

WEB PORTAL DEVELOPMENT FOR GIS APPLICATION AND PHYSICAL SENSORS

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Abstract: Data is the most important component in Geographic Information System(GIS). Today, it is possible to collect them using many types of devices including sensors, like temperature sensors, humidity, wind speed, precipitation, pressure, light, motion, sound, vibration, color changes, CO2 etc... With sensors collecting data and sending them into a station in real time, geospatial analysis can be made also, combining values and getting the results needed to take decisions. These sensors are being used in many areas like precision agriculture to monitor the growth of plants, habitat monitoring, pollution, disasters, climate change, land slide, security, just to name a few. In the field of disaster anticipation and prevention, sensors can be used as an early warning system. A GIS web portal can show modeling process maps, combining data that are being collected in real time to preview some phenomena. This paper examines the importance of physical sensors in GIS and a portal to show real-time geospatial analysis.

Keywords: GIS; Wireless Sensor Networks(WSN), webGIS.

1. Introduction

In 2011, Namibe province (Angola) experienced a large flood. Hundreds of people died and thousands lost their homes (Figure 1). However, every year the same story has been happening. There is no mechanism to preview these phenomena and the people always face the same problems year after year.

Usually, the big question is whether the citizens will be updated about the behavior of the environment, weather forecast, and what will happen in the next days if there is a brusque change in the environmental conditions.

In Namibe, the farmers in the Valley of River Bero, Giraul and Curoca, have been the most affected. More than 25,000 tons of various products have been destroyed. A large extent of arable land was flooded and destroyed by floods.

In Angola, March 2015, a very strong rain killed more than 85 people in Benguela in two days (figure 1). In Luanda, the rain destroyed around 11,900 habitations and more than 25,000 people were affected by this catastrophe. In agriculture zones, the rain devastated a large area of crop, making production impossible. Many *KIMBO* (villages) year after year are affected by floods. When the river is full, all agricultural zones are destroyed from the day to night.



Figure 1: Floods and affected people in Namibe province (Angola). Source: voaportugues.com

Using sensors can be one solution to send emergency alerts when the water surpasses a desired level of the river, expediting the preview of catastrophe and reduce consequence.

A map showing the previewed behavior of rivers in the latter days should avoid the surprise and mitigate the impact of catastrophes in these provinces. It should make people prepared for the coming days.

Sometimes, it is possible to forecast an environmental catastrophe three days before it happens, which can make all the difference.

Others scenarios like border invasion attempts are regular in border provinces in Angola, mainly in Zaire and Cabinda provinces. Mechanisms to finish with vulnerability of borders are necessary.

2. Geographic information systems (GIS) vs. wireless sensor networks (WSN)

2.1 GIS technology

Geographic Information Systems (GIS), are a specific type of information system for analyzing geospatial data and mapping. GIS are an organized collection of hardware, software and geographic data designed to efficiently capture, store, update and manipulate all forms of geographically referenced information. GIS are used to make decisions and visualize categorized data in many aspects of the society. (Saumini, et al., 2012, p.18)

In short, GIS add value to geospatial data. By allowing data to be organized and viewed efficiently, by integrating them with other data, by the analysis and by the creation of new data that can be operated on. GIS create useful information to help decision-making (Heywood, et al., 2006, p.18). GIS are thus a special class of information systems, one that incorporates spatial considerations. It is possible to subcategorize GIS into more specific information systems such as traffic management, environmental information, soil information, facilities management, market analysis and fisheries management information systems.

GIS software has been designed to address a wide range of spatially related questions or procedures; in one sense, the headings listed below, are rather arbitrary because any single functionality may incorporate two or more functions.

Measurement: the knowledge of distance or the spatial(aerial) extent or volume of a feature or incident will be basic but important and, using proximity analysis, GIS can establish the distance of objects relative to a theme or to other objects. Any units of measurement can be deployed, finding statistical measurements such as sum, mean, mode and standard deviation.

Distributions and relationship: Spatial distributions of object may be either random and regular or clustered, and GIS have the functionality, usually via the use of the nearest neighbor analysis, to describe distributions in these terms. Using contiguity analysis, they can also calculate the relationship between differing distributions across the surface, spatial autocorrelation.

Network analysis: This analysis applies to linear features such as transport routes, rivers, pipelines and cable network. Analysis can establish least costs routes, shortest path routes, degree of connectivity, etc. Measurement in network analysis can be in terms of monetary units, distance, time, etc.

Temporal analysis: Spatial changes can be in absolute terms or defined overtime. Thus, it is valuable to know, for instance, the varying rates of growth of an urban area over equal consecutive time periods, to identify the proportional changes in land use for a given area over time. The long-term collection of remotely sensed data greatly expedites time series analyses.

Modeling: This is a wide heading that frequently includes “What if” scenarios, or models which are developed to show what a likely distribution of an object might be, given its known distribution in a sample area, and this can be done for past, present or future scenarios. Optimum location analysis is a modeling procedure that attempts to optimize the location of any activity based on known inputs of the principal production functions. Digital terrain modeling allows for the inclusion of the height dimension for GIS analysis of slopes, aspect, contours and volumes.

Interpolation: This is simply the generation of missing values based on a set of known values within a study area. For instance, if a series of spot heights (altitude) are known, then it is possible to interpolate contour lines for the same area. Interpolation can be applied to a wide range of measured values.

The most important component in a GIS is data, and data are organized and managed with the help of a database management system (DBMS). Data in GIS provides a simplified, digital representation of earth features for a given region. The requisite data for any specific project must be carefully identified and acquired, and the quality of this data will determine the usefulness of the final GIS output.

Some questions that should be asked of any data to be collected may include (ESRI 2012a):

What is the data needed for?

