Aeroallergens Database Design

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ABSTRACT

The increasing need for the daily report of aeroallergens and in an effort to bring computer engineering technology into aerobiology, this project focuses on integrating computer engineering solutions with aerobiology to streamline and facilitate easy storage, manipulation and retrieval of data related to aeroallergens studies by developing an intuitive and easy to use computer application. Currently in Puerto Rico, we are in charge of two stations in San Juan and Caguas, to report the daily fungal spores and pollen counts to the American Academy of Allergy, Asthma & Immunology. Currently, these stations rely on manual laboratory counters to make accurate spore counts and maintain this data in Excel format with very limited functionality. In this project, we developed a database and its related software application to replace this tedious manual process with a reliable and feature packed software.
The aim is to enhance and facilitate the recording and reporting of fungal spores and pollens by means of useful and intelligent features such as: 1. Automated arrangement of spore counts into MySQL database. 2. Ability to retrieve, view and manipulate spore information utilizing any characteristic for the spore. 3. Ability to generate different graphical representations of the data instantaneously. 4. Ability to store and reference images. 6. Ability to relating the spores count with the weather factors.

Keywords: Aerobiology, spores, MySQL, Database .

1. INTRODUCTION

The application initially was developed as a special project to interface a Comp-U-Diff counter with the computer but soon evolved into a complete independent software system seeing as the standard keyboard on a computer offered many more keys and further simplicity of not having to purchase a counter and connect it separately. Not only offering simplicity we began to observe the need for a software system specialized in aerobiology that could offer automatic organization of tabled results and graph generation.

The software's first function is to take a string of keys generated by the user where each represented a spore type and automatically scan the string for keys and assign the values to a table which is stored in excel.xls format. The second function is to be able to allow access through the program to access these tables and to modify them as needed although alternately it is possible to manually change the values by accessing the tables from the operating system and simply changing them. The third function is to be able to generate charts; this is to be done by storing key values in an access database and then later retrieving these and graphing them with visual basic. The fourth and final function is to store images and retrieve them later through the program.

The program is relatively new and was started in February 2008 so it is still in its prototype beta version and customized to work with the current system that is used in Puerto Rico and is not a generalized system as it is still in its infancy. But I have seen the need in not only Puerto Rico but in other places as well for a system like this and decided to demonstrate the progress as of now to create awareness of the software that is to come.

2. RELATED WORK

2.1 IMAGE-PRO PLUS, DEVELOPED FOR: MEDIA CYBERNETICS

Image-Pro Plus is the ultimate image analysis software package for fluorescence imaging, quality assurance, materials imaging, and various other scientific, medical, and industrial applications. The most powerful member of the Image-Pro software family, Image-Pro Plus includes extensive enhancement and measurement tools and allows you to write application-specific macros and plug-ins (Media Cybernetics).

2.2 IQBASE IMAGE DATABASE

Manage your valuable Image-Pro Plus image data and collaborate via the web using the IQbase image database (Media Cybernetics).

2.3 IMAGE-PRO BUNDLES

Combine Image-Pro Plus with tools to automate your microscope, improve image resolution, render 3D images and manage complex acquisition modes (Media Cybernetics).

2.4 THEORETICAL FRAMEWORK

Aerobiology is a branch of biology that studies organic particles, such as bacteria, fungal spores, very small insects and pollen, which are passively transported by the air (Comtois et al., 1999).

One of the main fields of aerobiology has traditionally been to measure and report quantities of airborne pollen as a service to allergy sufferers (Sterling et al., 1999). A problem has been identified in the process of recording and reporting daily spore counts, as such that is stated as follows: In the day to day management of pollen counts from aerobiological samples of national networks, only a small portion (usually from 12 to 15%) of the daily microscope slide is read. It is generally believed that, otherwise, too much time will be spent reading slides for a minimal increase in precision (Larson, 1993).

The previous statement is based on an average. And this problem is further worsened by the fact that a study conducted states that while the twelve transverse traverse method gave slightly better approximations of the spore concentration, the increase in accuracy may not justify the extra effort required to analyze with this method (Spieksma, 1991). These problems give rise to the need for a faster method of reading and storing these counts such as to have more accurate and easier readings.

