FROM QGIS TO PYTHON: COMPARISON OF FREE AND OPEN TOOLS FOR STATISTICAL ANALYSIS OF CULTURAL HERITAGE AND DATA REPRESENTATION

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ABSTRACT:

The onset of the Covid pandemic in 2020 changed the approach to work, research, and study. This period has been a wake-up call for public administrations, the private sector, and the academic community, to digitise their data. In Italy, digital and information technologies for the protection and enhancement of cultural heritage, which were an imperative for more than a decade, have been accelerated. This paper aims to collect and to process openly available data on patrimony from OpenStreetMap and the Lombardian Geoportal. The study is divided into two phases: a simple statistical analysis of cultural heritage in Monza is obtained, and the results are presented graphically. Firstly, built-in tools and Python Console of QGIS are evaluated, to filter attributes and add geometrical values to the downloaded material. Secondly, plug-in DataPlotly and an online coding application named Replit are assessed. The results are presented and compared in terms of their flexibility, quality of visual representation, customisation, and simplicity of use. Tools developed through and for QGIS are easy to use and available to everyone. Additionally, coding applications can be integrated for more refined results. This approach fosters interdisciplinarity, bridges the gap between professionals and non-expert users of GIS, and opens a range of opportunities for future collaborations. The citizen, as a mapper, can be involved in the administrative decision-making process, contributing with data collected *in situ*. Collaboration between these two sides can potentially produce the better for evaluating the contemporary built environment and its undividable part of cultural heritage.

1. INTRODUCTION

1.1 Importance of Open Data

The situation and circumstances of the pandemic impacted the whole planet. Researchers found this period especially difficult in terms of conducting field surveys and visiting sites. Cyberspace became the main platform for interaction between research groups all over the globe. Given the impossibility of conducting surveys and investigations in person and pursue face-to-face discussions, many researchers needed to find an alternative, to be able to continue their work. This period has also been a wake-up call for everyone, from public administrations to the private sector and the academic community. There is a growing need for digitising data and making them free and available to various stakeholders (Amankwah-Amoah et al., 2021). This approach can strengthen planning processes at various scales, from local to global, where the openly accessible data can circulate freely. The pandemic pushed interaction to the virtual space like never before, including social networks, open-source data initiatives, crowdsourcing projects, and online conferences. Depending on the field of study and infrastructure of the country, researchers adapted to the new conditions at different paces, but the change was inevitable (Krause et al., 2021).

In Italy, a country famous for its cultural heritage, researchers, administrations and students needed to overcome challenges to continue their work and education. Although it does not focus on other influences, such as economic and social, this paper discusses the grave impact on scientific research. As a solution, the cultural sector has been innovated with data digitisation and has been paired with already available data created before the pandemic. Creation of virtual and augmented realities, online

databases, interactive maps, digital twins of cultural heritage and sharing material with other research groups and engaging local communities *in situ*, became a standard recovery strategy (OECD, 2020). Digital and information technologies for the protection and enhancement of cultural heritage have become an imperative that was mirrored in several important European and national recommendations and guideline reports. Over the past decade, Italy began its journey towards digital heritage, and there has been an increasing interest in adopting modern technologies in all sectors (Scuderi and Salvetti, 2019). Questions that were highlighted during the crisis were focused on answering how one can conduct research without visiting the site, and to what degree open data can support analysis.

1.2 Position of the Study

The collection of materials that are currently available online from OpenStreetMap and regional Geoportals required steps for classification and analysis of their completeness, relevance, and quality. The study was made from the position of a researcher working remotely during a crisis period. The methodology developed provided basic Python scripts and evaluated the use of built-in tools of the free and open-source software (FOSS), to obtain spatial and statistical information about cultural heritage, in medium to small historical centres. The purpose of the study is to create the basic code and develop the guidelines, such that non-expert users are able to replicate and improve on the results. This approach will be valuable for all stakeholders, including researchers, citizens and students, by using all available material online to show the potential of inter-connecting freely available sources.

The amount of available online data is vast. To meet the objectives of this work, a specific case study was selected.

Choosing a medium-small sized historical centre that is well-known for its patrimony, can give certain indications of how cultural heritage is described, categorised and catalogued in cities that are smaller but not less historically significant.

