# Using Linked Data to Ensure that Digital Information about Historical Figures of Loja Remains Accessible and Usable

Alexander Sánchez, Nelson Piedra, and Juan Carlos Morocho

Universidad Técnica Particular de Loja, San Cayetano Alto S/N, 1101608, Loja, Ecuador.
{ajsanchez9, nopiedra, jcmorocho}@utpl.edu.ec

**Abstract.** As a contribution to the Semantic Web this project seeks to preserve and disseminate historical data, through the publication of Linked Data of Historical Figures of Loja, Ecuador. The publication is carried out following the principles of Linked Data through a life-cycle that includes a research process for the specification of reliable data sources, the modeling of information, the generation and publication of RDF data, the validation of the RDF generation and finally its exploitation through the development of a Web site, where the Linked Data becomes an invisible layer to the users with interest in the domain of the published data.

**Keywords:** Semantic Web, Linked Data, RDF, Historical Figures, Loja, Ecuador, History, Culture



## 1 Introduction

Various demographic, technological and economic changes have been driven by the Web. Behind them is the fundamental desire of people to connect, communicate, share and participate [18], motivations that Internet continues to facilitate in ways never before imagined. Undoubtedly, the Web is one of the main technological advances of the 20th century. However, this has not always been the case, it has evolved over time and technological advances: Web 1.0, which consisted of plain text shown in HTML pages, with unorganized data and that did not follow any standard [18]; Web 2.0, a set of social, economic and technological trends, that collectively form the basis of the next generation of the Internet: a more mature and different medium, characterized by user participation, openness and network effects [19]; and, Web 3.0 or also called Semantic Web, a technological evolution of the current Web [4]. The Semantic Web is a rediscovery or fulfillment of what the Web pretended to be, a global space of linked data to which meaning is added [3]. The impact of this evolution state of the Web is accelerating as the adoption of the approach grows, and is more integrated into the daily lives of individuals and organizations.

The Semantic Web is a Web where information has much more meaning than in the current Web [4], since its users can make queries more quickly and

accurately, because the data is better structured and linked through a global information space [13]. The efforts to develop the Semantic Web are based on ontologies, which provide standardized and agreed representations of the (often heterogeneous) information produced by institutions [10]. One of the main characteristics of the Semantic Web is that it is decentralized, therefore, its information is distributed in several points. Thanks to this, we can all feed it with useful information that links to information already existing in the Semantic Web, with which we give way to Linked Data, one of the main concepts of the Semantic Web [3,28].

The commitment to share data and semantics through the Web [28], from different domains [27], part of the awareness that from the approach of open and linked data (Linked Open Data) contributes to the fulfillment of the mission of promoting open access and interoperability of information, which enables the possibility for third parties to re-use and adapt reliable information [21], quality, and with reuse costs close to zero. The domain of application is wide, there are different projects related to linked data in cultural institutions [9], archive [20], artistic [15], museums and libraries that provide standardized semantic resources of digital catalogs [11,23] and bibliographic resources [5] (these projects are aligned to the concept of LODLAM which means Linked Open Data in Libraries, Archives and Museums), scientific [22], academics [24], government, among others. In the local context, during the history of Loja, there have been people who excelled in different areas and made great contributions in different cultural genres. But despite the relevance of the legacy, their information is not found on the Web, not even digitized, but in physical sources such as books. Therefore, the cultural data little diffusion is a problem for a city that throughout its history has been characterized for being full of culture.

As a solution to this problem, this work aims to disseminate Historical Figures data from the city of Loja, using Linked Data techniques. This will be of great value within the cultural and social scope of our city and country. It allows the internationalization of this information, with certain standards recommended by W3C (organization that rules the Web in general).

This work aims to preserve the historical memory of Loja Historical Figures through Linked Data techniques. For which it is sought to reuse the existing information of Loja Historical Figures from different sources, to increase the veracity, quality and quantity of the data. Once the data has been collected, it is intended to transform the data into standard formats recommended by the W3C, such as RDF [8], so that in the future they can be easily reusable and consulted through SPARQL [12]. Finally, the aim is to develop a Web application as a means of disseminating the historical information that is the subject of the present work, so that the transformed data can be easily consumed and visualized by the users.

The organization of this work is based on sections that represent the different phases of the life-cycle proposed below.

