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Program
in **Geospatial**
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FireSpotter
A VGI-Based Forest Fire Reporting System

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FireSpotter

A VGI-Based Forest Fire Reporting System

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ABSTRACT

Forest fires are a serious problem in modern times, especially in semi-arid and Mediterranean climates. With the annual rise in number of forest fires and area burned, any help or information which a citizen in the field can provide to forest fire fighters and civil protection workers will aid in managing a forest fire scenario. This research devises an information system that allows ordinary citizens to submit forest fire sightings to the appropriate authorities. After the information system was created an accuracy assessment was conducted in order to assess the usability of the system.

KEYWORDS

Forest Fire Reporting System

Information System

Volunteered Geographic Information

Decision Support Systems

Geographical Information Systems

Spatial Decision Support Systems

ACRONYMS

VGI – Volunteered Geographic Information

GIS – Geographic Information System

OS – Operating System

API – Application Programming Interface

EPSG – European Petroleum Survey Group

DBMS – Database Management System

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1. INTRODUCTION

1.1 Forest Fires

'Forest fire' is a term that usually refers to an uncontrolled fire that occurs in a natural environment.

Forest fires usually have grave impacts in certain areas of the globe, being one of the main sources of environmental destruction. Forest fires entail pollution and water contamination as well as a loss of nutrients and ground microorganisms [Vidal and Devaux-Ros 1995].

Fires were once a natural phenomenon that did the following: 1) helped to shape species distribution, 2) contributed to the persistence of fire-dependent species, and 3) assisted the natural evolution of ecosystems. However, currently in many areas of the world increasing pressure by humans on the environment has resulted in more forest fires. In Europe, for example, only 5% of forest fires are from natural causes [Moore et al. 2003]. Often these fires cause irreversible damage to fragile, natural ecosystems and human assets. Fires are also a source of emissions into the atmosphere and cause the loss of extensive carbon sinks in tropical and boreal forests.

1.2 Forest Fires and Climate Change

Forest fires have a profound impact on the biosphere and our society in general. They cause loss of life, destruction of personal property and natural resources and alter the chemistry of the atmosphere. A forest fire is a primary process that influences the vegetation composition and structure of any given location. Fire helps shape the landscape mosaic and influence biogeochemical cycles such as the carbon cycle. Forest fire regimes, i.e. the pattern, frequency and intensity of the forest fires are not only the cause of climate change but also a consequence of it [Flannigan et al. 2000].

As presented by Wotawa, G. et al. 2001, 14% of the CO variability in the extra-tropical Northern Hemisphere can be explained by the boreal forest area burnt in North America, 53% by the area burnt in Russia. This suggests that forest fires have a significant influence on carbon emissions, greenhouse gases and climate change. Hence forest fire prevention and management should be a high priority for the climate change agenda. In the future, under a warmer climate, we can expect more severe fire weather, more area burned, more ignitions and a longer fire season [Flannigan et al., 2005].

1.3 Forest Fires in Europe and Portugal

Forest Fires in Europe, especially Southern Europe, are a major concern and a serious environmental risk. Every year thousands of hectares of forest are burned. As seen in Figure 1 below the problem regarding forest fires is greater in southern countries due to their drier climate. However, it is possible to observe some exceptions to this pattern, particularly in the spring of 2011. During this time there was unusually hot and dry weather in temperate Europe that induced remarkable fire activity significantly affecting countries such as Belgium, Ireland and the United Kingdom, which are normally excluded from the main forest fire risk areas [EFFIS 2010].

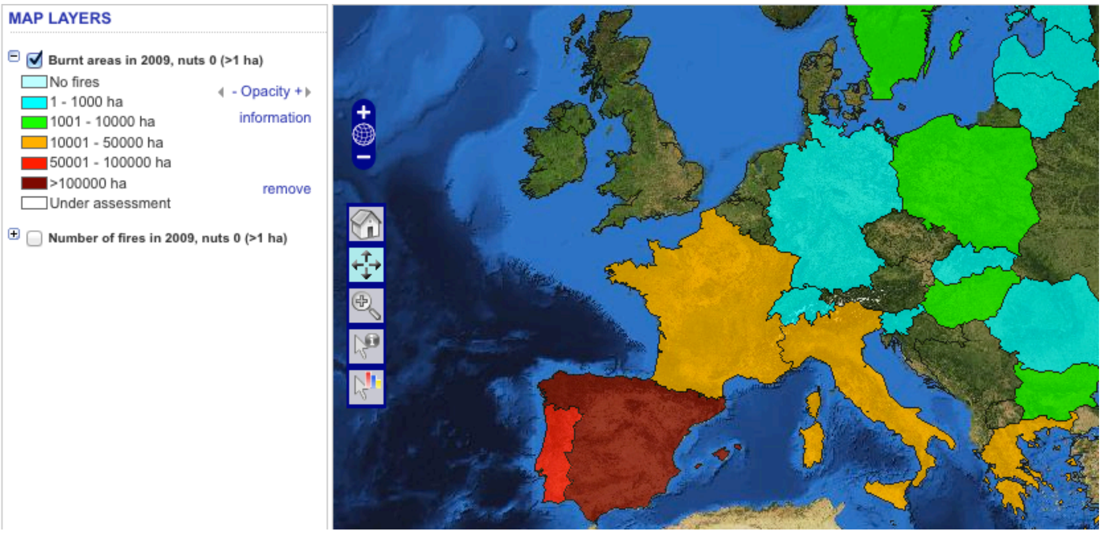

Figure 1 - Burnt Areas in 2009 in some European countries [EFFIS Viewer]

Portugal has a history of problems with forest fires with occasional years of very high values of burnt area. This is shown in Figures 2 and 3.

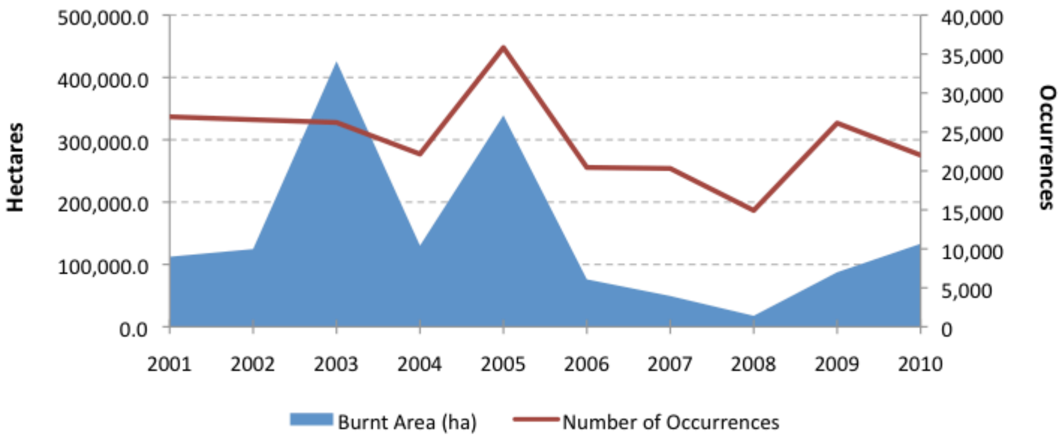

Figure 2 - Burnt Area and number of Occurrences of Forest Fires in Portugal between 2001 and 2010 [SGIF Database, 2010]

NUTS II Region	Number of fires			Burnt Area (ha)		
	≥ 1ha	< 1ha	Total	Shrub land	Wooded land	Total
Norte	2802	11780	14582	57006	27488	84494
Centro	842	4182	5024	28383	15787	44170
Lisboa	155	1436	1591	667	126	793
Alentejo	147	355	502	877	2 651	3528
Algarve	24	303	327	78	27	105
TOTAL	**3970**	**18056**	**22026**	**87011**	**46079**	**133090**

Table 1 - Number of Fires and Burnt area in Portugal (NUTSII - 2010) [EFFIS 2010]

In 2010 the total burnt area increased up to 133 090 ha, which represents 87% of the average of the previous 10 years (152 198 ha) [EFFIS 2010]. According to Vidal and Devaux-Ros 1995, forest and rural fires are one of the main causes of environmental degradation in Mediterranean countries.

Thus from available statistics and bibliography it is concluded that forest fires in Europe and in particular Portugal have a high impact on the environment and that serious public information campaigns plus fire detection and management efforts should be conducted in these areas.

1.4 Forest Fire Management

To develop a measured fire response we consider all of the components of fire management as summarized in Table 1.

System Process Components	System Tools
1 - ANALYSIS OF THE FIRE PROBLEM 1. Fire Likelihood -Ignition history 2. Consequence of Fire on Assets Economic Intensity Value Social Spread Rate Vulnerability Environmental Duration 3. Ecological context of fire	Maps (vegetation type topography, land tenure, assets, roads, landscape features, ignition distribution etc) Fire behaviour prediction tools Spatial databases Demographic information Cultural & Social Context of fire Ecological response to fire (fire histories, fire effects information, fire regimes, conceptual models)
2 - PREVENTION Ignition Reduction Strategies - Regulate fire use, educate fire users, technology improvements, development planning controls Impact Mitigation Strategies - Fuel reduction (e.g. by burning, grazing & other means) - Reduce asset vulnerability (e.g. through building construction standards) - Establish/maintain containment features (e.g. Roads, firebreaks fuel breaks etc) Fire Use Strategies - Ecosystem maintenance - Fire regime restoration	Fire use laws/regulations, enforcement programs Planning controls Education programs Fire behaviour guides, ignition and control resources, planning and reporting tools. Firebreak construction guides Building construction codes Ecological fire training Fire use education

System Process Components	System Tools
3 - PREPAREDNESS Strategies - Early Warning/Predictive systems - Community warning mechanisms - Detection and response infrastructure - Communications systems - Mobilisation & co-ordination plans - Response triggers and levels - Competent fire control staff	Climate and weather monitoring & prediction Fire Danger Rating system. FDR public notification means. Detection & suppression resource needs assessment. Fire detection, suppression & communications resources. Fire training systems and tools
4 - RESPONSE - FIRE FIGHTING OPERATIONS Detection and Reporting First Response Containment and Control Mop Up and Patrol Command and Control	Response mobilisation plans Operational responsibilities and procedures. Strategic information access tools Decision support tools Operational management systems
5 - POST FIRE RECOVERY Community Welfare assistance Economic loss reduction (e.g. salvage logging and replanting, infrastructure repair) Environmental repair	Damage assessment tools Recovery assistance plans and infrastructure

Table 2 - Forest Fire Management Process [Parsons, D. et al 1986]

A Forest Fire Reporting System, like the one that will be presented in this paper, aims to contribute to the components of Detection and Response Infrastructure, Communication Systems and Detection and Reporting. The main focus of academic efforts and research is mainly directed towards the analysis of the fire problem.

Although the impact of fires around the world is large, the available information on fires and their effects at the global or regional scales are still very limited. The need for early fire detection varies according to numerous factors. Fires constitute a threat when they occur in either fairly populated regions or areas of high environmental value. Hence the level of urgency for fire detection and fire fighting changes according to the fire scenario. For instance, natural fires, which may be considered a vital alteration of an ecosystem, do not need to be extinguished. They are only extinguished when they are considered a threat to human assets. On the other hand, fires caused by humans are often extinguished as soon as possible. Early detection of these fires is clearly aimed at fire fighting. Therefore, it is assumed that early detection is only needed when resources for fire fighting or fire control are available. An analysis of the requirements of the fire suppression community for early fire detection in Europe resulted in a maximum detection time of 15 minutes from the start of the fire [INSA, 2000]. This analysis showed that the value of the fire detection information decreases according to a negative exponential curve. This rapid loss of value concerning fire detection information can be easily explained. Fires are usually trivial to extinguish in an early stage but once a fire has reached a fairly large size then operations for fire fighting become very complicated and the control of the fire depends largely on the meteorological conditions that determine fire spread. Although all components of a forest fire management system are of high importance the primary focus of this paper is on the component of Detection and Reporting.