2.4.1 WHY IS THE SOFTWARE APPROACH A FEASIBLE SOLUTION?

Software provides us with many key features such as: providing feedback instantaneously without wasting time manually having to insert certain values to generate a graph in a separate application, minimizing human errors (partially because we cannot avoid an error in spore identification among other things) by placing the values automatically in the correct table spaces, minimizing time and effort of manually placing values from hardware counters into computer tables among other things. Software is also cost effective and can be easily upgraded to fit certain needs. The entire above statement can only effectively be accomplished by the use of computer software. The atmosphere that surrounds the earth is a mixture of essential gases that together form the air. Depending on the weather parameters and the degree of contamination, the air could condense, disperse or transport numerous aerosols, organic particles, virus, bacteria, fungi, pollens, and volatile substances. The aerobiology is the ecology of the atmosphere, and its procedures allow the quantification and identification of the most common biological particulate in the atmosphere: the fungal spores (D'Amato et al. 1995; Horner et al. 1995; Burge 2002). Constant exposure to high concentrations of this particulate can affect the respiratory airways in individuals that are immunologically compromised (Burge and Rogers 2000; Okten et al. 2005), causing allergic reactions (Dharmage et al. 2001; Sakiyan and Inceoglu 2003; Lara et al. 2006).

Clinical manifestations of hypersensitivity to fungi include different immunological mechanisms. The most common is due to the exposure of spores with diameters below 5 μm that found their ways into the lower respiratory tract reaching the bronchi and lung alveoli (Horner et al. 1995).

For this reason, rhinitis and conjunctivitis and asthma are the most frequent allergic diseases of fungal etiology (Batra Tomas 2003). The presence of spores in the air is related to multiple factors such as their size, shape, weight, and aerodynamic, hydroscopic, and electrostatic properties of their walls (D'Amato et al. 1995; Newhouse et al. 2004; Okten et al. 2005). Weather factors (wind, humidity, temperature, etc.) also affect the dynamism of these particles in the atmosphere (Tan et al. 1992; Craig and Levetin 2000; Burge and Rogers 2000; Levetin and Horner 2002; Bartra Tomas 2003; Ivey et al. 2003; Rodriguez-Rajo et al. 2004).

The most common spores in the air are basidomycetes, ascomycetes, Aspergillus, Penicillin, Cladosporium, Alternaria and other asexual fungi, much of which are associated with respiratory affections and often referred as allergens (Lopez et al. 1989; Lehrer et al. 1994; Horner et al. 1995; Epton et al. 1997; Gonzalo et al. 1997; Delfino et al. 1997; Chew et al. 2000; Levetin and Van de Water 2001; Levetin and Horner 2002; Newson et al. 2002; Bartra Tomas 2003). However, the distribution of species is not equal around the planet and fungi that are often common in template regions are not necessarily found in the tropics.

In Puerto Rico, respiratory conditions constitute an important public health problem by affecting 33.3% of the children attending school, and from this percentage 51.3% receive treatment (Perez Perdomo et al. 2003). The East-Central region of the island has been identified by the Puerto Rico Department of Health as one of the areas with the highest prevalence of the disease. This agency reports that the 0 to 17 years old group as highly predisposed (Seguinot-Medina and Rivera-Rentas, 2006). Recognition of the influence of environmental factors in the concentration and dispersal of biological particulates, the use of appropriate air sampler to quantify the density and diversity of the bioallergens in the atmosphere, and recognition of a vulnerable population in the island constitute effective means to design preventive programs, that in the short or long term, will aid in the prevention or control of respiratory conditions caused by the aeroallergens in the air.

2.4.3 ELABORATION OF A SPORE CALENDAR

The total number of fungal spores in the air can vary from less than 200 to more than a million per cubic meter. This concentration changes with accordance to the time of day, the season of the year, the geographical location, the presence of sources of fungi and also of an infinite number of other atmospheric conditions such as the rain, the humidity, the temperature, the amount of light, the speed and the direction of the wind. These are factors that can have direct effects upon the concentration of the particulate fungi. In fungi, the dispersion of spores is widely related with humidity and precipitation, certain basidiospores and ascopores require humidity to act, while exist other types such as deuteromicetos that need very little humidity to sporulate. The meteorological phenomenon produces a compendium of factors that in conjunction can augment or minimize the amount of aeroallergens in the medium. (Edmondson et al. 2005). Aerobiological studies renounce the presence of fungal spores all throughout practically all months of the year, oscillating their concentration without following any pattern. In example, in studies realized in different countries it has been proven that spores of the species Cladosporium are the most frequent (Angulo et al. 1999). Of this species, Cladosporium herbarum, it has been signaled as the main cause of allergy, due to the high concentration that reach the conidian. Other fungal spores such as Alternaria, Fusarium, Aspergillius and Penicillium are much less abundant.