Where the data might come from and is the data source reliable?

What are the specific geographic features required?

What attribute of those features are required?

How current must the data be?

Will periodic data updates be required and, if so, how frequently?

A vast range of equipment have been developed for almost every type of data gathering. Over the past few decades these equipments have gradually changed from being mechanically or analogue based to being digitally based, and today very few data is gathered by non-digital means.

In recent years improvements in sensors manufacturing technologies have occurred driven by post-process, high-speed, low-power and low cost microelectronic hybrid circuits, modern signal conditioning methods and advances in miniaturizations technologies. Wireless sensor network is an equipment package system that consists of one or more automatic sensors, and communication systems. Each sensor point in the sensor network is equipped with a radio transceiver or micro-controller and energy source.

Advances in sensor technology and wireless communications have made networked micro-sensors possible, where each sensor individually senses the environment but collaboratively achieve complex information gathering and dissemination tasks. A network of sensor nodes spread across a field has the capacity to provide temporal and spatial data regarding the properties of the environment.

Wireless sensor networks may be used to monitor the condition of the physical environment, such as: temperature, humidity, wind speed, precipitation, pressure, light, motion, sound, vibration, color changes, CO₂, etc., which is usually in real time mode. These sensed data are physically sent to the base station for compilation.

GIS are being used to help in management and predictions. A color-coding display may be used to visualize monitored data in the geographical locations displayed using geographic information system.

2.2. Usage of physical sensors

Multiple large scale disastrous events continually occur. The 2014 Indian Ocean tsunami devastated a dozen countries, killing more than 275,000, with thousands missing, and leaving millions homeless. In September 2005, Hurricane Katrina, a category three storm, caused significant damage in several US cities, including New Orleans, LA, Mobile, AL, and Gulfport, MS. Several hundred people were killed and thousands left homeless(<http://www.whitehouse.gov/reports/katrina-lessons-learned/chapter1.html>). In October 2005, an earthquake of magnitude 7.6 occurred in Kashmir, Pakistan. 40,000 fatalities made it the most fatal earthquake ever to occur in the Indian subcontinent. Thousands were vulnerable to exposure due to the onset of winter and loss of homes.

In 2006, Europe experienced record floods along the Danube River causing severe damage and evacuations in Hungary, Romania, Bulgaria and Serbia. The 2006/2007 typhoon season in Malaysia, Singapore and Indonesia resulted in 400,000 people being displaced. The 2007 California wildfires resulted in the loss of nearly 2200 homes and over \$1 billion dollars in damage (<http://www.cbsnews.com/stories/2007/10/24/national/main3401265.shtml>).

In March 2015, a very strong rain killed in two days more than 85 people in Benguela, Angola. In Luanda, the rain destroyed around 11,900 habitations and more than 25,000 people were affected by this catastrophe. In agriculture zones, the rain devastated a large area of crops, making production impossible (<http://www.rtp.pt/noticias/index.php?article=815805&tm=7&layout=121&visual=49>). Many *KIMBO*(villages) year by year are affected with floods. When the river is full, all agricultural zones are destroyed from day to night.

Along with increasing global population, the magnitude and frequency of disasters appears to be increasing. Governments and disaster response agencies must manage disaster processes and consequences in order to mitigate, prepare for, respond to and recover from disasters. Effective, disaster management and response demands rapid utilization of information and data from many sources. The ability to seamlessly integrate and distribute

digital data into spatially explicit formats for rapid assessment and analysis during and post disaster is improving.

The suite of geospatial technologies (GIS,GPS and internet) are playing an increasingly important role in disaster management, response and preparation. Remotely sensed data provide earth observation information that can be displayed in conjunction with other digital, spatial data in a geographic information system for analysis.

The use of internet enhances the delivery of geospatial technologies to a larger audience, facilitating the exchange of information, and increasing the speed of communication. One form of external assistance is the online disaster-response community that comprises of formal and informal networks of people acting as sensors, collecting, processing, and delivering information where it is needed.

In this era of ubiquitous sensors and sensor network deployments, the management and tasking of these sensors, including their associate metadata, sensed percepts, and capabilities, along with representing the underlying phenomenology, has become an enormous challenge. GIS have wide-spread utility in a variety of domains for the management of complex data obtained from remote sensing, automated mapping and facilities management systems, and a myriad of other applications.

2.3 WSN technology

A wireless sensor network (WSN) (sometimes called a wireless sensor and actor network (WSAN)) is a spatially distributed autonomous sensor to monitor physical or environmental conditions, such as temperature, sound, pressure, etc., and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications, such as battlefield surveillance. Today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" — from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor

node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

WSN are commonly used for various applications: habitat monitoring, pollution, disaster, climate change, landslide, agriculture, security just to name a few. Many systems have been proposed in agriculture, for example: systems integrating environmental and soil sensors, GPS module, etc.. These systems collect information, such as luminance, temperature, humidity, wind direction, wind speed, EC, pH, CO₂, etc., through sensors. This information is used for monitoring the environment at crop plantations, and provides real-time environmental monitoring and various application services. This kind of crop monitoring system contributes to food-safety issues by improving consumer confidence about the quality of agricultural practices in the field.

For precision agriculture, sensors are being used to monitor growth of the plant. Integrated information and production based farming system is designed to increase long-term, site-specific and whole-farm production efficiency and productivity.

In the field of disaster anticipation and prevention, sensors can be used as an early warning system. Sensors can be placed in various areas, and when the possible disaster is detected sensors will send related data to the central station. A further process occurs at the central data station, providing citizens and authorities with an early warning of a possible catastrophe. In addition, information from sensors is usually coupled with a GIS, making possible to find out the safe points that are protected from disaster.