1.5 Forest Fire Detection and Reporting

Forest Fire Detection and Reporting was, in the past, typically conducted in traditional manners consisting of simple, non-technological means. Fire lookout towers provided shelter for “fire lookouts” that reported incidences of fires to the respective authorities. Fire lookout towers had high visibility, normally standing on mountaintops or other high vantage points. The fire reporting process employed diverse systems such as telephones, carrier pigeons and heliographs.

However, today new technologies and tools are constantly adapted and created in order to report rural and forest fires. Both preventive and post fire detection systems are useful to defend areas against fire. Fire fighters in charge of parks and forest zones must have the latest technology and must be properly equipped to do fire forecasting. The next section presents the primary, most modern techniques used to report forest fires.

Physical Sensors and cameras

Sensors are instruments that detect variations in certain properties and thus can be used to detect forest fires. Temperature sensors can evaluate if certain temperature thresholds are passed indicating a possible forest fire. Wireless Sensor Networks are created in order to relay the information registered by the sensors to a central database or repository where it can be processed and interpreted.

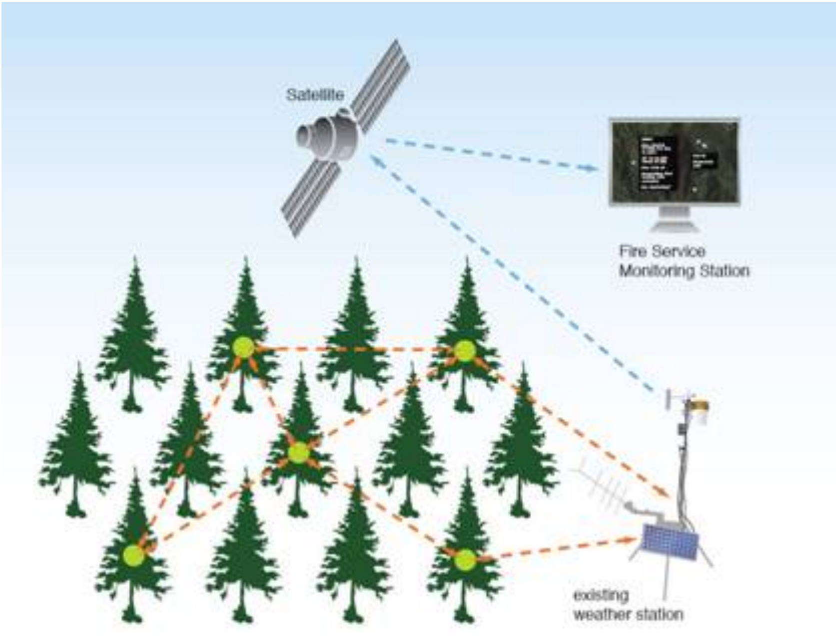

Figure 3 - Forest Fire Wireless Sensor Network [Altenergymag 2008]

However, due to the high costs for implementing this system it is only used in very specialized, high value areas or areas with particular needs. Cameras, which operate in the visible light range, are an equally expensive system of detection and reporting due to the complex image analysis algorithms needed. In addition there is the equally demanding and expensive human analysis of the camera data (images).

Lloret et al. 2009 developed a Forest Fire Detection and Reporting System that combines sensors to detect forest fires and cameras to validate the existence of the forest fire. The cameras permit the fire fighters to verify the existence of a fire and avoid false alarms.

Remote Sensing

Remote sensing, a specific form of sensor and/or camera, is an alternative to traditional onsite, *in-situ* sensors. Remote sensing is a powerful and widely used tool for monitoring and observing the current situation of forests and forest fires occurrences. Fire detection algorithms are run on remotely sensed images in order to obtain the presence of forest fires. Although these fire detection algorithms are automated the National Oceanic and Atmospheric Administration (NOAA) has not been able to completely eliminate the human element from their fire detection procedures [Miller et al. 2005]. This limitation is being overcome by training neural networks to mimic the decision-making process, which constitutes the human element of the entire process.

Another limitation of remote sensing based fire detection and reporting systems is the low re-visit frequency of earth observation satellites over a region. This creates the possibility of the creation and extinction of a forest fire before a satellite re-visits the same region.

An alternative to the common forms of forest fire detection information is the use of citizens themselves. If citizens act as sensors for fire detection and reporting systems, the costs are low due to the use of voluntary and helping spirit of citizens. Citizens have every incentive to serve as vehicles for the preservation of their areas since it is these areas that provide them with their livelihood. This modern trend of citizen-provided geographic information is termed volunteered geographic information (VGI).

1.6 Volunteered Geographic Information

Recent Internet evolution has permitted an unprecedented increase in content created by non-specialist users thanks to a reduction in technical barriers [O'Reilly 2005]. User-generated content has multiplied enormously with the advent of social media applications like Facebook, Twitter and YouTube.

When such user-generated content has a geographical dimension it is referred to as volunteered geographic information (VGI). VGI has a huge potential to engage citizens in place-based issues and provide a significant, timely and cost-effective source of information for geography and other spatially-related fields of research and management [Goodchild 2007].

However, the emergence of this new type of information and the transformation of past GIS users into present GI producers creates and generates interesting points that should be taken into consideration:

- Quality, credibility, precision, accuracy of VGI data
- Usability and usefulness of VGI data due to the massive amounts of data and the post-processing efforts to convert the data into information
- Privacy issues

1.7 VGI and Forest Fire Detection

VGI has been implemented in several fields but as a source of information for Forest Fire Detection there are only few applications. Nuñéz-Redó et al. 2011 recently presented a prototype of an information system that leverages scientific data and web 2.0 content and applies it to a forest fire monitoring situation. The Joint Research Center of the European Comission is also focusing on using VGI, in particular Location-Based Social Networks (LBSN) Information to gather spatio-temporal data on forest fires. A Case Study of a major forest fire event in the South of France during the month of July 2009 was used to demonstrate the reliability of LBSN Information as a source of valid information for the management, planing, risk and damage assessment of forest fires [Longueville et al. 2009]. Although not a specific tool for the detection of the fires, it could be adapted in order to serve this purpose.

2. OBJECTIVES

The **main goal** of this research is to create a Forest Fire Reporting System based on VGI input from citizens and modern web technologies. The idea of the system is that a Citizen may report the location of a forest fire, plus metadata, using a mobile application created specifically for the purpose. The information submitted consists of two pairs of coordiates plus bearing values. This information is then used, with an intersection algorithm, to calculate the estimated fire location. More information in the subsequent chapters is given regarding the information submitted and the algorithm to calculate the forest fire location. In the end, all of this information is made accessible via an Internet-based web map. In this manner, forest fighters and fire management decision makers can utilize this information to assess whether or not there is a need for action. This information can also serve the goal of documenting the fire and its progression through time.

The **main research questions** investigated are:

- What is the order of magnitude of the accuracy value that would define the system and the forest fire location calculation algorithm as credible and useful?
- Does the system provide enough accuracy (correspondence between the reported and the true value) to make the system credible and useful?

3. SYSTEM DESIGN

In order to transfer and process citizen-based VGI to a forest fire fighter or decision-maker a uni-directional three-tiered information system was created.

The three tiers (layers) of the information system are:

1 – Mobile Application

2 – Spatial Database

3 – Web Map

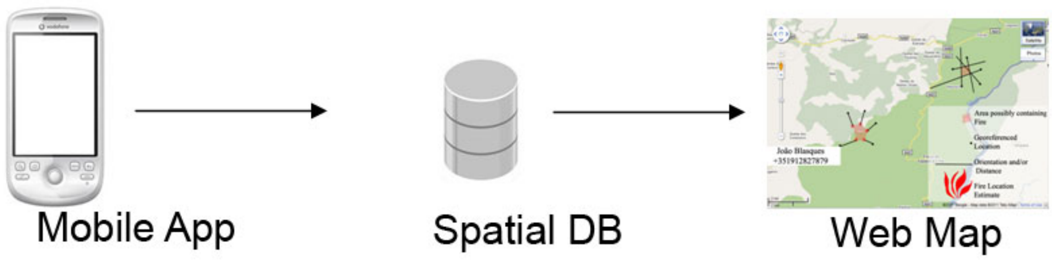

Figure 4 - The three tiers of the information system

The citizen uses the Mobile Application in order to submit the VGI. This information is sent to the forest fire location calculation algorithm and stored in the spatial database. Finally, a web map connected with the spatial database presents the processed information to the forest fire fighters and decision-makers.

In order to calculate the location of the forest fire the citizen submits the following data twice, at two different locations:

- Coordinate location
- Bearing (pointing at the fire location)
- Photograph of the fire
- Ancilliary data (name, email, phone number, any additional comments pertaining to the forest fire)

After the submission of the data, the system calculates the location of the fire by the means of a trignometric process called triangulation. This trignometric process in our specific case is demonstraded in Figure 5.

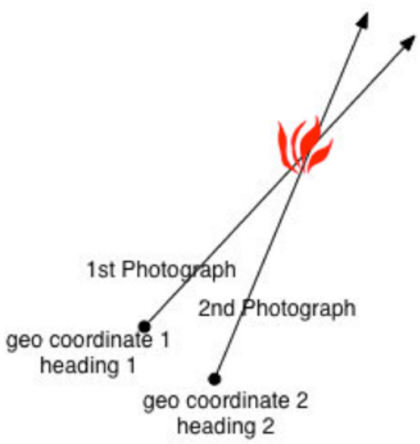

Figure 5 - Triangulation process derived from coordinate and heading pairs

4. DATA MODEL

The main purpose of the system is to transfer information regarding the location and meta-data of forest fires. This transfer occurs when the citizen (via a mobile application) provides information to the decision-maker (via a web map). In order to do this there is an intermediate step where the data are stored in a database. Here we use a spatial database to store data that pertains to geographic features. Various data types, and encoding characteristics are taken into consideration and are further discussed in Sections 4 and 5. The data submitted by the citizen and stored in the spatial database is organized and related according to the data model that is presented in Figure 6.

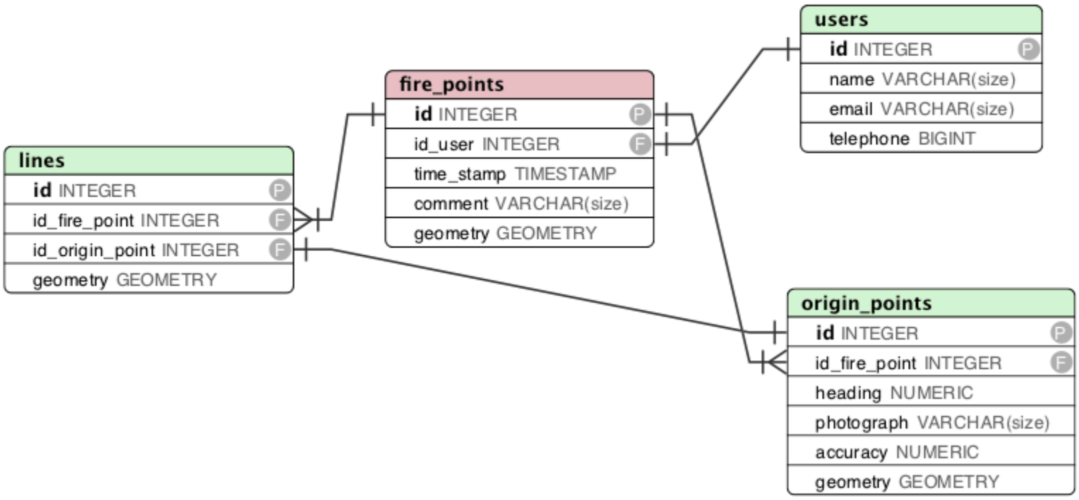

Figure 6 - FireSpotter Data Model (Logical Schema)

The data model's primary focus is the fire_points table that contains the actual location of the fire (geometry), the time at which it was submitted and an optional comment added by the user. The other tables are all related with this primary table (through foreign key associations) and provide ancilliary data in order for the end-user to know how this data was created.