With the name spore calendar it is designates a graphical representation that resumes the annual dynamic of the main types of spores of a certain location, ordered in conjunction with the period of sprouting. This type of representation, that reunites in only one graph all of the aerobiological information of a certain location, and facilitates the comprehension of the fungal composition of the atmosphere in every moment of the year, informs us of the spores that can result most dangerous y outlines the relative importance of some spores compared to others. Even though a calendar with the data of one year of samples is already very valid information, it results much more representative those calendars that are elaborated with the average of many years of study, since in those calendars we can show the variability among many years that has as a cause meteorology and those that present certain species that alternate between years of high production and years of low production.

Finally, the recounts of spore and pollen are a invaluable weapon for identifying bio particles that provoke allergic reactions, all over Puerto Rico, where it does not exist a spore calendar and this type of condition is

treated according to treatments that have been applied in other latitudes of the world, without taking into account that it is a tropical island, with distinct environmental conditions. Even though in the last decades there has been an increase in the interest to study the effects of environmental contamination in human health, the fungi's role and its effect on the pulmonary airways is still to be clarified.

3. Materials and Methods

Since this is software the only materials used are the software products this includes:

- MySQL
- Visual Basic 2008
- Microsoft Office
- Burkard: volumetric spore trap (Dynamic)
- MK-3: volumetric spore trap (Static)
- Nikon 80i Upright Microscope, with fluorescence, DIC, and polarization microscope techniques.
    - Camera: 2 mega-pixel color camera
    - Effective number of pixels: 1600 x 1200 (1.92 million pixels)
    - Live image: 800 x 600
    - Chip imaging area: 11.8mm x 8.9mm
    - Pixel pitch: 7.4 microns
    - Photo eyepiece magnification: 1x
- Davis Instruments 6162C-WIFI VantagePro2 Plus Cabled WiFi Weather Station
    - Measures Outdoor Temperature, Outdoor Humidity, Wind Speed, Wind Direction, Rainfall (Precipitation), Barometric Pressure, Indoor Temperature (console) and Indoor Humidity (console)

Personal Computer: Hewlett Packard HP Pavilion dv2000 AMD Turion64X2 Processor 1.8 GHz clock, 2 Gigabytes of ram, Windows Vista Business OS 32 bit Version SP1, NVIDIA GeForce Go 6150 graphics card. Visual basic 6 was chosen to develop the software based on that it is the simplest to learn and yet very featured packed and with very few bugs.

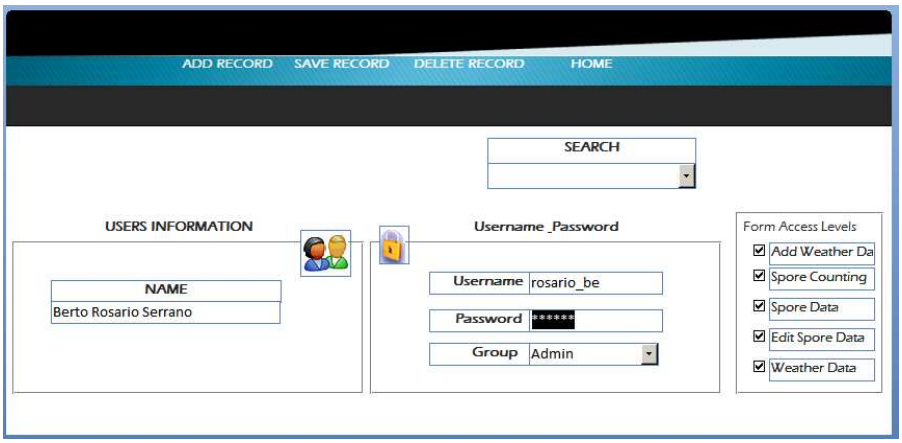

Figure 1: Present process to count spores

Figure 1 shows the actual process of spore counting.(a) Burkand equipment special collector of air samples, inside this equipment there is installed a crystal laminate which is impregnated with silicon where it will remain for 24 hours and is impacted with the twelve 2 hour impacts.(b) impacted crystal laminate(c) preparation of the laminate with co flour, list to mount in the microscope;(d)spore viewed through a 100 magnification lens(e)count process of each spore, that are temporarily registered in a temporary mechanical device called a piano;(f) transfer of the registered data from the piano to the computer in an excel sheet;(g) spore images are taken according to specific

criteria by an expert, that is observing through the microscope; up to this point the process is repeated twice(h) report generation, and lastly results are published in the AAAAI. This process has duration of approximately 6 hours with a high rate of errors during the transfer of data. A solution to this problem is SporeCount.

