account the costs, the availability and the efficiency.

The involvement of people is mandatory to interact with the database, because the efficiency and continuity of the project will be ensured by this kind of relationships. Users should feed the database with their images and benefit of the services provided by it, hence the necessity to have an online interface available.

1.2. Objectives

The aim of this project was to conceive, develop and implement an online oblique photography repository for Northeastern Portugal. This repository should be a reference for images and all the information needed to support the application of RP methods and techniques in the region.

The purpose of the web site is multifaceted; it was designed to serve the following goals:

- Offer users the possibility to upload their own historic or current photographs ;
- Provide a platform for users to search for images of the region (Trás-os-Montes);
- Provide users the main resources to learn more about the inventory and monitoring of landscapes in several levels (can be used for assessment of the effect of climate change, land cover changes, etc.);
- Provide managers and scientists a large amount of data about landscape change through images that would be extremely difficult to collect otherwise.

1.3. Methodology

For this project, the approach can be broken down as follows:

- Literature review for better understanding the repeat photography approach and the database structure and website interfaces;
- Choice of tools and methods;
- Design of the database and the interface;
- Implementation of the database;
- Implementation, validation and evaluation of the system.

1.4. Document organization

This document is organized into five chapters:

- The first chapter consists of an introduction presenting the objectives and the methodology to follow in this paper.
- The second chapter is dedicated to examine documentation about repeat photography and an overview about related work.
- The third chapter presents the adopted methods and exploited materiel.
- The development of the database and the design of the website will be the subject of the fourth chapter.
- The methodology evaluation and the results obtain from the usability tests will be detailed in the final chapter.

2. Related work

2.1. Oblique photography

Oblique photography refers to images “taken with the camera axis intentionally directed between the horizontal and the vertical” (Wolf, 1983) and “terrestrial” alludes to the fact that it is taken from an elevated ground-based observation point, instead of an aerial platform. It presents another form of generation of data to communicate the change of the landscape at the local scale, using a huge collection of pictures of aerial photographs (Chandler et al., 2002; Corripio, 2004)

The usefulness of aerial photographs has been recognized within ecological management as a valuable source for historical analysis (e.g. Morgan and Gergel, 2013; Morgan et al., 2010), but it is also increasingly used in the analysis of cultural landscapes (Michelin et al., 2011; Stichelbaut, 2006).

While aerial photography and satellite imagery are the usual data sources used in remote sensing, land based oblique photographs can also be used to measure ecological change (Stockdale et al., 2015).

One of the most interesting examples of application of oblique photos has done in Denmark after World War II. A study based on a collection of oblique images covering all parts of Denmark recorded between 1930 and 1990 to illustrate the changes that have a place in the rural landscape at the local scale to help authorities take decisions of Layouts (Svenningsen et al., 2015).

2.2. Repeat photography

Repeat photography is the process of replicating a previously taken photograph, typically for purposes of observing and assessing change (Bebis et al., 2011).

The first study based on RP led by a Bavarian professor, Sebastian Finsterwalder, in 1889. He pioneered the use of repeat photography as a temporal surveying instrument in measurement of the geology and structure of the Alps and their glacier flows. The measurement techniques he developed and the data he produced are still in use to discover evidence for climate change.

Several studies used repeat photography as a scientific tool to assess many aspects of changes over widely differing landscapes. The scientists demonstrate the use of this technique to record the effects of climate change on the landscapes (Chen et al., 2011), to track changes in the land use (Bass 2006; Webb et al., 2010; White and Hart, 2007; Zier and Baker, 2006), and to assess the erosion (Graf, 1978). The interpretation of changes can be simplistic, and repeat photography can reveal the causes and the effects that may be an indicative of future changes in the landscape (Webb et al., 2010).

Changes in river system have also been recorded in several repeat photography projects (Graf 2000). Repeat photography was helpful to answer many question about fluvial dynamic, erosion and deposition (Butler, 1994; Osterkamp et al., 1995; Cluer, 1995). For instance, the effect of plants on the resistance of erosion (Graf, 1978), and the response of the channel alteration to the mining (Graf, 1979). Others researches was made on the basis of this method to understand the geomorphic nature of river system, and to produce a solid reconstruction of past conditions that framed the evolution of streams (Trimble, 2009).

Repeat photography can be a powerful educational and political tool in making decisions concerning the environment, to increase public awareness, to understand changes and the likely consequences of the decisions of land use, to document the damage caused by using old landscape where a new manager cannot intervene or take action for rehabilitation (Bullock et al. 2004).

Monitoring the landscapes after natural disasters is another area of wide application of repeat photography. This method was used after the disaster recovery of Hurricane Katrina (the most damaging hurricane of the busy 2005 season, affected an area of some 90,000 square miles and claimed the lives of more than 1,800 people) to establish an innovative way of evaluating needs and priorities in the recovery area within the affected communities, and also following the reconstruction of the built environment after Hurricane Katrina geographically and temporarily in Mississippi (Burton et al., 2011).

The strengths of repeat photography lies in the length of time that covers (can reach more than 100 years), another very significant lies in the relative cost / effectiveness, especially in developing countries where climate change, and also the evolution of land use methods that contributes to change the landscape at a large scale (Webb et al., 2010).

Repeat photography was underestimated in the assessment of landscape changes due to the evolution of technology that tracks the landscape with several methods, but it was clear that combining images with the results of other tools can provide a broad overview of the changes that could not be reached otherwise (Moore et al. 2016).

2.3. Application of repeat photography

The satellite imagery can never replace the usefulness of repeat photography in studies of landscape changes due to the wide span of time available and the relative cost / efficiency (Byers 2000; Webb et al., 2010).

The areas of application of the method are diverse: the climate change, the geosciences, plant population ecology, the evolution of ecosystems and cultural change etc.

- **Glacial studies**

The retreat of glacier in the Alpes was the first subject of repeat photography (Diane E. Boyer, 2007). Since the 1889s techniques and methods were developed for surveying and evaluating the dynamic of massif glacial (Schmidt and Nüsser, 2009; Marston, 1991; Kamp et al. 2013).

Many articles examining the loss of glacial massif in mountains were published. They quantified the loss using either only repeat photography, or combining its results with other tools like remote sensing and public interview (Byers 2008). The photographs taken in these studies constitute an important historical records, as well as a data collection of interest to those studying the glaciers response to climate change.

- **Quantitative studies of environmental changes**

Change in land used over time, as mentioned before, is one of the most discussed subject of repeat photography (Kull 2005; Masubelele et al.; 2015; Munro et al. 2008). Dramatic increases of population numbers boosted the need of forest and fodder production which explain the change in agriculture land, transformation of arable land to other use such as afforestation, urbanization and recreational area, this issues were explained by repeat photography (Vaishar 2004).

A recent study by M. J. C. Patrício (2014) at the University of Lisboa was based on the repeat photography to obtain direct evidence of the evolution of the landscape Arrábida, and possible environmental changes. For this reason, a system has been set up to record the visual changes to develop a diachronic profile of the property applied to this world's

heritage site. Considering a significant interval of time, the ultimate goal was to establish a database that is growing more and more which allows a continuous interpretation of photographic documents.

Webb et al. (2010) recommended the use of photography in monitoring the plants population in demographic studies and those interested by directional trends.

- **Ecosystems changes**

Documentation of change in the ecosystems is one of the major studies that supported the necessity of the use of repeat photography.

The breadth of possibilities of using repeat photography in the several area was shown clearly by applying it in three continents, more over in three different ecosystems ranging from forest ecosystems in South America to riparian ecosystem in Australia, and the combination of results with other metrics of land use provide a semi-quantitative analysis of landscape changes (Veblen et al., 1994; Nyssen et al., 2010; Lewis, 2002).

Repeat photography can serve supporting the results of different tools since it can document certain elements of ecosystem that cannot be observed otherwise (Angell and McClaran, 2001). Despite the repeat photography, aerial photography, and satellite imagery have different scales at different resolutions, the longer time period offered by repeat photography may be as important as the quantitative potential for vertical imagery in ecosystem change applications.

- **Cultural application**

The application of repeat photography in anthropological issues and human geography is relatively new. Smith provided a document in 2007 which examines the application of the repeat photography as distinctive and innovative method in visual anthropology, tried by this document to answer questions such as:

-how is ethnography practice encountered in visual anthropology and visual art?

-how are archives encountered in visual anthropology and visual art?

-how does repeat photography produce a shared ethnographic space?

One of the studies which is based on the method for documenting changes in patterns of land use coupled with the human experience was led by Bass (2006) in Honduras. Another example, in Scotland, where Rohde (2004) has shown how changes in the practices of land use affects the landscape in the cultural community. In addition, he

discussed how the Scottish highland changes by responding to climate change, urbanization and land use practice.

2.4. Repeat photography databases

The collection, storage, formatting, handling and use of information are provided by database management systems. It is one of the most powerful tools that provide quick access to information in complex systems, since it allows users to sort, search, add and delete records easily.

Historical photographs are available in large archives and can be obtained via internet. Moreover, large libraries are turning more and more towards numeric data and to make them available online. Institutions that do not make their collections available online see a regression in terms of users, hence the importance of publicly assessable databases.

Many studies were founded on exploitation of the database's characteristics, especially to store and manage the data that will be useful for a long terms such as monitoring of landscapes through repeat photography.