5. TECHNOLOGICAL ARCHITECTURE

After the FireSpotter system was loosely designed and conceptualized, the next design and planning phase consisted of defining the technological architecture of the system. Several options were tested regarding the spatial database (PostGIS [PostGIS 2012]) and web map components (GeoExt [GeoExt 2012] and OpenLayers [OpenLayers 2012] webmap served by GeoServer [GeoServer 2012]). However, the option presented below in Figure 7 was the one chosen to be used due to time restraints and limitations regarding technological knowledge of the researcher.

Figure 7 - Technological Architecture of the FireSpotter System

The Mobile Application is a hybrid application made with HTML, CSS and Javascript languages through Phonegap [PhoneGap 2012]., Phonegap is an application platform and a native wrapper is created utilizing it. It is still a web application running inside a hosted browser control although it has several characteristics and capabilities of a native application. PhoneGap permits our web application to communicate with the native sensors of the mobile device which is very important since our application uses the GPS, compass and camera sensors of the mobile device in order to generate the needed base data (coordinates, bearing and photograph) used for the calculating the fire location. In order to communicate with the sensors Javascript code was created utilizing the PhoneGap API, which then makes the appropriate, corresponding native calls and bridges. The User Interface was optimized with a mobile development framework called Jquery Mobile [Jquery Mobile 2012].

The Spatial Database is a set of Google Fusion Tables [Google Fusion Tables 2012] all connected through standard SQL principles and design (see section 4. Data Model). Google Fusion Tables is a data management system made available as a web application. Google

Fusion Tables can be structured and organized to create a standard relational database with the added advantage of supporting spatial features. No advanced features of a spatial database are available in Google Fusion Tables (e.g., triggers, functions) so data processing was conducted on the mobile application side before being submitted to the database. Google Fusion Tables also makes available a RESTful SQL API that can be accessed through standard HTTP requests.

The Web Map consists of an application created using the HTML, CSS and Javascript languages. It is populated with data from Google Maps API and Google Fusion Tables by means of APIs.

6. DEVELOPMENT METHODOLOGY

A simple linear development process was used to follow the data lifecycle from creation to processing to storage to display. The development steps followed were:

1. Mobile Application Development (data creation)
2. Forest Fire Location Calculation Algorithm (data processing)
3. Submission of Data to Database – PHP Script (data storage)
4. Database (data storage)
5. Web Map (data/information display)

The whole development process was backed up and versioned in sequential small steps through local, GIT [Git 2012], and cloud-based, Github [Github 2012], versioning systems. This permitted simple and instant rollback actions to previous steps whenever an untraceble error occurred.

6.1 Mobile Application Development

The mobile application FireSpotter is comprised of three main components:

- User interface design and development
- Obtainment of Data from Device Sensors
- Forest fire location calculation algorithm

User Interface Design and Development

The User Interface (UI) of the Mobile Application was designed in order to fulfill the functional requirements of the mobile application. The main content consists of 5 application windows which do the following:

- Explain the program functions and purpose
- Describe how to use the application
- Allow the user to obtain information from the mobile device's native sensors
- Submit wildfire information to the appropriate authorities.

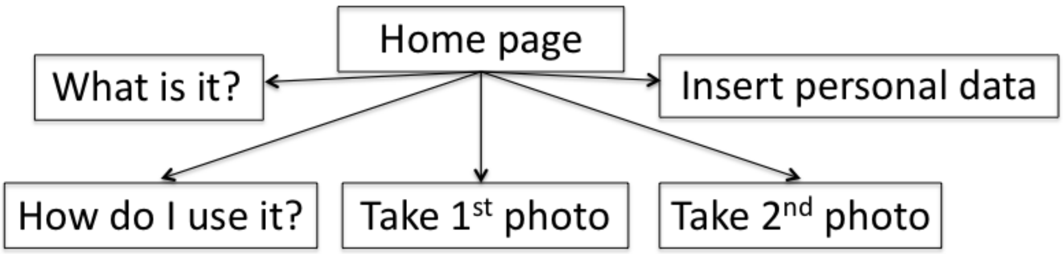

Figure 8 - Mobile Application Sitemap

The Home Page is a menu connecting all of the application pages along with a submit button to send the final contente to the spatial database.

The **What is it?** page explains the concept of the application and its purpose.

The **How do I use it?** page explains how the application should be used in order to obtain useful results.

The **Take 1st photo** and **Take 2nd photo** pages are where the citizen retrieves native sensor data (location, bearing, photograph) from the mobile phone.

The **Insert personal data** page permits the citizen to submit personal and ancilliary data.

The mobile application has several states (dialog, transition and confirmation) in order to fullfill the standard functionalities (data validation and feedback to the user) expected of a mobile application.

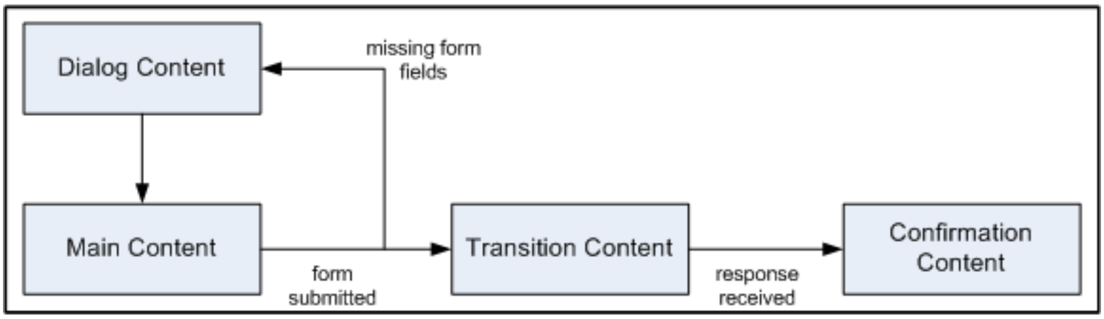

Figure 9 - States and State Transitions of the Mobile Application

Obtainment of Data from Device Sensors

The mobile application obtains sensor data by using specific calls to methods of PhoneGap objects,. These objects are the gateway to the device's OS where the sensor action will be executed. After the action completes a response is sent from the device's OS back to the mobile application which stores it in the form of programming data types (variables, arrays).

The type of heading response, magnetic or true north heading, was an important parameter to define regarding the device's compass sensor. The True North Heading was chosen due to the ease of integration with projected maps. The source code for the mobile application UI can be found in Annex A. Source Code of Index.html (Mobile Application User Interface).

Forest Fire Location Calculation Algorithm

The Forest Fire Location Calculation Algorithm is the component of the FireSpotter system which transforms the submitted data into useful information. The Forest Fire Location Calculation Algorithm has the goal of calculating the geographic coordinates of the forest fire. This is done by the means of a triangulation process using the 2 coordinate+heading pairs submitted by the citizen using the FireSpotter application.

In order to execute the geometrical algorithm the coordinates obtained from the mobile application were projected onto a Cartesian grid in order to more easily calculate distances between points. The projection system used was the Albers Equal Area Conic Projection in order to provide minimal distortion between two standard parallels and to preserve local angles. It therefore fits a large area without the need to change the projection system. Improvements regarding projection systems and world-wide applications are discussed in the Future Work chapter.

The formulas used were based on coordinate geometry, specifically calculating the intersection of two straight lines. Each line on a geometric plane can be defined by various means. However, with the data provided (point + heading) by the mobile application, the only manner to represent it is by the point-slope form given in Equation 1.

$$y = m(x - P_x) + P_y \qquad (1)$$

An example of the point-slope representation of a line is shown in Figure 10.

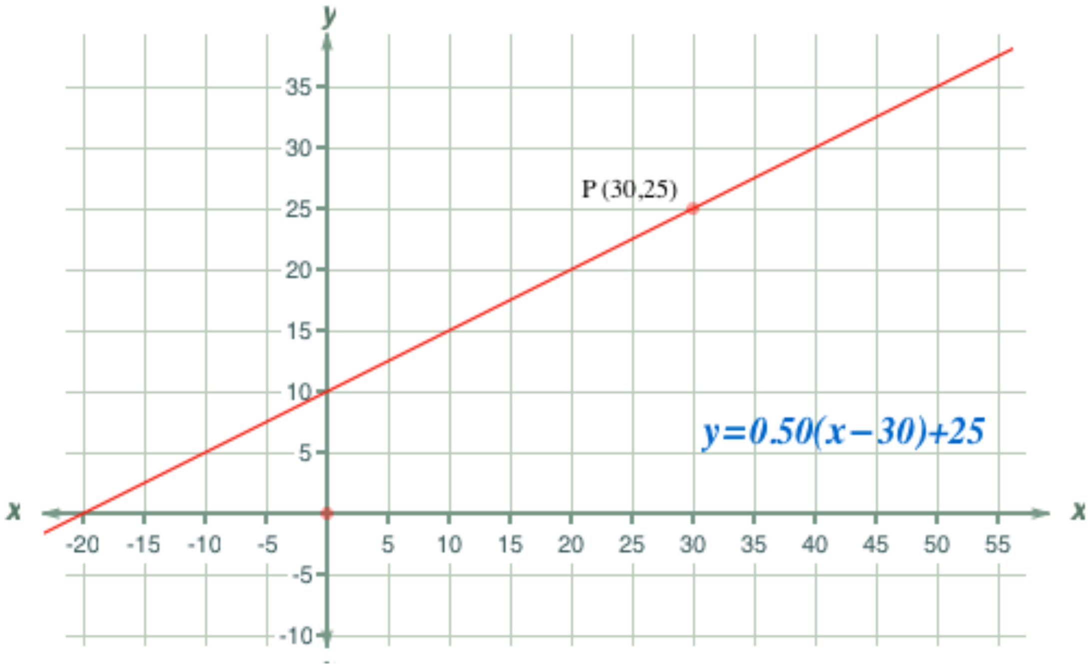

Figure 10 - Demonstration of the point-slope representation of a line

Although the coordinates obtained from the mobile application were projected onto a cartesian grid the headings were not and cannot be used directly in a cartesian grid geometrical calculation. In order to utilize the true bearing value in a cartesian coordinate system the value of the true bearing was subtracted from 90 as shown in equation 2. This is due to the 0º value in the true bearing reference system is 90º different than in the standard cartesian coordinate reference system. .

$$mathangle = 90 - heading \quad (2)$$

With the data provided by the mobile application, one can define the two represenions of the line by equation 1 and then set them equal to one another in order to obtain the intersection point of the two lines as shown in Figure 11 and Equation 3.