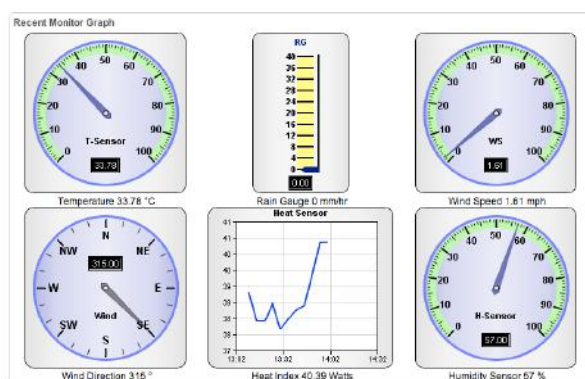


Figure 2: General example of data sensors.

The main characteristics of a WSN include:

- Power consumption constraints for nodes using batteries or energy harvesting
- Ability to cope with node failures (resilience)
- Mobility of nodes
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Cross-layer design

So the cross-layer can be used to make the optimal modulation to improve the transmission performance, such as data rate, energy efficiency, QoS (Quality of Service), etc.. Sensor nodes can be imagined as small computers which are extremely basic in terms of their interfaces and their components.

Hardware: There is an increasing number of small companies producing WSN hardware and the commercial situation can be compared to home computing in the 1970s. Many of the nodes are still in the research and development stage, particularly their software. Also inherent to sensor network adoption is the use of very low power methods for radio communication and data acquisition.

In many applications, a WSN communicates with a Local Area Network or Wide Area Network through a gateway. The Gateway acts as a bridge between the WSN and the other network. This enables data to be stored and processed by devices with more resources, for example, in a remotely located server.

Software: Energy is the scarcest resource of WSN nodes, and it determines the lifetime of WSNs. WSNs may be deployed in large numbers in various environments, including remote and hostile regions, where ad hoc communications are a key component. For this reason, algorithms and protocols need to address the following issues:

- Increased lifespan
- Robustness and fault tolerance
- Self-configuration

Lifetime maximization: Energy/Power Consumption of the sensing device should be minimized and sensor nodes should be energy efficient since their limited energy resource determines their lifetime. To conserve power, wireless sensor nodes normally power off both the radio transmitter and the radio receiver when not in use.

Operating systems: Operating systems for wireless sensor network nodes are typically less complex than general-purpose operating systems. They more strongly resemble embedded systems, for two reasons. First, wireless sensor networks are typically deployed with a particular application in mind, rather than as a general platform. Second, a need for low costs and low power leads most wireless sensor nodes to have low-power microcontrollers ensuring that mechanisms such as virtual memory are either unnecessary or too expensive to implement.

It is therefore possible to use embedded operating systems such as eCos or uC/OS for sensor networks. However, such operating systems are often designed with real-time properties. TinyOS is perhaps the first operating system specifically designed for wireless sensor networks. TinyOS is based on an event-driven programming model instead of multithreading. TinyOS programs are composed of event handlers and tasks with run-to-completion semantics. When an external event occurs, such as an incoming data packet or a sensor reading, TinyOS signals the appropriate event handler to handle the event. Event handlers can post tasks that are scheduled by the TinyOS kernel some time later. LiteOS is a newly developed OS for wireless sensor networks, which provides UNIX-like abstraction and support for the C programming language.

Data integration and sensor Web: Data gathered from wireless sensor networks are usually saved in the form of numerical data in a central base station. Additionally, the Open Geospatial Consortium (OGC) is specifying standards for interoperability interfaces and metadata encodings that enable real time integration of heterogeneous sensor webs into the Internet, allowing any individual to monitor or control Wireless Sensor Networks through a Web Browser. As nodes can inspect the data they forward, they can measure averages or directionality for example of readings from other nodes. For example, in sensing and monitoring applications, it is generally the case that neighboring sensor nodes monitoring an environmental feature typically register similar values. This kind of data redundancy due to the spatial correlation between sensor observations inspires techniques for in-network data aggregation and mining.

2.4 WSN applications

Process Management

Area monitoring: Area monitoring is a common application of WSNs. In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored. A military

example is the use of sensors to detect enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines.

Health care monitoring: Medical applications can be of two types: wearable and implanted. Wearable devices are used on the body surface of a human or just at close proximity to the user. The implantable medical devices are those that are inserted inside the human body. There are many other applications too e.g. body position measurement and location of the person, overall monitoring of ill patients in hospitals and at homes. Body-area networks can collect information about an individual's health, fitness, and energy expenditure.

Environmental/Earth sensing: There are many applications in monitoring environmental parameters, examples of which are given below. They share the extra challenges of harsh environments and reduced power supply.

Air pollution monitoring: Wireless sensor networks have been deployed in several cities (Stockholm, London and Brisbane) to monitor the concentration of dangerous gases for citizens. These can take advantage of the ad hoc wireless links rather than wired installations, which also make them more mobile for testing readings in different areas.

Forest fire detection: A network of Sensor Nodes can be installed in a forest to detect when a fire has started. The nodes can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation. The early detection is crucial for a successful action of the firefighters; thanks to Wireless Sensor Networks, the fire brigade will be able to know when a fire has started and how it is spreading.

Landslide detection: A landslide detection system makes use of a wireless sensor network to detect the slight movements of soil and changes in various parameters that may occur before or during a landslide. Through the data gathered it may be possible to know the occurrence of landslides long before it actually happens.

Water quality monitoring: Water quality monitoring involves analyzing water properties in dams, rivers, lakes & oceans, as well as underground water reserves. The use of many wireless distributed sensors enables the creation of a more accurate map of the water status, and allows the permanent deployment of monitoring stations in locations of difficult access, without the need of manual data retrieval.

