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Open Data, a new approach with GIS components

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Abstract

In this work, we wanted to develop a proposal to improve the Open Data Infrastructure in Universitat Jaume I.

To do this, we have studied the definition of Open Data and its principles. In addition, thanks to the rise of GIS technologies, we have studied how to add some GIS components to our proposal. These components are to manage spatial data, to visualize spatial data and to process spatial analysis. We have also made a comparison between different Open Data Infrastructures to get a general idea of how is running today. From a practical perspective, it can give a requirements for an implementation of an Open Data Infrastructure for Universitat Jaume I. Finally, we made a two cases study and we have done a test that has given us some ideas as future work.

Keywords

Open Data
Open Data Infrastructure
GIS Components
Transparency
Participation
Collaboration
Framework
Spatial Analysis
Visualization
Life Cycle

Acronyms

API - Application Programming Interface
CSV - Comma Separated Values
GEOJSON - Geographic JavaScript Object Notation
GIS - Geospatial Technologies System/Science
ICT - Information and communications technology
JSON - JavaScript Object Notation
REST - Representational State Transfer
GPS - Global Positioning System
UJI - Universitat Jaume I
iOS - iPhone OS

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Chapter 1

Introduction

The objective of this chapter is to summarize the scope of the present thesis. To do this, in section 1.1 we suggested a motivation for our work. The context of the thesis is in section 1.2. The objectives of this thesis are explained in section 1.3. The research questions and hypothesis are listed in section 1.4. Finally, the methodology and the organization of this thesis are in section 1.5.

1.1 Motivation

We live in times of change [Oscar Cortés, 2013].On the one hand, we have an institutional crisis that has generated discontent among citizens and politicians. The spanish corruption, combined with ineffective institutional responses, is likely to have produced widespread dissatisfaction and distrust on the part of Spanish citizens [Manuel Villoria et al., 2012]. In Spain, a process of change started when a few demonstrated through movement 15M in 2011 with the support of people. The 15M was followed with interest by the majority of citizens and more than 70% of the population valued it positively [S. Martí i Puig, 2011].

Further, we have a technological transformation centered internet and mobile devices. According to a survey of AIMC[1], 85% of respondents reported having used a smartphone to connect to the internet with an average of more than 3 hours of daily consumption of news being the main reason for access [AIMC, 2015]. One reason for this change is the rise of Web 2.0. According to Wikipedia:

[1] Association for Media Research

Web 2.0 describes World Wide Web sites that emphasize user-generated content, usability, and interoperability. A Web 2.0 site may allow users to interact and collaborate with each other in a social media dialogue as creators of user-generated content in a virtual community, in contrast to Web sites where people are limited to the passive viewing of content.

The tools used in Web 2.0 are blogs, wikis, podcasts, videos, images, social networks. The most important innovation of Web 2.0 is to make the Web into a platform for publishing and production of content and applications by any user [Domingo et al., 2010].

In parallel, there are many authors and many social groups who support the thesis that people are calling for more transparency, more participation and more cooperation in administrations as one method to resolve this crisis and they are similar to web 2.0 [Rubio, 2014]. These three concepts are also included in the definition of Open Government. Open Government is the governing doctrine which holds that citizens have the right to access the documents and proceedings of the government to allow for effective public oversight [Lathrop, Ruma, 2010]. A transparent government encourages and promotes accountability of government to citizens and provides information on what it is doing and its plans of action. The objective is to inform the public all the information necessary for it to work critically. A government that promotes citizen participation favors the right of citizens to actively participate in shaping public policy and encourages the Administration to benefit from the knowledge and experience of citizens. A government that promotes collaboration involves and engages citizens and other agents in the proper work of the Administration [Oscar Cortés, 2013].

Finally, according to the European Commission, Open data refers to the idea that certain data should be freely available for use and re-use [EC, 2011]. European Commission support open data for 4 reasons:

- Public data has significant potential for re-use in new products and services.
- Addressing societal challenges – having more data openly available will help us discover new and innovative solutions.

- Achieving efficiency gains through sharing data inside and between public administrations.
- Fostering participation of citizens in political and social life and increasing transparency of government.

The Open Data foundations are transparency, collaboration, participation. These foundations are exactly the same as the Open Government and also the same as spanish people claim to solve their problems. Open data is a tool that can help solve this problem.

1.2 Context

To contextualize the topic in this thesis, we must first define what is Open Data. Open data can be a movement. Open Data is the idea that some data should be freely available to everyone to use and republish as they wish, without restrictions [Wikipedia, 2016].

Open data can be a infrastructure. As we mentioned in section 1.1 Web 2.0 and Internet have transformed the society. Therefore, the idea of opening data for everyone is much more feasible. Today, when we refer to an organization it has an open data, in fact, we are saying that the organization has a web site with public information available to everyone.

The main objective of this thesis is to develop an Open Data Infrastructure of the University Jaume I. For this, the first step will be to define what an Open Data. Sunlight Foundation defined a series of principles Open Data. With these principles we resolve the ambiguity that generates the idea of opening data.

According to IGN[2], 80% of the information managed by administrations may contain a spatial reference [Suarez, 2012]. This aspect invites us to consider with special attention the information from an Open Data applied to an institution like the University Jaume I especially becomes important. Therefore, the next step will be to define the GIS components and apply them to our proposal of Open Data Infrastructure.

In short, the goal of this thesis will be to develop a proposal for an Open Data Infrastructure that supports spatial data.

[2] Instituto Nacional de Geografía

1.3 Objectives

In particular the objectives of this thesis are divided into the following parts.

- To define an Open Data that allows managing spatial data.
- To made a comparison on different Open Data Infrastructure previously selected.
- To develop a proposal Open Data Infrastructure for the University Jaume I.
- To make a questionary to test the usability of Open Data Infrastructure and to analyze results.

1.4 Research questions and hypothesis

From the previous context this question is considered to be answered during this thesis.

- Which improvements can be made in UJI Open Data?
- Which GIS components can be useful for the UJI Open Data?
- What contribution can have our proposal of UJI Open Data?

1.5 Methodology and Organization of the thesis

The study begins with a literature review in some depth of concept of Open Data, a brief explanation of the objectives and some questions that resolve this work.

Secondly, the theoretical framework, explains the principles of Open Data that we need to know. These are the requirements of our Open Data Infrastructure. In addition, we also need to know which components has a GIS application to apply in our Open Data Infrastructure.

Thirdly, we are going to do a brief study and classification of Open Data in the main administrations in Spain to compare our requirements so that we can specify our Open Data Infrastructure with certain guarantees.

Fourth, we explain the strengths of the proposed development of our Open Data Infrasctructure.

Fifth, we explain the fact feedback ten developers to determine the level of acceptance of our Open Data Infrastructure.

Finally, we are going to discuss the final results and the future work.

Chapter 2

Literature Review

2.1 Introduction

The literature review is divided into three main chapters plus a final conclusion.

The first section 2.2 talked about the context of the Open Data on concepts of transparency, participation and collaboration and how these concepts help to develop our proposed Open Data explained in this paper. The current concept of Open Data is not understood without theses terms and helps to contextualize the Open Data Movement in our society.

In the second section 2.3 we do a Open Data definition as specific as possible and we explain each principles of Open Data. We also explain the requirements of our proposed Open Data that support each of these principles.

In the third section 2.4, we explain why GIS is a important contribution to our proposed Open Data. How we can add spatial information in our Open Data, such as how to process and view geographical data. Based on the GIS definition we explain the components applied to our Open Data proposal.

Finally, we make the first brief in section 2.5, explanatory summary of what Open Data proposal should be.

2.2 Transparency, Participation, Collaboration and how contribute to this proposal

The Open Data movement are focused in three aspects, transparency, participation and collaboration[Patrice McDermott, 2010]. There are many versions of Open Data [Borglund, 2014]. That is why The Sunlight Foundation identifies and establishes the principles that explain in the next section 2.3. However, all open data have in common the three pillars mentioned above.

Open Data is a tool that helps transparency. This allows citizens to access the data published since they are always available for use. We imagine for example, the publication of the annual accounts of an organization or the geographic information of the public buildings have. In addition, the opportunity to add new data sets is very wide.

Open Data is a tool that helps to participation. Citizens can help to add new information. They can also warn that such information may not be appropriate. Participation can be manifested in many forms, from a person detects any incorrect information, for someone to propose a new set of data that does not exist or a fault in particular. This directly affects the quality of published data, as well as provide a means for the public to show their opinion about the services offered.

Open Data is a tool that helps collaboration. It is also called shared value because the information can be used for everyone freely. There is a benefit to the organization and there is a benefit for those who use the data for their own benefit. As the information is public, any person or company can make use of the information. Therefore, to use this information to develop their own mobile applications is an initiative that adds value to the organization that has a Open Data and the individual developer of mobile application, as it is generating a shared value[Garcia, 2014].

The Open Data initiative improves interoperability between administrations, in our case, between universities, but also with the local government or educational administration. In addition, it also seeks cooperation with the private sector related to universities.

In short, Open Data is a tool that provides information freely so that anyone can use all the information. The quality of information is important, therefore, Open Data users is allowed to participate in the creation and modification of data. Finally, Open Data helps collaboration with the organization, internally and externally with other public or private organizations.

2.3 Principles of Open Data and how contribute to this proposal

According to Open Knowledge Foundation[1] open data is defined as data that can be freely used, reused and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike. In 2008, because of the definition falls short of 8 operating principles of Open Data were established.

To achieve these purposes, the data must meet several characteristics. In fact, open data should be able to be freely used, reused and redistributed by anyone, being, if necessary, subject only to acknowledgment of authorship and redistribution under the same or a similar license to the original[Open Knowledge, 2014]. All these characteristics that must define the data is usually collected on the known principles of open data, driven by the Sunlight Foundation[2], which are generally accepted in the context of open data projects developed worldwide.

1. **Completeness**. All public data is made available. Public data is data that is not subject to valid privacy, security or privilege limitations. Datasets should be as complete as possible.

   In our Open Data, the data is always available and can export all the information presented. In addition, so that this information can be reused, an application developer can use the information in their apps.

2. **Primacy**. Data is as collected at the source, with the highest possible level of granularity, not in aggregate or modified forms.

   The data of the Open Data should be considered as a source and verified information. This point is beyond our proposal because our datasets are a test.

[1] Open Knowledge Foundation
[2] The Sunlight Foundation

3. **Timeliness**. Data is made available as quickly as necessary to preserve the value of the data.

   Both the web application and the web service is always available for use. If the service shuts down, all applications and who want to see the information they can not.

4. **Accessible**. Data is available to the widest range of users for the widest range of purposes.

   The information is considered as open public you will always have to be accessible. In our application all the information available.

5. **Machine processable**. Data is reasonably structured to allow automated processing.

   The information on our Open Data is structured in simple datasets. The data types that make up a dataset can be text, a number or a spatial data, such as a point or a line. All information of a dataset is structured and hence, it is possible to display and then represent it.

