GEOG 689 – WEB GIS

Creating and Interactive Map of Informal Settlements in Lima, Peru

Final Report

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Introduction
Urbanites who cannot obtain adequate shelter through formal channels must rely on informal settlements for housing. These informal settlements can be both a blessing and a curse for cities in developing countries. On one hand, informal settlements relieve the city of having to provide affordable housing to its growing population. On the other hand, informal areas can create health and fire hazards for the residents. Informal settlements are usually built on the outskirts of the city. As the city grows some of the settlements are incorporated into the formal city. Unemployment tends be high in informal settlements and residents must rely on the informal economic sector. Due to a lack of financial and material resources, the houses are built out of 'inadequate' materials such as mats, mud, adobe bricks.

Lima Peru overlooks the Pacific coast on a valley surrounded by hills and mountains. Known as ascentamientos humanos (human settlements), Lima's informal settlements spread away from the city and into the surrounding mountains. Many of these settlements lack basic needs, such as potable water and public schools. However, as the formal city expands, informal areas are incorporated into the formal city and given access to electrical grids, water networks, and schools.

In order to identify these areas and their characteristics I used census data provided by the Peruvian national census of 2007 and data provided by the GIS department of the School of Architecture at The Pontifical Catholic University of Peru (PUCP).

The Commission
This project was commissioned be Dr. Cecilia Giusti of the Texas A&M Landscape and Urban Planning Department. Dr. Giusti researches development in developing countries and has a special interest in Lima because she grew up in the city. For the original project, she wanted a dataset of informal areas. However, because of the nature of the class this project was for, the resulting map needed to be online as well.

Acquiring and Preparing the Data
Data district and CAPECO region were provided by P. Moschella in the Geography department of PUCP. Communication between us was established by M. Malpartida of the Architecture department at PUCP.

To help in determining the location of the informal areas and their characteristics, I used census data provided by Peru's 2007 census found on the census website. The rationale behind this is that informal settlements exhibit certain characteristics, such as lower education, housing types and materials, and lower rates of connection to public utilities. From the census I chose 8 characteristics: population density, primary education as the highest level completed, percent of the population 15 years and younger, connection to public water networks, percent of house with walls built out of inadequate materials, percent of squatter base home and land ownership, and employment in the second and third sector. The rational for the last 2 characteristics was that Lima has a very low unemployment rate according to the census. The question asked is 'did you work last week' to which about 55 percent replied 'no' but only 4 percent of that were actually looking for work; the rest provided reasons such as disability, student, or housewife. Thus I decided to use employment type. Because Lima is a city, there is little activity in the primary sector which narrowed it down to the tertiary and secondary sectors. Those working in the informal economy and those with less education would be more likely to work in the secondary sector. The census data is at the district level.

Informal settlements in Lima are built on the outskirts of the city up the hillsides and through the narrow valleys. To show how the settlements follow these unique physical patterns, I included elevation contours using 200 feet intervals.

Once acquired, the data and shapefiles were joined and converted to Keyhole Mark-up Language format (KML).This method was chosen because I wanted the user to be able to see the data in the form of choropleth maps in order to gain an understanding of the spatial pattern of the data and therefore of the characteristics of the districts. The darker areas and the red areas represent higher values while the lighter areas represent lower concentrations.

Tools

As stated earlier, ArcMap 10.1 was used to create the KML files, Google Earth was used to unzip them, and Google Drive was used to host them. The website was created using HTML and CSS and is hosted by a Windows server on the Texas A&M network. The map was created using JavaScript and Google Maps API version 3. The functions to create the toggle boxes were created using JavaScript.

Methods

The idea behind this project is to identify informal areas on an online map that is available to anyone who has an interest, specifically the customer. By examining the characteristics of each area, the user could determine where an informal area would most likely be located.

Because the focus of the webpage is the interactive map, I wanted the website to be simple and make the map the center of attention. The website also needed an area for checkboxes to turn layers on and off. Everything else would be for aesthetics. Initially, the map had four divisions: a header with the title, a footer which is mainly for aesthetics, the map, and the area for toggle boxes. I added a fifth, below the checkboxes, to include information about the informal areas and the layers along with links to more information. The five divisions sit inside of a larger division, the container, which has sizing properties set to 'auto,' meaning that the page will automatically fit to the screen. The sizing dimensions of the five divisions are set as percentages within the container. Because the map is the most important item, and the toggle boxes do not take up very much room, the division that hold s the map is set to 80% width while the information and toggle box divisions are set to 20% width. Lima's flag consist of two birds holding a shield on a yellow background. I chose the same yellow color as the background for the site to relate the site to the city and set the header and footer to a darker yellow to create an aesthetically pleasing boundary on the page.

I chose Google Maps as the base for the final map because the interface is well known and well used; there were plenty of code and advice that I could use for my project. Google Maps would provide an interactive map that was simple to use and create. The Google Earth view was also a deciding factor. There is a 4 megabyte limit when it comes to I did not want to overload the maps with information that could be easily gathered by examining an image, such as water sources and terrain type. The map framework is based off the simple JavaScript code provided in the Google Maps API v3 examples.

Choropleth maps can tell much information at a single glance and are a good way to compare areas. Therefore I chose to use choropleth maps as the layers for the map. To do this, data was gathered from the Peruvian Census site and shapefiles from Diva-GIS site. The data from the census were compiled into CSV tables. The data were then imported into ArcMap 10.1. The tables were joined to the districts shapefile and the DEM raster from Diva-GIS was converted to vector based contours. The layers were turned into semi-transparent choropleth maps to show concentrations. The resulting layers were then converted into KMZ files using ArcMap's Layer to KML tool, and later unzipped in Google Earth.