Natural disaster prevention: Wireless sensor networks can effectively act to prevent the consequences of natural disasters, like floods. Wireless nodes have successfully been deployed in rivers where changes of the water levels have to be monitored in real time.

Chemical agent detection: The U.S. Department of Homeland Security has sponsored the integration of chemical agent sensor systems into city infrastructures as part of its counterterrorism efforts. In addition, DHS is supporting the development of crowdsourced sensing systems that will draw upon chemical agent detectors embedded in mobile phones.

Industrial monitoring:

Machine health monitoring: Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionality. Wireless sensors can be placed in locations difficult or impossible to reach with a wired system, such as rotating machinery and untethered vehicles.

Wireless sensor networks are also used for the collection of data for monitoring of environmental information, this can be as simple as the monitoring of the temperature in a fridge to the level of water in overflow tanks in nuclear power plants. The statistical information can then be used to show how systems have been working. The advantage of WSNs over conventional loggers is the "live" data feed that is possible.

Water/Waste water monitoring: Monitoring the quality and level of water includes many activities such as checking the quality of underground or surface water and ensuring a country's water infrastructure for the benefit of both human and animal. It may be used to protect the wastage of water.

Structural Health Monitoring: Wireless sensor networks can be used to monitor the condition of civil infrastructure and related geo-physical processes close to real time, and over long periods through data logging, using appropriately interfaced sensors.

Entertainment Industry

Music Technology: Wireless sensor networks are also used in music technology, for example to sense live performers, and transmit the sensor data to a central computer which then plays back sound or visuals in sync with the music. One example of such an application are the Audiocubes, smart objects which form a star network and which can sense each other's location, orientation and relative distance, as well as distance to the user of the network (i.e. the performer).

3. GIS vs. Internet

3.1 Openlayers

Web mapping is the process of designing, implementing, generating, and delivering maps on the Web and its products. *Openlayers* is a powerful, community-driven, open source, pure JavaScript web mapping library. With this, we can easily create our own web map mashup using a myriad of map backends. Displaying maps with *Openlayers* is relative easy, fast and interactive for both desktop and mobile devices.

Openlayers is a client-side JavaScript library for making interactive web maps, viewable in nearly any web browser. Since it is a client-side library, it requires no special server-side software or settings. We can use it without even downloading anything! Originally developed by MetaCarta as a response, in part, to Google Maps, the 2.x series of the library has grown into a mature, popular framework with many passionate developers and a very helpful community.

Openlayers is not a map server, it just consumes services from maps servers. It is a JavaScript library, focused on object oriented programming(OOP) (Gratier, 2014).

The process for creating a map with OpenLayers requires, at a minimum, the following things:

- Include the OpenLayers library files;
- Creating an HTML element that the map will appear in ;
- Creating a layer object from a ol.layer.* class;
- Creating a map object from the ol.Map class by adding a layer;
- Creating a view from the ol.View class to set for the Map class (defining the area

where the map will initially be displayed);

```
<!doctype html>
  <head>

    <title> Hello OpenStreetMap </title>
    //Include the OpenLayers library files
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
      type="text/css" />

    <link rel="stylesheet" href="../assets/css/samples.css"
      type="text/css" />
    // - - - - -
  </head>
  //Creating an HTML element that the map will appear in
```

```

<body>

  <div id="map" class="map"></div>
  <script src="../assets/ol3/js/ol.js">
  </script>
  <script>
    //Creating a layer object from a ol.layer.* class using Openstreet map as backend
    var osmLayer = new ol.layer.Tile({
      source: new ol.source.OSM()
    });
    // Creating a view from the ol.View class to set for the Map class (defining the area
    where the map will initially be displayed)
    var birmingham = ol.proj.transform([-1.81185, 52.44314], 'EPSG:4326', 'EPSG:
    3857');
    var view = new ol.View({
    center: birmingham,
    zoom: 6 });

    //Creating a map object from the ol.Map class by adding a layer

    var map = new ol.Map({
    target: 'map'});
    map.addLayer(osmLayer);
    map.setView(view);
  </script>
</body>
</html>

```

If we open our html file in our web browser we will see the image bellow. It can be hosted on a server or opened as a file.

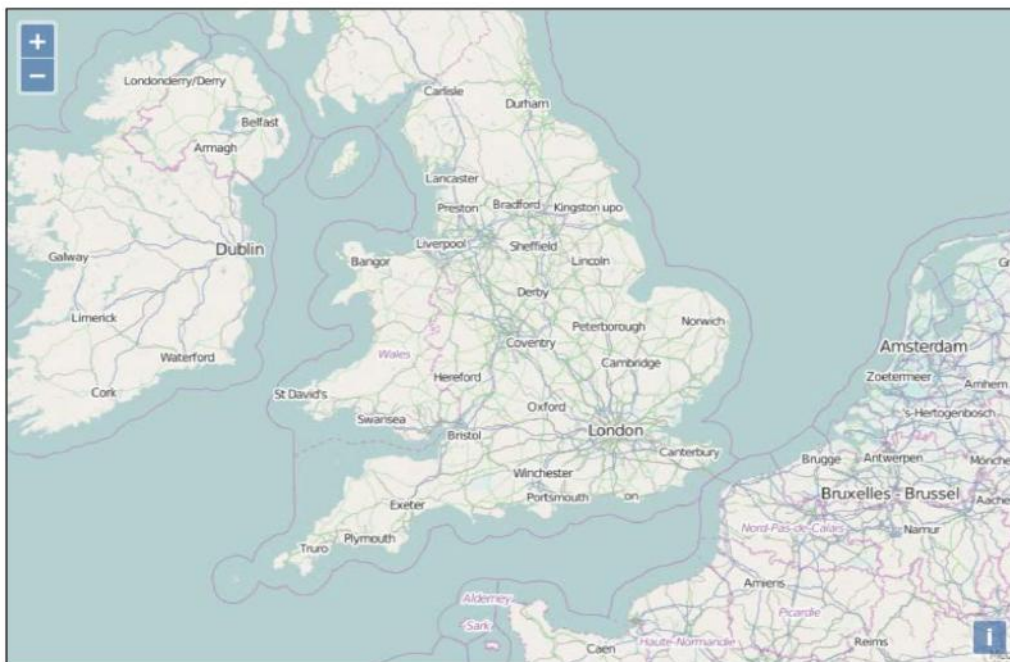


Figure3:Example of an image contained in a html file.