6. **Non-discriminatory**. Data is available to anyone, with no requirement of registration.

   In our dataset is no need to register to access the information. But to manage information and create a dataset or edit another.

7. **Non-propietary**. Data is available in a format over which no entity has exclusive control.

   The format that we use our dataset is internally JSON. We can export the information in JSON or CSV format, which are open formats. Add other formats is possible and does not require too much difficulty to implement it.

8. **License-free**. Data is not subject to any copyright, patent, trademark or trade secret regulation. Reasonable privacy, security and privilege restrictions may be allowed.

   The information of the Open Data must be open non-proprietary information.

9. **Permanence**. The capability of finding information over time is referred to as permanence.

10. **Usage Costs**. There should be no cost to access the data.

2.4 GIS components and how contribute to this proposal.

Once we have established the basic requirements that you will have our Open Data, in this chapter we make a GIS definition with the GIS components that our proposal have. Next step, we make several comments about how important are spatial data in our open data.

Our starting point of this study begins with the need to add spatial information to our open data. We know that 80% of the information managed by the Administration contains a spatial reference[Suarez, 2012]. Accordingly, if we are to develop an open data for administration, in our case, the university, it is very important to study the spatial references. So, we explain the definition of a GIS application and then we explain the requirements that our application have.

Basically, a GIS must allow performing the following operations[Olaya, 2011]

- **Spatial data management**. A GIS must be able to read, edit, storage spatial data.

- **Spatial analysis**. A GIS must be able to perform processes on spatial data.

- **Visualization of the results** as a maps, reports or other formats like geoJSON.

2.4.1 Data

The geographic data that have been considered for the construction of our Open Data are points, lines and polygons. The representation format that has been considered is GeoJSON [geojson.org, 2008]. GeoJSON is an open standard format designed for representing simple geographical features, along with their non-spatial attributes, based on Javascript Object. Notation. JSON is a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate[json.org, 2008].

The management of geographic data in an Open Data presents the challenge of establishing a usable implementation[Newman et al., 2010]. Users need to understand how geographic data can be managed with a simple method. In the chapter 4 we explain how we develop a possible solution.

GeoJSON can take many forms:

To a point, the representation may be as follows

```
{
  "type": "Feature",
  "geometry": {
    "type": "Point",
    "coordinates": [125.6, 10.1]
  },
  "properties": {}
}
```

To a line, the representation may be as follows

```
{
  "type": "Feature",
  "geometry": {
    "type": "LineString",
    "coordinates": [[30, 10], [10, 30], [40, 40]]
    }
  },
  "properties": {}
}
```

To a polygon, the representation may be as follows

```
{
  "type": "Feature",
  "geometry": {
    "type": "Polygon",
```

```
        "coordinates": [[[30, 10], [40, 40],
                         [20, 40], [10, 20],
                         [30, 10]]]
        }
    },
    "properties": {}
}
```

GeoJSON format not only serves to represent simple geometries, it is also possible to make multiple representations as a group of geometries, they are called FeatureCollection. These geometries can be used to display the results of spatial analysis applied in our Open Data.

As we have said before a GIS application must be able to manage spatial data. Our Open Data manages spatial data with geoJSON. We may introduce a point or polygon GeoJSON manually typing like a string. We can also introduce a point or polygon using a map and drawing the figure we need. Therefore, one of the first challenges is to facilitate the use of spatial information for people who use the Open Data from the administrative to the end developer. In the case of a developer we need to document the open data[Suarez, 2012]. If we document the Open Data, each of the datasets, we facilitate the use of Open Datay and we increase participation, which is one of the objectives of an Open Data.

Another issue is that json and geojson are free and open formats. In developing apps, they are most commonly used formats. Therefore, we are helping to interoperability between administrations and companies using our Open Data. Collaboration is an important piece in the Open Data movement.

2.4.2 Process

Spatial analysis is one of the basic functions of GIS. A GIS always incorporates a number of formulations that allow getting results and spatial data. These formulations represent processes that can be very simple or extremely complex. There are different types of spatial analysis[Olaya, 2011].

In our proposal, we have the following groups agreggation, measurement, transformation, classification and other spatial analysis. As stated above, the display format we use is GeoJSON. We decided to use only points, lines and polygons.

When performing a process such as transformation, the result could be a multiple or complex geometry

2.4.3 Visualization

Any type of information can be represented graphically, which it usually facilitates the understanding of that information or part of this. Many of the characteristics of information are easier to study when they rely on some visual element[Olaya, 2011].

In the case of geographic information, the visualization is not only a way more work with that information, it makes it easier and intuitive processing that information. The geographic information has an inherent visual nature, since space itself is understood graphically by humans. We must not forget that geographic information is stored in a traditional maps. A map is itself a representation visual the information on geographical[Olaya, 2011].

In our proposal, we may use a map in many parts of the application, in the process of creating data, in the process of editing data, in the process of reading data, in the process of obtaining the results of a spatial analysis.

2.5 Summary of what Open Data proposal should be

We make a brief summary of the elements that we have explained that will be considered for the implementation of our proposal.

- The construction of the our Open Data should respect the Principles of Open Data.
- The Open data should allow the management, the processing and the visualization of spatial data through the geojson format.
- The formats of Open Data must be a open formats, to increase the use of the Open Data.
- There must be a well explained documentation.

2.6 Related work

We have found some related work with the idea of adding GIS components in an Open Data Infrastructure. The first work is ArcGIS Open Data in section 2.6.1. The problem is the high cost of using this technology. The second work is the geoportals in section 2.6.2.

2.6.1 ArcGIS Open Data

Before we close this chapter, I would like to mention an initiative of ESRI on building your own platform Open Data which is currently under development and has many similarities with this project. Perhaps its major disadvantage is the high cost of its license.[esri, 2015]. For ESRI the benefits are:

- Improve basic functions of democracy and access to information.
- Provide a platform of innovation.
- Promote civic engagement.
- Encourage cross-jurisdictional and -agency data collaboration.
- Drive economic growth and value.
- Layer complex data to improve decision-making and reduce costs.
- Improve transparency for citizen engagement.
- Improve communications during a crisis.
- Improve data quality and create standards.
- Improve data quality because the information being shared comes from the government.

2.6.2 Geoportal and Linked Open Geodata

A geoportal is a type of web portal used to find and access geographic information (geospatial information) and associated geographic services (display, editing, analysis, etc.) via the Internet. Geoportals are important for effective use of geographic information systems (GIS) and a key element of Spatial Data Infrastructure (SDI) [Wikipedia, 2016].

LinkedGeoData is an effort to add a spatial dimension to the Web of Data / Semantic Web. LinkedGeoData uses the information collected by the OpenStreetMap project[3] and makes it available as an RDF knowledge[4] base according to the Linked Data principles[5]. It interlinks this data with other knowledge bases in the Linking Open Data initiative [Linkedgeodata.org, 2016].

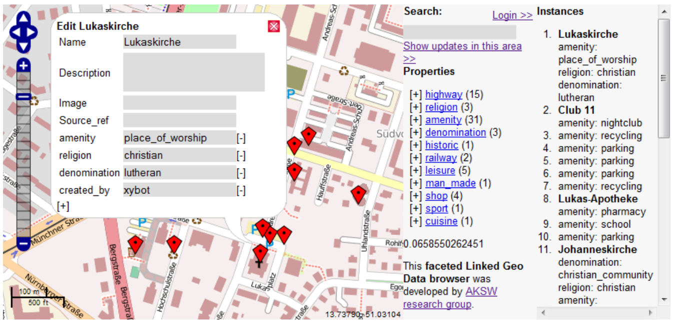


Figure 2.1: This is a browser in a linked open geodata.

These projects are focused on the semantics of the web.

[3]Open Street Maps
[4]Resource Description Framework
[5]Linked Data

Chapter 3

Open Data Benchmarking

3.1 Introduction

In this chapter we make a comparison of the various Open Data of that is in the Spanish government. It gives us some insight into what elements can be important in drawing conclusions for the implementation of our Open Data Infrastructure. Furthermore, we can compare the different Open Data Infrastructures with the specific UJI Open Data and we observe what elements would be necessary to add.

Therefore, this chapter explain what questions we have chosen first to do the test. The questions or the reasons to perform benchmark are grouped into two groups. The first group are questions regarding whether the Open Data Infrastructures complies or not with the principles of Open Data. The second group are questions regarding the Open Data consume spatial data. And then we add some generic issues.

Once we have specific questions and explained, the next step will perform benchmark on the following selected Open Data Infrastructure. We make a final conclusions explaining the key elements.

Finally, we make a few comments on the current situation of UJI Open Data and specify that similar elements with other Open Data Infrastructure have. This will help us define the final requirements for which we have relied for the implementation of this proposed Open Data Infrastructure for the University Jaume I.

3.2 Explanation for the comparative

The first group deals with the principles of Open Data. This is to compare whether the Open Data maintain the principles or infringe any of its principles.

1. **Display datasets**. If the datasets are available and view information on the web portal.

2. **Has documentation**. If the information is properly documented datasets as shown in Figure 3.1. It is therefore to recognize if the web site not only displays information but also displays information about the structure of each dataset and operations that can be applied to them. Also if it is able to export the information could be one of the operations.

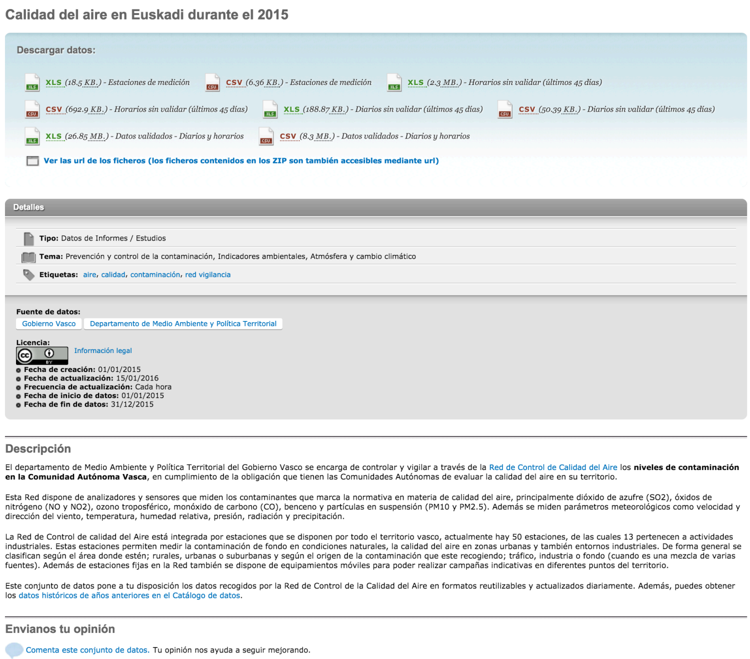


Figure 3.1: Euskadi Open Data Infrastructure view displaying the information of a dataset.

