Research Project

Pauliceia 2.0: A Spatiotemporal Platform for Digital Humanities

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Abstract

The digital humanities are becoming a growing and unavoidable reality for those working with historical knowledge. They have gained intellectual and institutional footing among scholars across disciplines, who have proceeded from arguing for their potential to discussing their practice and implications. Such discussions include the question of defining an epistemological identity for the field, along with the theoretical and practical implications for scholarship and within the institutional structures that evaluate a scholar's work.

This project aims to design and build a computational platform for collaborative historical research. The principal goal is to develop state-of-the-art software tools, such as a web portal and Geographical Information System (GIS) plugins, that allow humanities researchers to create, organize, store, integrate, process and publish urban history data sets. The proposed platform will integrate all these tools. Historical urban data sets represent the evolution of urban *spatial* locations over *time* and are, therefore, *spatiotemporal* data sets. The development of this platform faces many challenges in Geoinformatics: (a) *how to model, store, geocode, handle and visualize spatiotemporal data sets*; (b) *how to integrate historical urban information with spatiotemporal data sets from other domains, such as public health or transportation services, that are available on the web by different providers*; (c) *how to define and link semantic information to urban history data sets*; and (d) *how to promote collaborative work among researchers, facilitating smooth information sharing and access to knowledge.*

To test and validate the proposed platform, we will perform a use case using digital historical cartographic data sets of the city of São Paulo covering the period of its urban and industrial modernization (1870-1940). We will organize these data sets in a spatiotemporal database. The platform will provide access to this database and allow interaction among researchers, who will be able to contribute to the database events that can be spatially and temporally represented. In doing so, scholars will be able to produce maps and visualizations of their own research and at the same time contribute to the data within the system. This project will enrich understanding of the history of São Paulo during the above-mentioned period in addition to offering an innovative model of research for the digital humanities that fosters collaborative work and free knowledge flow.

Resumo

As chamadas humanidades digitais vêm se constituindo em realidade crescentemente incontornável para aqueles que trabalham com o conhecimento histórico. Já não se trata mais tanto de questionar suas possibilidades de afirmação junto à comunidade acadêmica em questão, mas de discutir os desdobramentos dela, tais como a necessidade (ou não) de definir alguma identidade epistemológica para a área e as implicações teóricas e práticas no cotidiano do pesquisador e nos sistemas institucionais de avaliação do seu trabalho.

O presente projeto objetiva a concepção e o desenvolvimento de uma plataforma computacional para pesquisa histórica colaborativa. A ideia principal é desenvolver ferramentas de software no estado da arte, tais como um portal web e plugins de Sistema de Informações Geográficas (SIG), que permitam a pesquisadores de ciências humanas criar, organizar, armazenar, integrar, processar e publicar conjuntos de dados de história urbana. A plataforma integrará todas essas ferramentas. Os dados de história urbana, enquanto representação da evolução de localizações *espaciais* urbanas ao longo do *tempo*, são dados *espaço-temporais*. Dessa forma, o desenvolvimento da plataforma implica em muitos desafios em Geoinformática: (a) *como modelar, armazenar, geocodificar, manipular e visualizar conjuntos de dados espaço-temporais*; (b) *como integrar informações de história urbana com conjunto de dados espaço-temporais de outras áreas, tais como saúde pública e mobilidade, que estão disponíveis na rede por meio de diferentes provedores*; (c) *como definir e vincular informação semântica a um conjunto de dados de história urbana;* e (d) c*omo promover o trabalho colaborativo entre pesquisadores*, facilitando o compartilhamento e o acesso ao conhecimento.

Para testar e validar a plataforma proposta será desenvolvido um estudo de caso com uma base cartográfica histórica da cidade de São Paulo referente ao período de sua modernização urbano-industrial (1870-1940). As informações serão organizadas em uma base de dados espaço-temporal. A plataforma permitirá o acesso a essa base de dados e a interação entre pesquisadores interessados, que por sua vez poderão alimentar a base com eventos passíveis de representação espacial e temporal. Dessa forma, pesquisadores serão capazes de produzir mapas e visualizações de suas próprias pesquisas, ao mesmo tempo em que alimentarão o sistema com suas informações.

Pretende-se, assim, criar as condições para o enriquecimento das abordagens da história de São Paulo daquele período, fazendo-o em conformidade com os mais recentes e interessantes desdobramentos das chamadas humanidades digitais, voltados ao trabalho colaborativo e à livre circulação do conhecimento.

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1. Scientific Problem

1.1 A Platform for Digital Humanities: challenges for humanists

The digital humanities have drawn increasing institutional support and intellectual interest among scholars working on historical research in universities throughout the world. Digital humanists have gone from lobbying for their place within the academic community to discussing the potential need to define an epistemological identity and the implications of the field from theoretical, methodological, and institutional perspectives.[1] The present project explores these questions and concerns across the humanities, in general, and for historians, in particular.

The most recent developments of knowledge production regimes demonstrate that such production should take a collaborative approach enabling easy sharing and access to knowledge. The free circulation of knowledge has indeed become a core feature of digital humanities (Spiro, 2012). This development owes in no small part to the technologies themselves, which establish horizontal networks and enable fluid electronic traffic and exchange of information. The history of modern computation itself is directly linked to academic and scientific culture, which are structured by the concept of knowledge as a public good (Carlotto & Ortellado, 2011, p. 77-102). In the 1950s, when the first commercial mainframes were available, the number of professionals with the knowledge to properly program these machines was extremely small; their maintenance and development depended on unconditional and open cooperation (Carlotto & Ortellado, 2011, p. 78). Circumstances changed with the release of personal computers at the end of the 1970s. Propelled by counterculture currents from the 1960s through the decade following, personal computers came to represent a victory against the State and/or corporations, which, ironically, were the exclusive owners and controllers of information technology.

In the years following other trends emerged that threatened the supposed democratic and liberating nature of computing technologies. These date to Bill Gates' letter to a hackers club in Silicon Valley[2] questioning the free use and reproduction of computer programs. Since then, there has been a generalized and extremely successful offensive to commercialize information technology as well as the knowledge produced by it. In the process, the scientific and academic communities witnessed the rapid degradation of the concepts of open and public knowledge when facing competitiveness and intellectual property (Carlotto & Ortellado 2011, p. 93).

Counterbalancing this recent history are the digital humanities, which seem to constitute a healthy ecosystem to practice knowledge sharing and collaborative work. This becomes more evident when looking into academic and scientific sectors. The role of the world network of computers, in particular web 2.0, has boosted this aspect. It places value not only in the broad dissemination of studies and investigations, but also

1 For a general reference of digital humanities, see (Gold, 2012) (also available at: http://dhdebates.gc.cuny.edu, accessed on January 1st /2015).