Many databases were developed in order to store digital images of landscapes, serving as a helpful repository to track landscapes for different aims. For example, to encourage indigenous peoples to participate in the management and sustainable use of the physical environment, to reduce gaps in knowledge about the decline of biodiversity and actions to reverse the trends, identify gaps in knowledge, policy support and capacity building to support the interface between politics and knowledge (Díaz et al. 2015; Koetz, Farrell, and Bridgewater 2012; Pert et al. 2015).

The approach of repeat photography requires conservation of photographs for several years, to build a complete collection of historical landscape photographs which will form a perfect database for others researches (Marcus Nüsser, 1997). This interactivity between scientists was ensured by the creation of Santa Rita Experimental Range (SRER) in 1903, one of the largest digital archive that provides a long-term measurements and repeat photograph collections that have been collected systematically over 21,000 ha.

Another famous database called the U.S. Geological Survey (USGS) is one of the largest archive of repeat photography; it contains images from the American Southwest, from northwestern Mexico and Kenya. USGS, maintained by the Desert Laboratory

Collection, has many roles in terms of providing data that is important to understand the changes in desert environments because of climate variation and land use practice.

3. Methodolgy

3.1. Database

Database, also called electronic database, any collection of data, or information that is specially organized for rapid search and retrieval by a computer. Databases are structured to facilitate the storage, retrieval, modification, and deletion of data in conjunction with various data-processing operations (Parker and Morley, 2015).

3.1.1. Relational database model

The A relational model was introduced by E. F. Codd in 1970. It has since been used as a theoretical and practical basis for many investigation and applications as well.

The research that led to the relational model was motivated by the need to achieve three main objectives (Paredaens et al., 1989)

- **The data independence objective:** clear distinction between the physical and logical aspect in the management of databases (including database design, data recovery, and data manipulation);
- **The communicability objective:** structure the model as simple as possible to allow all kinds of users and programmers to understand data in a common way to facilitate communication between them about the database;
- **The set-processing objective:** the introduction of high level concepts allowing users to express operations on chunks of information at once. This entailed the ability to express in a single statement, processing multiple sets of records at a time.

To meet these three main objectives, it was necessary to take a new look at data processing and forget all the data structuring concepts that are unfamiliar for users, for example, the repeating groups and related structures (Codd, 1982).

To represent data and the relationship between them, the relational model uses a collection of tables that have a logical structure defined and maintained by the database manager. It is a kind of association between three important components (Sumathi and Esakkirajan 2007): a) the structural part, which defines the database (DB) as a set of relations, b) the integrity part, maintained by primary and foreign keys, and c) the

manipulative part, based on a set of relational algebra and calculus, these latter constitute the principal tools to manipulate data in database.

The relational model allows the manager to separate the logical (definition of the database tables and relationship) and physical (storing and retrieving data from physical storage) database design which caused its domination over other models (Teorey 2011).

3.1.2. Entity Relationship (ER) model

To design a relational database for a particular purpose, it is important to create a model for it. To build a good model requires a good understanding of the problem we are modelling, thus the main challenge is to describe the problem clearly and precisely.

The ER model, introduced by Peter Chen (1976), seems adapted to the methodologies that help the development of large and complex databases based on simple and semantically interesting models. There are many other information modelling approach such as fact-oriented model and object-oriented model, but E-R model still the most widely used approach for data modelling (Halpin and Morgan 2010).

« An entity is a "thing" which can be distinctly identified. A specific person, company, or event is an example of an entity. A relationship is an association among entities. For instance, "father-son" is a relationship between two person" entities » (Chen, 1976).

Once the requirement specifications of the database are defined in full, it can easily develop an ER diagram. Firstly, we must define the entities and relationships, then attributes to each entity and every relationship, integrity constraints and rules of derivation on attributed (Teorey et al., 1989).

Those three components; entity, relationship and attributes constitute the basic object of the ER model and contribute to a simple form which make the concept easy to learn and to apply in many different area. This simple form is a very useful tool to communicate with the end users (Teorey et al., 1989).

3.1.3. Database management system (DBMS)

A database management system is a collection of programs that run on a computer and that help user to get, update, and protect information, in general to manage information. The first fundamental aspect of a database system is the way data or information is represented (Paredaens et al.1989; Ramakrishnan & Gehrke, 2003)**.**

More often, database applications are developed using a database management system. This is a software system for maintaining databases and answering queries about them. The same DBMS may handle many different databases (Halpin and Morgan 2010).

We can use the features of databases (e.g. data independence, efficient data access, data integrity and security etc.) to manage data in a robust and efficient manner. A DBMS is an indispensable tool for managing information as it is an integrated part of computer science (Stonebraker 1981).
Database management systems serve as intermediaries between database and user which can access the data in the database only trough DBMS. The most important advantages to have a DBMS between application and database are that data can be shared among numerous application and users and that DBMS integrates the many different user's views of the data into a single all-encompassing data repository (Coronel and Morris 2016).

3.1.4. SQL (Structured Query Language)

SQL is a data sublanguage for accessing relational database that are managed by relational DBMS. SQL is used to query, insert, update and modify data. As the definition suggests, it is often used in association with another language for the specialized purpose of accessing data (Melton and Simon 1993).

SQL is a comprehensive language for controlling and interacting with a database management system since it is used to control all of the functions (e.g. data definition, data retrieval, data manipulation etc.) that DBMS provides for its users, thus SQL is more than a query tool (Groff and Weinberg 1999).

SQL is available in any relational database management system. SQL isolates the application programmer from the internal mechanisms of DBMS (ICPC, 2015).

3.1.5. MySQL

MySQL is an open source relational database management system that helps to store data in separate tables rather than putting all in a single table. This improves the speed and flexibility of the whole.

The tables are linked by defined relations that make possible the combination of data from several tables on request. SQL in the "MySQL" stands for "Structured Query Language": the standard language for database processing. MySQL runs on virtually all

platforms, including Linux, UNIX, and Windows. Although it can be used in a wide range of applications, MySQL is most often associated with web-based applications and online publishing (DuBois et al., 2004).

MySQL architectural characteristics are different from others DBMS, and make it useful for a wide range of purposes as well as making it a poor choice for others. It is not perfect, but it is flexible enough to work well in very demanding environments, such as web applications (Schwartz et al., 2012).

Despite MySQL has many competitors that can be adopted to numerous tasks, it is recommended since it is characterized by (Greenspan and Bulger, 2001):

- **Cost-Effective:** we may well create databases with Oracle, Sybase, Microsoft SQL Server, and PostgreSQL, but it will cost us a lot. MySQL is free for development and can be used in a live production environment for a minimal cost;
- **Quick and powerful:** It is extremely fast for the small to medium-size database and for websites or applications that are web content services;
- **Continuous improvement:** The developers release updates by adding several characteristics in a strategic rate to improve it frequently.

Having a database is not enough to define the purpose, but the way how you organize your data specify it. To be more effective and useful, it is necessary that end users can interact with it, that is why it is not surprising when we find that several applications were experienced mostly in the web (Reese, Yarger, and King 2002).

3.2. PHP/JavaScript

PHP and JavaScript are two languages among the most popular choices for developing web applications, originated as easy to use, specialized and supported by huge documentation (Amanatidis and Chatzigeorgiou, 2016).

PHP, which stands for "Hypertext Preprocessor" is a free programming language, mainly used to produce dynamic web pages via an HTTP server. PHP code may be embedded into HTML code, or it can be used in combination with various web template systems, web content management systems and web frameworks.

According to (Welling and Thomson, 2008), PHP has several advantages compared to other languages:

- **Performance:** it is fast, and users can make million queries per day. This indicates that PHP exceeds all its competitors.
- **Integration with databases**: PHP has a native connexion towards almost database systems. Users can access databases via PDO (PHP Database Objects) which assures coherence taking into consideration security issues during access;
- **Integrated library** : PHP was designed for web programming, consequently the users can exploit many integrated functionalities which allows almost of programming tasks just with a few script lines;
- Adaptability, source code, availability of supports and documentations, cost, ease of learning etc.

According to W3Techs[1], 81.7% of websites were done with PHP. In the last few years, PHP was designed to be the most used language in the web platforms and its development was not only quantitative but also qualitative, every day more and more businesses are based on PHP, this create a lot of opportunities of jobs for PHP developers (Ristić and Jevremović, 2014).

PHP supports the imperative, procedural (our case), object oriented and reflective programming paradigms. It was established for web development to produce dynamic web pages, that's why it's integrated into HTML documents and interpreted on a web server (S. S. Al-Qahtani and al. 2010).

JavaScript is a scripting language that is incorporated to HTML tags or XHML, to further enhancing the presentation and interactivity of web pages (Van Lancker 2008). It is an interpreted language programming with object-oriented capabilities, when it is interpreted the results is client-side JavaScript (Flanagan 2006). It is considered one of the most important languages as it is for web browsers; its association with browsers makes it one of the most popular programming languages. Among the ideas that make it more powerful: functions, loose typing, dynamic objects and an expressive object literal notation (Crockford 2008).

JavaScript occupies an extreme position in dynamic spectrum comparing to the other object-oriented languages, seen that everything can be changed, the fields and methods of an object to its parents, and this is a challenge to static analysis techniques (Richards et al. 2010).