4. Structure of SporeCount Tool

SporeCount is a tool that contemplates in its design rules of usability such as the norms of HCI – Human Computer Interface, that make this an easily installable tools and easy to use. SporeCount is a toll created to count organism, understanding to be organisms anything susceptible to be counted such as: spores in the air, blood cells, people, trees, etc. The test with SporeCount tool was made with spores of air.

The figure 2 shows with more detail the steps for manipulation of images. It's important to outline here that the database of images is created utilizing the metadata of each image taken; these are organized in forms automatically by SporeCount, permitting easy and fast access afterwards.

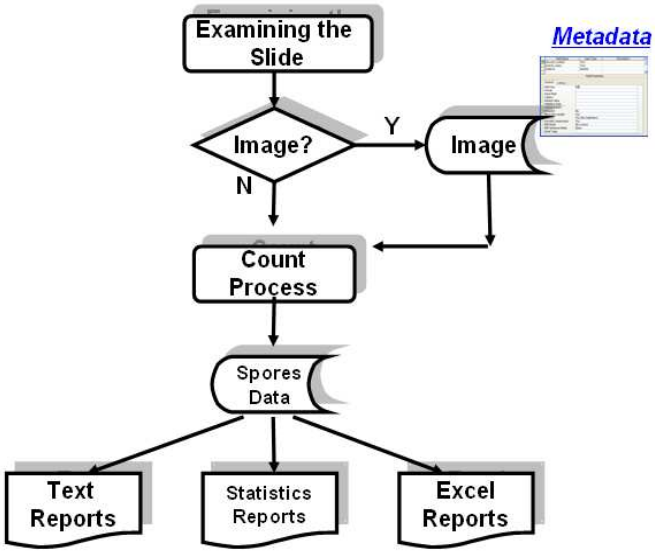

Figure 2: Scheme logical-general of SporeCount

4.1 Design and Description of SporeCount Software

SporeCount is designed in Visual Basic as a main programming language and the database are created and manipulated with MySQL. In the following we make a description of each of the screen contained in the software:

4.1.1 Main Access window:

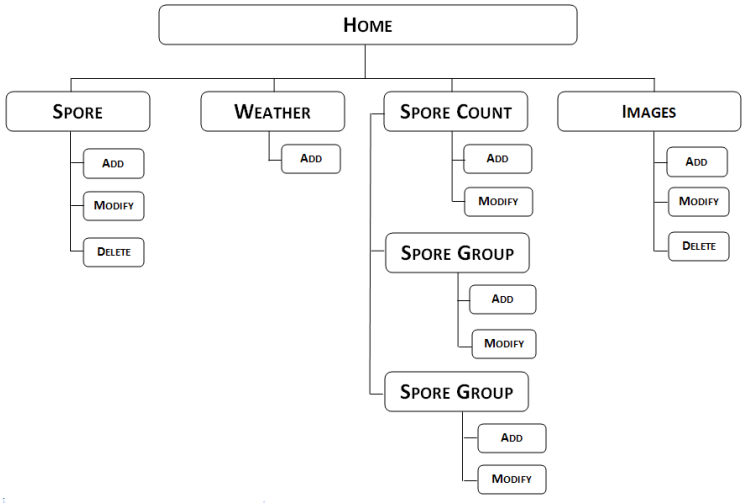

Figure 3: Scheme general of SporeCount

The first phase of the project is creating a database with the necessary tables to add information and transaction; the database will be having a table relationship that allow manage the records effectively. The original database was created using a Microsoft Access application, but the database was migrating to MySQL, the name of database used was spore.

4.1.2 Relational Database Design

The benefits of a database that has been designed according to the relational model are numerous. Some of them are:

- Data entry, updates and deletions will be efficient.
- Data retrieval, summarization and reporting will also be efficient.
- Since the database follows a well-formulated model, it behaves predictably.
- Since much of the information is stored in the database rather than in the application, the database is somewhat self-documenting.
- Changes to the database schema are easy to make.

The basic principles behind relational database design and demonstrate how to apply these principles when designing a database using Microsoft Access and PostPresql.