3. **Which formats use**. If the information can be exported and specify which formats as shown in Figure 3.2.

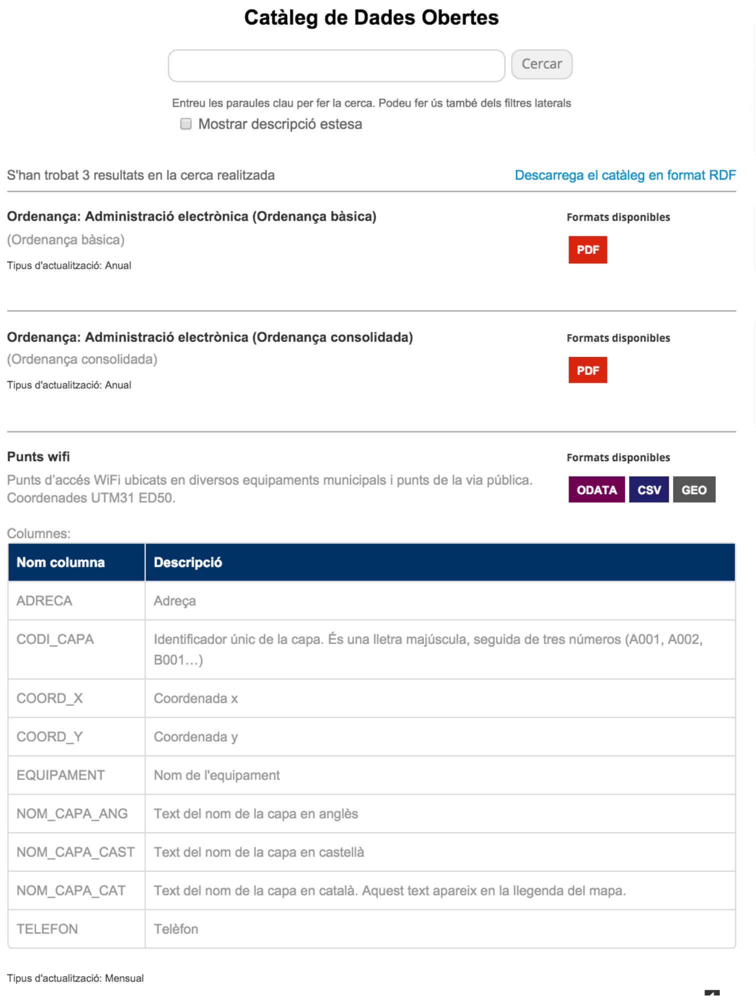


Figure 3.2: Barcelona Open Data Infrastructure view displaying a datasets with their available formats.

4. **Registration required**. If a registration is needed to access the data.

5. **Payment required**. If you need to pay to use the data.

6. **Violates some principles**. If you violate some other principle, which specify.

The second group deals with the GIS component. This is to compare whether the Open Data can be considered an application that meets the definition GIS.

6. **Has GIS capabilities**. It has any GIS component as shown in Figure 3.3.

7. **Spatial Data**. Which spatial data manage the Open Data.

8. **Spatial Analysis**. If the Open Data process spatial analysis.

9. **Display Spatial Data**. If the Open Data can display geographic information.

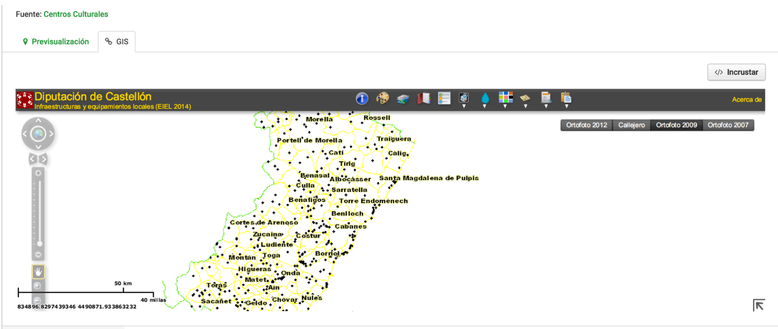


Figure 3.3: Castellón Diputación Open Data Infrastructure view displaying a map in a dataset.

Other questions that we considered for the comparison we include the following.

11. **Has a tutorial**. If there is any guide on how to use the Open Data.

12. **Number of datasets**. The number of datasets have the Open Data.

13. **Users can contribute**. Users can interact with the Open Data, ie, they may propose new datasets or may contact the administrator of the Open Data.

14. **Has an API REST service**. If the Open Data has a REST API for third-party applications can consume the data in your apps as shown in Figure 3.4.

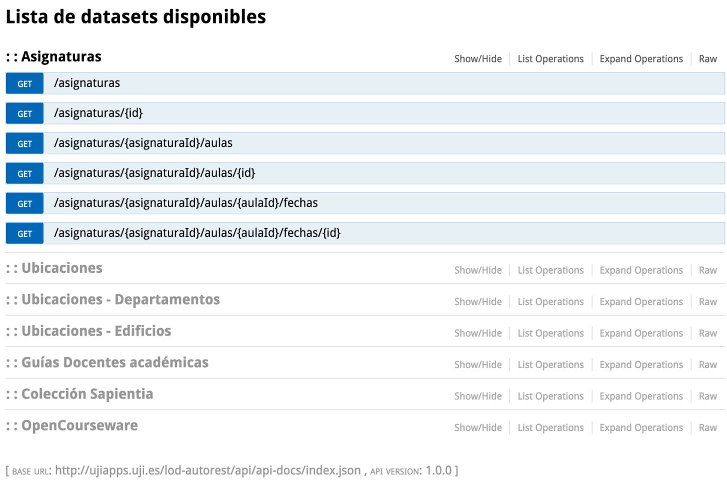


Figure 3.4: UJI Open Data Infrastructure view displaying a REST API documentation of available datasets.

3.3 Results

OD Name	OD Url
Euskadi	http://opendata.euskadi.eus/w79-home/es
Valencia	http://www.gvaoberta.gva.es/open-data
Barcelona	http://opendata.bcn.cat/opendata/ca
Spain	http://datos.gob.es/
Aragon	http://opendata.aragon.es/
Navarra	http://www.gobiernoabierto.navarra.es/es/open-data
Castellon	http://opdipcas.alfatecsistemas.es:8081/organization/diputacion-de-castellon

Table 3.1: Open Data Names and Urls.

	Euskadi	Valencia	Barcelona	Spain	Aragon	Navarra	Castellon	UJI
Display datasets	Yes	No	Yes	No	Yes	Yes	No	No
Has documentation	Yes	No	No	No	Yes	Yes	No	No
Which formats use	xls, csv, xml	pdf, ods	xls, csv, xml	pdf, html	shp, gml, geojson, xml	csv, json, shp, xml, xls	geojson, json, xml, shp	csv, json, xml
Registration required	No	No	No	No	No	No	No	No
Payment required	No	No	No	No	No	No	No	No
Violates some principles	No	Yes	No	Yes	No	No	Yes	Yes
Has GIS capabilities	Yes	No	No	No	Yes	Yes	Yes	No
Spatial Data	Yes	No	No	No	Yes	Yes	Yes	No
Spatial Analysis	No	No	No	No	No	No	No	No
Display Spatial Data	No	No	No	No	No	Yes	Yes	No
Has a tutorial	Yes	No	Yes	No	Yes	Yes	No	No
Number of datasets	458	2	326	9003	2530	Undefined	1	5
Users can contribute	Yes	No	No	No	No	No	No	No
Has an API REST service	Yes	No	No	No	Yes	Yes	No	Yes

Table 3.2: Open Data Results.

The following conclusions may be drawn.

- The high number of datasets is not relevant. What is important is the quality of the data. Euskadi datasets are very well designed, whereas the open state data are merely independent unrelated files.
- One of the requirements of an Open Data is to display the information in a clear and understood by the user. We have found 4 Open Data Infrastructures that do not show the information in a simple and understandable way. Display information is on the portal both their values and the structure of the dataset.
- The documentation is important to show how the dataset part. It helps to use. We have found up to 5 Open Data Infrastructures which have no documentation.
- The formats offered by each open data varies each and in most cases are provided two or more formats.
- All Open Data Infrastructures studied does not require payment or services are offered for use.
- Only 3 Open Data Infrastructures found using spatial data. Only two of them display information through a map and none of them processed some kind of spatial analysis.
- 3 Open Data Infrastructures has some sort of tutorial to help users successfully using the tool. Only one encourages active participation through contests of ideas.

3.4 Current Status of UJI Open Data

As seen in the above comparison, the UJI Open Data has some other limitations on the Open Data compared

- The datasets are not explained by their structure.
- The datasets are not displayed clearly.

- The datasets are available in various formats.
- It does not have any geographic component.
- There is no guidance, nothing is displayed. Only formats that are available.
- There is no contact to propose new datasets or warn of an error.
- There is no API Rest.

Chapter 4

Open Data Development

4.1 Introduction

This chapter explains how we design and implement the proposal to improve the UJI Open Data. We have choosed the requirements drawn from the previous chapters. The firts step in section 4.2 is a brief summary of the requirements we have assumed.

In section 4.3 we explain briefly what technologies we used. The Open Data Application is basically divided into three logical parts.

The sequence of steps from a dataset is created until it is used by an application called lifecycle[den Broek et al., 2013]. In section 4.4.1 we talk about the part of the administration. This part is responsible for managing information on the Open Data by the admin users. In section 4.4.2 we talk about the documentation site. In the documentation the Open Data shows all information about each datasets as its definition or their attributes. In section 4.4.3 we talk about the web service of the Open Data to communicate with external apps.

Finally, the last section we talk about some case studies in section 4.5. The first case study is about the departments of Universitat Jaume I in section 4.5.1. With this example, we use the import option to get information from the current UJI Open Data.

The second case is about the waste containers of Universitat Jaume I in section 4.5.2. With this example, we show how to consume data in a mobile application from the UJI Open Data.

4.2 Requisites

We need to define and specify the requirements for implementation of our Open Data. In section 2.3, we make a definition of Open Data and in section 2.4 we make a GIS definition applied to Open Data. Now we apply the theory to specify how the implementation of an Open Data system is defined.

This proposal should not be understood as a closed work. It is a starting point in the work and development of a tool that may be of interest not only for this university, also for any institution.

An open data contains a number of datasets. A dataset is a collection of information that contains a number of data type. This data type can be a string, a number or a spatial data as a point or a polygon.

A dataset can contain additional information related to the dataset that help better describe the dataset. This information is called metadata. Metadata may help to create order in datasets by describing, classifying and organizing information[Zuiderwijk et al., 2012]. In our open data we considered as metadata a contact email, a text description of the dataset and a location that determines a central point of the dataset if it uses spatial data.