2 The letter was written in 1976 and can be accessed at: http://cryptnet.net/mirrors/texts/gates1976.html (accessed on April 14th 2015).

in opportunities for collaboration and putting into practice those theoretical values. Therefore historians working within digital humanities benefit from a wide variety of technological options to disseminate their research widely and to participate in collaborative investigation across boundaries of time and space.

The possibilities offered by digital humanities scholarship also bring with them a number of complications and concerns. In other words, the influx of computational technology into the everyday routine of a historian is likely to present new challenges.[3] There is not significant precedence for humanities scholars integrating computational technology into the fabric of their research. Circumstances are quite different for scholars within natural or social sciences, long accustomed to building research around such technologies. Moreover, there is a certain reluctance among historians to adopt practices that are associated both with objectivist ambitions and quantitative methodologies considered to be a part of historiographic positivism (Gregory & Ell, 2007, p. 13-14; White, 2008, p. IX; Churchill & Hillier, p. 62). A computer's logic, characterized practically through "0s" and "1s," appears to some the antithesis of the historian's realm, which is full of uncertainties, nuances and incompleteness (Bodenhamer, 2008, p. 222).

However, some of the technological developments associated with digital humanities challenge the classic dichotomy between social thought and the world of computers. Some of these technologies have the potential to subvert radically such dichotomy. For example, these technologies upset traditional distinctions between producer and consumer. Geotechnologies, in particular, represent this potential well. Maps have long been associated with objective knowledge (Harley, 1989, p. 1-20). The advent of digital cartographic technology, which involves several levels of automation, inflated the perception of objectivity dramatically (Harley, 1989, p. 2). In the 1980s, J. B. Harley, author of a classic reflection over the power of maps and an influential critic of the idea of their scientific objectivity, asserted that both their power and seeming scientific objectivity were strengthened as a consequence of increasing automation in cartography. Such an argument looks quick different in the contemporary moment of the worldwide web and especially the web 2.0 platforms that are democratizing map production in ways never before practiced and seldom imagined. Social groups that are traditionally considered as subordinate, such as worker unions, indigenous populations, homeless peasants, or *quilombola* communities (escaped slave settlements common throughout South America), no longer have to accept the representations of space provided by the State. They often have the capacity to create their own maps for use in the development of political, cultural, or social projects. One of the main technologies employed in such practices is Geographic Information Systems (GIS).

The last decade and half witnessed an increasing interest in GIS technologies among historians and the development of important initiatives that are mature enough to provide proper shape to a new paradigm for spatial history.[4] By analyzing the accumulated production up to this moment, a fact that draws attention is

3 The remarks that follow have already been partially presented in the research project "Implementação da tecnologia de sistemas de informações geográficos (SIG) em investigações históricas", granted as FAPESP research grant between August 2013 and July 2015; and in the communication "As humanidades digitais e o ofício do historiador", presented at I Seminário Internacional em Humanidades Digitais no Brasil, October 23rd to 25th 2013, São Paulo.

4 Literature already consists of important collections considered as references. The first to appear were special editions of the Journal *Social Science History* (vol. 24:3), in 2000, and *History and Computing*, v. 13, in 2001. More recent and with more experience, is Knowles, 2008.

that, since its beginning, GIS in historical research has prioritized urban history. An initial milestone is Loren Siebert's study on Tokyo's history, published in 2000 (Siebert, 2000, p. 537-574). Several subsequent publications have been released. In 2011, Donald DeBats and Ian Gregory coordinated and produced a dossier, "Historical GIS and the study of Urban History," published in the Journal *Social Science History* (Gregory & Debats, 2011, p. 455-463). These authors assert that GIS has directly contributed to the advancement of knowledge in history and that the principal topic within this field is urban history. The authors list several explanations, including the strong tradition within urban studies to recognize the geographic significance of their investigations. They support these claims with six examples of studies developed in North America between 1975 and 1989.[5] Scholarship outside of the region would fit into this list as well, such Caio Prado Júnior's studies on the city of São Paulo during the 1930s (Prado Jr., 1935; 1941).[6]

Proceeding from and based in these historical and theoretical considerations, this project aims to develop a space-time panorama on the history of the city of São Paulo between 1870 and 1940. During this period the city went through a dramatic process of urbanization, almost unique in terms of contemporary history.[7] As a result, a critical mass of historians has been compelled to conduct research on a vast array of themes within the period. A project based on the history of the city in this period will therefore benefit from wide appeal to many researchers and the density of academic production completed and in progress.

1.2 A Platform for Digital Humanities: challenges for computer scientists

To properly support digital humanities research, we need an innovative computational platform that integrates different kinds of software tools. These tools include a web portal and GIS plugins. This platform will allow humanities researchers to create, organize, store, integrate, process and publish urban history data sets.

This section presents the main technological challenges to overcome in developing a computational platform for digital humanities:

(a) How to model, store, geocode, handle and visualize spatiotemporal data sets.

Historical urban data sets represent the evolution of urban *spatial* locations over *time* and are, therefore, *spatiotemporal* data sets. Thus the computational platform proposed by this project requires the capacity to handle information of spatial and temporal nature. In Geoinformatics, there is no consensus on

5 Namely: the studies produced by Kathleen Conzen (1976) and Michael Conzen and Kathleen Conzen (1979) on Milwaukee; Michael Katz about Hamilton, Canada (1975); John Kellogg about segregation in Lexington, Kentucky (1982); Sherry Olson of Montreal (1989); and the Philadelphia Social History Project (Gregory and DeBats 2011, p. 457).

6 These works were consolidated in (Prado, Jr., 1983); which in turn is an edition of a paper that appears in "Evolução Política do Brasil e outros estudos".

7 Even though Brazil did not experience the classical model of urbanization that the central areas of capitalism did, more intricately related to the industrial revolution, as warns Emilia Viotti da Costa (Costa, 1977, p. 179).

how to model, store and handle spatiotemporal information in computational systems. The research in this project will ultimately propose new means and models to achieve this elusive goal, building on the previous work published by the project group (Ferreira et al, 2014).

In geotechnologies, static spatial information is represented following well-established models and concepts. This includes the dichotomy between object-based and field-based models (Galton, 2004). Examples of long-standing concepts are vector and raster data structures, topological operators, spatial indexing, and spatial joins (Rigaux et al, 2002). Most existing GIS and spatial database systems are based in these concepts. In the literature, there are many proposals of conceptual models to represent and handle spatiotemporal data in computational systems. However, there are not yet available full-scale and comprehensive GIS and database systems that can handle spatiotemporal information (Yuan, 2009).

Since the beginning of the 2000s, the GIS community has made a serious effort towards spatial data interoperability. The International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC) have proposed standards to represent and store spatial information in data files and database systems as well as to provide spatial data via web services. Geography Markup Language (GML) and Keyhole Markup Language (KML) are examples of data formats proposed by OGC for spatial data interchange. Spatial extensions of traditional object-relational Database Management Systems (Spatial DBMS), such as PostGIS and Oracle Spatial, deal with vector spatial information in compliance with the OGC Simple Feature Access (SFA) specification. Regarding web services, there are standards for spatial data, metadata and processes, such as Web Feature Service (WFS), Web Coverage Service (WCS), Catalogue Service Web (CSW) and Web Processing Service (WPS).