## 2 Methodology

Linked Data is a combination of techniques, tools and Web standards that allow the World Wide Web to evolve from a document network to a knowledge graph (KG) [21]. When applied to the domain of digital cultural heritage and digital humanities, the linked data transforms the way information is described, shared, discovered, analyzed and visualized. In this sense, the methodology for the publication of Linked Data of Historical Figures consists of a life-cycle that is shown in Figure 1, based on the cycle proposed by [25], the guides presented in [23].

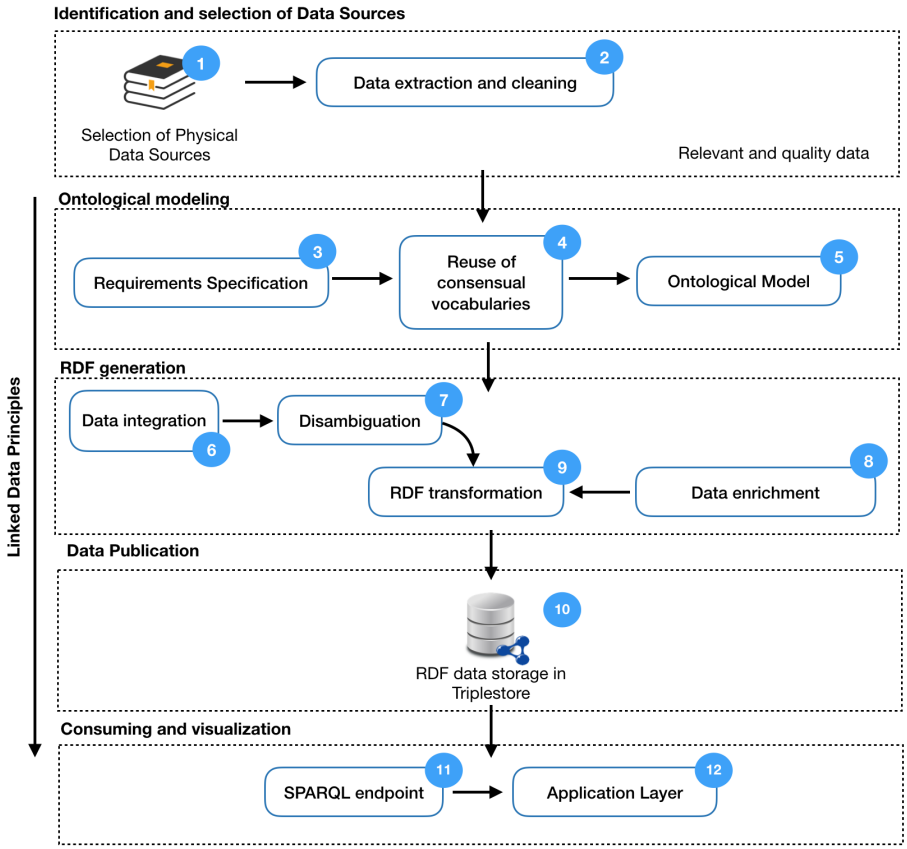


**Fig. 1.** Life-cycle for the publication of Historical Figures

The techniques of Semantic Web and Linked Data (or "Data Web") are of great importance for initiatives related to the historical knowledge management efforts of a locality, since they allow to preserve knowledge, share data, both

among related institutions and all kinds of external domains that can reuse this knowledge in new and different ways. Next, the process carried out as part of this work is described.

## 3 Phase of Data Sources Identification and Selection

### 3.1 Data Sources Identification and Analysis

The data to be published belong to Loja Historical Figures. According to Larousse [14] illustrious is defined as someone: "that stands out extraordinarily in some activity." In addition, the word "distinguished" is used as a synonym, which according to [6] is defined as an adjective to a person: "who excelled in something, especially an activity, and is valued for it". In the local context it is about Historical Personages to recognized writers, poets, musicians, politicians, and other people highlighted by their knowledge and contributions to the community of Loja. As well as for having an irreproachable behavior and leaving a legacy to future generations.

The figures data are obtained mainly from physical sources of local governments such as the libraries of the Municipality, Prefecture and House of Culture of Loja. Several sources have been identified in order to validate their veracity. In addition, semantic digital sources are identified, where data is obtained in RDF that enrich the data obtained from physical sources. Figure 2 shows the data sources identified.