We need to use a technology that allows to visualize the spatial information on a map. In Web 2.0 user interaction is done through web forms. We need a tool that allows to add spatial data using a web form and anyone can understand the process of adding information on any dataset. Furthermore, the Open Data documentation must be well explained.

The Open Data uses json, csv and GeoJSON. They are open formats.

Using information from each dataset the Open Data has to be able to perform spatial processes. As discussed in section 2.4 a spatial process is an operation on the data returned by another spatial information.

To complete the Open Data we need to implement a RESTful API. A RESTful API is an application program interface (API) that uses HTTP requests to get information or send information[Techtarget, 2015]. We explain in section 4.4.3 this web service.

4.3 Technologies

As we mentioned in section 1.1, Web 2.0 was a change that allowed users to interact on web applications. There are many Web 2.0 tools such as blogs or social networks. Therefore, it has been considered to implement the Open Data infrastructure as a web application. In addition, we selected nodejs as server-side application. According to Wikipedia:

> Node.js is a development platform built on top of Google's V8 JavaScript virtual machine. While JavaScript engines (including V8) are traditionally run in Web browsers to form the client side of aclient/server application, the Node.js libraries are focused on building server-side applications in JavaScript.

Then we can list the following advantatges:

1. Node.js uses the same language on the server side and the client.
2. Oriented management to manage inputs and outputs. This is especially important for applications with a high number of requests, as in our case.
3. Designed to manage access to databases.

Node.js is not recommended for heavy applications. It is designed to manage large number of communications between clients and servers[Iscar, 2015]. There are many projects using Node.js. LinkedIn, the business-oriented social networking service uses Node.js. GitHub, a web-based Git repository hosting service uses Node.js.

In Node.js, the framework for building web applications is called Express. According to Wikipedia:

> Express is a minimal and flexible Node.js web application framework that provides a robust set of features for web and mobile applications.

We decided to use MongoDB as the database because it works with JSON and Node.js works fine with MongoDB. According to Wikipedia:

> MongoDB (from humongous) is a cross-platform document-oriented database. Classified as a NoSQL database, MongoDB eschews the traditional table-based relational database structure in favor of JSON-like documents with dynamic schemas (MongoDB calls the format BSON), making the integration of data in certain types of applications easier and faster.

Finally, to display the spatial data on a map we decided to use Leaflet.js. According Leaflet.js:

> Leaflet is the leading open-source JavaScript library for mobile-friendly interactive maps. Leaflet is designed with simplicity, performance and usability in mind. It works efficiently across all major desktop and mobile platforms.

There is a virtual machine with a version of the Open Data Infrastructure. We have used a Amazon Virtual Machine[1]. The address are:

- Documentation site: http://54.200.166.214:3000/
- API service for Departments: http://54.200.166.214:3000/api/Departments
- Administrator site: http://54.200.166.214:3000/structures (We do not recommend access this area for safety)

4.4 Life Cycle

The sequence of steps from a dataset is created until it is used by an application called lifecycle[den Broek et al., 2013].

The life cycle is divided in two sections. In section 4.4.1 an admin can add a new dataset, can add new fields in a dataset and can add spatial data in a dataset. This section is responsible for adding new data. The other section is responsible for display data, both section 4.4.2 and section 4.4.3 display the same data in different way. In section 2.5 we conclude the documentation must be a well explained. In section 4.4.3 we explain about a external application can use one of our datasets.

[1] Amazon Web Services

4.4.1 Administrator

The task of the user admin is to manage the information in the Open Data. An user admin can add new datasets as shown in the Figure 4.1. When a dataset is created, it does not contain any data. The Figure 4.2 shows a list of the datasets available. We have two options, to manage the structure of each dataset and to manage the content of each dataset.

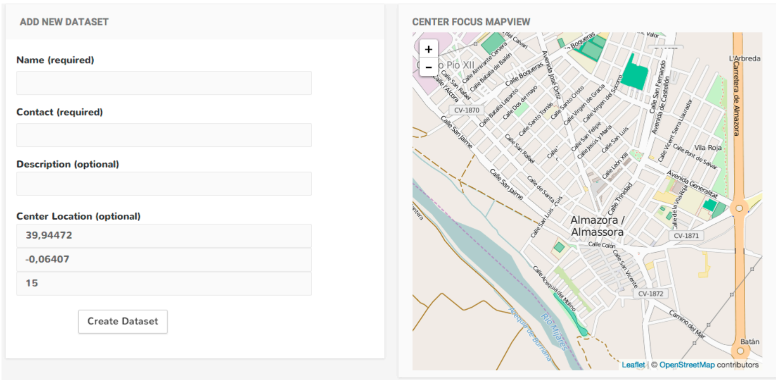
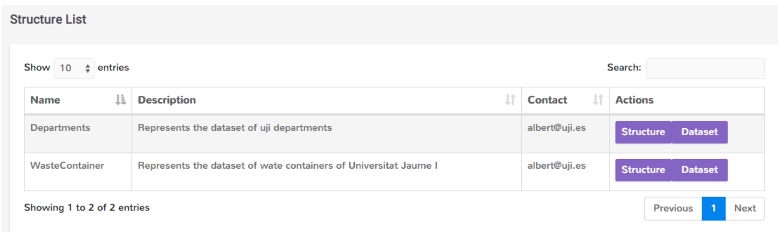


Figure 4.1: When we are creating a new dataset, we have the following view where we have to add a dataset name, a email contact, a description and spatial point.



Structure List

Show 10 entries Search:

Name	Description	Contact	Actions
Departments	Represents the dataset of uji departments	albert@uji.es	Structure Dataset
WasteContainer	Represents the dataset of wate containers of Universitat Jaume I	albert@uji.es	Structure Dataset

Showing 1 to 2 of 2 entries Previous 1 Next

Figure 4.2: You can view the list of datasets through a table consisting of a series of values such as name, description, contact and two buttons to access the dataset structure and content of the dataset.

When a dataset is created, it does not contain any data. The next step will be to add new fields in Figure 4.3 shows that the different types of data held by the Open Data.

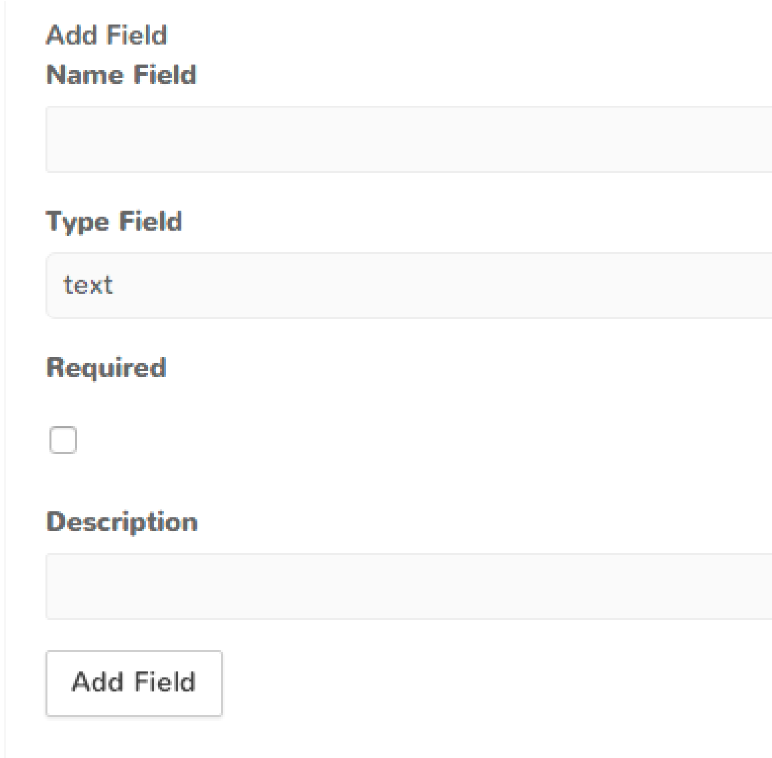


Figure 4.3: When we are creating a new field for a dataset, we need to add a name, type, if the data is required and a description.

The Type Field is a selector in the web form that shows the different types of data of the Open Data Infrasctructure. The types that are available are as follows:

- Text can represent a string or simple text.
- Number can represent a integer o floating number.
- Url represents a link of internet.
- File represents a binary file like a image or pdf.
- Point represents a location point in geojson format.
- Line represents a linea in geojson format.
- Polygon represent a polygon in geojson format.

There are a more functions like, delete a specific field, import data from an external source and eliminate the dataset. These functions are in the same view in Figure 4.4

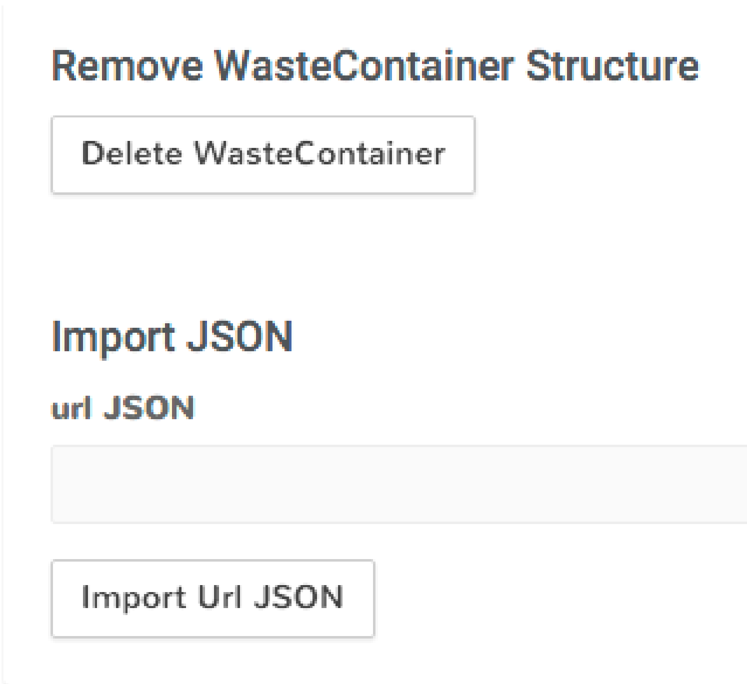


Figure 4.4: In a dataset there are other functions like to remove dataset and to import data.