The compliance with ISO and OGC standards has assured a high degree of spatial data interoperability. Many GIS tools and libraries provide spatial data files, databases and web services that follow these specifications. Standards are useful to promote spatial data interoperability. However, few results have been achieved regarding spatiotemporal data interoperability. Most OGC and ISO standards are related to spatial but not spatiotemporal data. There are not standards on how to store spatiotemporal data in spatial database systems or files as well as on how to provide such data through web services.

(b) How to integrate urban history data with spatiotemporal data sets from other domains, such as public health and urban transportation services, readily available on the web by different providers.

A Spatial Data Infrastructure, or SDI, is a platform that facilitates the interaction between people and data by providing required technologies, policies and standards (Rajabifard et al., 2002). SDI as a sharing platform aims to facilitate the access and integration of multi-source spatial data within a holistic framework with a number of technological components including policies, standards, access and the interaction between spatial data stakeholders and spatial data (Mohammadi, 2008).

Currently, all SDIs are based on a set of common web services standards, the so called OGC Web Services.[8] These web services can be grouped in three categories: data, metadata and processing. Web service

8 http://www.opengeospatial.org.

specifications for spatial data include Web Map Server (WMS), Web Feature Service (WFS) and Web Coverage Service (WCS). Catalogue Service Web (CSW) is a standard to publish and search collections of metadata for spatial data, services and related objects. Specifications for geospatial processing services include Web Processing Service (WPS).

In Brazil, the use of geospatial information has become frequently employed in government planning and socioeconomic and environmental studies by government authorities. Several institutes produce such information, including: INPE, Embrapa, IBGE, Brazilian Armed Forces and Ministry for Environment. A major challenge of these institutes is to make the data available on standardized web interfaces to enable sharing and effective use of such data.

The Brazilian Government, in an attempt to address this issue, enacted a decree 6666 of November 27th 2008 to create the INDE – the National Infrastructure for Spatial Data. The purpose of this Institute is: to catalog, integrate and accommodate the existing geospatial data produced and maintained by the Institutes of the Brazilian Government so that they are easily located, explored and accessed for a wide variety of uses, by anyone with access to the Internet [http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2008/Decreto/D6666.htm]. This Institute has adopted interoperability standards among the mentioned geospatial systems.

In this project, we will develop the OGC web services to disseminate historical urban data sets according to INDE specifications. Using these services, we can integrate the historical urban information with other data sets provided by different institutions in the INDE web portal (VINDE - www.visualizador.inde.gov.br/).

(c) How to promote collaborative work among researchers, enabling easy sharing and access to knowledge.

Researchers face what appears to be an ever-growing number of data sets. The pace of this information is accelerated through social network sites like Twitter, Facebook and Flickr and crowdsourcing platforms like Wikipedia, which has developed a massive corpus of knowledge and made it opened to the public. There is no shortage of thoughtful criticism on this kind of data and the implications of its use within academic research (Boyd and Crawford, 2012).

In addition, there is a significant change from traditional methods of organizing data and publishing it on the web. For instance, Linked Data is a method of data publishing based on web standards such as RDF, URIs and the HTTP protocol that allows connecting data from different sources (Berners-Lee, 2006). It has drawn attention of researchers and a community of volunteers that based on this paradigm have developed DBpedia (http://dbpedia.org/) a huge open database built from extracting structured information from Wikipedia and adding links to more information outside Wikipedia (Auer et al., 2007).

The emergence of Volunteered Geographic Information (Goodchild, 2007), or VGI, has helped to expand the amount of data about geographic features of our world. VGI has led to projects such as OpenStreetMap (Bennett, 2010) and Wikimapia. The former, in particular, has produced a complete

ecosystem to deal with volunteer collaboration which resulted in a large open database of features not restricted only to routing applications. A state of the art in VGI was published by Horita and others (Horita et al., 2013) in which a Systematic Literature Review on the topic was duly discussed. Although their focus was on disaster management, the study takes into account several issues more broadly relevant as well as other publications that discuss crowdsourcing and VGI.

To some scholars, VGI is being considered “a human side of the sensor revolution,” motivating citizens to participate in the collection of spatial information. Song and Sun assert that citizens “can act as efficient 'microGI' generators with the mobile data contribution tools” (Song & Sun, 2010). They propose to develop applications that employ VGI based on mobile technology (mobile platforms associated with the mobile cloud) so that citizens may participate in urban management. A framework has been proposed to develop VGI applications in order to capture data (Davis Jr. et al., 2013). It is based on coordinating both web-based tools and mobile applications. This framework allows customizing information collected by citizens and presents a case study on noise sources. The idea is for the citizens to complain to the proper authorities about excessive noise.

The proposed platform to contain urban history maps of the city of São Paulo can utilize VGI to collect feedbacks or even new information to be included in the history database. The platform must be made available to receive such information from citizens in general and must, at some point in time, develop a module to verify the quality of the content. Nowadays, crowdsourcing has become a productive approach in several domains, ranging from problems in streets to forest fires and other disasters. In terms of historical maps, citizens can positively contribute to complement the data available in the platform's database such as correcting some existing information of the maps or even including new geoinformation of a building or a site that has not yet been catalogued by the platform.

(d) How to define and link semantic information to urban history datasets.

When designing a spatiotemporal platform, it is necessary to deal with three aspects of the data: 1) the spatial aspect which consists of geometry; 2) the temporal aspect which defines the interval of existence of the geometries; and 3) the semantic aspect of an object, which aims to provide with a meaning beyond the geographic. There are two approaches to handle the semantics of the spatial temporal objects: 1) using Linked Open Data, and 2) defining a spatial and temporal ontology that can be used to perform reasoning.

The goal of Linked Data is to allow people to share structured data on the web. An important step is the transformation of the data from a particular form into a common format, the Resource Description Framework (RDF), so that it can be easily integrated with other data already transformed in this format. All the data that is compatible with the Linked Data Principles comprises the Linked Open Data (LOD) cloud. Recently, spatial and temporal extensions to RDF have been proposed and implemented. GeoSPARQL is a recent OGC (Open Geospatial Consortium) standard that allows representing and querying geospatial data on the Semantic Web. Also, the data model stRDF accompanied by the query language stSPARQL are extensions of the standard RDF and SPARQL for representing and querying geospatial data that changes over time.