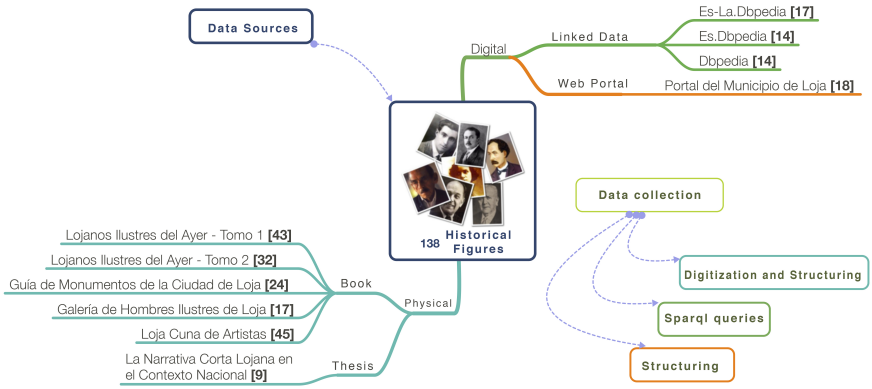


**Fig. 2.** Summary of Data Sources

Next, the data is extracted from the identified sources, digitized and finally structured, obtaining a total of 138 figures. The data is of quality, since its accuracy increases as there are more data sources that complement and confirm the information already collected.

### 3.2 URIs Design

URIs are global and permanent identifiers [2,23]. There are several guides for the design of URIs, one of them is Cool URIs [26], where two types of URIs are mentioned: URIs Hash and URIs Slash (303). The first one is recommended to use to identify resources that are not documents, it contains a fragment that is separated from the rest of the URI by the symbol "#". While the second one is used to identify resources that are not regular Web documents, and is separated from the rest of the URI by the symbol "/" [26].

With the foundations of [2] and [26], and based on the recommendation in [29] of using Slash URIs instead of URIs Hash, mainly because of the possibility of configuring a URI for each resource separately, despite needing two HTTP requests to recover a single resource, it is decided to use Slash URIs (/), following its recommendations: (a) Use meaningful URIs; (b) Define a base URI, from which the rest of the URIs are defined; and (c) Separate the ontological model URI (TBox) from the resource URIs (ABox). Table 1 shows the URI structure to represent the Loja Historical Figures.

**Table 1.** URIs Structure.

| | |
|---|---|
| **Base URI** | http://data.utpl.edu.ec/ipers |
| **TBox** | http://URI base/vocabulary/class — property |
| | **Examples** |
| | http://data.utpl.edu.ec/ipers/vocabulary/Person |
| | http://data.utpl.edu.ec/ipers/vocabulary/firstName |
| **ABox** | http://URI base/resource/class/instance |
| | **Example** |
| | http://data.utpl.edu.ec/ipers/resource/Person/MiguelRiofrio |

## 4 Ontological Modeling Phase

After completing the specification phase, where the data sources were identified, selected, analyzed, and their data were extracted. The next phase of the life-cycle consists in determining the ontology that allows modeling the data domain to be published.

The most important recommendation made by [29] is to reuse as much as possible available vocabularies. This approach allows to reduce the time for the development of the ontology, which supposes a saving of effort, resources and time. The methodology used as a guide for the development of our ontology is the so-called "NeOn Methodology", developed by the Ontology Engineering Group of Computer Science School at Universidad Politécnica de Madrid [16].

### 4.1 Requirements Specification

The first activity to carry out the ontological modeling is the Requirements Specification, where a series of tasks is performed, whose output is the Ontology Requirements Specification Document (ORSD). The Ontology Requirements Specification Document shows the purpose, scope, possible users and uses, as well as Competence Questions of the ontology to be developed. The latter allow to validate the ontology through Sparql queries, once implemented in an ontology language such as OWL.

### 4.2 Reuse of ontological resources

After making the specification, where the ORSD is obtained as output, a high-level ontological modeling is performed, as a first approach to entities and relations to be modeled in the ontology. Followed, the search for vocabularies that allow representing the entities and relationships of the high-level model. For this, the website "Linked Open Vocabularies" (LOV, see http://lov.okfn.org) is used. Among the reused vocabularies we have: Friend of a Friend (foaf), Dbpedia Ontlogy (dbo), Schema, Dublin Core Metadata Terms (dct), Bbccore and Skos.