[1] https://w3techs.com/

Considering the reasons and features presented, we chose PHP and JavaScript to implement the necessary scripts to achieve the functions desired of the website.

3.3. Content Management System (CMS)/Joomla

A CMS (Content Management System) is a set of applications that allow developers to manage and publish contents. The use of CMS tools help programmers to avoid spending time on visual design and site administration (O. Sahl et al., 2013).

A content management system (CMS) is a software application or set of related programs that are used to create and manage digital content, without losing time in technical details of presentation (Simpson, 2005.).

A CMS allows to anyone even if he doesn't have knowledges about HTML, PHP, JavaScript and MySQL to manage, upload, download, delete and edit the contents of the website (Robertson, 2003).

Joomla is an award winning CMS used for developing different applications on the web. It's not only free, but it's can be used to build interfaces of any CMS (Rahmel, 2009). Pulg-ins, Modules and components are improving to support several needs of the users, and contribute to extend the functionalities of Joomla (Alexander and al. 2012).

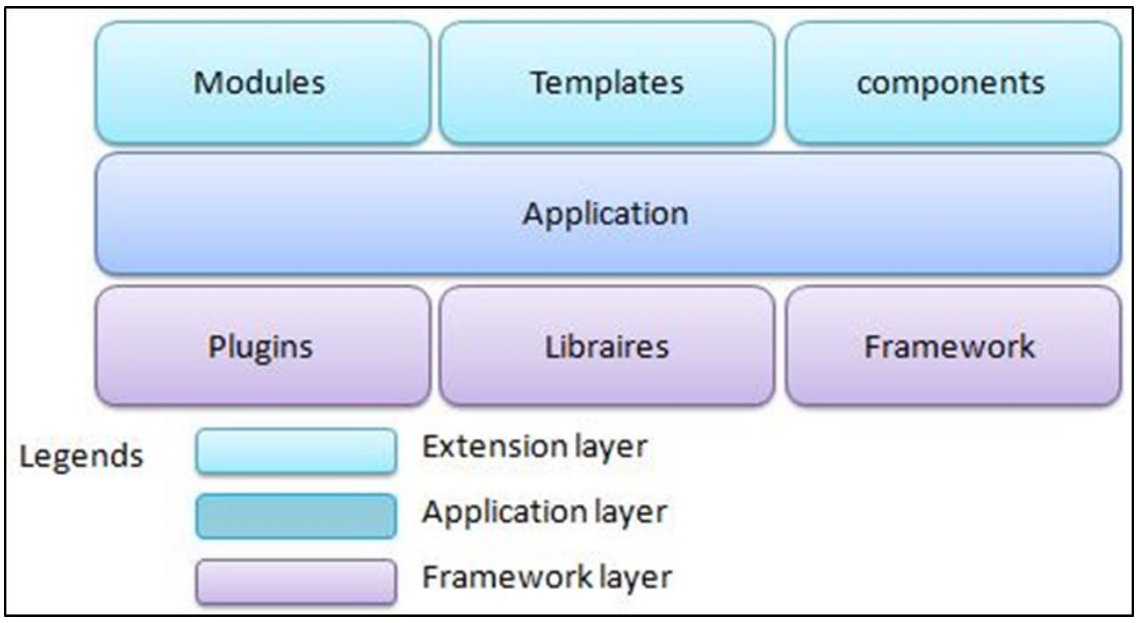

Figure 1. Diagram representing the architecture of Joomla

https://docs.joomla.org/API16:Framework

Joomla uses MySQL as a backend to store several kinds of data, using PHP and SQL languages to connect the website with the database and also to make all the operations needed to manage the database, for instance: upload and download photographs.

As we have mentioned before, Joomla is a CMS, provides several functionalities helpful to build a website (
Figure **1**). It is not always possible to find all functionalities available by default, but we can easily add extensions. There are five types of extensions for Joomla (e.g. Component, plugin, modules, templates and languages), each of them handle specific functionality. We will focus just on those that were used during the development of the website:

- **Plugins:** The one used is "Sourcerer", which enables to place PHP and any kind of HTML style code (including JavaScript) right in to the content, not only in the articles, but also in the categories, modules, component etc.
- **Modules:** are a flexible extensions used for pages rendering. They are like a "boxes" that are arranged around the component, for example: the login module.
- **Templates:** are responsible of the design of the interface. Joomla provides many different templates that allow change the look of the website. We kept just those that are provided by default.

4. Developed work

Using the materiel and methods presented in the previous chapter, we designed, developed and implemented Digitalandscape: an online database established to register landscape images in the region of Trás-os-Montes and all kind of information that can be helpful to track and assess the changes, using repeat photography.

In the following sessions, we will present in detail all the steps completed in the process. Those include the establishment of the database, the design of the interface, and the development of scripts to manage the database from the interface.

4.1. System architecture

Digitalandscape is accessed using an online interface that provides interactivity between the users and the database that is implemented on the server in order to use the web services developed.

4.1.1. Framework

As we have defined the database purposes, it was mandatory to choose the right methods and the appropriate tools that help to achieve the objectives taking into consideration the efficiency, strength, speed, compatibility with all operating systems, speed and cost.

In order to construct the database, we used MySQL as a system for managing the data based on SQL language. PHP and JavaScript were used to allow programming interactivity (request and response) between the users and the database. In addition, we provide an interface for the users using Joomla.

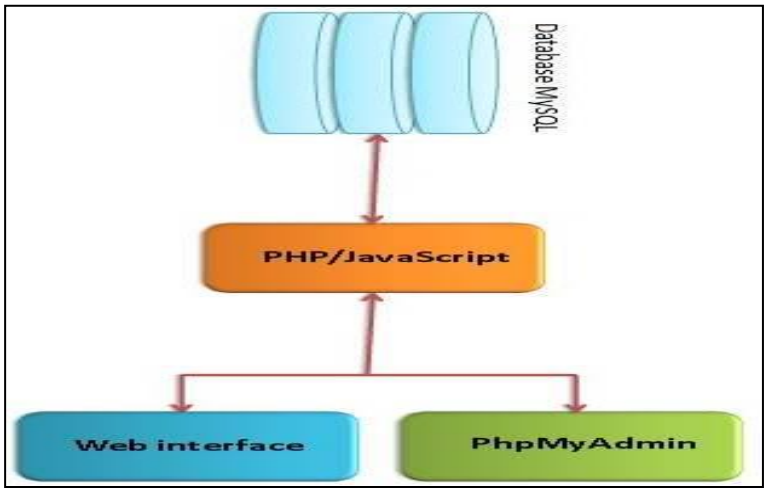

Figure 2. Simplified diagram of the software structure of DigitaLandscape

The software structure and the development platform were selected because of their simplicity and because they are easy to establish and use, but also because the use of these tools is free of charges.

The interactions with the database are done through a web server, through an interface that was created with Joomla.

4.1.2. Conceptual Model

Figure 3 presents an overview about the system's functional architecture:

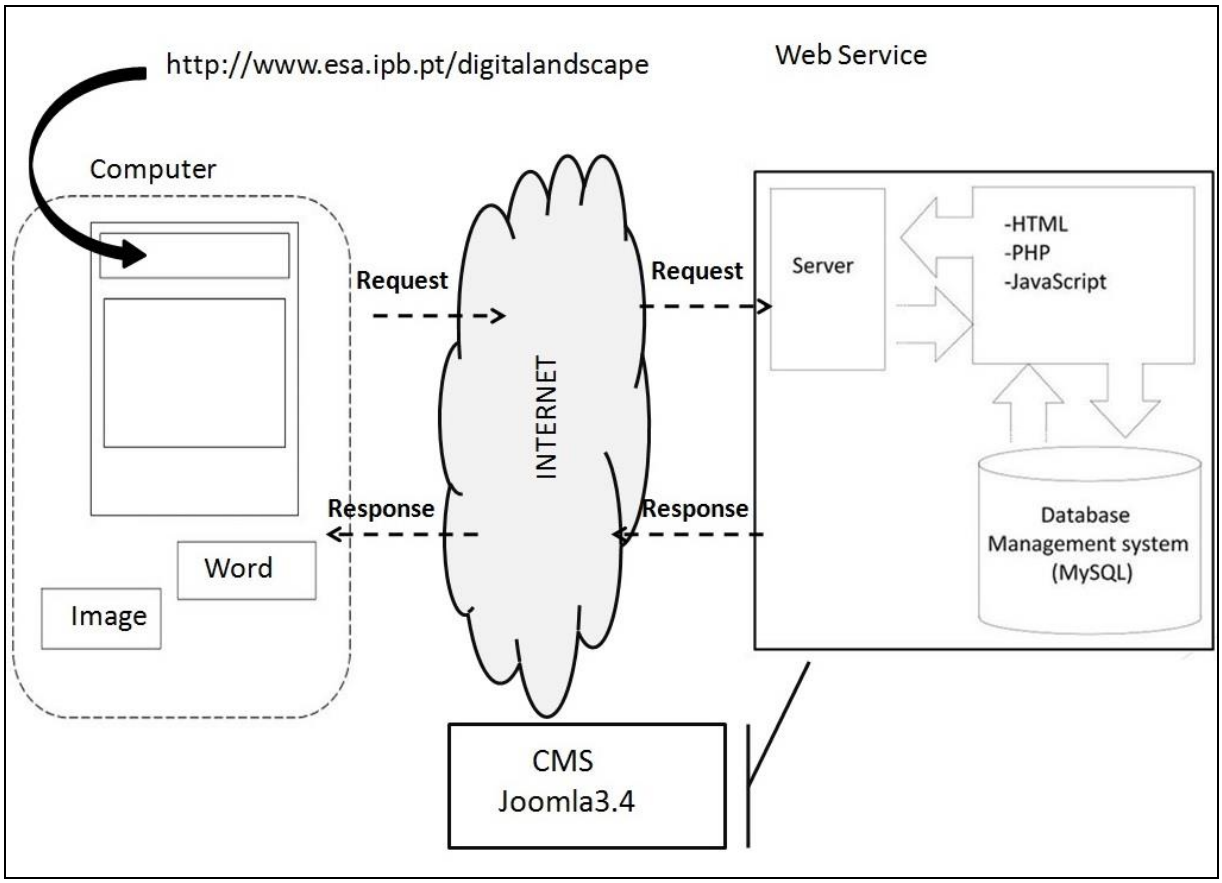

Figure 3.The Digitalandscape system's functional architecture

The web application architecture consists of three major tiers; the web browser in which the user's interaction takes place, the web server that contains the program logic, and database management server which ensures the data processing. The information process in the application is passed through each tier (Kamhawi, 2010).