Ontologies offer the means for creating formal representations of concepts, properties and relationships between concepts. Traditionally ontologies have been applied to static domains, in the sense that entities represented in these ontologies do not change over time or space. However spatial objects are dynamic; it is possible that an object changes their attributes and spatial representation along time. Dynamic ontologies are suitable for describing static scenes with static objects but also enable representation of events with objects and properties changing in time and space. Representation of both static and dynamic information by ontologies, as well as querying and reasoning over static and dynamic ontologies, are not trivial. One method for achieving this goal includes the SOWL, Spatio-temporal Representation, Reasoning and Querying over the Semantic Web. SOWL supports quantitative and qualitative expressions. Another distinctive feature of the SOWL model is spatiotemporal reasoning support which consists of a set of inference rules applying on temporal and spatial relations. Their purpose is to assert additional implied facts to the knowledge base (i.e., determine the spatial or temporal relation between two objects given their relations with a third one).

In this project, we will develop a model to link semantic information to spatiotemporal urban history datasets. To achieve this goal, we will investigate the use of LOD together with ontologies.

1.3 Knowledge Creation, Dissemination and Expected Impacts

The platform to be developed will be, in itself, the main and the most powerful means of communication and dissemination of the achieved results, since it will enable the collaborative mapping of the history of São Paulo, the ultimate objective of the project. In addition, a blog will be developed in order to galvanize discussion among interested researchers and to elaborate historiographic analyses with visualizations produced from the platform.[9] Traditional means of scientific dissemination will naturally be employed as well, such as workshops, conferences and academic publications.

As the project is designed in accordance with the principles of the valorization of collaborative work and free sharing of knowledge, all products will be fully available for use and reproduction. Researchers interested in other places and types of urban history will therefore be able to adapt the basic model developed by the project to conduct their analyses. In other words, the methodology and developed cyberinfrastructure will serve not only scholars devoted to the relatively narrow cadre working on the history of São Paulo in the late nineteenth and early twentieth century.

9 Inspiration is from Digital Harlem, that maintains blog at https://digitalharlemblog.wordpress.com.

2. Specific Aims

This section describes two work packages and their milestones.

2.1 Work Package 1: Geohistorical Material

The time frame of the project is from 1870 to 1940, during which the city of São Paulo underwent a dramatic process of urbanization that turned it into an industrial metropolis. In order to accomplish the proposed project objectives, the project team has delimited a specific section of the city to serve as its principal spatial frame over the period of inquiry. This decision owes both to practical and historiographical concerns. For instance, in order to construct a database with the street numbers of buildings and/or properties – an essential step in the development of an instrument for data fed by future platform users – the related data mass and the resulting workload could exceed project capacity of labor resources and time.

Given this reality, the project organizers determined the spatial scope of the project to be the area of the city defined by the map of São Paulo of 1868, attributed to Eng. Carlos Frederico Rath (Annex 2).[10] The area was urbanized by 1870 and underwent numerous subsequent transformations. Furthermore, the city center played a fundamental role in the expansion of the city during the period to be addressed. The space delimited by the 1868 map will always correspond to the oldest area of the city, regardless of the date on which one could work, and will therefore permit richer analysis of change over time by means of the construction of multiple layers.

The first step of the project will be to submit the 1868 map to scanning, georeferencing and vectorization in order to integrate it into the project platform. The project team will choose at least one map per decade for the years following up to 1940. Each of these maps will serve to "update" the layout of that part of the city. In addition, the project will construct a database to organize information regarding the number of street buildings and properties contained in the area. This database shall include the changes during the time frame, not just of the numeration of buildings, but also of the names of the streets and the legislation that regulated these changes.

The activities implied in this work package are:

1) **Training of the project team.**

For the use of involved technologies, such as GIS and interactive alternatives on the internet; understanding

10 More information on this map in http://www.arquiamigos.org.br/info/info20/i-1868.htm (acessed in March 3rd).

of theoretical aspects, i.e., history of São Paulo and those related to epistemological relationships among history, geography and digital humanities.

2) **Geoprocessing of the 1868 map.**

Scanning, georeferencing and vectorization of the map of the city of São Paulo, 1868 (Annex 2), corresponding to the spatial area established for the project.

3) **Definition of the additional cartographic base.**

Based on scientific criteria, defined by the team, a set of maps, drawn from the period between 1870 and 1940, shall be selected to most accurately track transformations of the area defined by the 1868 map. Layers will be vectorized in order to indicate the changes in this area during the time frame of the project.

4) **Database for geocoding.**

A database will be developed with information about buildings and properties which have their location identified in time and space through their respective numbers. This information will be fed to the logical structure of the project platform in order to allow other points to be fed by means of extrapolation of what is already informed. This step is essential for the interface to receive subsequent data from future users. The greater the number of points identified, the greater the accuracy of the resulting base. Thus the use of all types of historical sources (legislative documents, newspapers, license plate books, advertisement leaflets, etc.) is essential for the improvement of the platform to be built.

5) **Platform test.**

A preliminary version of the platform and its interface will be available for test nine months before the project completion. A group of researchers who specialize in the history of São Paulo will be invited to feed the platform. The project team will subsequently assess the performance of the interface, thereafter making necessary adjustments.

6) **Curatorship of historiographical discussion and dissemination of results.**

During the test phase of the interface mentioned above, the project team will curate digital and in-person fora to discuss the impact of the project and its results for the historiography of São Paulo. The primary audience of this activity will consist of the group of researchers invited to test the interface. In addition, partial and final results of the project will be subjected to the traditional means of scientific communication.

Timetable of the Work Package 1:

Activity	Months																							
	Year 1												Year 2											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Capacitation																								
2. Map of 1868																								
3. Cartographic base (1870-1940)																								
4. Database for geocoding																								
5. Platform test																								
6. Historiographical discussion																								

2.2 Work Package 2: Spatiotemporal Platform

Figure 1 presents the architecture of the proposed platform. The development of this platform can be divided in the following 5 activities:

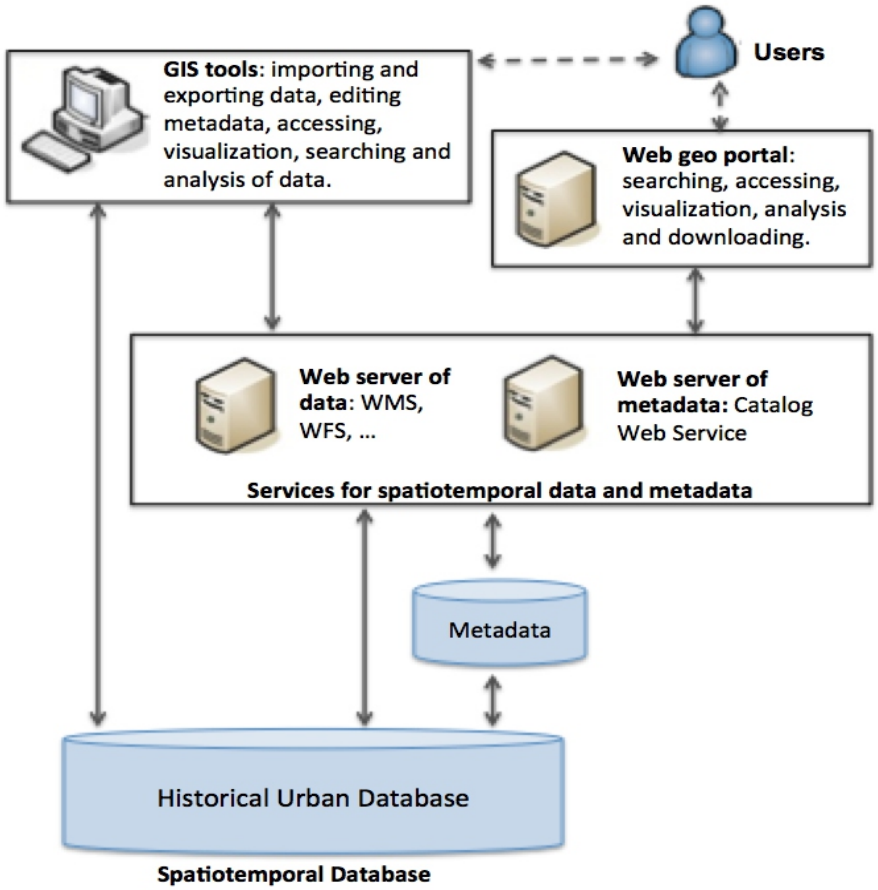

Figure 1 – The architecture of the proposed platform.

1) **Design and build a spatiotemporal database with the historical urban data**.

Data Models must be designed to hold not only the historical information but also the contributions that will populate the database. In this project, we will study and propose a model to store historical urban data and collaborative information in a Spatial Database Systems (Spatial DBMS). Spatial DBMS are extensions of traditional object-relational database management systems to deal with vector spatial information in compliance with the OGC Simple Feature Access (SFA) specification. Example of Spatial DBMS are PostGIS and Oracle Spatial. The idea is to extend the OGC SFA specification to support spatiotemporal information. Besides that, we intend to develop a TerraView GIS plugin to allow users to create and add spatiotemporal data sets in a Spatial DBMS, based on the model that will be proposed.

The urban data set must be semantically enriched to perform qualitative spatial knowledge representation for a set of objects. The semantic information can be described in an ontology, allowing the relationship between quantitative and qualitative data.that can be used to perform reasoning.

2) **Design and develop web services for these spatiotemporal data sets.**

Web services will have to be developed to allow access to the historical information from the database. Access refers to the process of retrieval, user queries on some important aspect on the data itself, and, depending on the permissions of the users, the capacity to upload new historical data. As the idea is to make the information from this particular historical database available to researchers and/or users of other domains, it is essential that, at some level of the tool, operations must be developed to export, regardless of the formats stored in this particular database, to others. In order to achieve this, some of these web services must have the capacity to comply with OGC standards (for further information, see Section 1.2a).

3) **Develop a web portal to access, query and visualize these spatiotemporal data sets. Researchers will collaborate with new information through this portal**.

The portal will consist of applications for general and collaborative users. While general users will have access to information within the portal to conduct analysis, collaborative users will be able to retrieve and upload data. While it is not necessary for general users to have specialized knowledge of geotechnologies, in order to contribute data collaborative users must possess an intermediate understanding of such tools.

4) **Develop geocoding for the spatiotemporal datasets.**

Users will be able to perform geolocation as a part of the web interface. After entering an address, the historical database will be queried and return its coordinates. This method will enrich the database with new information from historical researchers while at the same time enabling those users to produce custom-made maps for their own research.

5) Develop map edition operations for the spatiotemporal datasets.

Develop facilities to compose maps with specific information such as inclusion of text, symbols, etc. This will be available on the client side in order to maintain the integrity of the historical database.

Timetable of the Work Package 2:

Activities	Months																							
	Year 1												Year 2											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Spatiotemporal database																								
2. Web services																								
3. Web portal																								
4. Geocoding																								
5. Map edition																								

3. Preliminary Results and Know-how of the Project Researchers

This project is a joint effort among researchers from four distinct institutions: Arquivo Público do Estado de São Paulo (APESP), Emory University (EU), Instituto Nacional de Pesquisas Espaciais (INPE) and Universidade Federal de São Paulo (UNIFESP). The Principal Investigators are Dr. Luis Antonio Coelho Ferla (UNIFESP) and Dr. Karine Reis Ferreira (INPE). Other associated researchers involved are Dr. Daniela Musa (UNIFESP, campus of São José dos Campos); Dr. Janes Jorge and Dr. Fernando Atique (UNIFESP, campus of Guarulhos); Dr. Gilberto Ribeiro de Queiroz (INPE) and Dr. Nandamudi Lankalapalli Vijaykumar (INPE).

Many of the participants of the project team belong to the research group Hímaco (History, Maps and Computers), coordinated by Luis Ferla. This group was started in August 2010 and explores the possibilities of using geotechnologies in historical research. Between 2013 and 2015, the group developed the project "Implementation of GIS technology in research in history," with a partnership with Núcleo de Acervo Cartográfico of the Arquivo Público do Estado de São Paulo (Cartographic Public Collection of the State of São Paulo) and financed by CNPq and FAPESP.[11] Within its scope, a pilot study "Floods in the city of São Paulo: spatial coverage and social impacts (1870-1940)" was developed, coordinated by Professor Janes Jorge. This experience facilitated the development of extensive technical and methodological support to elaborate the proposed project and established confidence in the success of the initiative.

An urban environmental historian, Dr. Jorge has studied the late nineteenth and early twentieth century history of São Paulo's Tietê River and has published O Rio que a Cidade Perdeu: O Tietê e os Moradores de São Paulo, 1890-1940. Dr. Atique, working with Dr. Janes and Dr. Ferla at the same UNIFESP

11 The results of this project can be accessed at: www.unifesp.br/himaco.

campus, studies spatial history and the built environment. While still at the Universidade São Francisco, Itatiba Campus, he served as Coordinator of the Urbanism and Architecture Program. He has won awards for his research and teaching at every institution he has served. Among his recent works is a study of the "practice" of soccer in São Paulo, rooted in investigations of two major stadiums.

The Department of History of UNIFESP has a partnership with the Public Archives of the State of São Paulo (APESP) since 2011, which led to an agreement that formalized it in September 2012. This allowed the engagement of the Cartographic Collection Division staff in projects that Hímaco group developed. UNIFESP and APESP share a firm commitment to continue the partnership in the implementation of the project presented here (Annex 3).

Daniela Musa works at ICT - UNIFESP (campus of Sao Jose dos Campos) and has experience in conceptual modeling and ontologies. Since 2014 she is a researcher in the project "Descartes - Discovery in trajectories using images and social networks" in conjunction with University Federal of Santa Catarina (UFSC). In Descartes, her work is to develop an ontology to represent qualitative data of time-based characteristics of trajectories.