### 4.3 iPers Ontology

In this section, the iPers (Illustrious Personages) ontology is presented after its conceptualization has been captured in the High Level Model, and the vocabularies to be reused have also been selected. For its elaboration, the principles for the design of ontologies mentioned in [1] are taken into account. iPers allows modeling the personal data of Historical Figures, as well as their family relationships, creative works, actions taken, important moments in their life such as obtaining a prize or academic title, or also a stage such as their academic education or a job performed.

Figure 3 shows an extract of the iPers ontology, which describes the classes, properties and relationships that represent the figure basic information. The core element of the iPers ontology is the Person class, reused from the foaf vocabulary that models each figure, the basic data such as first and last names are also modeled using foaf.

The data related to the birth dates, death dates and gender are modeled with the Schema vocabulary, in the same way as birthplace and death place, for which the Place class is reused and linked by object properties to Person. The Bbccore vocabulary is also used with the knownFor property to describe the reason why the figure is remarkably well-known and important.

On the other hand, the vocabulary of Dbpedia (dbo) models important data of the figure like: occupation, that denotes the activities to which it is dedicated; residence, represents the places where they have lived habitually; nationality, very important since it not only represents the country of birth, but also other countries of which the nationality is a carrier due to long stays or other reasons; and finally the property of data birthName, which allows to distinguish the

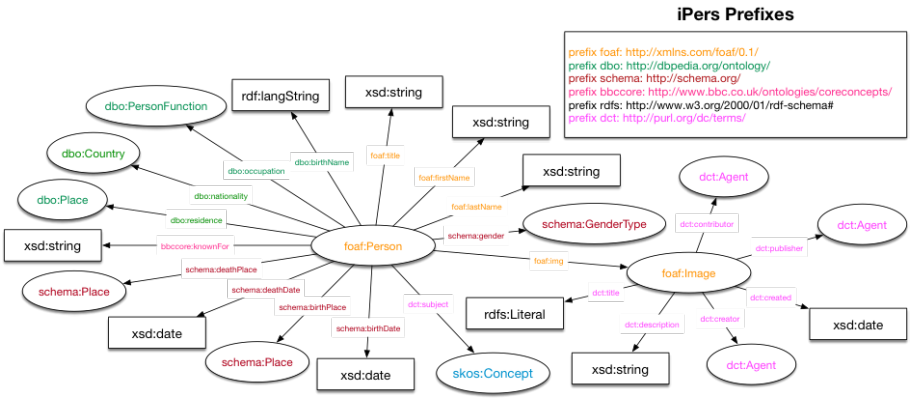


**Fig. 3.** iPers Ontology - Personal Data

birth name of the figure if it were different from the current one, for example the birth name of Matilde Hidalgo de Procel would be "Deifilia Matilde Inés Hidalgo Navarro".

The Skos vocabulary with its Concept class categorize the figures by their occupation and years of birth and death. Finally, the last class created with reference to personal data and that models the figure image (photograph or portrait) is Image of the foaf vocabulary, which uses the properties of Dublin Core (dct) to represent its metadata.

### 4.4 iPers Ontology Implementation

The iPers ontology implementation is done through the Protégé tool, through the OWL ontological language, defined as standard by the W3C to develop ontologies. Protégé is an open source ontology editor developed by Stanford University that allows the creation and editing of ontologies in a very intuitive graphical environment.

First, the IRI of the iPers ontology is entered. Followed by the general annotations that describe the ontology, and finally establish the vocabularies prefixes to be reused. Then, based on the ontological model, the classes and properties of data and objects are created, together with their annotations, descriptions and respective characteristics. For all the elements of the ontology, label and comment annotations are defined, while in the case of properties, the domain and range are added, and also characteristics such as transitivity or symmetry.

Finally, Figure 4 shows the implementation result of the iPers ontology in Protégé.