- **interface:**

It's the visible and interactive part of the system which translates tasks and results to something that user can understand, accessible at **http://esa.ipb.pt/digitalandscape/.**

At this level, the users via a browser can perform different requests, such as upload, download, filter images according to date, theme, location and reshot. In return, the information requested will be sent after the treatment of requests on the interface.

- **services:**

It is the functional part of the website. Different rules of management and control of the system are implemented at this level. It acts as a server for client and as a client in relation to the third part. The treatment of operations quoted before is based on the services provided at this tier.

- **data management:**

Refers to the database and all programs that help to display, write, access and manage data. This tier contains the process of the information transaction of the website.

The services provided by DBMS at this level depend on the kind of request performed by the client in the first tiers (interface) as shown in Figure 3.

4.2. Database: Structure and implementation

In our work, we have created a database for storing images of Tràs-os-Montes landscapes and all information used to their description for the purpose of monitoring and assessment based on repeat photography.

The aim is to have two tables for images. The first is for all historical images or those taken for the first time. On the basis of this table, we created a second table in order to build a collection of images of a same landscape at different dates.

Then we tried to define all the variables that can help in the description of imagery:

- Landscape descriptors: to locate the landscape, identify which kind of problems are affecting landscape, and also to specify the techniques used because it has an effect on the image quality
- The photograph: for a performance assessment;
- Techniques used: to avoid the judgment of some aspects that may be due to lighting, exposure, contrast, resolution etc.

4.2.1. Structure and tables

The database uses MySQL DBMS, it is composed by several tables that are normalized and conceived under the principles listed in section 3.1.1.

In what follows, we present the tables in the database with their structures that are different from each other because of difference of their roles:

- **Store**

Photographs must be well described in terms of theme, location, date, technique used, who take it. It has to have a name to be well defined.

We must also specify the hour and the date because the quality of images it is changing during the time and also because it is one of the factors that can influence the images analyze during the landscape assessment.

In the table structure, we use LONG_BLOB data type that allows storing large size and high resolution images.

- **Reshot**

This table is very important to achieve the most important aims of our work. Because of this table we can build a collection of images that represent the same landscape in different dates.

After storing the first image, the database provides to the users a random and unique code. This code is responsible for establish a reshot relation.

Every time that users try to add a new image for their collection, they must have this code to store the new image.

- **Point-View**

In order to retake the same picture, the users have to locate the point of view using geographic coordinates if possible. Moreover, they have to indicate the municipality and parish as well as weather conditions.

The idea is to look for an historical image of landscape and try to retake it from the same point of view, which explains how is difficult to provide this kind of data for the database.

- **Municipality and Parish**

Those tables are already prepared, users have just to select the municipality and parish in two corresponding list.

It is important to know this information, because it can explain some changes in the landscape; each municipality has its characteristics (Management project, population size, area, land use etc.) that can be useful to analyze the results obtained from repeat photography.

- **Theme**

Each image must necessarily present a theme that reflects the problems and factors affecting the area studied. It can be used also to filter images according to the user's needs.

- **Author and user**

Author refers to the owner of the image, while a user refers to the person who is registered in the website and uses the provided web services

We have distinguished between those two tables to control properly the users, and to keep the consistency of the database.

- **Tech**

Technical aspects (e.g. exposition, contrast, light condition etc.) are inseparable from the practice photographer. Those items will be subject to an exchange between photographers as images must be retaken under the same conditions.

4.2.2. Entity-Relation model

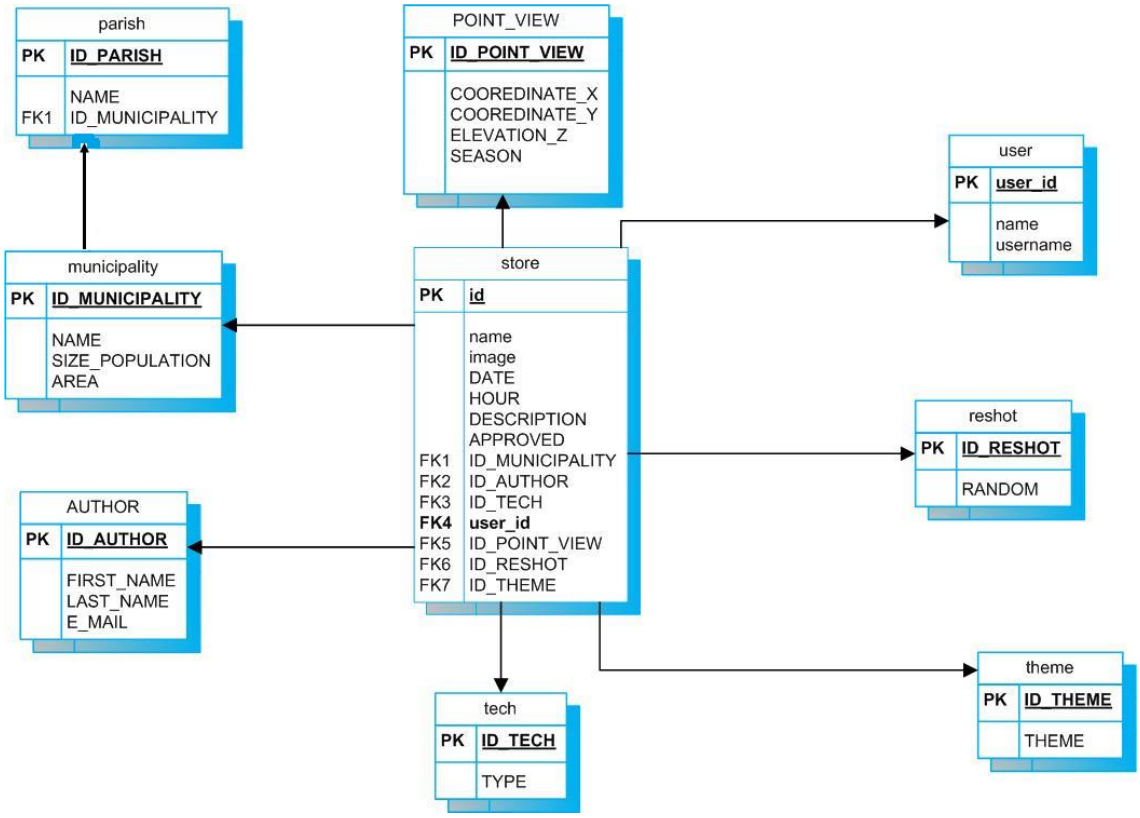

Figure 4. Entity-Relation Diagram

We mention in this diagram the most important relationship to establish a consistent database, and to answer to the objectives defined previously. Examining the diagram, we notice that “store” table have an axial importance, because it is related to all tables, consequently any modification will has necessarily repercussion on others tables. For this reason, we didn’t establish physically the relations between tables, but we have proceeded with another method that allows the same function; we used SQL to join tables every time that is necessary, namely using the function “WHERE”. In the excerpt of code1 we provide an example that explains how we can relate the tables

```
$requete = "SELECT * from store WHERE DATE = $date";
```

Code 1. Excerpt of the script explaining the joining of tables

4.2.3. Implementation and maintenance

We adopt XAMPP (*X Apache MySQL Perl PHP*) to install a pack of software to create the website, and also to set up a local web server for testing and developing the scripts. It is very important to optimize the structure of tables through tests to achieve a stable version of the database.

PhpMyAdmin is the standard admin panel of the databases; it provides a simple and effective interface. It simplifies several tasks, like creation of tables and definition of their structure and management of different databases.

After establishing and testing the first version of the database, we have deleted some tables because of their uselessness such as “administrator” as its function is already assured by Joomla. We have also added the table “Reshot” that allows to build a photography collection, provided prepared lists for “municipality”, “parish”, “theme” and “techniques” in order to avoid redundancy (one term can be written in several ways) that can affect the effectiveness of the images search.

In terms of maintenance of the database, we have developed an approval system of photography that requires a moderator to control the photography uploaded and to delete those that do not complies with the website objectives.