Karine Ferreira and Gilberto Ribeiro work at INPE and have wide experience in geographical information systems and spatial web platform development. They are part of the group that develops TerraLib library, TerraView GIS and TerraBrasilis web portal (Ferreira et al, 2015). Recently, they are researchers in two ongoing projects whose aims include the development of a computational platform that deals with spatiotemporal data sets: (1) FAPESP project "e-Sensing - big earth observation data analytics for land use and land cover change information" [web page: http://www.esensing.org]; and (2) INPE-Boeing project "Geotechnologies for Efficient Energy Crop Management" that is a collaborative effort between Brazil's National Institute for Space Research (INPE) and Boeing Research and Technology – Brazil (BR&TB) [web page: http://www.dpi.inpe.br/boeing/doku.php]

Nandamudi Lankalapalli Vijaykumar has worked at INPE since June 1978. His experience is in Software Engineering, in particular, model-based software testing, and ontologies for Software Testing Processes, Performance Evaluation Modeling and Information Systems. He has been involved in the Institute's Graduate Program in Applied Computing since 2001. He participated in research projects funded by FAPESP, CNPq and CAPES besides serving as a Visiting Post Doctoral Research Fellow at the University College Cork (2003-2005) funded by the European Union.

The project team also includes a professor in the Department of History at Emory University and a doctoral student in History at the same university; one doctoral student in History at Unicamp; one doctoral student in Geography at USP; one professor of the Department of Social Sciences at Unifesp; four students of History at Unifesp; two historians; one Master in Urban Planning and Geography; one master in Geography working at APESP; one geographer at APESP; and a technician in conservation at APESP, totaling twenty-two people.

In addition to the strengths of the institutions involved, it is important to emphasize the diverse training and specializations of the researchers involved. The Computer Scientists of the team, from INPE and the Institute of Science and Technology of UNIFESP, all work with applied computing and geotechnology. Most of the researches that deal with History and Geography belong to Hímaco Group, cited above, and therefore already have experience with geotechnology and their use in historical research. In turn, the three doctoral students are completing their research making extensive use of Geographic Information Systems, at USP, Unicamp, and Emory University, respectively.

Finally, it is important to note that the partnership with Emory University goes beyond the participation of the teacher and doctoral candidate in the research team. As the letter attached to this project (Annex 4) certifies, that institution proposes to "collaborate with both expertise and technology from the Emory Center for Digital Scholarship." To make this collaboration even more effective, "the Claus M. Halle Institute for Global Learning will provide additional funds to help bring Brazilian members of the eScience team to Emory for additional workshops." These workshops will take place at Emory University's Center for Digital Scholarship, one of the leading centers for digital humanities in the United States.

The project team considers quite strategic this partnership, as the use of Geographic Information Systems in historical research still has an undeniable dimension of technology transfer, given the current stage still quite uneven among the most developed centers and Brazil. When looking to make it within the scope of a research project and with the collaboration of an institution that houses advanced initiatives in the area, there is the conviction that in this way the desired knowledge gains will be effectively achieved.

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Annex 1 - Plan of Activities for Fellowships

Activities Plan for Postdoctoral Fellowship

Specification:

PhD Scholar; 18 months.

Project Title:

History of Property Numbering in São Paulo and its Database (1870-1940)

Summary:

This project of Post-Doctoral Fellowship is associated to the main proposal presented to the FAPESP eScience Research Program, which aims to provide an internet platform for the collaborative mapping of the History of São Paulo from 1870 to 1940. The grantee should investigate proper literature and documentation to reconstruct the evolution of the property numbering in São Paulo and its regulation. As part of the project, a database should be built with the properties that have an identified location in time and space through their respective numbers, given the particular space selection performed by the project crew. Based on the inclusion of these properties information into the São Paulo's historical base map, new other points should be included in the database, by extrapolation, which will work through the geocoding interface provided by the project. Thus, the research on the history of property numbering in São Paulo is an essential step to build and provide such collaborative platform.

Activities:

- Bibliographic research: the bibliographic selection comprises the history of São Paulo from 1870 to 1940, especially what concerns the regulation of property numbers;
- Bibliographic analysis: reading and book report of the related literature;
- Source's research: investigation of two sets of sources related to the historical of property numbering: a) laws, decrees, codes and regulations; b) official documents produced by the municipality to register changes on the properties numbers through time, as well as existing data found in the cartographic material used in the project. These sets of sources will allow the identification of points in the base map, regarding time and space;
- Source's analysis: reading and book report of the related sets of sources;
- Database building: the points collected in the source's research should feed a geodatabase, which will support the geocoding process in the historical platform developed by the project;
- Study Group: the grantee should participate in systematic discussions of the project study group, whose goal is the theoretical and practical training in areas related to this research, such as the history of São Paulo, relations between geography and history, digital humanities, software use, etc.;
- Final report: the used methodology and the results obtained should be systematized in an appropriate report.

Schedule:

Activity	**Bimester**											
	year 1						**year 2**					
	1	2	3	4	5	6	7	8	9	10	11	12
Bibliographic research												
Bibliographic analysis												
Source's research												
Source's analysis												
Database												
Study group												
Final report												

Products:

- Historical of property numbering in São Paulo from 1870 to 1940;
- Database of properties located in time and space
- Final Report

Activities Plan for an Intern

Requirements:

Undergraduate (In Progress); 12 hours weekly, 24 months.

Title of the Project:

Web portal and OGC Web Services

Abstract:

The project proposal submitted to eScience call, to which a inter fellowship is requested, has the objective of developing a platform (in the internet) to collaboratively map the history of São Paulo during 1870-1940. One activity of this project is to build OGC web services to disseminate the historical urban database and a web portal to access and visualize such database using these web services. The intern shall work on this activity.

Since the beginning of the 2000s, the GIS community has made a serious effort towards spatial data interoperability. The International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC) have proposed standards to serve spatial data via web services. These web services can be grouped in three categories: data, metadata and processing. Web service specifications for spatial data include Web Map Server (WMS), Web Feature Service (WFS) and Web Coverage Service (WCS). Catalogue Service Web (CSW) is a standard to publish and search collections of metadata for spatial data, services and related objects. Specifications for geospatial processing services include Web Processing Service (WPS).

The compliance with ISO and OGC standards has assured a high degree of spatial data interoperability. Many GIS tools, libraries and web portals are able to access spatial data sets disseminated through OGC web services. Standards are useful to promote spatial data interoperability. The Brazilian National Infrastructure for Spatial Data (INDE) is based on these standards.

The intern shall create these OGC web services, following the INDE specifications, to disseminate the historical urban database and to integrate with data sets provided by other Brazilian institutions. Besides that, the internal will create a web portal, based on TerraBrasilis technology, to access, query and visualize the historical urban database through these web services.