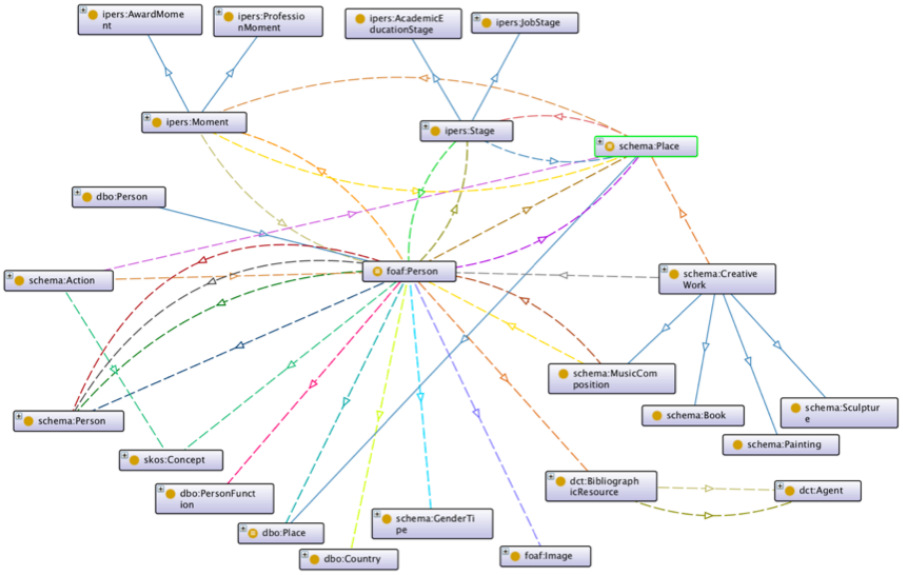


**Fig. 4.** Implementation outcome of the iPers ontology in Protégé

### 4.5 Validation

After completing the iPers ontology implementation process in the tool for creating and editing ontologies, Protégé, the model validation is carried out using two tools:

- OntOlogy Pitfall Scanner! (OOPS!): Developed by the Ontology Engineering Group of the Universidad Politécnica de Madrid for the detection of failures in the design of ontologies, where it also recommends what actions to take to solve them.
- RDF Validator: RDF validation service provided by the W3C for the detection of errors in the triples analyzed.

## 5 RDF Generation Phase

The present phase consists of taking the data from the data sources selected in the Specification Phase and transforming them into RDF according to the ontology resulting from the Modeling Phase. This section details the necessary tasks for a correct generation of data, such as: transformation, cleaning and linking of data.

### 5.1 Transformation to RDF

The transformation task is the main one of this phase, whose objective is to convert to RDF the data of the Historical Figures after they were collected

in the first phase. There are several tools that automate this task, called RDF converters. They are chosen depending on the format in which the data are found and the volume of them. In this case, the OpenRefine tool is used in its version 2.7, since it allows to work with unordered data and perform tasks such as: cleaning, transformation and linking of data [17]. This last characteristic is very important for the task after the transformation and cleaning, the reconciliation with external data sources. In addition, the RDF Refine extension is also used in version 0.8.0, which is what actually allows the transformation to RDF.

The procedure for the transformation is simple, first the file that contains the data in the tool is loaded. Next, the "RDF Skeleton" is edited, which is the one that specifies how the RDF data is generated based on the data contained in the file. The base URI for resources (Abox) is defined in the skeleton, which is specified in the design of Cool URIs [2]. Then the prefixes of the vocabularies to be used are added.

After configuring the RDF Skeleton that transforms the data based on the iPers ontological model, the export is made to an RDF file. For which the RDF Refine extension allows exporting in two serialization formats: RDF/XML and Turtle.

Finally, it is verified that the transformation process has been carried out correctly, since in every automated task a subsequent verification is necessary to search for possible faults and rectify them.

### 5.2 Data Enrichment

The objective of data enrichment is to link the data with other external data sets, following the fourth principle of Linked Data, which states that links to other URIs should be included to discover related resources. The external data sets with which links are established are: Dbpedia (see http://dbpedia.org), Dbpedia in Spanish (see http://es.dbpedia.org) and DBpedia-Latinoamérica (see http://es-la.dbpedia.org), in that order.

The linking process for the present project is considered a hybrid between automatic and manual linking. The automatic linking is done for all the resources of place type by means of the reconciliation service offered by the RDF Refine extension, where the Dbpedia Endpoint Sparql is established and the property with which the related resources are searched, in this case rdfs: label . On the other hand, the manual linking is done with resources related to people, occupations, professions, organizations, awards and genres of the works.

## 6 Data Publication Phase

The objective of this phase is to publish the transformed data to RDF, by storing it in a triplestore for later consumption. There are many database managers that support RDF storage, each with its characteristics and limitations. However, it is decided to use Open Virtuoso given its free code feature, in addition to allowing data loading in a simple way, and consulting them through an Endpoint Sparql.