The dataset view can display the information of the dataset. If the dataset has a spatial data, the dataset view shows a map displaying the values contained in the dataset. In Figure 4.5 we can see the dataset view. An admin user can add a new value, edit or delete it. We can also add new values through a web form as shown in Figure 4.6

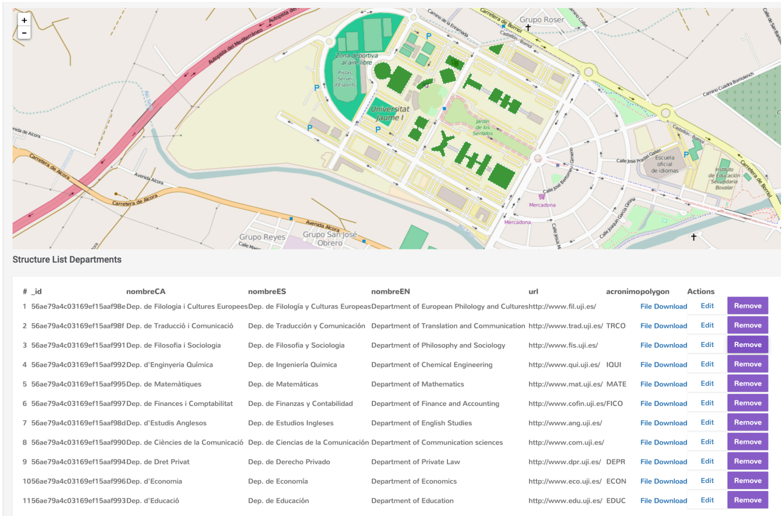


Figure 4.5: In a dataset view, we can see information data in a table and in a map.

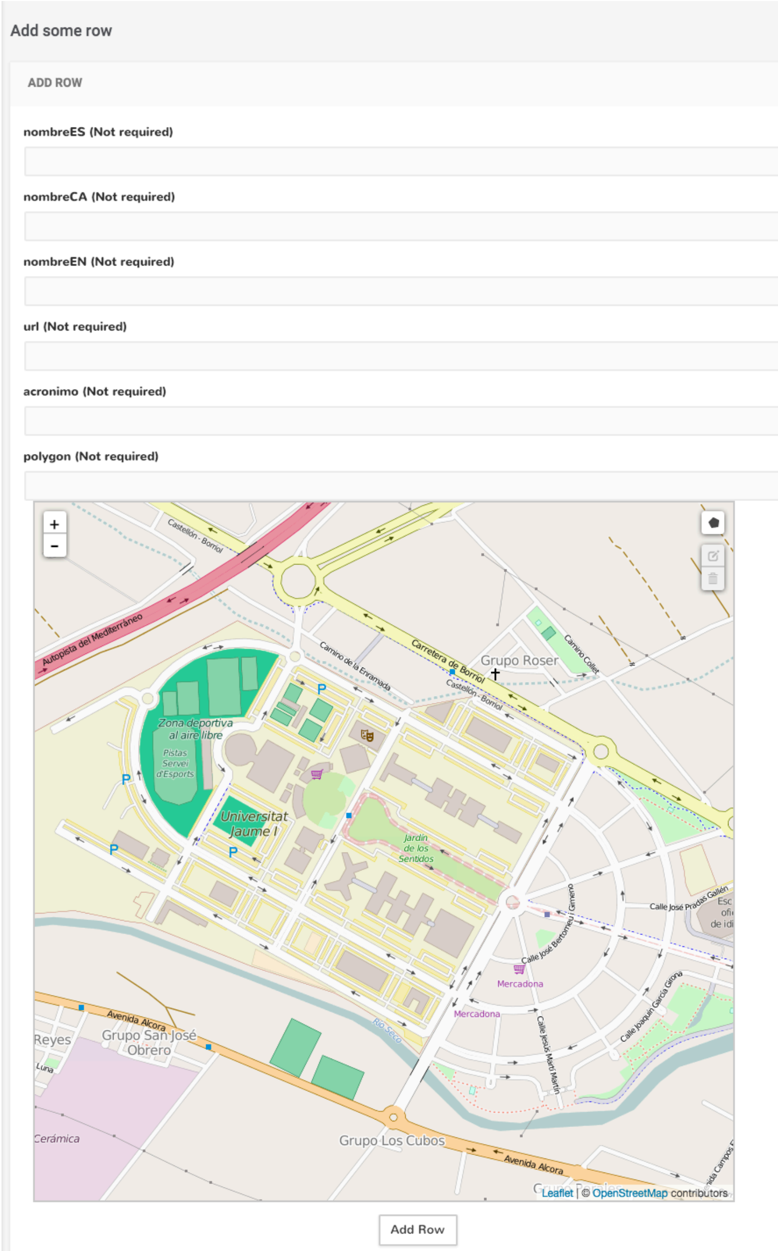


Figure 4.6: In a dataset view, we can add a new value in a dataset. Each value depends on the structure of the dataset previously created.

4.4.2 Documentation

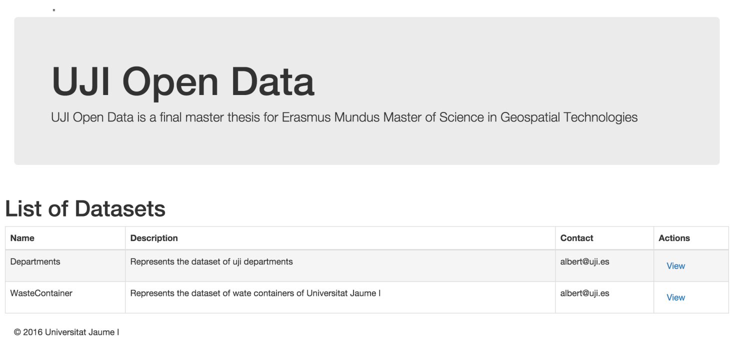
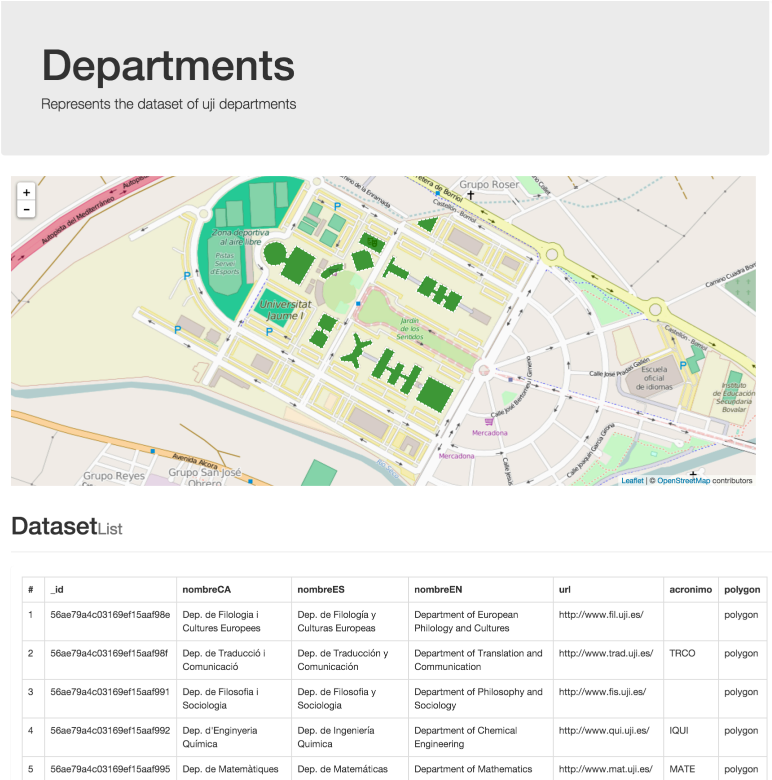


Figure 4.7: The documentation shows the list of the datasets where each dataset have one button to see the detail of each dataset.

The documentation shows the view that displays all the information of the datasets. The main part shows the list of datasets as shown in Figure 4.4. If we access to the documentation view of a dataset in Figure 4.8 we see how information is represented on a map and on a table. Then in Figure 4.9 shows the options to export the information and format are cdv and information relating to each of the fields that make up the dataset.



#	_id	nombreCA	nombreES	nombreEN	url	acronimo	polygon
1	56ae79a4c03169ef15aaf98e	Dep. de Filologia i Cultures Europees	Dep. de Filología y Culturas Europeas	Department of European Philology and Cultures	http://www.fil.uji.es/		polygon
2	56ae79a4c03169ef15aaf98f	Dep. de Traducció i Comunicació	Dep. de Traducción y Comunicación	Department of Translation and Communication	http://www.trad.uji.es/	TRCO	polygon
3	56ae79a4c03169ef15aaf991	Dep. de Filosofia i Sociologia	Dep. de Filosofía y Sociología	Department of Philosophy and Sociology	http://www.fis.uji.es/		polygon
4	56ae79a4c03169ef15aaf992	Dep. d'Enginyeria Química	Dep. de Ingeniería Química	Department of Chemical Engineering	http://www.qui.uji.es/	IQUI	polygon
5	56ae79a4c03169ef15aaf995	Dep. de Matemàtiques	Dep. de Matemáticas	Department of Mathematics	http://www.mat.uji.es/	MATE	polygon

Figure 4.8: The upper part of the documentation view shows a map and a table with the information of the dataset.

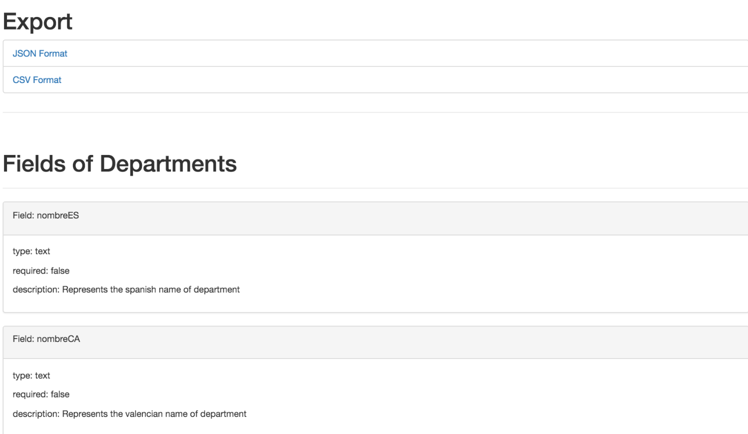


Figure 4.9: The documentation view shows two links to export in different formats and the information of each fields of the dataset.

Finally, in Figure 4.10 the documentation view shows a different spatial analysis with the definition of each and how to use it is.

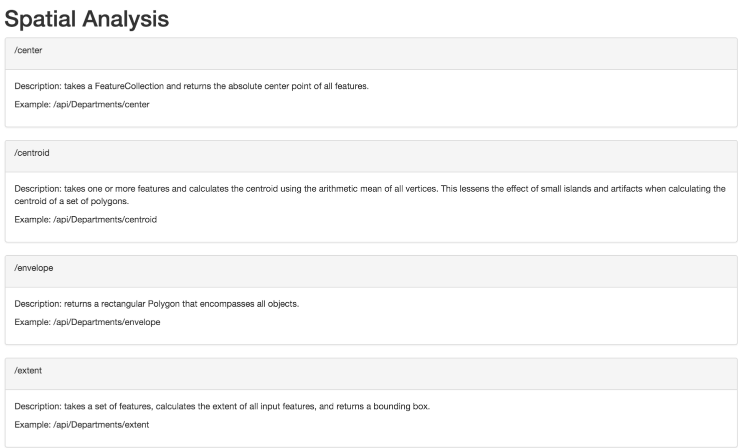


Figure 4.10: The documentation view shows list of available spatial analysis.