It just creates a simple *Openlayer* map. The control on the left side (the navigation buttons) is the Zoom control, which is an `ol.control.Zoom` object. We can click the buttons to navigate around the map, drag the map with our mouse, use the scroll wheel to zoom in, or use the keyboard's arrow keys.

`ol.control.Attribution` is added by default. It will be populated if a layer (such as OSM) has attribution info available. This control is on the bottom right corner and gives the credits for the data being used such as license and data producer.

3.2 Web Map Server (WMS) and Web Features Services (WFS)

The basic principle behind WMS and WFS services is that they allow us to specify the area of the map we want to look at (by sending a request), and then the map server sends back a response containing the map image. With *Openlayers*, we can choose to use as many different backends in any sort of combination as we'd like.

A map server (or map service) provides the map itself. There are a myriad of different map server backends. To name a few:

- The map server using WMS and WFS (such as the GeoServer, Mapserver and so on)
- Proprietary backends provided such as Bing Maps or Esri's ArcGIS Online, mainly based on proprietary data;
- Backends based on OpenStreetMap data such as the official OpenStreetMap, Stamen maps, or MapQuest maps.

With many web map servers, we do not have to do anything to use them, just supplying a URL to them in *OpenLayers* is enough. OSGeo, OpenStreetMap, Google, Here Maps, and Bing Maps, for instance, provide access to their map servers (although some commercial restrictions may apply with various services in some situations).

Sample of *Openlayers* consuming WMS from Bing Maps:

```
var sourceBingMaps = new ol.source.BingMaps({
    //Key
    key: 'Ak-dzM4wZjSqTlzveKz5u0d4lQ4bRzVI309GxmkgSVr1ewS6iPSrOvOKhA-CJlm3',
    // WMS image that we want. I specified Road, but we would consume the Aerial Image with or
    // without labels etc.
    imagerySet: 'Road',
    culture: 'fr-FR'
});
```

Openlayers consuming WMS from Geoserver:

```
var wmsSource = new ol.source.ImageWMS({  
    // Where is the wms  
    url: 'http://localhost:8080/geoserver/aut6/wms',  
    // Wich layer we want  
    params: {'LAYERS': 'aut6:wmsview'},  
    //Type of wms server.  
    serverType: 'geoserver',  
});
```

3.3 PostGis

PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL.

PostGIS adds extra types (geometry, geography, raster and others) to the PostgreSQL database. It also adds functions, operators, and index enhancements that apply to these spatial types. These additional functions, operators, index bindings and types augment the power of the core PostgreSQL DBMS, making it a fast, feature-plenty, and robust spatial database management system.

The PostGIS series provides:

- Processing and analytic functions for both vector and raster data for splicing, dicing, morphing, reclassifying, and collecting/unioning with the power of SQL;
- Raster map algebra for fine-grained raster processing;
- Spatial reprojection SQL callable functions for both vector and raster data, etc.

Most commonly, PostGIS is used by Open Source Mapping Servers. Most also conform to OpenGIS Consortium (OGC) mapping standards. Below are some acronyms for standards supported:

-WMS (Web Map Service), WFS (Web Feature Service), WFS-T (Web Feature Service Transactional (ability to edit)), WCS (Web coverage service), WPS (Web Processing service), WMTS (Web Map Tile service).

Data can be extracted from PostGis database using SQL. Below are some vectors and rasters queries that can be used to extract geographic data from database.

For vector format data:

Select * from TABLE where:

ST_Contains - Returns true if and only if no points of B lie in the exterior of A, and at least one point of the interior of B lies in the interior of A.

ST_Intersect - Returns TRUE if the Geometries/Geography "spatially intersect" - (share any portion of space) and FALSE if they don't (they are Disjoint). For geography -- tolerance is 0.00001 meters (so any points that close are considered to intersect)

ST_Buffer - Returns a polygon with buffer distance required.

ST_Distance - Returns the distance between objects;

ST_Crosses — Returns TRUE if the supplied geometries have some, but not all, interior points in common.

ST_Touches — Returns TRUE if the geometries have at least one point in common, but their interiors do not intersect.

ST_Area, ST_Lenght etc...

For raster format data:

ST_NearestValue — Returns the nearest non-NODATA value of a given band's pixel specified by a columnX and rowY or a geometric point expressed in the same spatial reference coordinate system as the raster.

ST_Neighborhood — Returns a 2-D double precision array of the non-NODATA values around a given band's pixel specified by either a columnX and rowY or a geometric point expressed in the same spatial reference coordinate system as the raster.

ST_SetValue — Returns modified raster resulting from setting the value of a given band in a given columnX, rowY pixel or the pixels that intersect a particular geometry. Band numbers start at 1 and assumed to be 1 if not specified.

ST_PixelAsCentroids — Returns the centroid (point geometry) for each pixel of a raster band along with the value, the X and the Y raster coordinates of each pixel. The point geometry is the centroid of the area represented by a pixel.