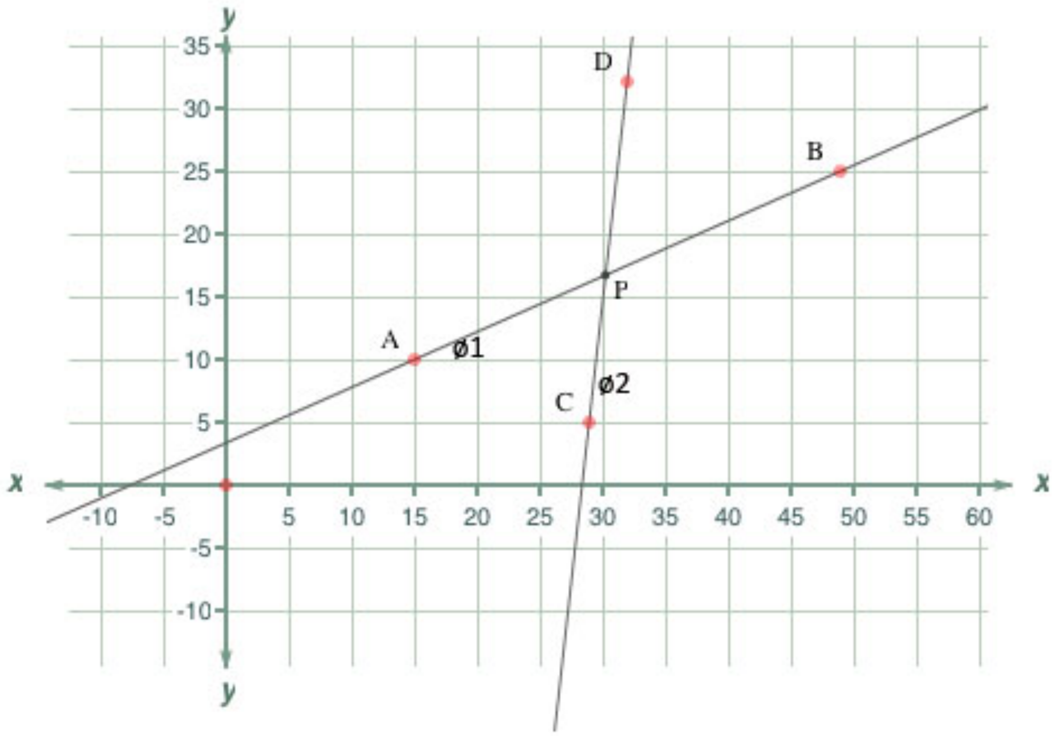

Figure 11 - Representation of the crossing of two lines in a cartesian grid (in order to support the visualization of the equation 3)

$$\tan\theta_1 \times \left(x_p - x_a\right) + y_a = \tan\theta_2 \times \left(x_p - x_c\right) + y_c \quad (3)$$

After the definition of the forest fire location this cartesian coordinate was transformed into a geographic coordinate in order to be represented in the web map. The source code used to create the Forest Fire Location Calculation Algorithm can be seen in Annex C. Source Code of geocalculations.js (Forest Fire Location Calculation Algorithm).

6.2 Submission of Data to DataBase – PHP Script

A PHP script transports the processed data from the mobile application to the spatial database. The mobile application submits the data to the PHP script by means of an HTTP Post Request. The PHP request receives the data and completes the job of transferring the data into the database.

In the future this step will be removed to take out an unnecessary step in the architecture that slows down the submission process and makes the code maintenance of the application more complex. This intermediate step utilizing a PHP Script could be substituted with a direct data submission from the mobile application to the database by means of AJAX requests.

Due to the database being a Google product, authentication and authorization of the application is necessary in the case of the PHP Script. Authentication consists of the application being able to log onto a Google Account via scripting mechanisms. Authorization permits read and write access to the data stored in the user's Google Applications. Google has several authentication and authorization protocols and the protocol used here is Client Login [Google Client Login 2012].

The insertion of data into the database consists of an SQL API call, via an HTTP Request, to each of tables of the database. The SQL actions performed are all "Insert Into Table" actions. The data inserted into the database was mainly alpha-numeric data and geographic coordinates of points and lines. The text representation of the geographic coordinates were converted to the KML format in order to be inserted into the database. The source code used to create the mobile application UI is in Annex D. Source Code of submit_to_db.php (Submission of Data to Spatial Database).

6.3 Database

The Database creation consisted of table creation data type definitions. A data model can be seen in Figure 6 of Chapter 4. Adjustments to the source code had to be made in order to fit the data model with the possibilities available from Google Fusion Tables. The main adjustment done was the programatic creation of the primary and foreign keys in the database. This is a task which would normally be taken care of in any modern database management system (DBMS).

6.4 Web Map

The web map's purpose is to clearly and simply present the information stored in the different tables of the database. A Google Map Web Application was created to address this goal. The Google Map Web Application consists of a dynamic web map with a Google base layer and all of the Google Fusion Tables as additional layers. The Google Base Layer projection uses Google's close variant of the Mercator projection, EPSG:900913. All aditional Google Fusion Tables layers were automatically projected and transformed into WMS tiles by the Google Services.

The aditional layers are :

- users_fire_points (geographic points layer containing locations of fires and metadata)
- origin_points (geographic points layer containing points where VGI was submitted by citizens)
- lines (geographic lines layer containing lines used to calculate location of fires)

The users_fire_points layer is a layer created from the merging of two database tables: users and fire_points. By doing this the ancillary user data is joined with the fire_points data and can be seen simultaneously on the web map. The source code used to create the mobile application UI is provided in Annex E. Source Code of index.html (Web Map).

7. RESULTS

7.1 Mobile Application

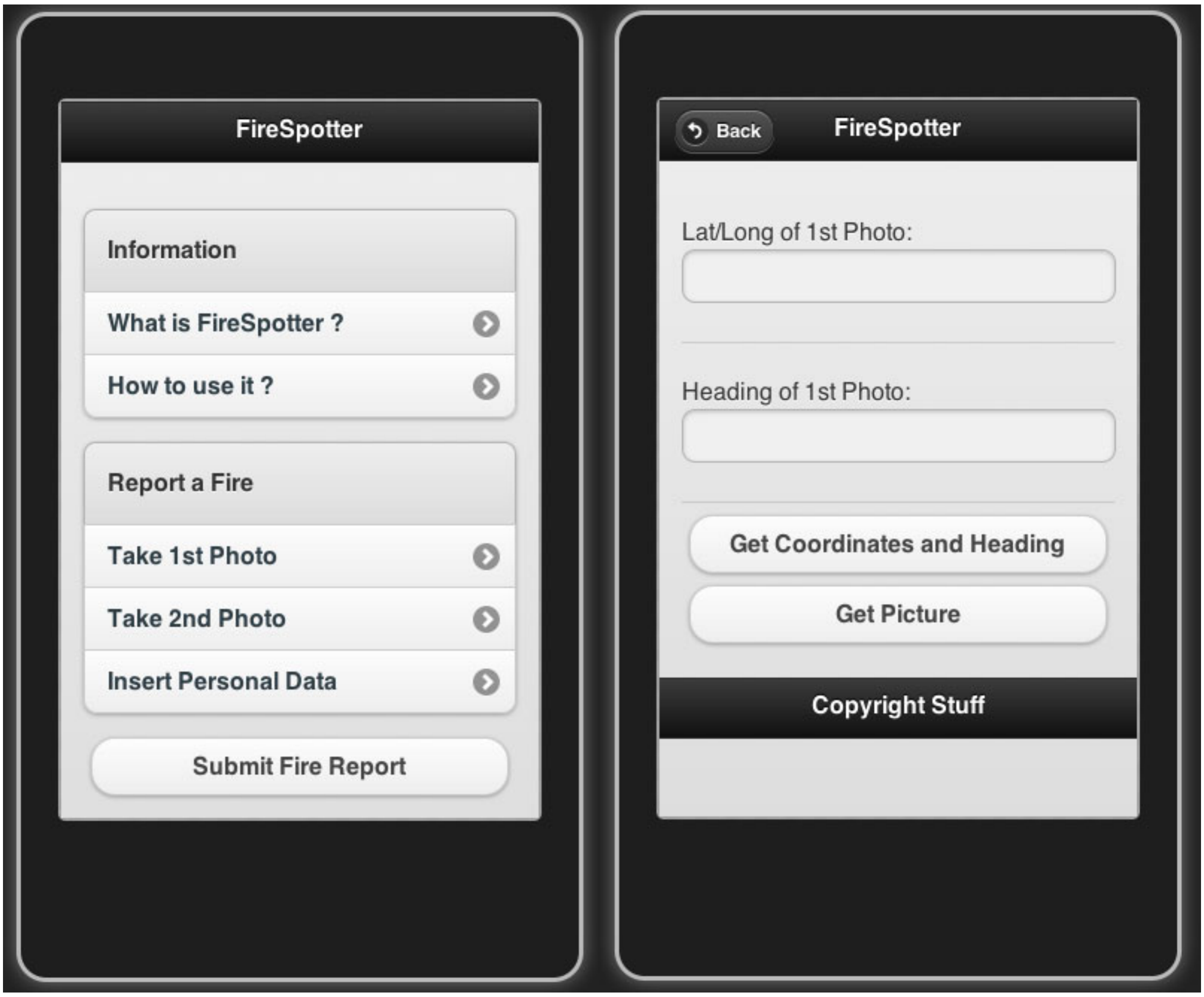

Figure 12 - Mobile Application User Interface

The mobile application is presently functional and achieves its intended purpose, to submit data relating to a forest fire to a central server. At the present moment, the application is only available for the Android OS. This is due to limitations in PhoneGap's comunication capacity with the compass sensor of other device OSs (IOS and Symbian).

An application build is available for Android nobile devices in the following GitHub repository.

https://github.com/tilakapash/FireSpotter/downloads

After downloading the zip file, the build file is inside the bin folder and the program is contained in the file firecitizenandroid321.apk.

7.2 Web Map

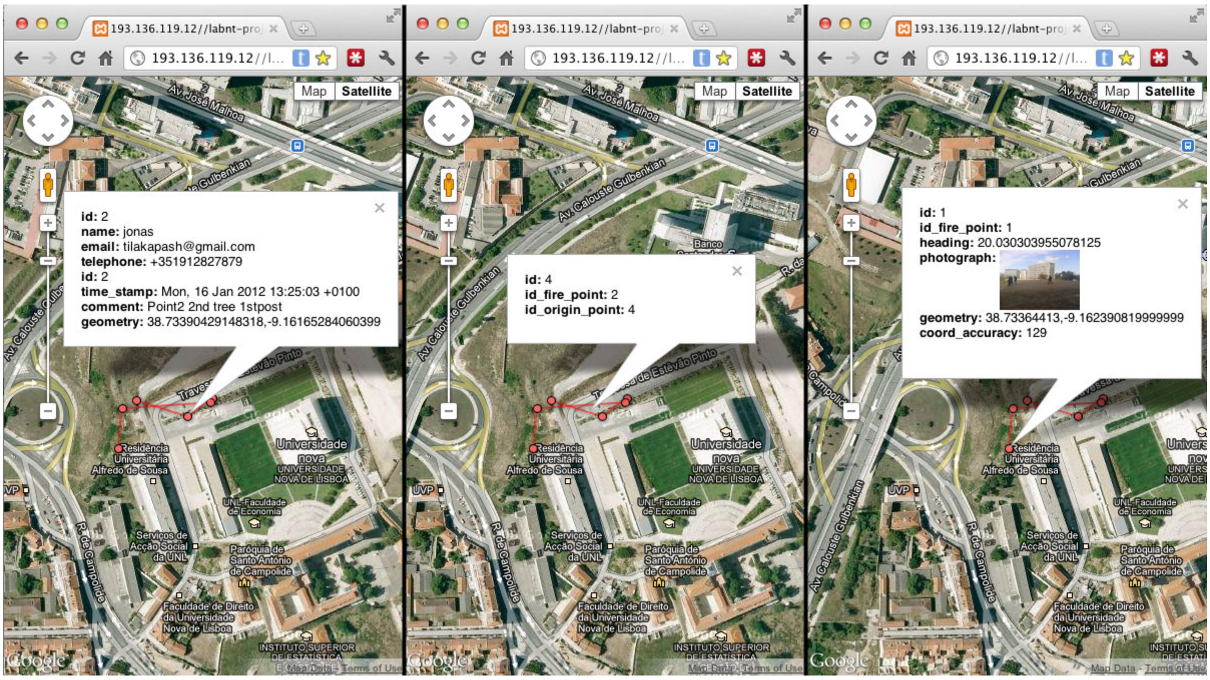

Figure 13 - Web Map User interface. Demonstration of fire_point, line and origin_point data, respectively.