4.4.3 API

A RESTful API is an application program interface (API) that uses HTTP requests to get information or send information[Techtarget, 2015]. The role of API is to generate a communication with other applications such as mobile applications. In section 4.5.2 we see a case study where an iOS application consumes information from a dataset.

Among the requests that can be performed through this API it is to view the information of each of their values, but as seen in the section 2.4 can also perform spatial analyzes an entire series. For example, the spatial analysis that have been proposed are as follows:

Name	Description of Spatial Analysis
center	returns the absolute center point of all features
centroid	calculates the centroid using the arithmetic mean of all vertices
envelope	returns a rectangular Polygon that encompasses all objects
extent	calculates the extent of all input features, and returns a bounding box
merge	returns a single merged polygon feature. If the input polygon features are not contiguous, this function returns a MultiPolygon feature
nearest	takes lat and lng params and returns the point from the set closest to the reference
pointonsurface	returns a Point guaranteed to be on the surface of the feature
tin	creates a Triangulated Irregular Network, or a TIN for short, and returned as a collection of Polygons

Table 4.1: Spatial analysis.

4.5 Case studies

The following case studies are examples of how we can use the open data. The first example in section 4.5.1 is a dataset about waste containers in which we will show how a mobile application can consume the data. The second example in section 4.5.2 is a dataset of the departments in which we will show how to import data from another open data.

4.5.1 Departments

Step 1: Getting the department information

We can access to UJI Open Data[2]. As can be seen UJI Open Data has six datasets in the next list and in the Figure 4.11

- OpenCourseware
- Guíes docents

[2] UJI Open Data

- Sapientia: Humanes i socials
- Sapientia: Jurídiques i econòmiques
- Sapientia: Tecnologia i experimentals
- Ubicacions dels departaments

Figure 4.11: UJI Open Data shows that has only six datasets.

As explained in the section 3.4, this open data has many limitations. So the first step we do is add a new dataset as shown in Figure 4.13. But firts, we need to understand the Department Location dataset in this link:

http://ujiapps.uji.es/lod-autorest/api/datasets/ubicaciones/departamentos


```
- {
      nombreCA: "Dep. d'Estudis Anglesos",
      nombreES: "Dep. de Estudios Ingleses",
      _id: "1882",
      nombreEN: "Department of English Studies",
      url: "http://www.ang.uji.es/"
  },
```


Figure 4.12: UJI Open Data Department Row

If we study a entry, in Figure 4.12, we can understand the fields which are as follows:

Field	Value
nombreCA	represents the name of department in valencian language
nombreES	represents the name of department in spanish language
nombreEN	represents the name of department in english language
url	represents url of department
acronimo	represents acronym of department

Table 4.2: Department Location Fields.

Step 2: Creating the department dataset

The second step is to create the Departments dataset. Firstly, we create the Department dataset as shown in Figure 4.13

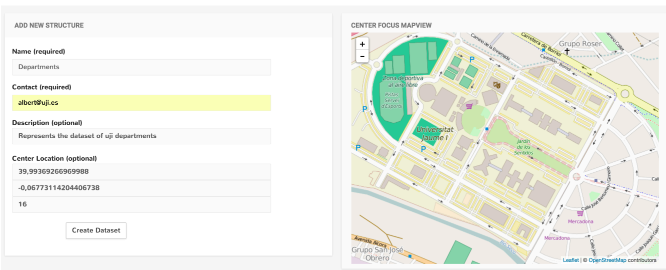


Figure 4.13: This is the view where we can create a new dataset.

Now, in Figure 4.14 we need to add this fields in the dataset and then, in Figure 4.15 we import the information with the next link:

http://ujiapps.uji.es/lod-autorest/api/datasets/ubicaciones/departamentos

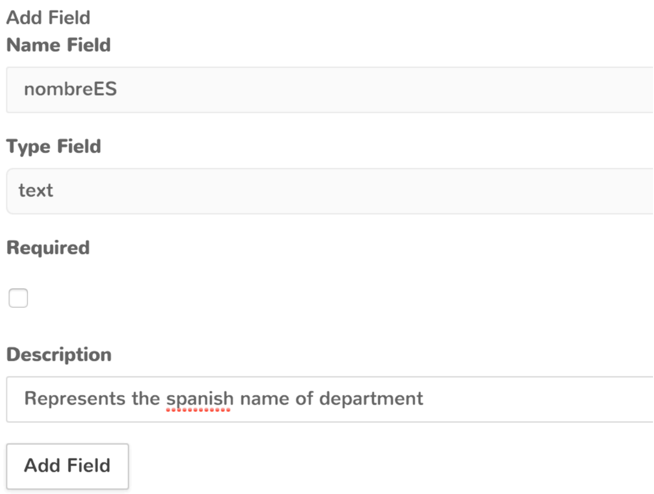
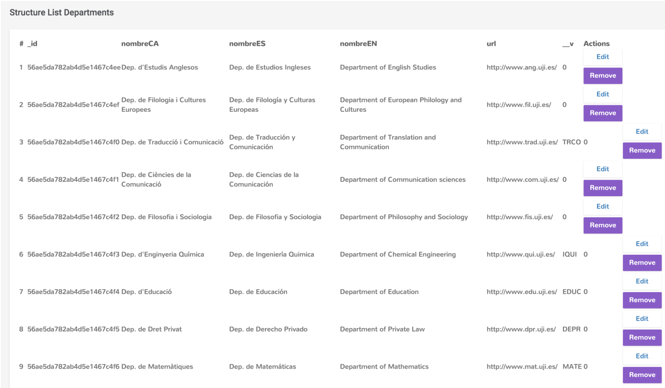


Figure 4.14: This is the web form where we can add a new field in the dataset.

Figure 4.15: This is the web form where we can import data from other Open Data Infrastructure

Step 3: Adding a polygon field in the dataset

The next step is to add a new polygon type because this dataset do not have spatial data as shown in Figure 4.16. We also need to update each row with a new polygon field attribute.



Structure List Departments

#	_id	nombreCA	nombreES	nombreEN	url	__v	Actions
1	56ae5da782ab4d5e1467c4ee	Dep. d'Estudis Anglesos	Dep. de Estudios Ingleses	Department of English Studies	http://www.ang.uji.es/	0	Edit Remove
2	56ae5da782ab4d5e1467c4ef	Dep. de Filologia i Cultures Europees	Dep. de Filología y Culturas Europeas	Department of European Philology and Cultures	http://www.fil.uji.es/	0	Edit Remove
3	56ae5da782ab4d5e1467c4f0	Dep. de Traducció i Comunicació	Dep. de Traducción y Comunicación	Department of Translation and Communication	http://www.trad.uji.es/	TRCO 0	Edit Remove
4	56ae5da782ab4d5e1467c4f1	Dep. de Ciències de la Comunicació	Dep. de Ciencias de la Comunicación	Department of Communication sciences	http://www.com.uji.es/	0	Edit Remove
5	56ae5da782ab4d5e1467c4f2	Dep. de Filosofia i Sociologia	Dep. de Filosofia y Sociologia	Department of Philosophy and Sociology	http://www.fis.uji.es/	0	Edit Remove
6	56ae5da782ab4d5e1467c4f3	Dep. d'Enginyeria Química	Dep. de Ingeniería Quimica	Department of Chemical Engineering	http://www.qui.uji.es/	IQUI 0	Edit Remove
7	56ae5da782ab4d5e1467c4f4	Dep. d'Educació	Dep. de Educación	Department of Education	http://www.edu.uji.es/	EDUC 0	Edit Remove
8	56ae5da782ab4d5e1467c4f5	Dep. de Dret Privat	Dep. de Derecho Privado	Department of Private Law	http://www.dpr.uji.es/	DEPR 0	Edit Remove
9	56ae5da782ab4d5e1467c4f6	Dep. de Matemàtiques	Dep. de Matemáticas	Department of Mathematics	http://www.mat.uji.es/	MATE 0	Edit Remove

Figure 4.16: When we import a dataset without any spatial data, it only displays a table with the information

In Figure 4.17, we need to add a new field with a polygon type.

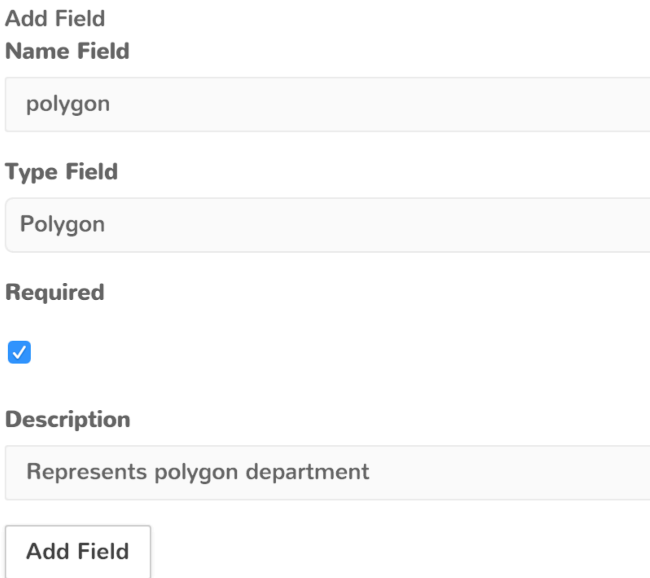


Figure 4.17: If we add a new field to an existing dataset, you have to edit each of their values manually.

Step 4: Drawing polygons for the dataset

The dataset has a geographic datatype. We can add a new department row, or we can edit an existent department. We edit the existents department in the dataset.

Figure 4.18: Sequence of figures where is shown the process of edition of a polygon.

In Figure 4.18 there is a sequence of figures as we can modify a polygon by clicking the mouse. If we click on the polygon icon, we activate the mode of creation a polygon. Now, we can click in different places and the last click must be the same than the first. When you finish, the first polygon dissapears and the second polygon conforms. In addition, the GeoJSON input is updated. Finally, if we want to modify a polygon, we have two options, if you double click on a vertex will disappear. We can also drag a vertex to change its position.

Notice that the way to create and edit a polygon try to be as simple as possible. Once we have updated all departments, we returned to the previous window. We have a map that shows the polygons departments and shows a table with the departments.