In addition, the Pubby tool is used, an application developed in Java that allows adding an interface to the Endpoint Sparql of Open Virtuoso, making it easier to access data and navigating through each of the resources stored in the triplestore [7]. Likewise, the navigation between resources serves as a detection of errors, especially in the URI of each of them, so it helps the feedback of the Generation Phase.

Next, the validation of the RDF generation is shown by Sparql queries based on the ontological model developed in the second phase.

Figure 5 and Figure 6 show the validation of the names, surnames, treatment title, gender and birth names of the Historical Figures through Sparql queries.

```
PREFIX foaf: <http://xmlns.com/foaf/0.1/>

PREFIX dbo: <http://dbpedia.org/ontology/>

PREFIX schema: <http://schema.org/>

SELECT ?personaje ?nombres ?apellidos ?tituloTratamiento ?genero
?nombreNacimiento

WHERE {

        ?personaje a foaf:Person ;

        foaf:firstName ?nombres ;

        foaf:lastName ?apellidos ;

        foaf:title ?tituloTratamiento ;

        dbo:birthName ?nombreNacimiento ;

        schema:gender ?genderType .

        ?genderType rdfs:label ?genero .

}
```

**Fig. 5.** Sparql query that validates names, surnames, treatment title, gender and birth names of the Historical Figures

| personaje | nombres | apellidos | tituloTratamiento | genero | nombreNacimiento |
|---|---|---|---|---|---|
| http://data.utpl.edu.ec/ipers/resource/Person/Beatriz_Cueva_De_Ayora | "Beatriz"@es | "Cueva de Ayora"@es | "Doña"@es | "Femenino"@es | "Beatriz Cueva Betancourt"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Matilde_Hidalgo_De_Procel | "Matilde"@es | "Hidalgo de Procel"@es | "Doctora"@es | "Femenino"@es | "Delfilia Matilde Inés Hidalgo Navarro"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Javier_Ezequiel_Riofrio_Eguiguren | "Javier Ezequiel"@es | "Riofrío Eguiguren"@es | "Canónigo"@es | "Masculino"@es | "Francisco Javier Ezequiel Riofrío Eguiguren"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Vicente_Rodriguez_Witt | "Vicente"@es | "Rodríguez Witt"@es | "Doctor"@es | "Masculino"@es | "Cornelio Vicente Rodríguez Witt"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Juan_Maria_Riofrio_Riofrio | "Juan María"@es | "Riofrío Riofrío"@es | "Monseñor"@es | "Masculino"@es | "Alfonso José Alejo Riofrío Riofrío"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Benjamin_Carrion | "Benjamín"@es | "Carrión"@es | "Doctor"@es | "Masculino"@es | "Manuel Benjamín Carrión Mora"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Jose_Felix_De_Valdivieso | "José Félix"@es | "de Valdivieso"@es | "Doctor"@es | "Masculino"@es | "José Félix Valdivieso y Valdivieso"@es |
| http://data.utpl.edu.ec/ipers/resource/Person/Isidro_Ayora_Cueva | "Isidro"@es | "Ayora Cueva"@es | "Doctor"@es | "Masculino"@es | "Isidro Antonio Ramón Ayora Cueva"@es |

**Fig. 6.** Results of the validation of names, surnames, treatment title, gender and names of births of the Historical Figures

# 7 Consumption and Visualization Phase

The consumption and visualization consists in the exploitation of the published data through applications with graphical interfaces, friendly to normal users, who have little or no knowledge in terms of Semantic Web technologies. In addition, being the historical data the topic of the data published in the present project, the outcome of this phase represents a cultural contribution for the community of Loja.

The application developed in this work is web-based and allows the visualization and search of both the Historical Figures and their works. It is developed through the Django web framework with the SPARQLWrapper library, which allows consulting the Open Virtuoso Sparql, obtaining the result in JSON format and converting it to more manageable formats for processing. Regarding the design of the application, the Bootstrap framework is used as a basis. Figure 7 shows an extract of the web application, where the RDF data consumed and visualized through user-friendly interfaces are appreciated.