4.3. Web based service and interface developed

The web applications support users-interactions through web interfaces, persistence of data, transaction support and dynamic web pages. A web application can be divided in two different components: client-side that is responsible for pages rendering, server-side which is for business process execution and Web page construction (Li and DBSec 2011)

The users interact over a network using a browser with the web applications that is typically composed of a database (or the back-end) and Web pages (the front-end). Web pages can be static or dynamic, static when the contents are fixed and dynamic when the contents depend on users input (M. R. Girgis and al. 2014).

Considering the previous definition, Digitalandscape is a dynamic website since the content of the database is changing as long as the website is available on the internet.

More concrete details illustrate the nature of the web pages and the interactivity will be presented in the next sessions.

4.3.1. Integration: interface and database management (JOOMLA)

Digitalandscape was designed to facilitate storage and manipulation of historical photographs as intuitively as possible. The interface was personalized by adding some items to the menu: “Upload” to upload new photographs and the corresponding information, “Reshoot” to ensure reshot relations and “Advanced Search” to query photographs by date, theme, location and reshoot.

Figure 5. Digitalandscape interface

As we can notice from **Figure** 5, the interface provides help for end users to understand the aims of the website and to use it and also some information and references regarding repeat photography approach.

4.3.2. PHP Modules / JavaScript

The scripts were written using an IDE (Integrated Development Environment) and they were tested in a local environment, then implemented in pages provided by Joomla.

PHP Scripts must be necessarily between two tags for opening and closing (<? php and?>). In order to ensure the process of the website, the connection between Web server and DBMS must be established, the following script shows how we proceeded (**Code 2**):

```
$bdd= mysql_connect ("localhost", "Digitalandscape","password")
or die (mysql_error());
mysql_select_db ("database") or die (mysql_error());
```

Code 2. Excerpt of script explaining connection to DigitaLandscape database

After having successfully connected to MySQL, we start to realize the referred objectives:

- **Uploading images**

The first objective of this work is to allow users saving and storing their images (**Erro! A origem da referência não foi encontrada.**) in a structured database, taken into consideration the conditions at the photographing time. This helps to recuperate them when it's necessary using a unique random code provided by the DB.

They can also, with the same random code (reshot), upload another image of the same landscape in a different date to build a collection that will be useful in the repeat photography approach.

```
$file = $_FILES['Image']['tmp_name'];
if (!isset($file)) echo "please select an image.";
      else{
      $Image = addslashes(file_get_con-
tents($_FILES['Image']['tmp_name']));
      $Image_name =addslashes ($_FILES['Im-
age']['name']);
      $Image_size =getimagesize ($_FILES['Im-
age']['tmp_name']);
               if ($Image_size == FALSE) echo "That's
not an image";
                    Else {if (!$insert =
mysql_query("INSERT INTO
    store(name,image,ID_AU-
THOR,ID_POINT_VIEW,ID_THEME,ID_TECH,
           ID_MUNICIPALITY,ID_RESHOT,DATE,HOUR,DE-
SCRIPTION)            VALUES('$Image_name','$Im-
age','$lidaut','$lidpt','$theme','$tech','$mu-
ni','$lidrsht','$date','$hour','$desc')"))

 echo "Problem uploading image.";
 else{echo "     this is your reshoot to upload an-
other image to this collection ";}}}
```

Code 3. Excerpt of script explaining uploading image

Users can insert several kinds of images (png, jpeg, jpg) with maximum size of 537 Megabytes. We accept also all kind of tools used to get the images like film negative, postcard, painting etc.

For security issue, the users have to be registered before uploading the images; this is to control the abusive use of some automatic system.

- **Downloading images**

The web site makes possible filtering images by date, theme, location and reshoot. Only images that are approved by the moderator are available to download.

To achieve this purpose, we have developed the following function (Code 4) that allows to show up the images

```
function getImage ($id, $name) {

$link = mysql_connect("localhost", "Digitalandscape",
"password");

mysql_select_db("database");

$sql = "SELECT image FROM store WHERE id=$id";
$result = mysql_query($sql,$link);
$row = mysql_fetch_assoc($result);
$imageName=$name;
$filename=basename($imageName);

$format=strtolower(substr(strrchr($filename,"."),1));
$ctype="image/jpeg";
switch ($format){
case "gif":$ctype="image/gif";break;
case "png":$ctype="image/png";break;
case "jpeg":
case "jpg":$ctype="image/jpeg";break;
default:
}

echo ' ';
echo 'Image:'. $id.' - '.$imageName;

echo '<dd>'.'<img height="700" width="500"
src="data:'.$ctype.';base64,' . base64_en-
code($row['image']).'"/>'.'</dd>';

mysql_close($link);}
```

Code 4. Excerpt of script explaining downloading images

- **Approval system**

As we have already mentioned in the previous paragraph, we have developed an approval system that permits to insert images into database after acceptance of the moderator, and that to assure a high quality of the input data.

- **Website dynamicity**

In order to make the use of the web site easier, we have prepared municipality, parish, theme and technique to uniform the manner of writing the terms. We developed a JavaScript function that allows the choice of the parish according to the municipality chosen. This is very important to facilitate the filtering of images.

Another example provided by the Code 5 explaining how users can check the geographical coordinates of the "point of view" using Google Maps.

```
<script>
function Compose_Google_Maps_link() {
    var x = document.getElementsByName("COORDINATE_X")[0].value;
    var y = document.getElementsByName("COORDINATE_Y")[0].value;
    var string = "https://www.google.pt/maps/@"+x+","+y+",15z";
    window.open(string);
}
</script>
```

Code 5. JavaScript to check the geographical coordinates using Google Maps

4.3.3. Users and available services

The website was conceived with two distinct groups of user in mind: visitors and researchers.

- **Visitors:** These can be non-visitors or visitors to the region; we anticipate the first ones to browse photographs to see changes in the landscape but not really contributing to the development of the website by uploading photographs; these users will be able to observe landscape changes available in the database. The other group can include the local population or those who visited the region, they contribute with their personal images and also download others images.

- **Researchers/Scientists:** In this group participants are interested in the repeat photography approach to identify changes in landscapes. They can download photos by location coordinates and take a photograph that repeats an historic photo location, and then upload it associated with some data (Coordinates, date, description, photographer, theme, others notes).

4.3.4. Users feedback and usability

Good testing involves much more than just running the program a few times to see whether it works. The two main reasons to do tests are to make a judgment about quality or acceptability and to discover problems (Jorgensen 2014)(Kaner et al., 1999).

To examine the web site functioning and the end users appreciation, it was mandatory to apply the most important operations.

After having uploading and downloading images, we highlight these important points:

- **Comprehensibility:** If the end users have well understood the aims of the website, if they knew how to use it and what kind of problems that can hamper the use. That led us or to improve the organizations of the interface or to change the method adopted.
- **Efficiency:** if the web site was useful to attain the objectives defined previously. In a more precise manner, if the users obtained the results that they expected from the web sites in terms of data and their usability.
- **Consistency:** this point matter just for project developer. After several uses of the database, we have to examine if the database is complete and perfect, or we have to improve it by adding or deleting some entities and relations.

We have to notice in this section, that the results of the websites potentially requires many years to collect, given the nature of the purpose of this tools, and also because the development of the database is dependent on the involvement of users into this work.

The most important operations that can be done are the following :

- **Uploading images**

Upload of photographs by users includes the definition of the location of the landscape photographed in administrative terms as shown in Figure 6.

Figure 6. Form to upload images and define their location

Then the user has to provide author data, as shown in Figure 7.

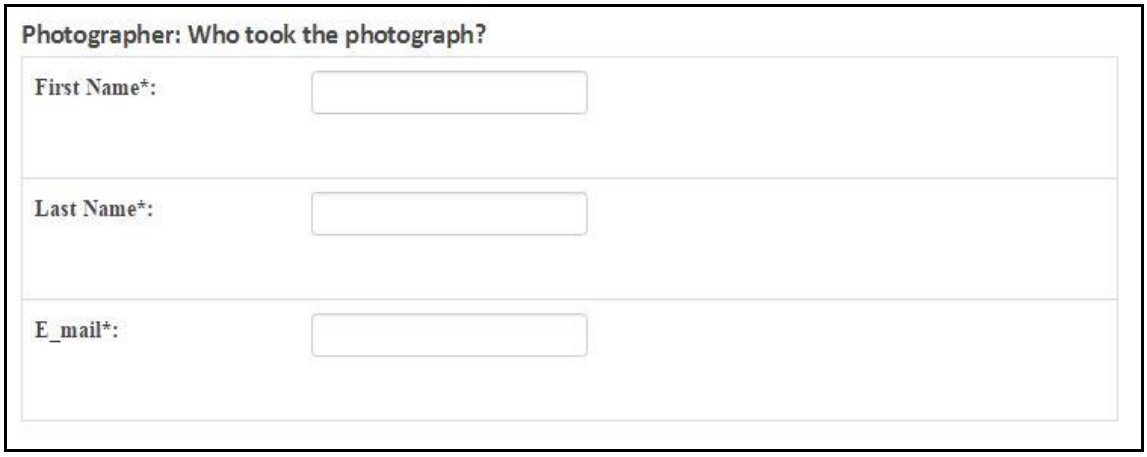

Figure 7. Form for author data

If it is possible, and depending on the availability of these kind of data, the user can provide the geographical coordinates, technique used and also the theme that is represented Figure 8