In order to achieve this, the intern shall: (a) conduct a literature review on OGC web services, INDE and geospatial web portals; (b) develop the OGC web services: WMS, WFS e CSW; (c) develop the web portal using the TerraBrasilis technology;

Activities:

-Literature review on OGC web services, INDE and geospatial web portals;

-Development, Validation tests and Documentation of OGC web services: WMS, WFS e CSW;

-Development, Validation tests and Documentation of a web portal;

-Weekly meetings with the research group of INPE in Geoinformatics;

-Final Report.

Schedule:

Activity												
	Year 1						**Year 2**					
	1	2	3	4	5	6	7	8	9	10	11	12
Literature Review												
OGC Web Services development												
Web portal development												
Final Report												

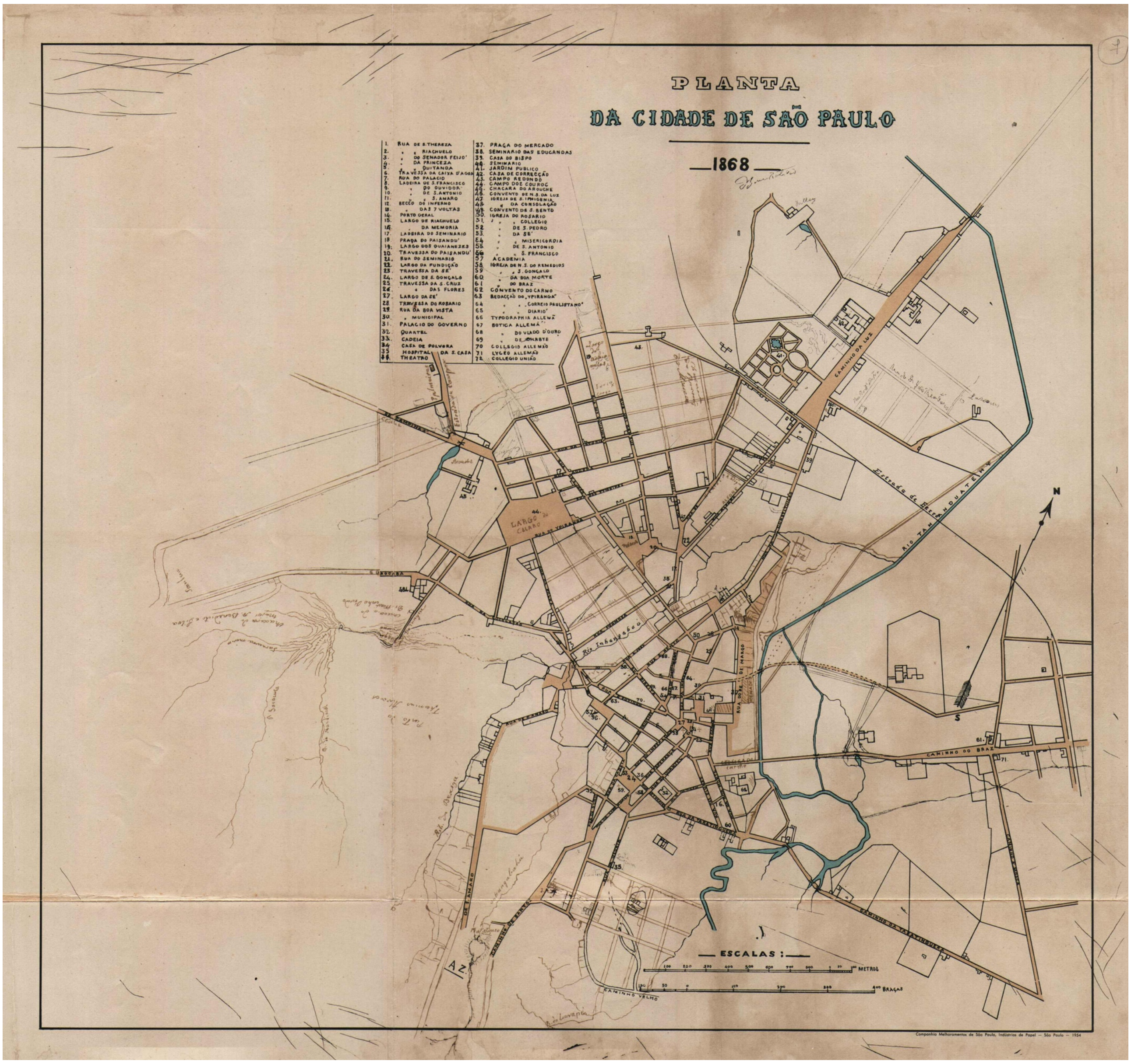
Products:

-OGC Web services;

-Web portal;

-Final Report.

Annex 2 - Map of the city of São Paulo in 1868


PLANTA
DA CIDADE DE SÃO PAULO
1868
1. RUA DE S. THEREZA
2. „ „ RIACHUELO
3. „ DO SENADOR FEIJO'
4. „ DA PRINCEZA
5. „ „ QUITANDA
6. TRAVESSA DA CAIXA D'AGOA
7. RUA DO PALACIO
8. LADEIRA DE S. FRANCISCO
9. „ DO OUVIDOR
10. „ DE S. ANTONIO
11. „ „ S. AMARO
12. BECCO DO INFERNO
13. „ DAS 7 VOLTAS
14. PORTO GERAL
15. LARGO DE RIACHUELO
16. „ DA MEMORIA
17. LADEIRA DO SEMINARIO
18. PRAÇA DO PAISANDU'
19. LARGO DOS GUAIANEZES
20. TRAVESSA DO PAISANDU'
21. RUA DO SEMINARIO
22. LARGO DA FUNDIÇÃO
23. TRAVESSA DA SE'
24. LARGO DE S. GONÇALO
25. TRAVESSA DA S. CRUZ
26. „ DAS FLORES
27. LARGO DA SE'
28. TRAVESSA DO ROSARIO
29. RUA DA BOA VISTA
30. „ MUNICIPAL
31. PALACIO DO GOVERNO
32. QUARTEL
33. CADEIA
34. CASA DE POLVORA
35. HOSPITAL DA S. CASA
36. THEATRO
37. PRAÇA DO MERCADO
38. SEMINARIO DAS EDUCANDAS
39. CASA DO BISPO
40. SEMINARIO
41. JARDIM PUBLICO
42. CASA DE CORRECÇÃO
43. CAMPO REDONDO
44. CAMPO DOS COUROS
45. CHACARA DO AROUCHE
46. CONVENTO DE N. S. DA LUZ
47. IGREJA DE S. IPHIGENIA
48. „ DA CONSOLAÇÃO
49. CONVENTO DE S. BENTO
50. IGREJA DO ROSARIO
51. „ „ COLLEGIO
52. „ DE S. PEDRO
53. „ DA SE'
54. „ „ MISERICORDIA
55. „ DE S. ANTONIO
56. „ „ S. FRANCISCO
57. ACADEMIA
58. IGREJA DE N. S. DO REMEDIOS
59. „ „ S. GONÇALO
60. „ DA BOA MORTE
61. „ DO BRAZ
62. CONVENTO DO CARMO
63. REDACÇÃO DO „YPIRANGA"
64. „ „ „CORREIO PAULISTANO"
65. „ „ DIARIO"
66. TYPOGRAPHIA ALLEMÃ
67. BOTICA ALLEMÃ
68. „ DO VIADO D'OURO
69. „ DE OHRBYE
70. COLLEGIO ALLEMÃO
71. LYCEO ALLEMÃO
72. COLLEGIO UNIÃO
LARGO DOS CURROS
CAMINHO DA LUZ
CAMINHO DO BRAZ
N
S
ESCALAS
METROS
BRAÇAS
AZ