ST_PixelAsPolygon — Returns the polygon geometry that bounds the pixel for a particular row and column.

ST_HasNoBand — Returns true if there is no band with given band number. If no band number is specified, then band number 1 is assumed.

3.4 Preliminary tests

All geospatial analysis algorithms can be developed by using for instance, Python programming language, ASP.NET, or other programming languages and by receiving and treating values, combined with other data from a given area to possibly produce new maps. Openlayers library is responsible for exhibiting the rasters on the internet.

As an example, I created a website, combining ASP.NET, Openlayers, Postgres database and Geoserver as a WMS server provider.

URL: www.juliochilela.info .

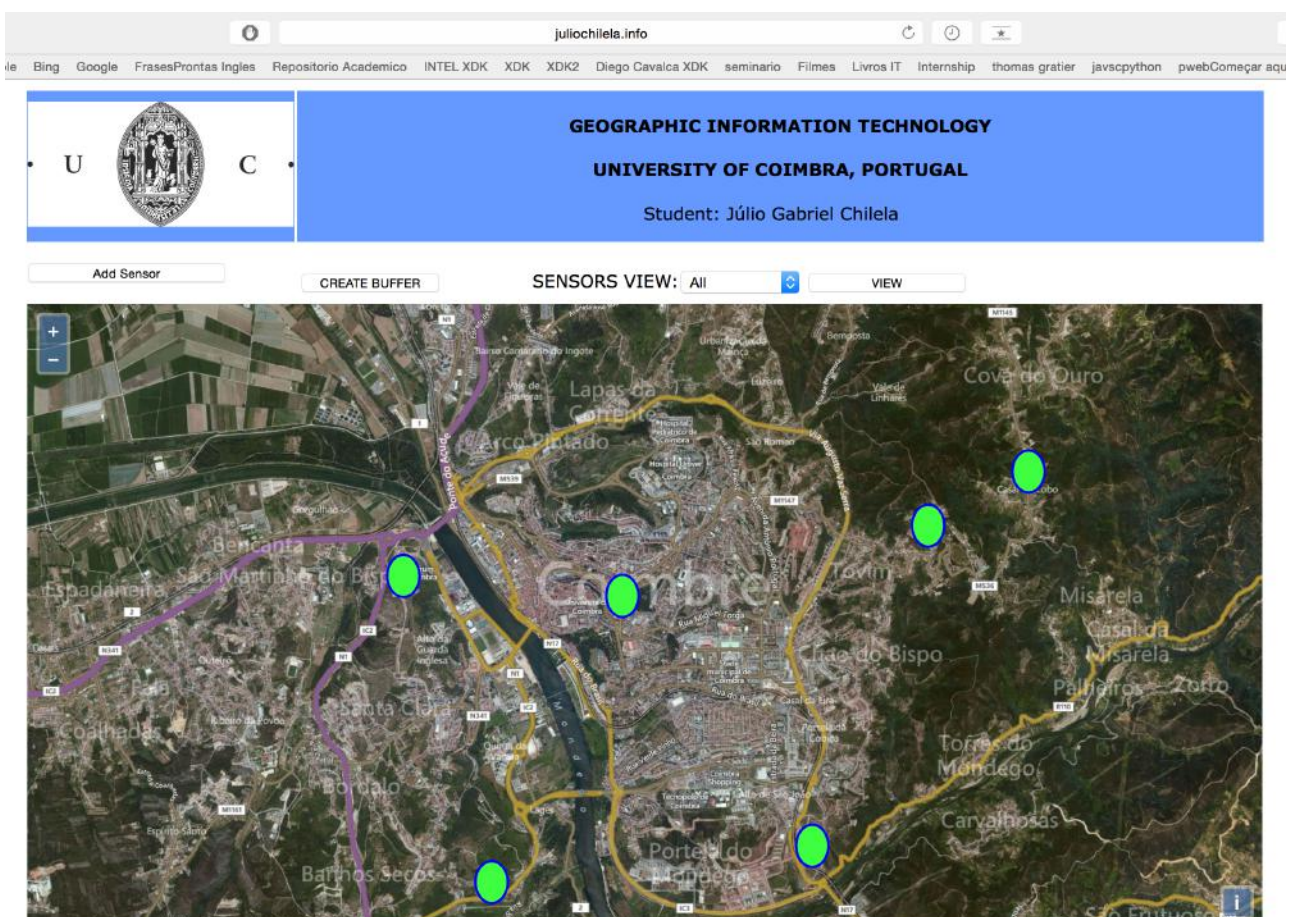


Figure 3: Geographic website Sample

Green points in figure 3 represent different sensors, spread over a given area.

Different types of sensors can be added if we click on the 'Add Sensor' button.

Figure 4: Add sensor. Simulating the min and max value of sensor.

By clicking on the “Add” button, it creates a geographical table in PostGis containing points geometry (latitude and longitude) and, the Geoserver is configured to be connected to Postgis and provide the WMS to openlayers with referenced table.

Different views of sensors are created by direct connection between ASP.NET to Postgres by an SQL query. Each button has a different SQL function in ASP.NET. For instance, when we go into the buffer page, ASP.NET is responsible for connecting to postGis database, going into the reference table, and creating a buffer view with user parameters.