DatasetList

#	_id	nombreCA	nombreES	nombreEN	url	acronimo	polygon
1	56ae79a4c03169ef15aaf98e	Dep. de Filologia i Cultures Europees	Dep. de Filología y Culturas Europeas	Department of European Philology and Cultures	http://www.fil.uji.es/		polygon
2	56ae79a4c03169ef15aaf98f	Dep. de Traducció i Comunicació	Dep. de Traducción y Comunicación	Department of Translation and Communication	http://www.trad.uji.es/	TRCO	polygon
3	56ae79a4c03169ef15aaf991	Dep. de Filosofia i Sociologia	Dep. de Filosofia y Sociologia	Department of Philosophy and Sociology	http://www.fis.uji.es/		polygon
4	56ae79a4c03169ef15aaf992	Dep. d'Enginyeria Química	Dep. de Ingeniería Quimica	Department of Chemical Engineering	http://www.qui.uji.es/	IQUI	polygon
5	56ae79a4c03169ef15aaf995	Dep. de Matemàtiques	Dep. de Matemáticas	Department of Mathematics	http://www.mat.uji.es/	MATE	polygon
6	56ae79a4c03169ef15aaf997	Dep. de Finances i Comptabilitat	Dep. de Finanzas y Contabilidad	Department of Finance and Accounting	http://www.cofin.uji.es/	FICO	polygon
7	56ae79a4c03169ef15aaf98d	Dep. d'Estudis Anglesos	Dep. de Estudios Ingleses	Department of English Studies	http://www.ang.uji.es/		polygon
8	56ae79a4c03169ef15aaf990	Dep. de Ciències de la Comunicació	Dep. de Ciencias de la Comunicación	Department of Communication sciences	http://www.com.uji.es/		polygon

Figure 4.19: Final result when we have edited the dataset entirely.

We are done. We were able to update the dataset of UJI departments in our system by adding a new field of polygon spatial type.

4.5.2 Waste Containers

Step 1: Creating the waste containers dataset

The first step is to create the waste containers dataset as shown in Figure 4.20

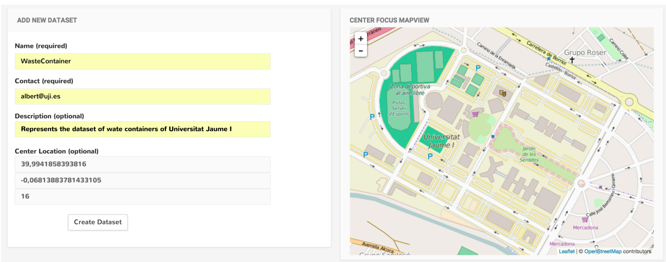


Figure 4.20: This is the view where we can create a new dataset.

The next step is to add some fields as shown in Figure 4.21.

Field	Type	Value
type	text	represents the type of a container
count	number	represents the number of containers in this point
point	point	represents the location of a container

Table 4.3: Description of each field of waste containers dataset.

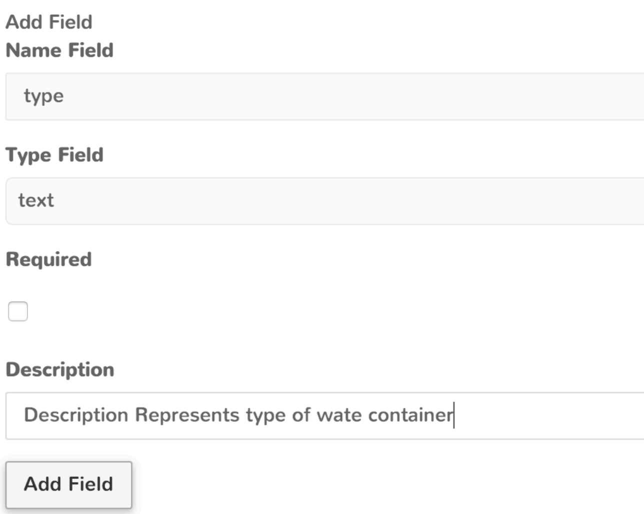


Figure 4.21: This is the web form where we can add a new field in the dataset.

Finally, we add some values in the dataset in Figure 4.22.

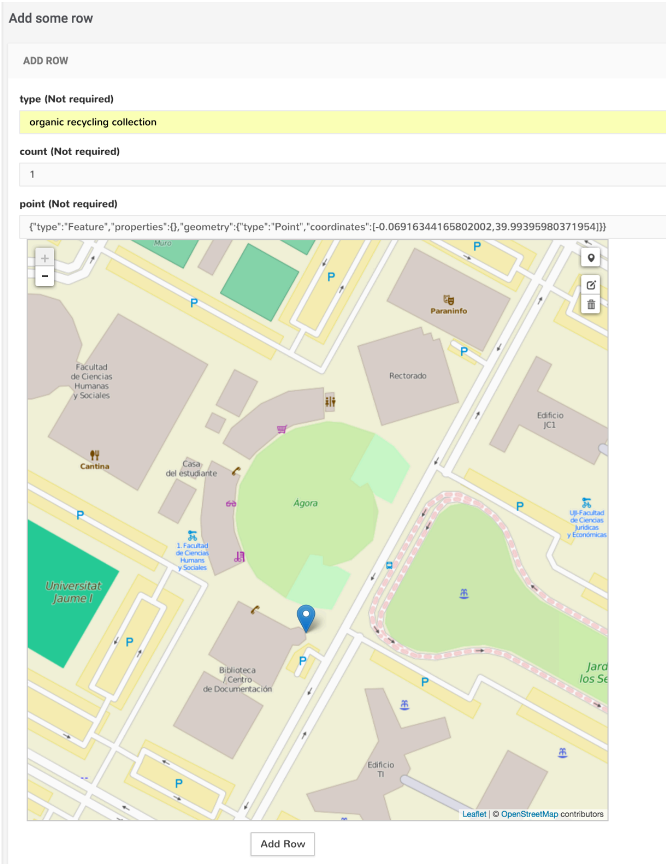
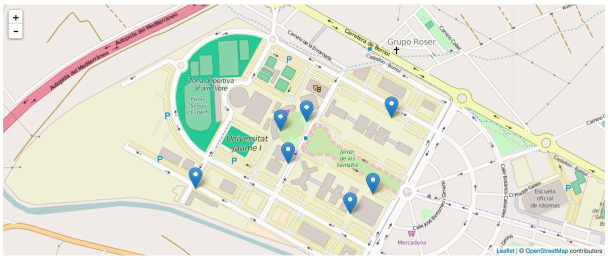


Figure 4.22: This is the web form where we can add a new field in the dataset.

Step 2: Consuming the waste containers dataset



DatasetList

#	_id	type	count	point
1	56c89433e09bea62303a2a2d	paper recycling collection	1	point
2	56c89471e09bea62303a2a2e	paper recycling collection	2	point
3	56c8948ce09bea62303a2a2f	glass recycling collection	1	point
4	56c894fae09bea62303a2a30	battery recycling collection	1	point
5	56c8950ee09bea62303a2a31	battery recycling collection	1	point
6	56c8953be09bea62303a2a32	organic recycling collection	1	point
7	56c8954be09bea62303a2a33	organic recycling collection	3	point

Figure 4.23: This is the documentation of waste containers dataset.

Now that we have the dataset ready, we create an app for ios but first we have to consult the documentation for information dataset. We want to consume this information in our mobile application. Figure 4.23 and Figure 4.24 show the documentation. The mobile app requires only two requests:

- Get containers /api/WasteContainer
- Get container by id /api/WasteContainer/id

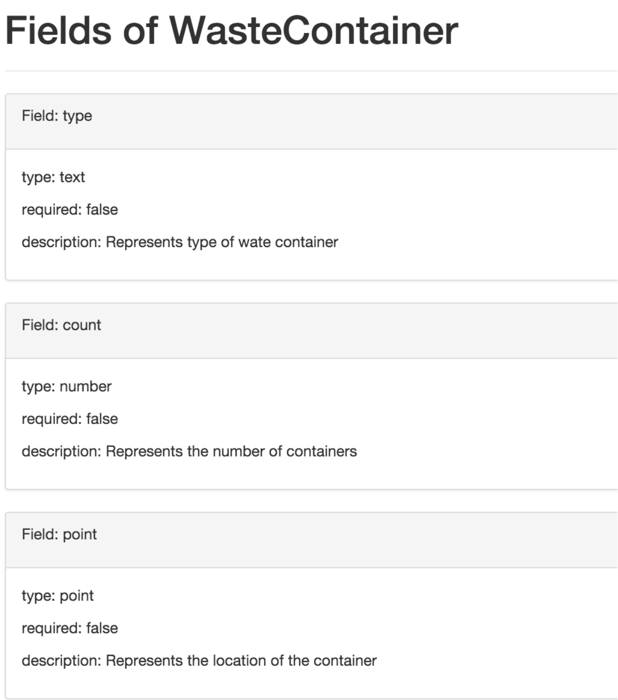


Figure 4.24: This is the fields of waste containers dataset.

For simplicity, the test program was developed in iOS for iPhone. The source code is available in this link:

https://github.com/agescura/UJIWasteContainers

We have designed an application with three views. The first view shows a map with the different containers. The second view is a table with information of the containers and, finally, the third view shows the detail of a container with a map showing its location. The Figure 4.25 shows this views.

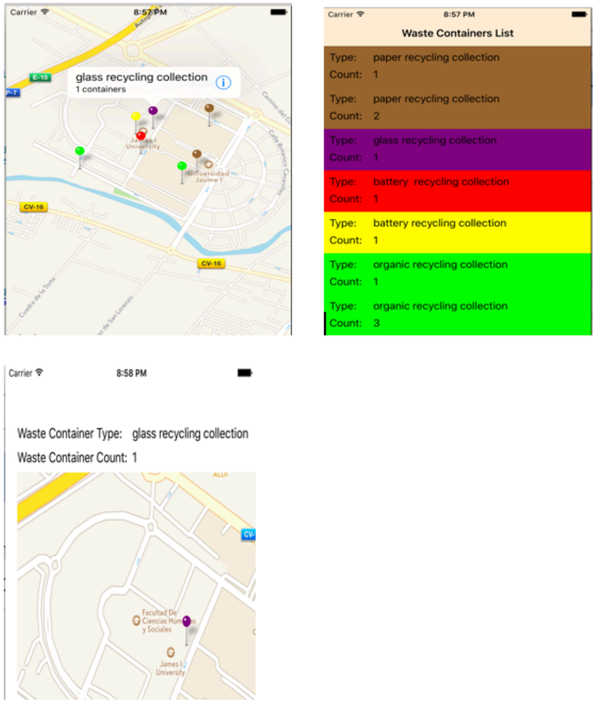


Figure 4.25: This is the iOS views.

Chapter 5

Open Data Feedback

The feedback has helped us to detect errors. In our case the feedback was focused on a developer who uses our datasets. The classmates did the feedback of the open data.

5.1 Test

We are going to develope an mobile app that shows the Almassora's drugstores information. To do this project we need an dataset of drugstore from our Open Data with specific information of each drugstore as shown in Figure 5.1 and Figure 5.2.

The functions we designed to build the applications are as follows:

- To get drugstore name list.
- To get each drugstore information.
- To get the nearest drugstore.