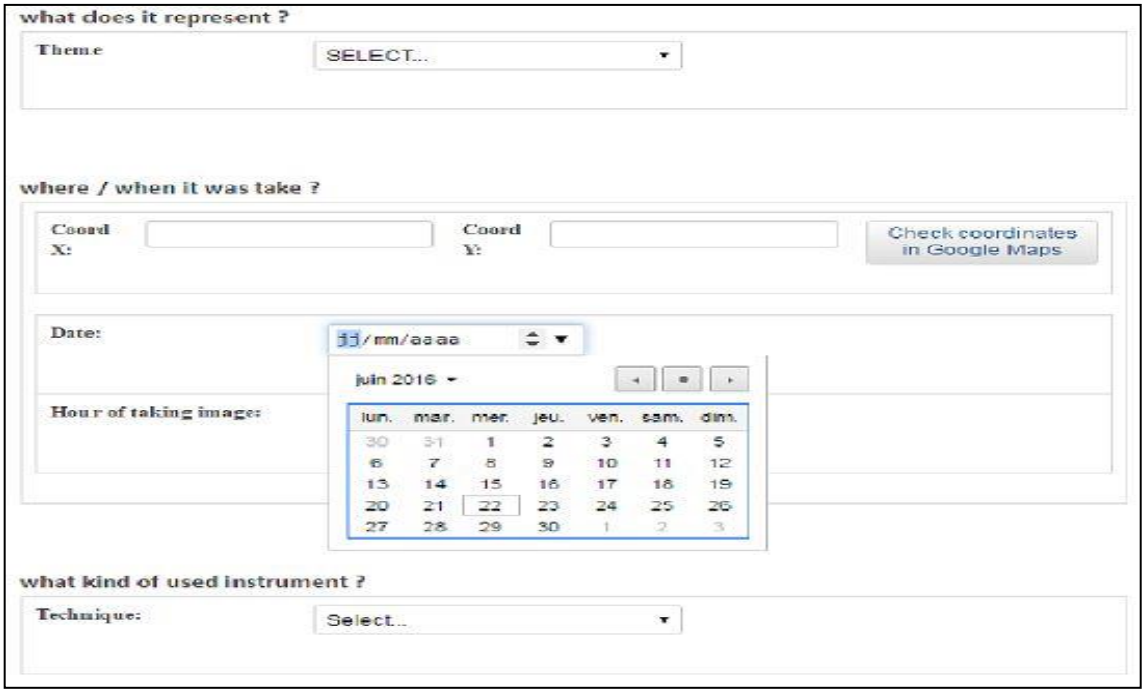

Figure 8 Form to define theme, technique and the geographical coordinates

Finally, and before uploading, the user can describe the image, the climate conditions, the problems that affect the landscape structure and all what can help to assess the changes in the region, as shown in the Figure 9.

Figure 9. Form to describe the image before uploading

- **Image querying**

Users can select images by date, location, reshoot. Therefore, images must be well represented and accompanied by all important information in order to analyze images and assess landscape (Figure 10).

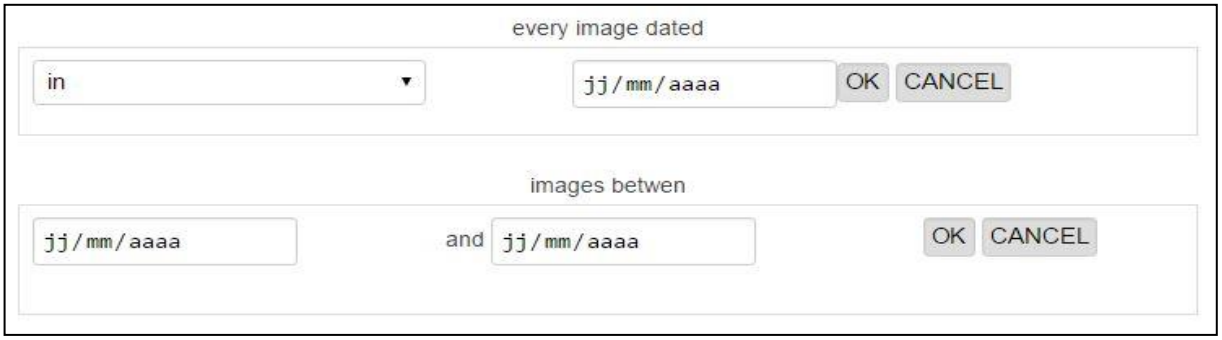

Figure 10. Form to filter images by date

4.4. Hardware and interconnection description

The experimental work was based on the resources of interconnection, storing and processing available at the CIESA – Computer Science Centre of the School of Agriculture the Polytechnic Institute of Bragança, using an hardware platform including a web server powered by a dual processor architecture, based on 2x Intel(R) Xeon(TM) CPU 3.20GHz, 64-bit, 2 MB L2 cache, 4 GB RAM and 80 GB HD. The server integrates the IPB (Polytechnic Institute of Bragança) intranet, being directly connected to the network main backbone using a fiber optics connection. The bandwidth available to connect to the Internet is 100 Mbps- bidirectional.

5. Results & Discussion

To validate the adopted methodology, problems of the system must be identified, starting from the database through the scripts until the web interface. To achieve this goal, we must not forget the human element, more than a "simple user" he's one of the most important components of the system, holding knowledge (Pierre-Emmanuel and Thierno 2014). A site developed without the user in mind may prove frustrating or challenging to use (Krug 2006).

To measure how the system responds to the user expectations, it was necessary to quantify all results obtained from the usability test. For this reason, we adopt the model of success of an information system proposed by DeLone and McLean in 2003 (Figure 11) which divides the system quality to 6 criteria:

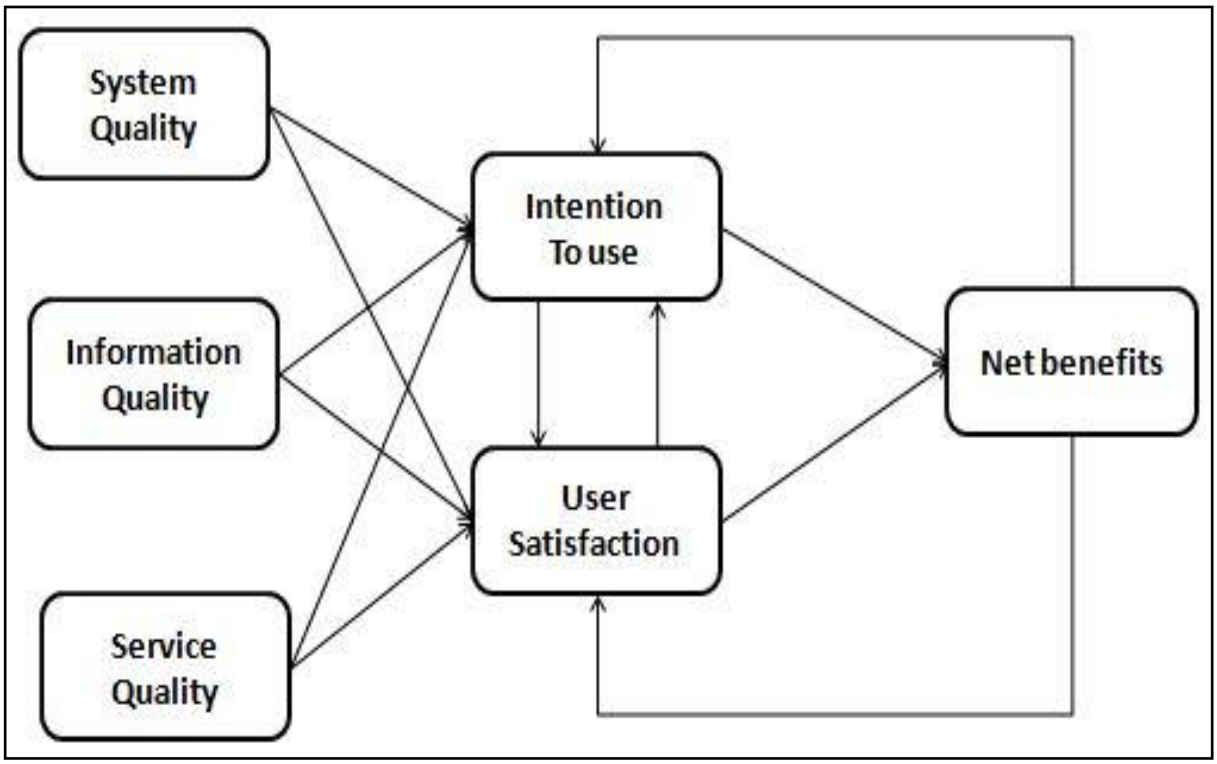

Figure 11 Success model of an information system (DeLone & McLean, 2003)

- **System quality:** represents the performance that a system reflects, namely: usability, adaptability, availability, reliability and response time;
- **Information quality:** represent the characteristics desired in the outputs of the system, such as relevance, clarity, accuracy, completeness, speed and ease to understand and to use.
- **Service quality:** represents the quality of the support that users receive from the server. The criteria used are: technical competence and response precision;
- **Intention to use:** represents the manner and degree of expertise which users demonstrated by using an information system. For example: the amount, frequency, the nature, the extent and purpose of use;
- **User satisfaction:** measures satisfaction related to the web pages and information delivered by the system;
- **Net benefits:** represents how the system can contribute to the realization of the objectives and how useful can be the database in providing images to assess the landscape changes.