A 1st prototype of the Web Map is available and functional at the following web address:

http://193.136.119.12//labnt-projects/firecitizen/php/webmap/index.php

As can be seen above in Figure 13, the outputs of the web map are:

- Fire points: predicted fire locations and their corresponding meta-data
- Lines: result of the geometric calculation using origin points and the true bearing direction reported by the user.
- Origin points: location where the citizen has volunteered the data.

8. VALIDATION AND PERFORMANCE TESTS

The FireSpotter system was tested using the Asus Eee Pad TF101. The main testing and validation conducted with the system was **exploratory accuracy assessment**. This was done in order to certify that the information, specifically the geographic location presented by the system, was valid in the real world.

A systematic approach was conducted where one imaginary fire was registered by means of the FireSpotter system at different locations in space. The coordinate values presented by the system were then compared with the coordinate values supplied by google maps and the difference between the two presents an accuracy estimation of the system. Although an actual accuracy assessment would have to take into consideration the accuracy errors of the google map points in reference to control points, this research did not take this into consideration due to resource restrictions. Since the points will be visualized on a google map this research considered the google map value as the ground truth.

The exploratory accuracy assessment was conducted for three elements of the FireSpotter system:

- Fire Points
- True bearings
- Origin Points (GPS Coordinates)

The accuracy analysis consisted in conducting a certain number of simulations of the system at certain distances from the fire points:

- 6 simulations each at 150m and 300m
- 3 simulations each at 600m, 900m, 1200m and 1500m

The estimated values calculated by the system where then compared with the google map values and an accuracy error was calculated. The error was averaged in order to obtain an estimate of the accuracy of the system at a certain distance from the fire location.

The accuracy analysis was conducted by a single user and so in order for the analysis to be representative the number of users and simulations would have to be greater.

Fire Points

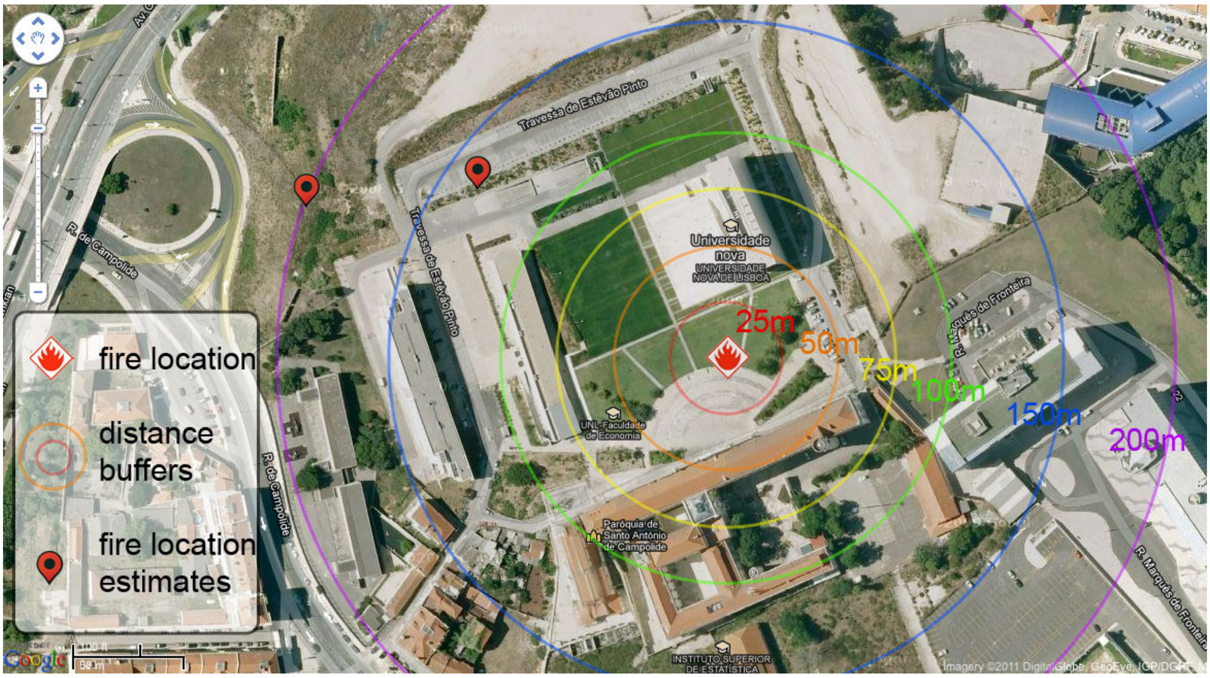

Figure 14 - Visualization of Fire Location Estimates in relation to Actual Fire Location

Several tests were conducted at different distances from the fire location and the resulting estimation differences were averaged for each distance. In this manner the system effectiveness at different distances can be obtained. The accuracy analysis of the fire locations estimate is a compound error due to the sum of the GPS sensor induced error plus the user's induced error in the estimated true bearing values.

Distance of Measurement from Fire Location (m)	Average Difference between Estimated and Real Forest Fire Location (m)
150	178.236
300	194.478
600	195.226
900	210.759
1200	282.331
1500	353.194

Table 3 - Effect of Distance on Accuracy of Forest Fire Location Estimation

As shown in Table 3 the accuracy of the forest fire location estimation does vary with the distance at which the measurements (GPS and true bearing readings) are taken. The accuracy is in the 120 to 250 m range.

True bearings

Figure 15 - Visualization of true bearing deviations from fire location

The difference between the estimated and real true bearings were calculated at different distances. The results at each distance were averaged and are presented in the table below.

Distance of Measurement from Fire Location (m)	Average Difference between Estimated and Real True bearing values (decimal degrees)
150	0.7728
300	1.2369
600	3.5632
900	5.2946
1200	4.6113
1500	6.1442

Table 4 - Average Difference between estimated and real true bearing values, at different distances of measurement.

We can observe a loss in accuracy of angle measurement as we move further away from the forest fire location. This can be due to human manipulation of the device and inability to point precisely at the object at increasing distances. It can be observed that the accuracy of the true bearing values dimnuishes with distance.

Origin Points

Figure 16 - Visualization of estimated Origin Points (GPS Readings) in relation to real values

The difference between the estimated and true origin points were calculated at different distances. The results at each distance were averaged and are presented in the table below.

Distance of Measurement from Fire Location (m)	Average Difference between Estimated and Real Origin Points (m)
150	163.852
300	174.311
600	156.411
900	155.613
1200	180.729
1500	161.194

Table 5 - Average Difference between estimated and real origin points values, at different distances of measurement.

If we compare the values of the origin points accuracy with the values of the forest fire location accuracy there is a direct proportional relation between the two which indicates that the origin point accuracy, or in other words the GPS accuracy, might be the main cause of lack of accuracy in the location of the forest fire. Several studies, [Serr, K., Windholz, T. and Weber, K. 2006] and [Wing, M. et al 2005] indicate that the average accuracy of consumer-grade GPS is between 1 and 10m which is very different from the 100m readings received with the mobile device used in this research. After literary research, it is widespread knowledge in the Internet that the particular accuracy of the Asus Eee Pad TF101, the mobile device used in this series of tests, is quite inferior to other models. It is reported that accuracy errors are in the range of 80 to 150m, which is the range of values obtained in our series of performance tests.

9. CONCLUSION

The **Main Research Goal** of this work was to design and implement an information system for citizens to report forest fires to the respective authorities. It is concluded that it can be done with the current technologies available and given that the users are granted certain conditions. These conditions are: ownership of a phone with an internet connection, GPS, and compass capabilities.

The **Research Questions** were analyzed during the Validation and Performance Tests phase of development and several conclusions were drawn in relation to the applicability and effectiveness of the FireSpotter system, as well as several main restrictions in order for the system to produce the best results possible.

Regarding the question of defining “what is the order of magnitude of the accuracy value that would define the system and the forest fire location calculation algorithm as credible and useful?” the research concluded that the best manner to define this order of magnitude would be to directly inquire to the users of the system and understand their conditions. The attempt to conduct this inquiry revolved around direct questions to civil service employees and fire fighters to present the value that they believe would be an accuracy threshold for a forest fire reporting system. The question was conducted to three individuals of the previously mentioned professions that responded that the accuracy value needed for a fire location would vary according to the dimension of the fire, visibility and accessibility of area in question. No order of magnitude, range of values or specific value was given by any of the individuals inquired. In this manner a direct answer to this research question was not obtained.

Regarding the question “Does the system provide enough accuracy (correspondence between the reported and the true value) to make the system credible and useful?” due to the close range of values and direct proportional relation between the origin points and forest fire location accuracies is that the FireSpotter system strongly depends on the accuracy of the GPS receiver of the mobile device, which in the case of all our simulations were in the 150m to 400m range. However, other devices with different value ranges in origin point accuracy should be tested in order to reach a more reliable conclusion. Due to the fact that this research question is completely dependent on the answer of the previous research question, this question cannot be properly answered. However, due to understanding the range of accuracy that the system is able to provide this question can be answered as soon as the the order of magnitude of the accuracy value that would define the system and the forest fire location calculation algorithm as credible and useful is answered.

Other major conclusions, not related with the research question, were reached in order for the correct functioning of the FireSpotter system. In order for the system to produce viable results the following guidelines for using the Firespotter system should be followed:

1. The angle between forest fire location and the two points of measurement (origin points) should produce approximately a 90º angle. This is in order to minimize the error of the forest fire location wich can scale exponentially when this angle is small. FireSpotter system only produces reliable results when the angle between the fire and the two measurement points are approximately 90º. This is due to the fact that the GPS value errors of the origin points would be converted exponentially into greater errors in terms of the fire location value, if the angle between the fire and the origin points would be less than 45º. What this conclusion implies is that a citizen, in order to submit the most accurate estimate of the fire location, the origin points should be separated by 1.5 times the distance to the fire and at a 45º between the fire location and the the opposite .

2. The distance between the two points of measurement (origin points) should be approximately 1.5 times the distance to the fire. This also minimizes the error of the forest fire location and complements with the previous point.

The above points are best demonstrated in Figure 17.

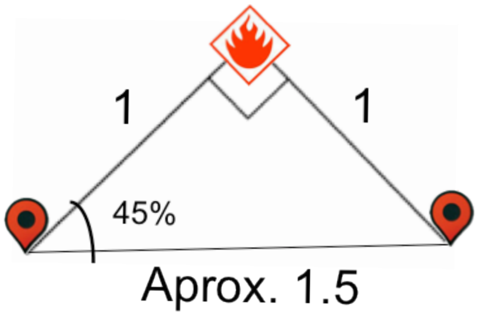

Figure 17 - Optimal Relation of distances and angles between forest fire and origin points

The reason these requisites should be followed in order to assure a result as accurate as possible is the fact that when the angle created by the fire location and it's two respective origin points diminishes, the probable error in accuracy increases. This is best explained with the figure 18 below. The 1X error in the GPS reading, due to the bearing staying the same can be propagated to a larger error in termso of the calculation of the fire location.