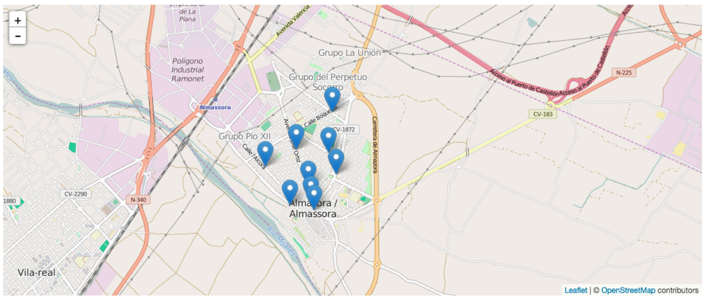
5.1.1 To get drugstore name list

To get the drugstore list we can use the next request:

```
http://<servername>/api/drugstoresAlmassora/
```

DrugstoresAlmassora

Represents the dataset of drugstores information of Almassora city



DatasetList

#	_id	name	point	address	telephone
1	56a4e726d1892e2a37a3b742	Farmàcia Berta Mallol	point	C/Jesús y María, 143 12550 Almassora Castellón España	964035548
2	56a4e7e1d1892e2a37a3b743	Farmàcia C. Grau	point	C/ Trinidad, 27 12550 Almassora Castellón España	964560710
3	56a4e853d1892e2a37a3b744	Farmàcia C. Serra	point	Av. José Ortiz 76 12550 Almassora Castellón España	964560721
4	56a4e8b6d1892e2a37a3b745	Farmàcia Clausell	point	C/Sant Pasqual, 13 12550 Almassora Castellón España	964560237
5	56a4e969d1892e2a37a3b746	Farmàcia Fuentes	point	C/ Alcora, 240 12550 Almassora Castellón España	964560555
6	56a4e9b2d1892e2a37a3b747	Farmàcia Moragrega	point	Av. Nueve de Octubre,123 12550 Almassora Castellón España	964190990
7	56a4ea00d1892e2a37a3b748	Farmàcia P. Grau	point	Av. José Ortiz, 7 12550 Almassora Castellón España	964560678
8	56a4ea3ed1892e2a37a3b749	Farmàcia Piquer	point	Av. Castellón, 24 12550 Almassora Castellón España	964560411
9	56a7c176b9c67d247168ef6f	Farmàcia Marta Arenós	point	C/ Sant Lluís, 2 12550 Almassora Castellón España	964028471

Figure 5.1: This is the documentation view of the drugstore dataset.

1. Access the documentation and access to open data dataset drugstore.
2. Study the attributes of this dataset.

Exercise: Do you like dataset documentation?

5.1.2 To get each drugstore information

Exercise: Make a request to return only one drugstore.

5.1.3 To get the drugstores are within a certain distance of our location

1. Access the documentation and access to open data dataset drugstore.

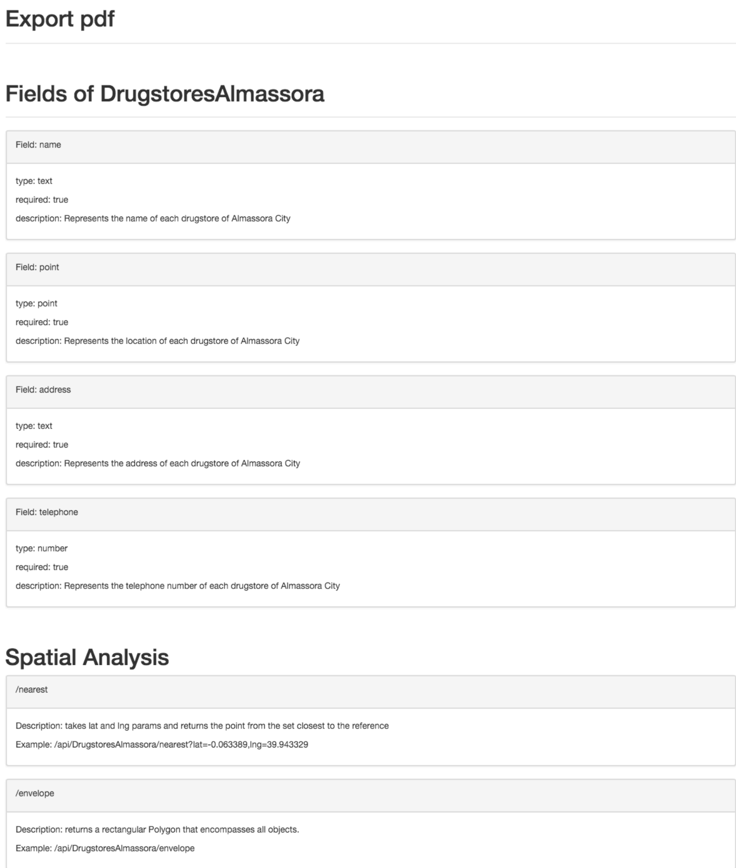


Figure 5.2: This is the documentation view of the drugstore dataset.

2. How you can make special requests.

Exercise: Use /nearest to get the nearest drugstore.

5.2 Results

The following are the most relevant of the comments.

- The documentation is clear, but they needed a tutorial with some example of use of dataset.
- The map of the documentation only shows each rows (points, lines or polygons). The map should show all responses of the API. It would be a way to

test the queries.

- They liked much the API returns certain spatial queries.

Chapter 6

Conclusions and Future Work

6.1 Conclusions

This work has been divided into two distinct parts. Firstly, we performed an analysis of the principles of Open Data and GIS components applied to Open Data Infrastructure. Followed have made a comparison with different Open Data Infrastructure that are running today. Secondly, we have developed a proposal for Open Data Infrastructure in Universitat Jaume I based on the above analysis and adding more functionality as the different components GIS.

The following are the improvements we have made:

- The information of each dataset is displayed both in a table and on a map if it contains spatial data. The structure of each dataset is also shown in the documentation.
- It can handle information for each dataset, such as creating a new dataset, edit its content and add new fields. In addition, we can import information from an external repository.
- You can use spatial data in datasets, points or polygons. We can display information on a map, and through, the REST API, we can perform spatial queries, as obtained, for example, the central point or the envelope of all points.

We have considered three GIS components:

- **To manage spatial data**. The management of geographic information using the format GeoJSON. Thanks to this format we can edit the geographic information.
- **To display spatial data**. Leaflet.js using a map we were able to visualize the geographic information.
- **To process spatial Analysis**. Using Turf.js have been able to make a spatial analysis inserted in our REST API Open Data Infrastructure.

Finally, what contributions can have our proposal?

We have seen two case studies, departments and waste containers, two possible examples of how it can serve our proposal.

In the case of departments in section 4.5.1, we have imported information on the current UJI Open Data. We added a polygon field and then we edited each of the values for a polygon that emulates an apartment. The result is a spatial dataset with the information they had each department and the polygon that have added. This information can now be used through our API or it can be exported in CSV format or JSON.

In the case of waste containers in section 4.5.2, we have created a dataset with a point field and have added a few values. The result is a spatial dataset with a series of points. With the API running, we have created a mobile application that consume this data. Thus, with this example, we have seen what would be the life cycle of an Open Data Infrastructure.

6.2 Future Work

As future work we have estimated the following points

- To add more data types like a circle, a color, or other types.
- If we deploy the Open Data Infrastructure in Universitat Jaume I, we need to know what kind of metadata we need.
- It has implemented a system user through a registration and a login. We can improve the participation of the Open Data if we allow users to edit the

datasets even a row of a dataset. There may be responsible for the dataset for drugstores and each drugstore could manage their own information. This technique is called ACL. An access control list (ACL) is a list of permissions attached to an object. An ACL specifies which users or system processes are granted access to dataset information. [ACL, 2016].

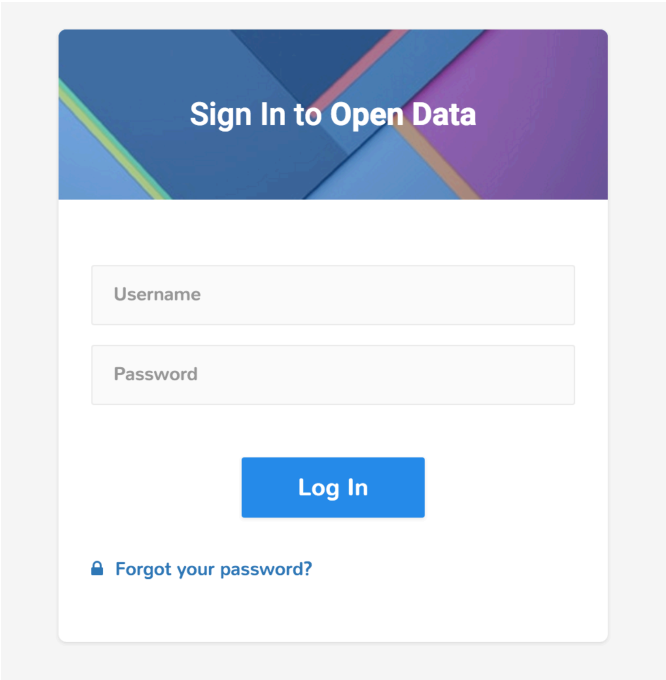


Figure 6.1: Open Data Login Example

- We need to add the recommendations of the feedback in section 5.2.
- In section 4.2 we decided some restricts. The system only allowed one file type in a single dataset and it only allows in a dataset a unique type of geographic data, ie a single point, line or polygon. We should eliminate these restrictions.
- Often the best way to improve an application is to keep usage statistics. We need to implement a statistics page.
- The system now makes few spatial analysis. We will add according to the needs. For example, we are designing a process that adds an attribute of

each polygon. The process divides the intersections between polygons and add each attribute. Something like Figure 6.2

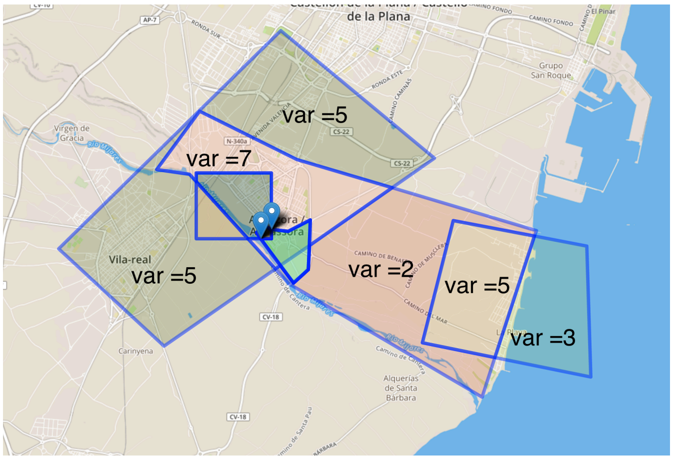


Figure 6.2: Sum Overlapping Attributes

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