The SQL goes into database in point geometry field and then creates a buffer (polygon) around the point with radius that the user established, and then, back into the main page and asks *openlayers* (library included in ASP.NET code) to go into Geoserver and get the WMS corresponding to the new buffer view. Below is a sample of query applied to get a buffer view.

```
mySQLString = "create or replace view vistabuffer" & Parameter1 & " as SELECT
ST_Buffer(ST_GeomFromText('POINT('||st_x(st_transform(the_geom,4326))||' '||
st_y(st_transform(the_geom,4326))||')')," & Val(Parameter2) & "0.000009, 'quad_segs=6'),
description,max,min,average,type from seminario where type='" & Parameter3& ""
```

In this query, parameter 1 is the name of the view; parameter 2 the buffer distance, and parameter 3 the type of sensor that the user wants to create a buffer for. If the chosen sensor is humidity, the buffer feature will only be created in Humidity sensors. There is still some work left to be done, like indicating a specific humidity sensor in which the buffer will be performed...



Figure 5: Creating a buffer.

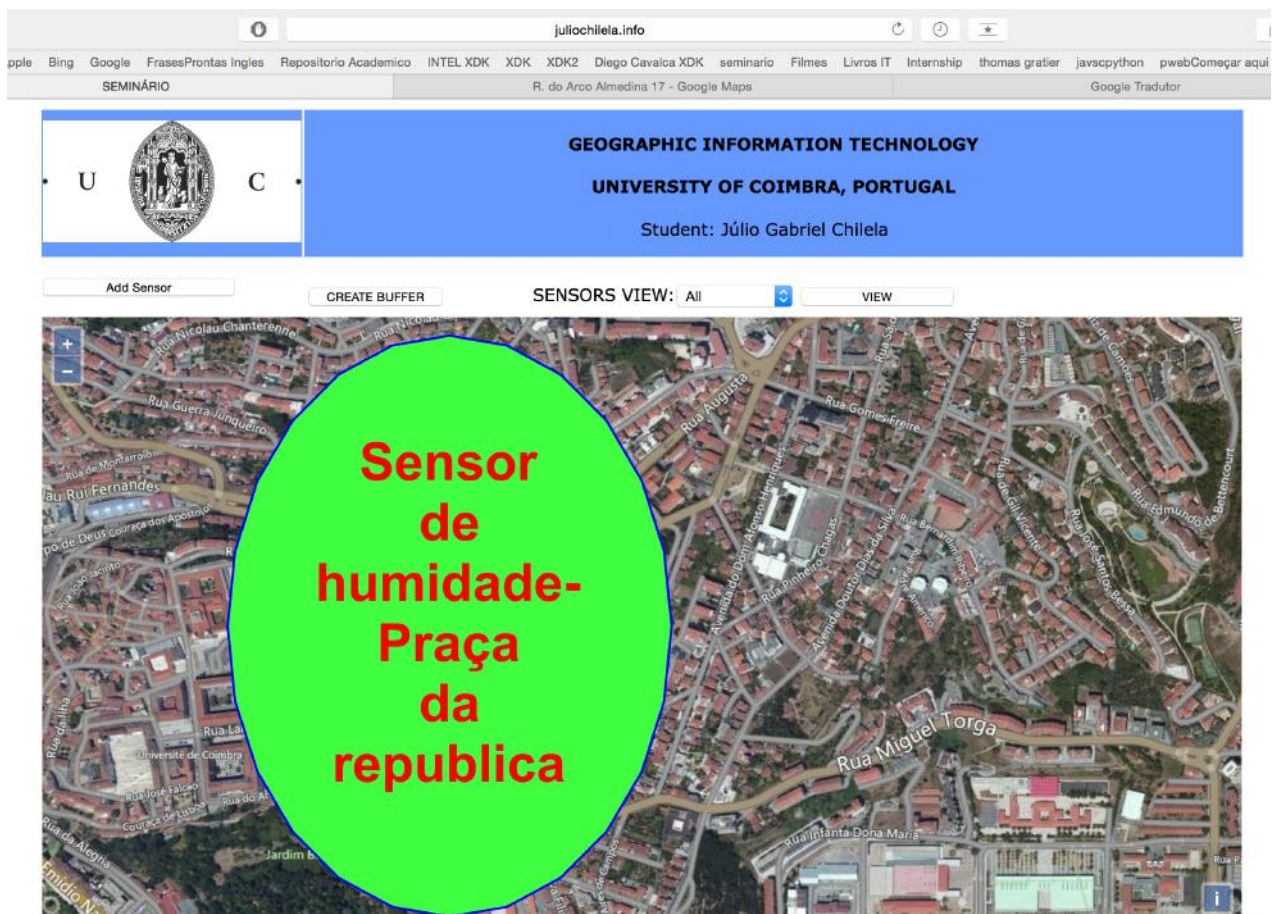


Figure 6: Buffer created in Humidity sensor.