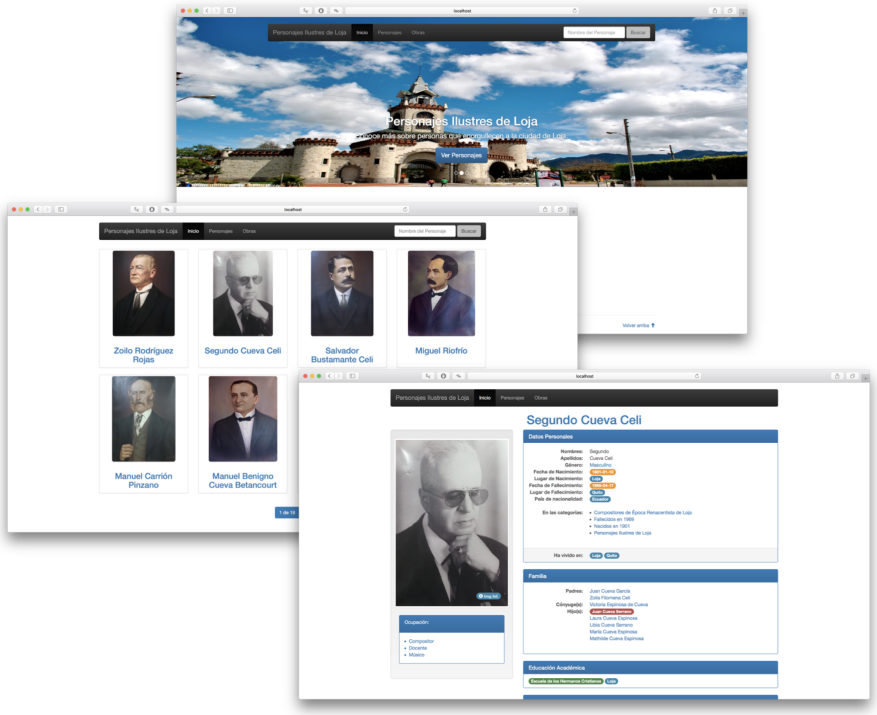


**Fig. 7.** Web application of Loja Historical Figures

## 8 Conclusions

In the domain of digital historical and cultural heritage, open and linked data is key to advance in knowledge management methods, actions that allow data to be open, allow reuse, and admit new uses of data. These values are common in other academic communities, including researchers dedicated to open science and reproducibility, as well as to the creators of knowledge graphs in certain domains.

Initiatives related to digital humanities can benefit from the experimentation of Linked Open Data, since recently published data sets have the potential to directly drive new research threads.

Once the present project has been completed, meeting the stated objectives, it is concluded that:

- The publication of data, especially those of a historical nature or with a cultural focus, represents an arduous work of research and data collection, given that these are not generally structured, and have not even been digitized, so so researchers must go to physical sources. Despite this, it is interesting because it allows preserving and disseminating data of great cultural value. Expressing this way, the true sense of technology, its social bond.
- The reuse of ontological resources, such as vocabularies, is a very important practice in the creation of ontologies. It allows to optimize the effort and time invested in this activity. In addition, the vocabularies, when reviewed and agreed upon, represent a standardization for the modeling of certain data domains, so using them adds quality to the developed ontology and facilitates interoperability with the data sets that use them. The iPers ontology models the relevant data of a person's life and can be reused to represent the information of Historical Figures, not only from Loja, but from any other place.
- The generation of RDF data of historical figures allows a semantic description of the information, which leads to more precise searches of the data generated and its easy reuse in other areas where such information is required.
- The reconciliation of data was a fundamental activity in the generation of RDF and data enrichment of historical figures. This activity is aligned to one of the principles of Linked Data: include links to other URIs to discover related resources. In this way, the enrichment of the information through the interoperability of the data is allowed.
- The consumption and visualization of data was the final phase of this work. The development of a web application that shows the published data is important especially if the data pretend to be available to people who, despite their interest in the data domain, do not have knowledge in Semantic Web technologies. Thus, the linked data becomes an invisible layer for the end user.

## 9 Future works

After the objectives proposed for this project have been met, possible future works are presented that will improve or expand their development: Automation of the data integration process, through the development of a system that allows to unify the data and show alerts in case of data different that correspond to the same value. Given that currently the language of the data collected is only Spanish, the translation to other languages is proposed to increase its visibility, thus obtaining greater dissemination. Increase the information of historical figures from other places in the country. Thus becoming the present work, the origin of an initiative at the national level to preserve the Ecuadorian Culture.

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