Annex 3 - Partnership between Unifesp and Apesp

Ministério da Educação
Universidade Federal de São Paulo

UNIFESP
UNIVERSIDADE FEDERAL DE SÃO PAULO
1933

Ofício Reitoria nº 335/2015

São Paulo, 23 de junho de 2015

Ao
Ilustríssimo Senhor
IZAÍAS JOSÉ DE SANTANA
Coordenador do Arquivo Público do Estado de São Paulo
Rua Voluntários da Pátria, 596
São Paulo/SP

Assunto: Manifestação de interesse.

26/06/2015

Prezado Coordenador,

Venho manifestar a decidida intenção dessa Universidade na efetivação do Convênio com a instituição sob sua direção, dedicado a *"Desenvolver e aprimorar o uso da tecnologia de Sistemas de Informações Geográficas (SIG) em Investigações Históricas nas Instituições Partícipes"*.

Tal disposição é motivada pelos resultados alcançados pela parceria até o momento, que incluem a realização da Exposição "O tempo e as águas: formas de representar os rios de São Paulo", a matéria de capa na Revista Fapesp de dezembro de 2013, a realização de dois seminários dedicados aos temas correlatos, a disponibilização dos resultados do projeto no site do grupo de pesquisa respectivo, além da divulgação da pesquisa em meios acadêmicos tradicionais, como produção de artigos e participação em eventos científicos.

Rua Sena Madureira, 1.500, 5º andar – Vila Clementino - CEP: 04021-001 – São Paulo – Capital
Telefones: 0xx11 – 5083-2120/5084-4079
E.mail: reitoria@unifesp.br

Nesse sentido, reitero a disposição de apoiar a celebração do Convênio em questão, na certeza de que ambas as instituições tem muito a ganhar com a continuidade dessa profícua parceria.

Aproveito o ensejo para enfatizar protestos de elevada estima e distinta consideração.

Atenciosamente,

Profa. Dra. Soraya Soubhi Smaili
Reitora da Universidade Federal de São Paulo - UNIFESP

Rua Sena Madureira, 1.500, 5º andar – Vila Clementino - CEP: 04021-001 – São Paulo – Capital
Telefones: 0xx11 – 5083-2120/5084-4079
E.mail: reitoria@unifesp.br

Annex 4 - Emmory University Letter

EMORY UNIVERSITY | The Halle Institute

March 7, 2016

Fundação de Amparo à Pesquisa do Estado de São Paulo
Rua Pio XI, 1500 - Alto da Lapa - CEP
05468-901 São Paulo/SP
Brasil

Dear Colleagues:

Emory University enthusiastically supports the eScience proposal "Pauliceia 2.0: A Spatiotemporal Platform for Digital Humanities" coordinated by Professor Luis Antonio Coelho Ferla (UNIFESP) and Professora Karine Reis Ferreira (INPE). Not only will Emory provide the international partnership for the grant via my office's Brazil Initiative (part of which is a formal relationship with FAPESP via the SPRINT program), but we will also collaborate with both expertise and technology from the Emory Center for Digital Scholarship.

Part of the eScience proposal includes funds for mobility for Emory faculty and students to participate in workshops in Brazil. If the FAPESP funds are awarded, the Claus M. Halle Institute for Global Learning will provide additional funds to help bring Brazilian members of the eScience team to Emory for additional workshops.

Emory University, the Office of Global Strategy and Initiatives, and the Halle Institute have made Brazil a top priority in its expansion of international research and teaching, based on a group of almost fifty faculty members working in and on Brazil and one of the top Brazilian Studies programs in the United States. FAPESP support for "Pauliceia 2.0: A Spatiotemporal Platform for Digital Humanities" will increase international collaboration and will lead to future funding requests from Emory faculty to foundations in the United States such as the Mellon Foundation and the National Endowment for the Humanities.

Sincerely,

Philip Wainwright
Vice Provost for Global Strategy and Initiatives
Director, Claus M. Halle Institute for Global Learning
Emory University

Emory University
1784 North Decatur Road, Suite 130
Atlanta, Georgia 30322
An equal opportunity, affirmative action university

Tel 404.727.7504
Fax 404.727.2772
www.global.emory.edu

Annex 5 - Third-party services budget

Sao Paulo, May 7, 2016

BUDGET

Project: PAULICEIA 2.0 – A Spatiotemporal Platform for Digital Humanities

Responsibles: Mr. LUÍS FERLA – UNIFESP, SAO PAULO, BRASIL

Ms. KARINE REIS FERREIRA – INPE, SAO JOSÉ DOS CAMPOS, BRAZIL

Service: GRAPHIC DESIGN and CONSULTANCY

1. Graphic Illustration

a. Maps *

Planning	R$ 3.000,00
Creation	R$ 5.000,00
Finalization	R$ 2.000,00

*It involves the graphic production of visual elements of great complexity. Are provided three (3) stages: planning, design and creation, submission.

2. Interactive Media – Web Interface

a. Graphic Design for Sites ** R$ 5.000,00

** Graphic design for use by programmers in Web language HTML / CSS templates and CMS platforms. The graphic design does not include logic programming and implementation of the site. Material delivered in layers such as PSD, AI, JPEG or PNG.

3. Design Consultancy

Technical Visit *** R$ 3.750,00

*** Considering the realization of 1 monthly technical visit, amounting to R$ 250.00 each, during the 15 months of the project. Includes spending with travel and about 4 hours of consulting.

TOTAL – Graphic Project = R$ 18.750,00

(Calculation Basis: ADEGRAF-BR 2013/2015)

Priscila Machado Meireles | Architect & Graphic Designer | Sao Paulo - BR | 55 (011) 9.7688.6893 | arq.meireles@gmail.com

Notes / General guidelines:

The stages of development and consulting comprise estimated period of 15 months.

The technical responsibility of the designer is restricted to the time of digital approval by responsible. The designer is not responsible for third-party production errors.

Project costs shall be reviewed when changes occur in the complexity of the project after briefing the approval, or the amount of material to be produced/diagrammed/edited exceed what was previously agreed.

Regards,

Priscila Meireles

Architect and Urbanist

Expert in Graphic Design

CAU BR code: A47.358-8