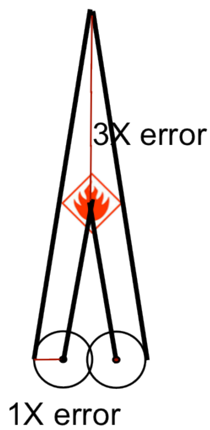

Figure 18 - Effect of below 90º angle on error of forest fire location calculation

10. FUTURE WORK

Due to the present prototype of the FireSpotter system being in its first iteration, several points of future work in several areas were defined as being important.

10.1 Testing

Further Accuracy tests will be conducted in order to reach conclusive answers to one of the research questions. These tests will consist in similar exploratory accuracy assessment as the ones conducted in the research however more users, devices and number of simulations will be conducted in order to increase the representativeness and confidence level of the accuracy assessment.

10.2 Optimization

The FireSpotter system needs to be optimized, in several different aspects, in order to create an easier usage and better performance.

Data Validation of user inputed data will have to be conducted in the mobile application in order to assure that the data submited is valid in type and in range of values. An intermediate step in the system, the one which consists in submitting the user submitted data to the database , should be optimized. The optimization consists in rewritting the functionalities of the PHP code into AJAX requests which would be done directly through the mobile application. This would save an intermediate step in the proccess which absorbs excess resources and makes the application slower.

10.3 Added Functionalities

Several additional functionalities are planned to be implemented to the FireSpotter system. A convex hull algorithm will be implemented in order to create a polygon which includes all fire points related with a single occurence of a fire. Additionally an algorithm to automatically change the projection system to the corresponding Universal Transverse Mercator projection (UTM) projection of the geographical area being analyzed.

10.4 Distribution

An equally important component of the project consists in developing a distribution plan in order to permit for citizens to test and utilize the FireSpotter system. For this, an attempt to present the FireSpotter system to the Portuguese Forest Fire Authorities will be conducted. If the Forest Fire Authorities do consider the project usefull it will be proposed that they organize and execute a distribution plan. This is due to the fact that it is out of the scope of this research and outside the capabilities of the researcher to conduct this distribution plan.

In order to support the project an appropriate publishing of the FireSpotter system will be conducted on the internet by means of a website which will make available the application executables, the source code and documentation.

BIBLIOGRAPHIC REFERENCES

ALEXANDER, M.E., AND THOMAS, D.A., 2003. Wildland Fire Behavior Case Studies and Analyses: Other Examples, Methods, Reporting Standards, and Some Practical Advice - *Fire Management Today,* **63**,4

ALTENERGYMAG 2008. Wireless Sensor Networks for a Green World

EFFIS 2010. Forest Fires in Europe 2010 Report nº 11, *JRC Scientific and Technical Reports*

EFFIS Viewer. website http://effis-viewer.jrc.ec.europa.eu/wmi/viewer.html

ELWOOD, S. 2008. Volunteered geographic information: key questions,concepts and methods to guide emerging research and practice. *GeoJournal*, **72**, 133–135

FLANNIGAN, M.D, STOCKS, B.J, AND WOTTON, B.M 2000. Climate change and Forest Fires. *Science of The Total Environment* **262**, 3, 221–229.

GEOEXT 2012. http://www.geoext.org/

GEOSERVER 2012. http://geoserver.org/

GIT 2012. http://git-scm.com/

GITHUB 2012. https://github.com/

GOODCHILD, M.F., 2007. Citizens as Voluntary Sensors: Spatial Data Infrastructure in the World of Web 2.0. *International Journal of Spatial Data Infrastructures Research,* **2**, 24-32.

GOOGLE CLIENT LOGIN 2012. http://code.google.com/apis/accounts/docs/AuthForInstalledApps.html

GOOGLE FUSION TABLES 2012. http://www.google.com/fusiontables/

JQUERY 2012. http://jquerymobile.com/

LLORET ET AL 2009. A Wireless Sensor Network Deployment for Rural and Forest Fire Detection and Verification. *Sensors*, **9,** 8722-8747

LLORET, J., GARCIA, M., BRI, D. AND SENDRA, S., 2009. A Wireless Sensor Network Deployment for Rural and Forest Fire Detection and Verification. *Sensors.* **9**, 11, 8722 -8747

LONGUEVILLE, B., SMITH, R., LURASCHI G., 2009. "OMG, from here, I can see the flames!": a use case of mining location based social networks to acquire spatio-temporal data on forest fires. *Proceedings of the 2009 International Workshop on Location Based Social Networks,* 73-80

MILLER, J. ET AL 2005. Automated Wildfire Detection Through Artificial Neural Networks. *Nasa Goddard Space Flight Center*.

MOORE, P. ET AL, 2003. Forests and wildfires: fixing the future by avoiding the past. *XII World Forestry Congress, Quebec City, Canada*

OPENLAYERS 2012. http://openlayers.org/

O'REILLY, T., 2005. What Is Web 2.0. Design Patterns and Business Models for the Next Generation of Software.

PARSONS, D. ET AL 1986. Natural fire management in National Parks. *Environmental Management Journal*. **10**,1,21-24

PHONEGAP 2012. http://phonegap.com/

POSTGIS 2012. http://postgis.refractions.net/

PULTAR, E., COVA, T.J., YUAN, M., and GOODCHILD, M.F. 2010. EDGIS: A Dynamic GIS Using Space Time Points. *International Journal of Geographical Information Science*, **24**, 329-346.

PULTAR, E., RAUBAL, M., COVA, T.J AND GOODCHILD, M.F. 2009. Dynamic GIS Case Studies: Wildfire Evacuation and Volunteered Geographic Information. *Transactions in GIS,* **13(s1)**, 85-104.

SAN-MIGUEL-AYANZ, J. ET AL, 2005 Active Fire Detection for Fire Emergency Management: Potential and Limitations for the Operational Use of Remote Sensing, *Natural Hazards*, **35**, 361–376

SERR, K., WINDHOLZ, T. AND WEBER, K. 2006.Comparing GPS Receivers: A Field Study.URISA Journal, 18,2, 19-23

SGIF Statistics 2010. website http://www.afn.min-agricultura.pt/portal/dudf/estatisticas

WING, M. ET AL 2005. Consumer-Grade Global Positioning System (GPS) Accuracy and Reliability. *Journal of Forestry*, **103**, 4, 169-173.

WOTAWA, G., NOVELLI P., TRAINER M. AND GRANIER, C. 2001. Inter-annual variability of summertime CO concentrations in the Northern Hemisphere explained by boreal forest fires in North America and Russia, Geophys. Res. Lett., 28(24), 4575–4578.

VIDAL, A. AND DEVAUX-ROS, C., 1995. Evaluating forest fire hazard with a landsat TM derived water stress index. *Agr. Forest Meteorol.* , **77**, 207-224.

ANNEXES

A. Source Code of Index.html (Mobile Application User Interface)

```
<!DOCTYPE html>
<html>
  <head>
    <title>FireSpotter</title>

    <meta name="viewport" content="width=device-width, initial-scale=1.0,
user-scalable=no"></meta>

    <!--CSS -->
    <link rel="stylesheet"
href="http://code.jquery.com/mobile/1.0rc2/jquery.mobile-1.0rc2.min.css" />

    <!--JS-->
    <script src="http://code.jquery.com/jquery-1.6.4.min.js"></script>
    <script src="http://code.jquery.com/mobile/1.0rc2/jquery.mobile-
1.0rc2.min.js"></script>
    <script type="text/javascript" charset="utf-8" src="libraries/phonegap-
1.2.0.js"></script>
    <script type="text/javascript"
src="http://jzaefferer.github.com/jquery-
validation/jquery.validate.js"></script>
    <script src="js/main.js"></script>

     <script src="libraries/proj4js/proj4js.js"></script>

     <script src="libraries/proj4js/defs/EPSG900913.js"></script>
     <script src="libraries/proj4js/defs/ESRI102013.js"></script>

    <script src="js/geocalculations.js" type="text/javascript"
charset="utf-8"></script>




  </head>
  <body>
  <!--      ******* HOME PAGE *************     -->

  <div data-role="page" id="home" data-title="Home.FireCitizen" data-
theme="c">

      <div data-role="header">
            <h1>FireSpotter</h1>
      </div><!-- /header -->

      <div data-role="content" id="contentMain">
      <ul data-role="listview" data-inset="true">
            <li><h3>Information</h3></li>
            <li><a href="#whatis">What is FireSpotter ?</a></li>
            <li><a href="#howtouse">How to use it ?</a></li>
```

```
        </ul>

        <ul data-role="listview" data-inset="true">
              <li><h3>Report a Fire</h3></li>
              <li><a href="#take1stphoto">Take 1st Photo</a></li>
              <li><a href="#take2ndphoto">Take 2nd Photo</a></li>
              <li><a href="#insertpersonaldata">Insert Personal Data</a></li>
        </ul>

        <!--FORM for submitting pictures-->
        <!--<form id="submitPhotos" method="post" enctype="multipart/form-
data">
          <input type="file" name="file">
        </form>
        -->

        <!--form for submitting all other data-->
        <form action="" id="submitFireReport" method="get" accept-
charset="utf-8">
          <input type="hidden" name="txtFirePointLat" id="txtFirePointLat">
          <input type="hidden" name="txtFirePointLong" id="txtFirePointLong">

          <input type="submit" value="Submit Fire Report">


        </div><!-- /content -->

        <!-- contentTransition is displayed after the form is submitted until
a response is received back. -->
        <div data-role="content" id="contentTransition"
name="contentTransition">
         <div align="CENTER"><h4>Your claim has been sent. Please
wait.</h4></div>
         <div align="CENTER"><img id="spin" name="spin"
src="img/wait.gif"/></div>
        </div>      <!-- contentTransition -->

        <div data-role="content" id="contentConfirmation"
name="contentConfirmation" align="center">
        <p>Your Fire Report has been successfully submitted.</p>
        <p>This concludes your interaction with this App.</p>
        <p>Fire Fighters or Civil Servants will contact you if any additional
information is needed. Thank you.</p>
        <p><span id="confirmation"></span></p>

        <!--Your confirmation number is: <span id="confirmation"
name="confirmation"></span>  </p>-->
        </div><!-- contentConfirmation -->


        <div data-role="footer">
              <h4>Copyright Stuff</h4>
        </div><!-- /footer -->
    </div><!-- /page -->

      <!--      ******* WHAT IS PAGE *************     -->
```

```
    <div data-role="page" id="whatis" data-title="What.is.FireCitizen">

      <div data-role="header">
        <a data-role="button" data-icon="back" data-iconpos="left" data-
rel="back">Back</a>
            <h1>FireSpotter</h1>
      </div><!-- /header -->

      <div data-role="content">
        <h3>What is Fire Citizen ?</h1>
            <p>FireSpotter is a mobile app for Citizens to report sightings
of Forest Fires to the responsible authorities in a quick and effective
way. </p>
      </div><!-- /content -->

      <div data-role="footer">
              <h4>Copyright Stuff</h4>
      </div><!-- /footer -->
    </div><!-- /page -->

    <!--      ******* HOW TO USE IT PAGE *************     -->


    <div data-role="page" id="howtouse" data-
title="How.to.use.FireCitizen">

      <div data-role="header">
        <a data-role="button" data-icon="back" data-iconpos="left" data-
rel="back">Back</a>
            <h1>FireSpotter</h1>
      </div><!-- /header -->

      <div data-role="content">
            <p>In order to report a fire you must :</p>

            <p>1 - take a photo of the fire (photo 1) with the fire in the
aproximate center of the photograph.</p>

            <p>2 - take, <span style="font-weight:bold;">at a different
location</span>, another photo of the fire (photo 1) with the fire in the
aproximate center of the photograph.
            <br /><br />NOTE: For optimal calculation of forest fire
location take the 2nd photo at 50 meters distance to the left or right of
1st photograph (in relation to the fire).
            </p>

        <p>3 - Insert personal data</p>

            <p>4 - Press "Submit Forest Fire Report" button on home
screen.</p>

      </div><!-- /content -->

      <div data-role="footer">
              <h4>Copyright Stuff</h4>
      </div><!-- /footer -->
    </div><!-- /page -->
```

```
<!--       ******* TAKE PHOTO 1 PAGE *************     -->


    <div data-role="page" id="take1stphoto" data-
title="Take.photo.1.FireCitizen">

      <div data-role="header">
        <a data-role="button" data-icon="back" data-iconpos="left" data-
rel="back">Back</a>
            <h1>FireSpotter</h1>
      </div><!-- /header -->

      <div data-role="content">
        <input type="hidden" name="image1URI" id="image1URI">
        <input type="hidden" name="txtAccuracy1" id="txtAccuracy1">
        <img style="display:none;width:200px;height:200px;" id="image1"
src="" />
        <!--<input type="hidden" name="txtImage1" id="txtImage1">-->

        <div data-role="fieldcontain"><label for="inputname">Lat/Long of
1st Photo:  </label><input type="text" style="text-align:center;"
name="txtCoord1" id="txtCoord1"></div>
        <div data-role="fieldcontain"><label for="inputname">Heading of 1st
Photo:  </label><input type="text" style="text-align:center;"
name="txtHeading1" id="txtHeading1"></div>
      <a href="#" data-role="button" id="getcoordsheadingbutton1">Get
Coordinates and Heading</a>
      <a href="#" data-role="button" id="takepicturebutton1">Get
Picture</a>
      </div><!-- /content -->

      <div data-role="footer">
        <h4>Copyright Stuff</h4>
      </div><!-- /footer -->
    </div><!-- /page -->

    <!--       ******* TAKE PHOTO 2 PAGE *************     -->


    <div data-role="page" id="take2ndphoto" data-
title="Take.photo.2.FireCitizen">

      <div data-role="header">
        <a data-role="button" data-icon="back" data-iconpos="left" data-
rel="back">Back</a>
            <h1>FireSpotter</h1>
      </div><!-- /header -->

      <div data-role="content">
        <input type="hidden" name="image2URI" id="image2URI">
        <input type="hidden" name="txtAccuracy2" id="txtAccuracy2">
        <img style="display:none;width:200px;height:200px;" id="image2"
src="" />
        <div data-role="fieldcontain"><label for="inputname">Lat/Long of
2nd Photo:  </label><input type="text" style="text-align:center;"
name="txtCoord2" id="txtCoord2"></div>
```

```
          <div data-role="fieldcontain"><label for="inputname">Heading of 2nd
Photo:  </label><input type="text" style="text-align:center;"
name="txtHeading2" id="txtHeading2"></div>
        <a href="#" data-role="button" id="getcoordsheadingbutton2">Get
Coordinates and Heading</a>
        <a href="#" data-role="button" id="takepicturebutton2">Get
Picture</a>
        </div><!-- /content -->

        <div data-role="footer">
          <h4>Copyright Stuff</h4>
        </div><!-- /footer -->
    </div><!-- /page -->

    <!--      ******* INSERT PERSONAL DATA PAGE *************     -->


    <div data-role="page" id="insertpersonaldata" data-
title="Insert.personal.data.FireCitizen">

        <div data-role="header">
          <a data-role="button" data-icon="back" data-iconpos="left" data-
rel="back">Back</a>
              <h1>FireSpotter</h1>
        </div><!-- /header -->

        <div data-role="content">
            <div data-role="fieldcontain"><label
for="txtName">Name:</label><input type="text" name="txtName" id="txtName">
</div>
            <div data-role="fieldcontain"><label
for="txtTelephone">Telephone:</label><input type="text" name="txtTelephone"
id="txtTelephone"> </div>
            <div data-role="fieldcontain"><label
for="txtEmail">Email:</label><input type="text" name="txtEmail"
id="txtEmail">              </div>
            <div data-role="fieldcontain"><label
for="txtComment">Comment:</label><textarea name="txtComment"
id="txtComment"></textarea>  </div>

        </div><!-- /content -->

        <div data-role="footer">
          <h4>Copyright Stuff</h4>
        </div><!-- /footer -->
    </div><!-- /page -->


    </form>
  </body>
  </html>

</html>
```