In order to bring the new KML layers into the map, I first tried putting the KMLs into a directory and calling them from there. However, after a little online research, I learned that KMLs can only be called from a publicly available online directory, such as a Google Drive or Dropbox. After bringing the KMLs into a public folder on Google Drive I inserted the KML files into a dictionary using JavaScript. Within the KML dictionary is a dictionary for each KML file, each with two keys – link and URL.

The interactivity of the map is based on the user turning the layers on and off to explore different characteristics of the districts in Lima. To do this, I the created toggle boxes in the createTogglers function using inner HTML to create dynamic toggle boxes that change when it is clicked and unclicked. The createTogglers call on the name key of the KMLs in the dictionary. The name is set to the right of the toggle box associated with it. The toggleKML function calls the KML file associated with the toggle box and stores it as an object. The highlight function appends the selection(s) to a list while the removeall function deletes the contents of the lists and unchecks the boxes. There are no instructions on how to use the toggle boxes; instead I included the startup function which checks the Districts layer and calls the layer when the page loads. When the page loads, the user will see a list of checkboxes with one of them checked and a Google Map with a layer on it. The idea is that the user will realize that these boxes can be checked and bring in another layer. All of these functions are called in the initialize function and initialize when the page is loaded.

Problems

When this project was commissioned by the client, I expected the client to have some research or knowledge concerning these informal areas that she would share with me. However, project direction from the client and communication with the client proved to be very difficult and unhelpful. Initially the client simply said that wanted a dataset of the informal areas. I had assumed that she would help me identify where these were as both she and I knew that I had no experience or knowledge of the city. Unfortunately, emails went unanswered and I heard nothing else from her regarding direction for the project or help in identifying these areas. In March I met two professors from Architecture School of PUPC who were visiting Texas A&M. Their research focused on urban planning and community projects in Lima. They put me in touch with a professor in the Geography Department at PUCP who provided some information on the city and the regional layers. Because time was running out and I did not want to create maps based on ignorance, I focused on merely examining the characteristics of the districts.

Language proved to be a minor problem with this project because I cannot speak it. Google's Translate tool was not able to translate the census questions on the page and some of the translations were incorrect or just did not translate well. I had to rely on my very small vocabulary to understand the questions and there were a few that neither I nor Google could translate. Additionally, the first data set sent by the Paola at PUCP was in Spanish and had Spanish based abbreviations.

Choropleth maps are not very helpful without a legend. Darker colors and reds represent higher concentrations in the layers; however, the range and the breaks are unknown. Legends in Google Maps are created using the different markers in the map. However, they layers are colors, not markers, making it very difficult to find examples of legends to include with each layer. To remedy this, I experimented with Google's experimental fusion tables. Rather than KML layers, I would create fusion table layers that would draw on the map when called, similar to the JavaScript framework of the KML files. Fusion table layers allow the owner to create legends and custom pop-up boxes based on the preset breaks and actual values. Fusion layers were the only examples of a color-based legend. The idea was that when a fusion layer was called, its key would be created and a custom info-window containing the value for the district of the selected attribute. Unfortunately, the fusion table layers would not draw when called. To see if the problem was in the actual table or in the code to bring in the fusion layer, I tested each layer individually. They worked, and I was able to make a custom info-window for each layer. Unfortunately, I could not get them together like the KML files, thus I had to abandon the fusion table idea. Aside from the fusion layers, I could find no information on how to make a legend. The next option was to create info-windows with the information. Unfortunately, setting up the architectural structure to bring in info-windows based on the selected layer was beyond my remaining time-frame and skill.

The greatest challenge to this project was working alone. Working in groups allows ideas to be passed around, application of different skill-sets, and division of labor to make work more efficient and research less time-consuming. Perhaps the legend and info-window issue could have been resolved if there were more people.

Future Projects

As mentioned before, choropleth maps have little meaning without a legend or the actual value. While researching the fusion table layers, I learned that these experimental tables are very limited in that only 5 can be called at a time and only one can be colored. The map has 8 choropleth layers so far, thus fusion layers are no longer an option. As fusion layers were the only method I found of creating a color-based legend, the legend idea is also out. Thus as a future project, I want to create the infrastructure and code necessary to bring in an info-window based on the top layer on the map. Unfortunately, the user would have to determine the breaks on their own, however, at least there will be a value associated with the color. The info-window will pop-up when a district is clicked. If possible, it would be interesting to have an info-window that displayed all of the district's values based on the layers selected. The info window would take the name key from the KML dictionary and the value from the database and display it as "KML Name = value."

Drawing order for the KMLs may be helpful, but only as far as the CAPECO zones and the district boundaries. Z values can be set in KML layers, however, due to a limited time frame, I was not able to do it.

It would be interesting to actually map the informal areas and display them online. Knowing the locations of these underserved areas and having the information open to the public could help with urban planning in Lima and community projects. The informal areas layer would be created in ArcMap and brought into the Google Map using the same method as the other KML files. The layer would look similar to the design of the CAPECO layer. To do this, I would need more information or collaborate with someone who knows the city and its informal areas.

Pictures would also be very interesting. Users, presumably Lima residents or researchers with experience in the area, could upload pictures of the informal areas and add them to the map. This may also help with identifying the informal areas, and can help the city determine the living conditions in these areas. It is also nice to have a closer visualization of an area; a map can only show so much of such a small area.

Conclusion

This project set out to create an online map of informal areas and their characteristics in Lima, Peru. Due to major problems with lack of data and communication, this project in incomplete in mapping the informal areas. However, it is successful in mapping out the characteristics of informal areas within the districts, though there is still work to be done. All said, the customer seemed pleased with the product, expressing that it is a good start.