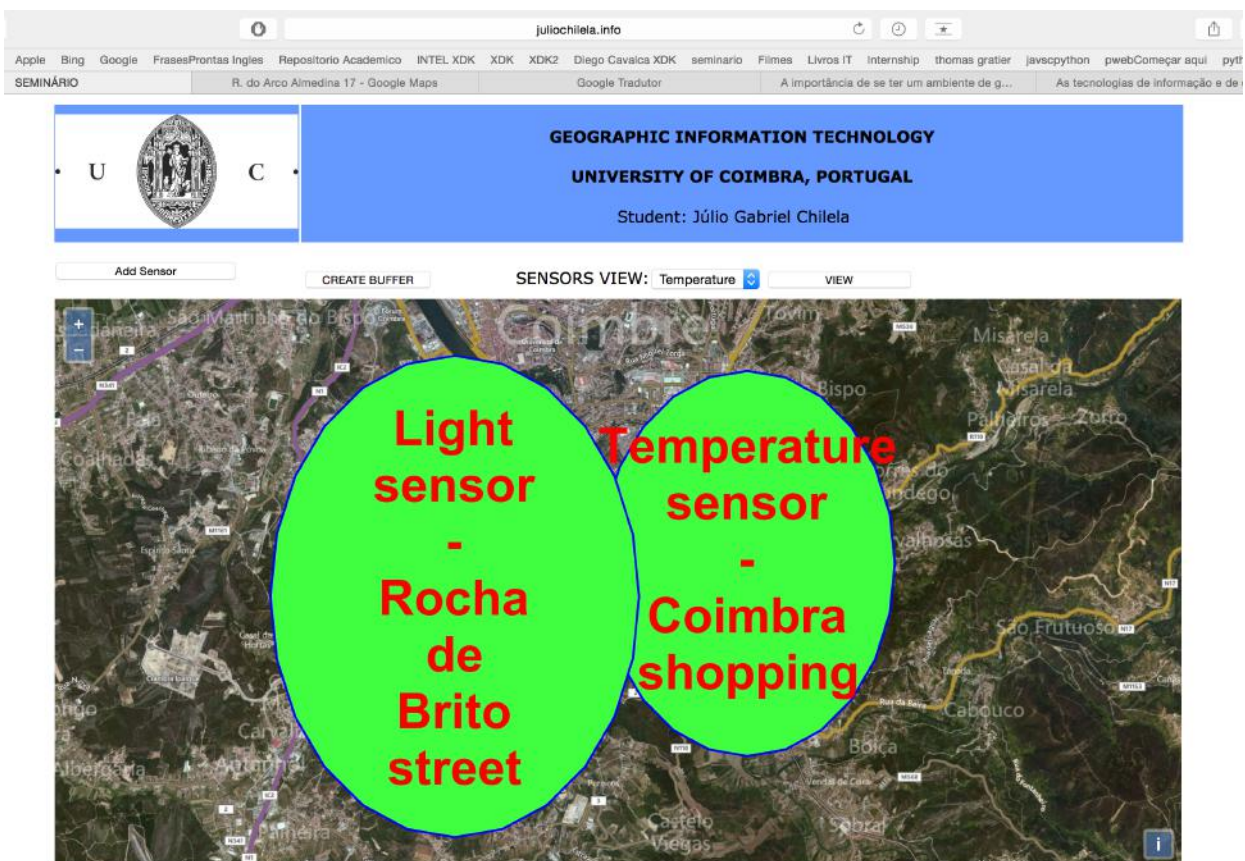


Figure 7: Examples of different buffers created in different types of sensors

With this small sample, we have an infinite analysis tool to proceed on geographical database and exhibit the result. Everything depends on the SQL query that we can apply in database and Openlayers will do the rest. For instance we can create buffer of 2 different sensors and get the intersection zone of performed buffer, we can also, use the digital model terrain and get the higher areas that will be affected with some phenomena etc...

4. Conclusions and future work

A GIS web portal can show maps with modeling processes, combining data that is being collected by sensors in real time to preview some phenomena. This is one of a large number of importances of sensors in GIS; allowing real-time geospatial analysis for prevention of floods for example. Maps can show potential zones or affected zones by floods.

A GIS portal connected to sensors can be useful to forecast the behavior of environment and to produce maps of everything; by combining data from heterogeneous sensors and providing useful informations for citizens.

The same web portal can be adapted to produce maps containing information such as water distribution around the city, gas, waste, traffic lights, energy distribution, air quality, water quality, carbon dioxide indexes to certain areas affected by the existence of certain plants etc., depending on type of sensor that exist in the city. These maps can increase the confidence of people about the services.

References

- 1- Honda, K., Shrestha, A., Witayangkurn, A., Chinnachodteeranun, R., Shimamura, H. (2009): A Field-servers and Sensor Service Grid as Real-time Monitoring Infrastructure for Ubiquitous Sensor Networks
- 2-Rahman, M. (2012): Low Cost Configuration of Data Acquisition System for wireless sensor Network
- 3- Saumini, K. (2012): An integrated Framework in Geographic Information System using Wireless Sensor Network
- 4-Felícísimo, A. M., (2014): Design of a WSN for the sampling of environmental Variability in Complex Terrain
- 5- Laituri, M., Kodrich, K. (2008): Online Disaster Response Community: People as Sensors of High Magnitude Disasters Using Internet GIS
- 6-RTP/Notícias (2015): Chuvas em Benguela. Available from <http://www.rtp.pt/noticias/index.php?article=815805&tm=7&layout=121&visual=49>
[accessed in 29-06-2015].
- 7-Geofferry, Aguilar, J. (2013): Advances in geographic information systems and remote sensing for fisheries and aquaculture
- 8-Farahani, H. (2014): Humidity sensors principle, mechanism, and fabrication technologies: A comprehensive review
- 9-Wikipédia (2011): Wireless sensor network. Available from https://en.wikipedia.org/wiki/Wireless_sensor_network#Air_pollution_monitoring
[accessed in 01-07-2015].
- 10-David, Yuri (2010): Geographic Information System Framework for the Management of Sensor Deployments
- 11- Jane, Kirk (2015): Toward an Environmental Internet of Things
- 12-Dilshan, Mustafa (2012). WikiSensing: An Online Collaborative Approach for Sensor Data Management
- 13-Baptista, Thiago (2013): A importância de se ter um ambiente de gerenciamento centralizado [online]. Available from <http://gestaonati.com.br/a-importancia-de-se-ter-um-ambiente-de-gerenciamento-centralizado/>
[accessed in 12-05-2015].

15- Estgv, A importância da internet. Available from <http://www.estgv.ipv.pt/paginaspeessoais/quental/trabs/psi/internet.htm>

[accessed in 12-05-2015].

16- Da Silva, JP (2012): Study of technologies for GIS environment develop.

17- Gratier, T (2014): OpenLayers 3 Beginners guide. Packt Publishing Ltd, Birmingham (United Kingdom).