4.1.3 DATABASE AND RELATIONSHIP DIAGRAM

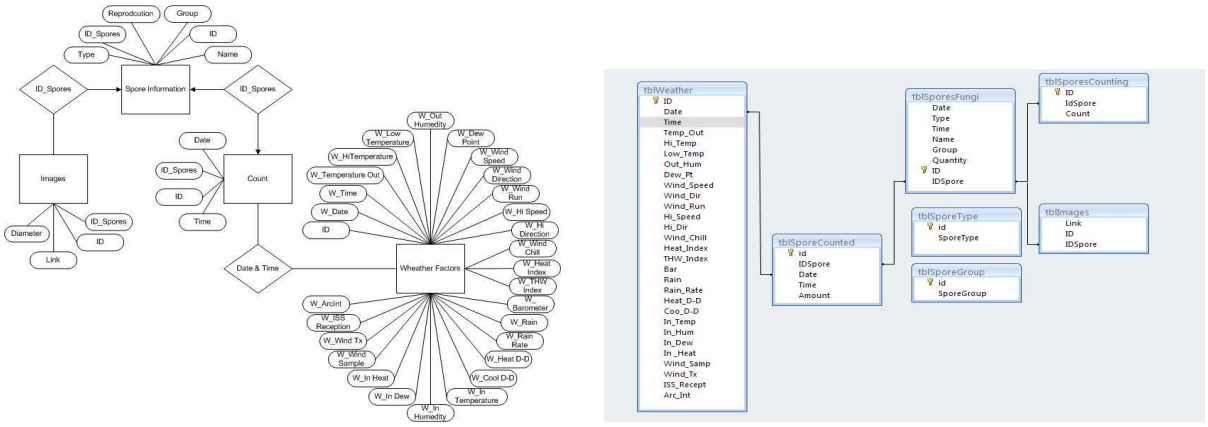

Figure 4: Database and Relationship diagram

4.1.4 MySQL Spore Database GUI:

The figure 5 shows the automatic process to count spores. The procedure that is followed from (a) to(d) showed in figure 1 are the same.(e)process of counting each of the spores, are registered directly to a database of spores, utilizing the own computer keyboard;(f) are the databases that register the information of the spores and the images that the expert wants to take according to their own criteria, these images are directly related to the day, hour, form and type;(g)distinct reports can be generated, from the database.

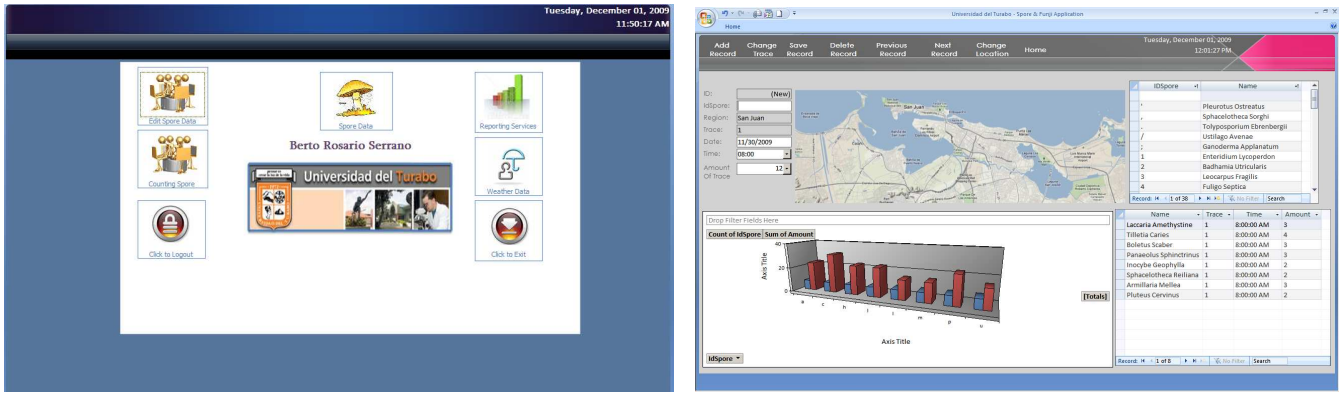

Figure 5: Main screen of Spores Count and Screen of Count Spores

5. FUTURE WORK

SporeCount is a versatile tool and is expected in the future implement the following:

- To make a version of SporeCount in Java
- To create a version of SporeCount that can be installed in portable equipment that allows to make this type of work of field in-situ.

6. CONCLUSIONS

Reduction of the time of count in preliminary tests in more of a 50%.

SporeCount, is not only useful in the count of spores of air made in mycology laboratories, if not in another type of works or laboratories such as clinical laboratories, alive specimen studies, inventories, taxonomy studies, between many others.

The software is the optimal solution to facilitating the research process involving spore and pollen counting. It will speed up and enhance feedback from this process and allow for more profound research to be done in much less time and will improve visual viewing by charts.

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