B. Source Code of main.js (Obtainment of Data from Device Sensors)

```
$(document).ready(function() {

////// INITIALIZATION ////////////

    // Global Vars
    var image1URI, image2URI, image1Name, image2Name;

    $.mobile.allowCrossDomainPages = true;
    $.support.cors = true;

    $("#contentTransition").hide();
    $("#contentConfirmation").hide();


/// FORM SUBMISSION ///

$('#submitFireReport').submit(function() {


    //CREATE FIREPOINT FROM SUBMITTED DATA

    //function in geocalculations.js
    var arrFirePoint =
geocalculate(document.getElementById('txtCoord1').value,document.getElement
ById('txtCoord2').value,document.getElementById('txtHeading1').value,docume
nt.getElementById('txtHeading2').value);

    //submit firepoint to form
    document.getElementById('txtFirePointLat').value = arrFirePoint[1];
    document.getElementById('txtFirePointLong').value = arrFirePoint[0];



    $("#contentMain").hide();
    $("#contentTransition").show();

    // var formserialized = $("#submitFireReport").serialize(); //TEST
    // alert(formserialized); //TEST



    // $.post("/firecitizenandroid321/assets/www/php/submit_to_db.php",
$("#submitFireReport").serialize(), function(data){
    $.post("http://193.136.119.12/labnt-
projects/firecitizen/php/submit_to_db.php",$("#submitFireReport").serialize
(), function(data){
        var formserialized = $("#submitFireReport").serialize();
        alert(formserialized);
        //$('#confirmation').text(data);
        $("#contentTransition").hide();
        setTimeout("$('#contentConfirmation').show()",2000);
        // $("#contentConfirmation").show();
```

```
    });

    /*
       TODO DRY the Code of submission of 1st Photograph
    */

    // submission of 2nd photograph
    var options2 = new FileUploadOptions();
    options2.fileKey="file";
    options2.fileName="newfile2.jpg";
    // options.fileName=imageURI.substr(imageURI.lastIndexOf('/')+1);
    options2.mimeType="image/jpeg";

    var params2 = new Object();
    params2.newFileName = image2Name;

    options2.params = params2;
    options2.chunkedMode = false;

    var ft2 = new FileTransfer();
    ft2.upload(image2URI, "http://193.136.119.12/labnt-
projects/firecitizen/php/submit_photos_to_db.php", win, fail, options2);
    //ft.upload(imageURI,
"/firecitizenandroid321/assets/www/php/submit_to_db.php", win, fail,
options);

    return false;

});

/////////////////// GET COORDS /////////////////

    $('#getcoordsheadingbutton1').click(function() {
        navigator.geolocation.getCurrentPosition(locationOnSuccess1,
locationOnError, {enableHighAccuracy: true});
        navigator.compass.getCurrentHeading(compassOnSuccess1,
compassOnError);
        return false;
    });

    $('#getcoordsheadingbutton2').click(function() {
        navigator.geolocation.getCurrentPosition(locationOnSuccess2,
locationOnError, {enableHighAccuracy: true});
        navigator.compass.getCurrentHeading(compassOnSuccess2,
compassOnError);
        return false;
    });

    var locationOnSuccess1 = function(position) {
        document.getElementById('txtCoord1').value =
position.coords.latitude + " , " + position.coords.longitude;
        document.getElementById('txtAccuracy1').value =
position.coords.accuracy;

    };

    var locationOnSuccess2 = function(position) {
```

```
        document.getElementById('txtCoord2').value =
position.coords.latitude + " , " + position.coords.longitude;
        document.getElementById('txtAccuracy2').value =
position.coords.accuracy;
    };

    var locationOnError = function(error) {
        alert('other error');
        alert('code: '    + error.code    + '\n' +
        'message: ' + error.message + '\n');
    };

    // onSuccess: Get the current heading
    function compassOnSuccess1(heading) {
        document.getElementById('txtHeading1').value =
heading.magneticHeading;
    }

    // onSuccess: Get the current heading
    function compassOnSuccess2(heading) {
        document.getElementById('txtHeading2').value =
heading.magneticHeading;
    }

    // onError: Failed to get the heading
    function compassOnError(compassError) {
        alert('Compass Error: ' + compassError.code);
    }


/////////////////// GET PICTURE /////////////////

    $('#takepicturebutton1').click(function() {

        // Take picture using device camera and retrieve image as base64-
encoded string
        navigator.camera.getPicture(onPhotoDataSuccess1, onPhotoFail, {
            quality: 50,
            destinationType: Camera.DestinationType.FILE_URI,
            encodingType: Camera.EncodingType.JPEG
            // targetWidth: 10,
            // targetHeight: 10
             });
     });

     $('#takepicturebutton2').click(function() {
        // Take picture using device camera and retrieve image as base64-
encoded string
        navigator.camera.getPicture(onPhotoDataSuccess2, onPhotoFail, {
            quality: 50,
            destinationType: Camera.DestinationType.FILE_URI,
            encodingType: Camera.EncodingType.JPEG
            // targetWidth: 10,
            // targetHeight: 10
             });
     });

    function onPhotoDataSuccess1(imageURI1) {
```

```
        // Get image handle
        var image = document.getElementById('image1');

        // Unhide image elements
        image.style.display = 'block';

        // Show the captured photo
        // The inline CSS rules are used to resize the image
        image.src= imageURI1;

        //pass location of image to global var
        var image1URI= imageURI1;

        //pass name of image to global var
        var image1Name= new Date().getTime();
        image1Name += '.jpg';

        // alert('image1Name is:' + image1Name); //TEST

        //pass image name to hidden input element of form
        document.getElementById('image1URI').value=image1Name;

        // submission of 1st photograph
         var options1 = new FileUploadOptions();
         options1.fileKey="file";
         options1.fileName="newfile1.jpg";
         // options.fileName=imageURI.substr(imageURI.lastIndexOf('/')+1);
         options1.mimeType="image/jpeg";

         var params1 = new Object();
         params1.newFileName = image1Name;

         options1.params = params1;
         options1.chunkedMode = false;

         var ft1 = new FileTransfer();
         ft1.upload(image1URI, "http://193.136.119.12/labnt-
projects/firecitizen/php/submit_photos_to_db.php", win, fail, options1);
          //ft.upload(imageURI,
"/firecitizenandroid321/assets/www/php/submit_to_db.php", win, fail,
options);


    }


    function onPhotoDataSuccess2(imageURI2) {

        // Get image handle
        var image = document.getElementById('image2');

        // Unhide image elements
        image.style.display = 'block';

        // Show the captured photo
        // The inline CSS rules are used to resize the image
        image.src = imageURI2;
```

```
        //pass location of image to global var
        image2URI= imageURI2;
        //pass name of image to global var
        image2Name= new Date().getTime();
        image2Name += '.jpg';
        // alert('image2Name is ' + image2Name); //TEST

        //pass image name to hidden input element of form
        document.getElementById('image2URI').value=image2Name;
    }

    function onPhotoFail(message) {
        alert('Photo captured failed because: ' + message);
    }

// SUBMIT PICTURES ONSUCCESS AND ONFAIL FUNCTIONS

    function win(r) {
        // alert("Code = " + r.responseCode);    //TEST
        // alert("Response = " + r.response);    //TEST
        // alert("BytesSent =" + r.bytesSent);   //TEST
    }

    // Error reporting
    function fail(message) {
        alert('Submit Picture failed because: ' + message);
    }
});
```