5.1. Methodology evaluation

To validate the adopted methodology, we had to assess the efficiency of the database, web interface and to verify the scripts. For this reason, we made a series of test to detect the problems related to the methodology. It was also important to have an idea about the user perception of the website interface.

In the E-R diagram, we can notice that the entities and the relationship as well as the attributes are relevant to the problem that we want conceive, thus it is the proper model for the adopted methodology.

The database is used effectively and responds to the objectives previously defined, representing what users can demand in terms of data, because its data are correct, complete, accessed efficiently and represent what user may need to apply repeat photography approach.

As we can notice in Figure 4, the data are also independent as it provides the possibility to modify the database without restructuring all the entities, this is very important because it ensures the database consistency.

Structure of the tables meets the requirement registration of data. As an example, Figure 12 show the structure of the “store” table that must be able to receive several kind of image with a large size and high quality.

	Champ	Type	Interclassement	Attributs	Null	Défaut	Extra	Action
	id	int(11)			Non	*Aucun*	auto_increment	
	name	varchar(100)	latin1_swedish_ci		Non	*Aucun*		
	image	longblob		BINARY	Non	*Aucun*		
	ID_RESHOT	varchar(11)	latin1_swedish_ci		Non	*Aucun*		
	ID_TECH	int(11)			Non	*Aucun*		
	ID_AUTHOR	int(11)			Non	*Aucun*		
	ID_POINT_VIEW	int(11)			Non	*Aucun*		
	ID_THEME	int(11)			Non	*Aucun*		
	DATE	date			Non	*Aucun*		
	HOUR	time			Non	*Aucun*		
	ID_MUNICIPALITY	int(11)			Non	*Aucun*		
	DESCRIPTION	text	latin1_swedish_ci		Non	*Aucun*		
	APPROVED	tinyint(1)			Non	*Aucun*		
	user_id	varchar(100)	latin1_swedish_ci		Non	*Aucun*		

Figure 12. The structure of "store" table

Figure 13 shows an example of the data stored in tables, we notice that all cases are filled properly which validates the structure of the database, and also the scripts used to manipulate inputs in the forms.

			id	name	image	ID_RESHOT	ID_TECH	ID_AUTHOR	ID_POINT_VIEW	ID_THEME	DATE	HOUR	ID_MUNICIPALITY	DESCRIPT
			85	Desert.jpg	[BLOB - 255o]	26	13	12	38	4	2016-05-17	11:08:00	4	Test4
			86	1600239_205189916351954_402174399_n.jpg	[BLOB - 255o]	27	12	1	39	9	2016-05-17	11:22:00	7	test soukaina
			87	Male-photographer-taking-pictures-in-Canadian-Rock...	[BLOB - 64,0 Kio]	28	3	1	40	11	2016-05-23	11:55:00	1	Test 5
			88	1.JPG	[BLOB - 47,3 Kio]	29	4	4	41	1	2016-05-23	13:40:00	1	Test 10
			89	equa.JPG	[BLOB - 11,8 Kio]	30	12	2	42	10	1991-09-10	15:15:00	1	TEST 16
			90	Test.gif	[BLOB - 22,3 Kio]	31	1	1	43	1	2016-05-23	16:20:00	1	This is for testi
			91	Bragança.jpg	[BLOB - 62,4	32	4	4	44	2	2016-05-24	10:36:00	1	test bragança

Figure 13. "Store" table contents

Generally, the script do not present many problems because they were tested before in a local environment, additionally the web browser can detect and locate the problems, and send an error, advertisement or notice as it is shown in the **Figure 14**.This is very

important because it allows to avoid spending time in checking the syntax and orthography.

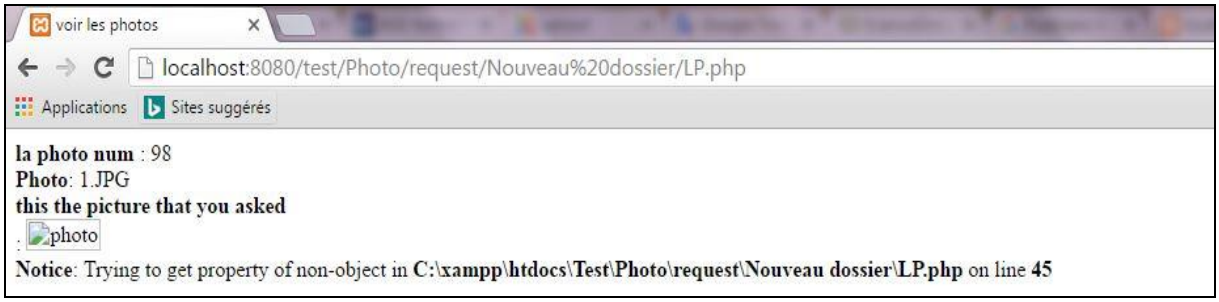

Figure 14. Message showing the error location

Concerning the presentation of the website, Joomla provides different templates (Figure 15) that control the web site appearance and layout. The user's perception is related much more to their experiences on the website than the appearance, but it does not prevent us to improve the presentation and choose the best template, however it should be objective and representative of the aims of the work.

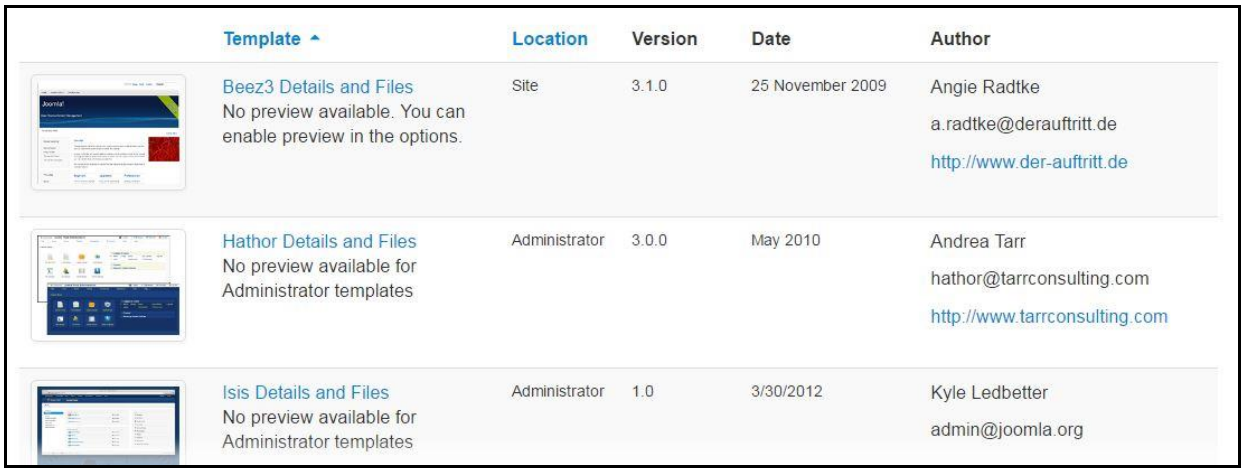

Figure 15. Joomla Template

The evaluation of the methodology adopted show that it is adequate for the nature of this work and also proper to achieve the goals. Thanks to this methodology, users can perform their operation easily and developers can also add a new functionalities without referring to other methodology.

5.2. Experimental results

In parallel to the adaptation of the methodology, it was important to know if the website corresponds to the objectives and the user needs. In this context, we have invited people to use the website freely, without any intervention from the moderator. The problems encountered were registered to be corrected. We have to mention that the participants don't constitute a representative sample to the target community, but they contribute to highlight some common problems that can occur during the use of the website.

As we have explained before, the most important task cannot be done if the users are not registered in the website, so this first step is provided by Joomla and easy to accomplish as we can notice in the **Figure 16**:

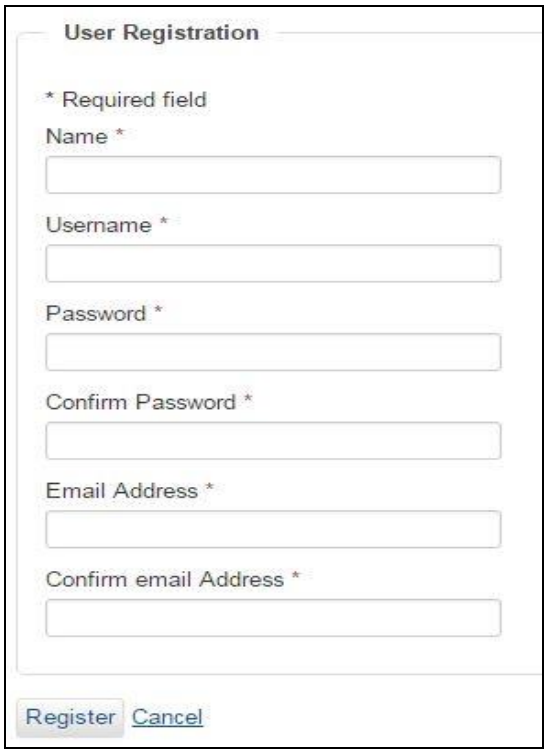

Figure 16. User registration form

Thanks to the user's feedback, we have listed some problems:

- Function of some textboxes was not clear such as "reshoot";
- Participants didn't understand the meaning of some sentences and words like "Repeat photography";
- Some participants were confused in the use of the website;
- Some participants didn't like the "ergonomic" interface.

We have noticed that before testing the usability of the website, users need to know the concept of repeat photography. For this reason we provide a definition of repeat photography, an overview about the website objectives and also some explanations that illustrate the role of each input in the forms (Figure 17). At this level, the participants were satisfied about the interventions, based on their signaling, motivated to contribute to the development of this work. This affirms the success of the usability test.

Figure 17. How to use the website

5.3. Results interpretation and conclusion

To return to the success model, the first three components must be evaluated first (Figure 11), since they are the determinants of "satisfaction" and "intention to use". The success of the system is expressed in "net benefit" that is realized at an individual or organizational level (H. Delone and R. McLean 2003).

The three first determinants influence directly and positively the “satisfaction” and “intention to use”, higher their quality is, more important are the influence (Petter et al., 2013). Additionally, there are many other variables that influence equally “the satisfaction” and “intention to use”, such as the formation and support of managers (Davis 1989). This explains why the users faced some problems like the ones listed before (paragraph 4.2). In this context we can predict that the website will constitute a useful tool for scientists and researchers to apply repeat photography approach.

Each component is measured using many quantifiable variables (Petter et al., 2013)as presented in **Table 1** . Through usability test, we notice that the system presents what the users need and expect in term of understandability, response time, use ease, clarity and completeness.

Table 1. Success Model Metrics references

System quality	Information quality	Service quality	Use	User satisfaction	Net benefits
Adaptability Availability Reliability Response time Usability	Completeness Ease of understandability Personalization Relevance Security	Assurance Empathy Responsiveness	Nature of use Navigation patterns Number of site visits Number of transactions executed	Repeat purchases Repeat visits User surveys	Cost saving Expanded markets Incremental additional sales Reduced search costs Time saving

- **System quality:** In the context of web application, the quality of the system appear firstly in the availability in the web, it is the case of our siteweb. All images in the database must belong to the region of Trás-os-Montes, this is one of the reason to add an option to check the geographical coordinates, but it still a difficult point to treat automatically, especially if user don’t insert this kind of input, thus the reliability of the website can be ensured in the beginning but it will be hard in the future.

Concerning the usability and response time, we affirm that is helpful to apply RP approach to assess landscape changes, users can refer to the website to get data needed quickly. This latter must be evaluated in the future given that the database will be more developed.

- **Information quality:** The images filtered are well presented and personalized to be more complete and more relevant.
- **Service quality:** The server can support all kind of operation the can be done in the website thanks to its feature already described. Additionally, it functions 24h/24h and 7d/7d.
- **Use:** the website constitute an interface for users, interested by repeat photography, to interact with the database that provides images to apply this concept.

The number of registered users in the website, until the moment of writing these lines, is 11 as shown in the Figure 18. Users executed several operations (e.g. upload historical image, reshot, filter images etc.).

Name	Username	Enabled	Activated	User Groups	Email	Last Visit Date	Registration Date	ID
INSSI Add a Note	Hanane	✓	✓	Registered		2016-05-26 20:30:57	2016-05-19 10:48:58	756
João Azevedo Add a Note	jazevedo	✓	✓	Registered		Never	2016-05-17 07:47:55	753
khadija Add a Note	khadija	✓	✓	Registered		2016-05-25 16:39:00	2016-05-25 15:58:44	759
khaoula msaouak Add a Note	khaoulams	✓	✓	Registered		2016-05-26 20:28:18	2016-05-25 16:14:22	760
sd Add a Note	sd	✓	✓	Registered		2016-05-25 16:30:06	2016-05-19 14:41:55	757
Sérgio Add a Note	sergiod	✓	✓	Super Users		2016-03-03 14:59:47	2016-02-22 16:45:32	752

Figure 18. Page show the registered users

- **User's satisfaction:** the participants who were invited to test the website were satisfied of the services provided by the system.

"Use" and "user satisfaction" are two correlated parameters, but we cannot confirm this relation through the website at the moment as we need more use repetition and more participants.

- **Net benefit:** also cannot be expressed now because we need to know how useful the website will be in the future in terms of productivity.

People are very goal driven when they access a website, so we must allow them to accomplish their goals in a reasonable time. Each problem or challenge can influence the patience of the users; consequently they leave the website to another one. Additionally, a successful experience on a website makes people likely to return (Oakley and Daudert 2016).

Time is one of the most important determinants of satisfaction and also intention to use (Meenan 2013). The time spent to achieve a task on the website is acceptable; it is very easy to find where users can perform an operation (e.g. upload or download) because of the interface simplicity. Filling the forms can take a few seconds according to the users, if they understood how to use the website or not, but mostly it is fast.

The success of the system is measured by net benefit that is related to economic incomes (H. Deleone and R. McLean, 2003). (Roh, Ahn, and Han 2005) proposed the profitability as an alternative, which is based on four items: (i) increase of the number of new users, (ii) increase of regulations and balances, (iii) decrease of user's agitation and (iv) increase of the overall profit. Therefore, a retro-relationship is established between net benefit and user satisfaction and intention to use.

The profitability appears in the utility of the website, in the data provided by the database and how it is presented. Consequently, a deeper work must be done in the field to collect historical images, to rephotograph them and to invite people to contribute in the database development.

Based on the methodology evaluation, the results of developed work, and the feedback of the participants in usability tests, we can conclude that the system meets the majority of objectives previously drawn, either at the level of establishment of a structured system that serve to the organization of historical images, or at the utility and productivity of this materiel for good practice of the repeat photography methods and techniques.

5.4. Critical review

The objectives defined in the beginning were, in general, achieved; they constitute now the basic functionalities of the website.

The unachieved objectives could improve the website quality and make it more sophisticated such as a region map that can be involved in the website. It could also contribute to make easier the verification of the geographical coordinates.

We could also apply repeat photography approach on the website by developing an application to change the opacity of images and superpose them. A case study could prove how useful the website can be in several areas: climate change, education, ecology, management.

People are usually based on a visual index (tree, stream, road, stone etc.) to georeferencing the point of view instead of geographical coordinates. Users can mention this kind of data in images description, but it is more helpful to add new columns to the entity “point of view”, and keep “description” to comment images.

Luminosity, contrast and other technical aspects of cameras can affect the image quality. Users should take them into consideration during the analysis of repeat photography results. We have avoided involving those aspects to keep the forms as simple as possible and to not stress the users with many details.

The assessment of the website performance was done only to have an overview about the usability. Even if we had based the evaluation on a proper model, but the determinants of each components were not quantified statistically and the sampling methodology was not objective given that the sample was restricted to one kind of users.

5.5. Future development

The development of a website and web services don’t stop after reaching of the first objectives, but it is a continued process. Every time an idea, new functionalities or a need occurs, we should develop the system to be more useful and more competitive comparing with other websites.

In order to have a functional database, a further work in the field should be done to collect historical images to feed the database.

Repeat photography is a useful method for monitoring the changes in the landscape; it is more powerful if it is combined with remote sensing. For this reason it would be interesting to map the landscapes photographed.

In case of a new study based on repeat photography, it would be more objective and statistically representative to draw a transect and define the point that seems important to photograph in order to have results that can be generalized in the study area.

In the same context, to have a significant result and to apply this approach perfectly, we should use the help of a professional photograph to take images from a scientific view and also to relocate landscapes precisely, and write a small document accompanying images to describe the dominant conditions during the itinerary (Michel et al., 2009).

Implementing an application that can compare images would be helpful in the analysis phase as we have already explained in the previous section. Developing a system that reject automatically images don't belong to the geographical area of the region, would be a future development too.

For the usability test, the use of a questionnaire destined to a representative sample of users would be more objective. We can also think to assure the protection of author's right for contributors who submit their personal images to encourage them to collaborate.

Numerous domains suffer of phishing website, including financial, social networking, search/portal websites (Abbasi et al. 2015). In 2013, phishing attacks increased 87 percent relative to the previous year.[2] It would be important to develop an anti-phishing method to protect author rights and personal data like passwords.

[2] http://media.kaspersky.com/

6. Conclusion

Backup the images of the landscapes is the most important factor for the success of the repeat photography approach. The establishment of a computer tool that allows managing digital images and any data related to the landscape is the first step to ensure efficiency of the analysis.

Moreover, the sharing of the information between users provides an important level of the productivity, since this kind of applications allows to avoid wasting time in data collection and ensures the reliability of the data.

This project describes the steps that led to the establishment of an online database as a tool to apply repeat photography in the analysis of landscape changes. According to this need, we developed this application which permits the interaction with the database through a web interface. The interface is not complex, it gives users ability to access all pages and forms, either to submit or download images.

The website was developed exclusively with an open source technology, using PHP/JavaScript language to perform transactions with MySQL relational database.

Comparing the initial objectives with the achieved results, we can say that the development of the application has reached the majority of the goals. We hope it will play a key role in the management of data related to the RP concept, mostly in the region of Trás-os-Montes.

This confirmation is based on usability test that we made. It will be more prominent when the database will be filled by all archived data.

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