C. Souce Code of geocalculations.js (Forest Fire Location Calculation Algorithm)

```
var WGS84Projection = new Proj4js.Proj('EPSG:4326');    //source
coordinates will be in Longitude/Latitude
var AlbersProjection = new Proj4js.Proj('ESRI:102013');      //destination
coordinates in m
var GoogleProjection = new Proj4js.Proj('EPSG:900913');      //destination
coordinates in m


function geocalculate(coord1, coord2, heading1, heading2) {

    // transform coords into nums
    var arrNumCoord1 = strToNum(coord1);
    var arrNumCoord2 = strToNum(coord2);

    // function and projections in geocalculations.js
    var arrCoord1Reprojected = reproject(WGS84Projection,
AlbersProjection,arrNumCoord1[1],arrNumCoord1[0]);
    var arrCoord2Reprojected = reproject(WGS84Projection,
AlbersProjection,arrNumCoord2[1],arrNumCoord2[0]);


    var mathAngle1 = bearingToMathAngle(heading1);
    var mathAngle2 = bearingToMathAngle(heading2);

    // convert angle to radians
    var radiansAngle1 = mathAngle1 * (Math.PI/180);
    var radiansAngle2 = mathAngle2 * (Math.PI/180);

    //get the tangents of the angles
    var tangentAngle1 = Math.tan(radiansAngle1);
    var tangentAngle2 = Math.tan(radiansAngle2);

    // create line functions
    // line equation from point x',y' and slopeø  ->  y= tanø*(x-x') + y'
    // var y1 = tangentAngle1 * (x1 - arrCoord1Reprojected[0]) +
arrCoord1Reprojected[1];
    // var y2 = tangentAngle2 * (x2 - arrCoord2Reprojected[0]) +
arrCoord2Reprojected[1];

    //calculate point
    var firePointX = (tangentAngle1*arrCoord1Reprojected[0] -
tangentAngle2*arrCoord2Reprojected[0] + arrCoord2Reprojected[1] -
arrCoord2Reprojected[1])/(tangentAngle1-tangentAngle2);
    var firePointY = tangentAngle1 * (firePointX - arrCoord1Reprojected[0])
+ arrCoord1Reprojected[1];

    // reproject to WGS84
    var firePointWGS84 = reproject(AlbersProjection, WGS84Projection,
firePointX, firePointY);

    return firePointWGS84;
```

```
}

function bearingToMathAngle(bearing){
    return 90-bearing;

}

function reproject(source,destination,x,y) {

    Proj4js.reportError = function(msg) {alert(msg);}

    var p = new Proj4js.Point(x,y);
    var pp = Proj4js.transform(source, destination, p);
    // alert('ISEGI point in Albers is:x= '+ pp.x + " , y= " + pp.y);
//TEST

    var returnpoint = [];
    returnpoint[0] = pp.x;
    returnpoint[1] = pp.y;

    return returnpoint;

}

function strToNum (strCoord) {
        // explode string
        var arrStrCoord = strCoord.split(',');
        var arrNumCoord = [];
        arrNumCoord[0] = parseFloat(arrStrCoord[0]);
        arrNumCoord[1] = parseFloat(arrStrCoord[1]);
        return arrNumCoord;
    }
```

D. Souce Code of submit_to_db.php (Submission of Data to Spatial Database)

```
<?php

//INCLUDES
include('ftlibrary/clientlogin.php');
include('ftlibrary/sql.php');
include('ftlibrary/file.php');

//CONSTANTS
define('IMAGEBASEURI', 'http://193.136.119.12/labnt-
projects/firecitizen/php/');
define("LINES", 2540214);
define("FIRE_POINTS", 2540131);
define("USERS", 2539972);
define("ORIGIN_POINTS", 2540046);

//FUNCTIONS
function getNextID($ftclient,$tableId)
 {
    $rowIds =  rtrim($ftclient->query(SQLBuilder::select($tableId,
array('id'))));
    $arrRowIds = array();
    $arrRowIds = explode("\n", $rowIds);
    unset($arrRowIds[0]);
    $id = max($arrRowIds) + 1;
    return $id;
 }

//get authorization token in order to input data into fusion tables
$token = ClientLogin::getAuthToken('firespotterapp@gmail.com',
'firespotterapp2121');
$ftclient = new FTClientLogin($token);


// NEW SUBMISSION OF ALL DATA

    //NEW SUBMISSION OF USER DATA
    // get next id of user via the database
    $intIdUser = getNextId($ftclient,USERS);

    $arrQUser = array("id" => $intIdUser, "name" => $_POST['txtName'],
"email" => $_POST['txtEmail'], "telephone" => $_POST['txtTelephone']);
    //$arrQUser = array("id" => $intIdUser, "name" => "jonas", "email" =>
"jfdsfds", "telephone" => 12345); //TEST

    //insert into fusiontable DB
    echo $ftclient->query(SQLBuilder::insert(USERS, $arrQUser));



    // NEW SUBMISSION OF FIREPOINT
```

```
    $latFirePoint = $_POST['txtFirePointLat'];
    $longFirePoint = $_POST['txtFirePointLong'];
    // $latFirePoint = 38.732299; //TEST
    // $longFirePoint = -9.160305;      //TEST

    // get next id of firepoint via the fusiontable
     $intIdFirePoint = getNextId($ftclient,FIRE_POINTS);

     $arrQUser = array("id" => $intIdFirePoint, "id_user" => $intIdUser,
"time_stamp" => date('r'), "comment" => $_POST['txtComment'], "geometry" =>
$latFirePoint.",".$longFirePoint);
     // $arrQUser = array("id" => $intIdFirePoint, "id_user" => $intIdUser,
"time_stamp" => date('r'), "comment" => "fdfds", "geometry" => "38.732299,-
9.160305"); //TEST

     //insert into fusiontable DB
     echo $ftclient->query(SQLBuilder::insert(FIRE_POINTS, $arrQUser));


     // NEW SUBMISSION OF 2 POINTS+HEADING OF WHERE CITIZEN IS STANDING
WHEN TAKING BOTH PICTURES
     // NEW SUBMISSION OF 2 LINES, EACH LINE REGARDING A POINT+HEADING PAIR

     for ($i=1; $i < 3; $i++) {

          $txtCoordName = 'txtCoord'.$i;
          $txtAccuracyName = 'txtAccuracy'.$i;
          $txtHeadingName = 'txtHeading'.$i;
          $imageName = 'image'.$i.'URI';

          //explode latlong form value into lat (element0 of array) and
long (element1 of array)
          $latLong[i]=preg_split("/[\s,]+/",$_POST[$txtCoordName]);
          // $latLong[i]=preg_split("/[\s,]+/","38.732699,-9.160405");
//TEST
          $lat[i]=$latLong[i][0];
          $long[i]=$latLong[i][1];

          $coordAccuracy = $_POST[$txtAccuracyName];

          $heading[i] = $_POST[$txtHeadingName];
          // $heading[i] = 320.4289245;        //TEST


          //POINT
          // get next id of origin_point via the fusiontable
           $intIdOriginPoint = getNextId($ftclient,ORIGIN_POINTS);

          $arrQOriginPoint = array("id" => $intIdOriginPoint,
"id_fire_point" => $intIdFirePoint, "heading" => $heading[i], "photograph"
=> IMAGEBASEURI.$_POST[$imageName] , "geometry" => $lat[i].",".$long[i] ,
"coord_accuracy" => $coordAccuracy);
          // $arrQOriginPoint = array("id" => $intIdOriginPoint,
"id_fire_point" => $intIdFirePoint, "heading" => $heading[i], "geometry" =>
$lat[i].",".$long[i]); //TEST

          //insert into fusiontable DB
```

```
          echo $ftclient->query(SQLBuilder::insert(ORIGIN_POINTS,
$arrQOriginPoint));

          //LINE
          // get next id of origin_point via the fusiontable
           $intIdLine = getNextId($ftclient,LINES);

          $arrQLine = array("id" => $intIdLine, "id_fire_point" =>
$intIdFirePoint, "id_origin_point" => $intIdOriginPoint, "geometry" =>
"<LineString><coordinates> ".$long[i].",".$lat[i]."
".$longFirePoint.",".$latFirePoint."</coordinates></LineString>");

          //insert into fusiontable DB
          echo $ftclient->query(SQLBuilder::insert(LINES, $arrQLine));

       }
```

E. Source Code of index.php (Web Map)

```
<?php

//INCLUDES
include('ftlibrary/clientlogin.php');
include('ftlibrary/sql.php');
include('ftlibrary/file.php');

//CONSTANTS
define('IMAGEBASEURI', 'http://193.136.119.12/labnt-
projects/firecitizen/php/');
define("LINES", 2540214);
define("FIRE_POINTS", 2540131);
define("USERS", 2539972);
define("ORIGIN_POINTS", 2540046);

//FUNCTIONS

function getLastID($ftclient,$tableId)
 {
    $rowIds =  rtrim($ftclient->query(SQLBuilder::select($tableId,
array('id'))));
    $arrRowIds = array();
    $arrRowIds = explode("\n", $rowIds);
    unset($arrRowIds[0]);
    $id = max($arrRowIds);
    return $id;
 }

function getLastCoord($ftclient,$tableId,$fire_pointLastId)
 {
    $rowIds =  rtrim($ftclient->query(SQLBuilder::select($tableId,
array('geometry'), "'id'=".$fire_pointLastId)));
    $arrRowIds = array();
    $arrRowIds = explode("\n", $rowIds);
    unset($arrRowIds[0]);
    $id = end($arrRowIds);
    return $id;
 }

//get authorization token in order to input data into fusion tables
$token = ClientLogin::getAuthToken('firespotterapp@gmail.com',
'firespotterapp2121');
$ftclient = new FTClientLogin($token);

//NEW SUBMISSION OF USER DATA
// get next id of user via the database
$fire_pointLastId = $intIdUser = getLastId($ftclient,FIRE_POINTS);
$strLastCoord = explode(',',getLastCoord($ftclient,FIRE_POINTS,
$fire_pointLastId));
$lat = str_replace("\"",'',$strLastCoord[0]);
$long = str_replace("\"",'',$strLastCoord[1]);
```

```
?>

<!DOCTYPE html>
<html>
<head>
<meta name="viewport" content="initial-scale=1.0, user-scalable=no" />
<style type="text/css">
  html { height: 100% }
  body { height: 100%; margin: 0; padding: 0 }
  #map_canvas { height: 100% }
</style>
<script type="text/javascript"

src="http://maps.googleapis.com/maps/api/js?key=AIzaSyDwwbSPFC06r1o4svHIKmf
kuMb4qLlQ84M&sensor=false">
</script>
<script type="text/javascript">
// var map;
function initialize() {
  var myLatlng = new google.maps.LatLng(<?php echo $lat.','.$long ?>);
  var myOptions = {
    zoom: 17,
    center: myLatlng,
    mapTypeId: google.maps.MapTypeId.HYBRID
  }

  map = new google.maps.Map(document.getElementById("map_canvas"),
myOptions);

  var linesLayer = new google.maps.FusionTablesLayer({
    query: {
      select: 'geometry',
      from: '2540214'
    },
  });

  var users_fire_pointsLayer = new google.maps.FusionTablesLayer({
    query: {
      select: 'geometry',
      from: '2548446'
    },
  });

  var origin_pointsLayer = new google.maps.FusionTablesLayer({
    query: {
      select: 'geometry',
      from: '2540046'
    },
  });

  linesLayer.setMap(map);
  users_fire_pointsLayer.setMap(map);
  // usersLayer.setMap(map);
  origin_pointsLayer.setMap(map);

}
```

```
</script>
</head>
<body onload="initialize()">
  <div id="map_canvas" style="width:100%; height:100%"></div>
</body>
</html>
```