2. RECOMMENDATIONS FOR DIGITISATION

Over more than a decade and a half, thanks to European Commission initiatives such as 'INSPIRE' – Infrastructure for Spatial Information in the European Community (European Commission, 2007) – and other governmental policies, spatial data have been made publicly available on different national, regional and municipality geoportals. In Italy, geoportals follow these guidelines and provide a substantial amount of freely downloadable data. For the region of Lombardy Geoportal[1] was created and sorted into thirty-four spatial categories based on the 'INSPIRE' directive (Bonora et al., 2013). Among other available spatial data for Lombardy, there are also shapefiles representing cultural heritage. Since 1998, the documents evaluating cultural heritage have been connected to the regional Geographic Information System (GIS) (i.e. Lombardian Geoportal). This was followed by the incorporation of the regional and national system through the integration of 'SIRBeC'[2] catalogues. 'SIRBeC' has been promoted since 1992, and it continues to collect, manage, and publish a vast amount of information about cultural heritage. It works through the exchange of data with ICCD[3], created by the Ministry of Culture, but having its own administrative and scientific autonomy (Medici, 1999).

Later actions, based on the decree of the Ministry (MiBAC, 2008), accompanied by a subsequent decree in 2017, included different activities devoted to the patrimony assigned to the ICCD. These actions involve the digitalisation of cultural heritage, research and technical-scientific documentation, and coordination of their cataloguing tracked through SIGECweb[4] (Desiderio et al., 2013). These regulations allowed public entities to share substantial information about spatial and non-spatial data with interested stakeholders (Moro, Mancinelli and Negri, 2017). The problem occurs when most of these catalogued documents and shapefiles become obsolete. Outdated documents do not reflect the real situation of cultural heritage nowadays. The survey can be a protracted process, and results come in the form of descriptive tables, which are not efficient or interactive ways of creating a live database to track changes that occur over time. The solution can be found in earth observations for landscape heritage assessment and participation of the local community, for timely updates on the state of the built environment (Jovanovic et al., 2021).

3. CASE STUDY OF MONZA

To evaluate the developed methodology, Monza was selected as a case study. It is a town in the north of Milan and it is famous for its architectural gems and invaluable gardens. Since Roman times, due to its strategic position, Monza became one of the most important towns. In the following period, around the sixth century, Monza started gaining its sovereignty from Milano, as a home to the royal court. This resulted in increased independence in administrative and religious power. From the 12th century, when town authorities were established, Monza's urban planning and economy thrived. In the following century, the high number of monastery complexes and churches gained strong religious power and reputation. In the 15th century, Monza was the key manufacturer and trader of woollen cloth.

Two centuries later, noble families and rising entrepreneurs searching for their place in high society, chose Monza to build their villas and residences for leisure. This affected the town's development (Bosisio and Vismara, 1970). In the 18th and 19th century, many changes in the urban tissue of Monza occurred. The demolition of medieval fortifications and old houses was followed by the construction of new stores, piazzas, and villas. Some exquisite examples of villas emerged in this period. One of them is Villa Reale, built from 1777 until 1780, which served as the archduke's palace. Around 1806, by the order of Napoleon I, Monza park was inaugurated. With onset of the industrial revolution, the expansion and development of the town ware accelerated. The second railway in Italy was made from Milan to Monza in 1840 (Agnoletto and Colombo, 2002). This period was characterised by a sprawl towards the periphery, substituting farmhouses and arable land.

The historic centre of Monza has many distinct types and layers of architecture, natural characteristics and land use. Describing the patrimony of the contemporary town and creating spatial and metadata, work performed by surveyors, is not an easy task. That is why, in order to evaluate complex urban creations, there is a need for an organised administrative body (e.g. Lombardian Geoportal, on the regional level and GIS of the Municipality of Monza, on the local level[5]) composed of professionals who should serve as the backbone in providing data for further use.

4. COLLECTED MATERIAL AND TOOLS

The scope of the research was collecting information about cultural heritage in Lombardy that is freely accessible online. All collected data were then loaded into one GIS project to be compared and further analysed. The first set of data was downloaded from the Lombardian Geoportal. The second set was taken from OpenStreetMap (OSM) through the web-based filtering tool Overpass turbo[6]. The third dataset is again from the OSM but it was downloaded using plug-in QuickOSM, directly in the software QGIS. Filter key *historic=** was used to identify features on OSM with both tools, while the key *boundary=protected_area* did not give any result. Data obtained from OSM, by two different approaches, are not identical. Downloaded information is the point, polygon, and line features vector files (Figure 1). After placing all transferred data into one project, file types, locations, completeness, and availability of each set were evaluated, as well as their metadata and attribute tables.

The established methodology was tested using the open and free software QGIS (version 3.18.2). Additionally, the built in Python

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Console (PyQGIS) was examined in QGIS, as well as the functions in the integrated toolbox. Statistical analyses were performed in the integrated development environment (IDE) named Replit[7] which is a free, open, collaborative and in-browser Python coding application. Selected tools were used to produce a custom list of cultural heritage values, filter attribute table, and to extract coordinates from point and polygon features. Moreover, Replit and QGIS plug-in DataPlotly were used for graphical representation of results, testing several types of plots obtained automatically or through code.
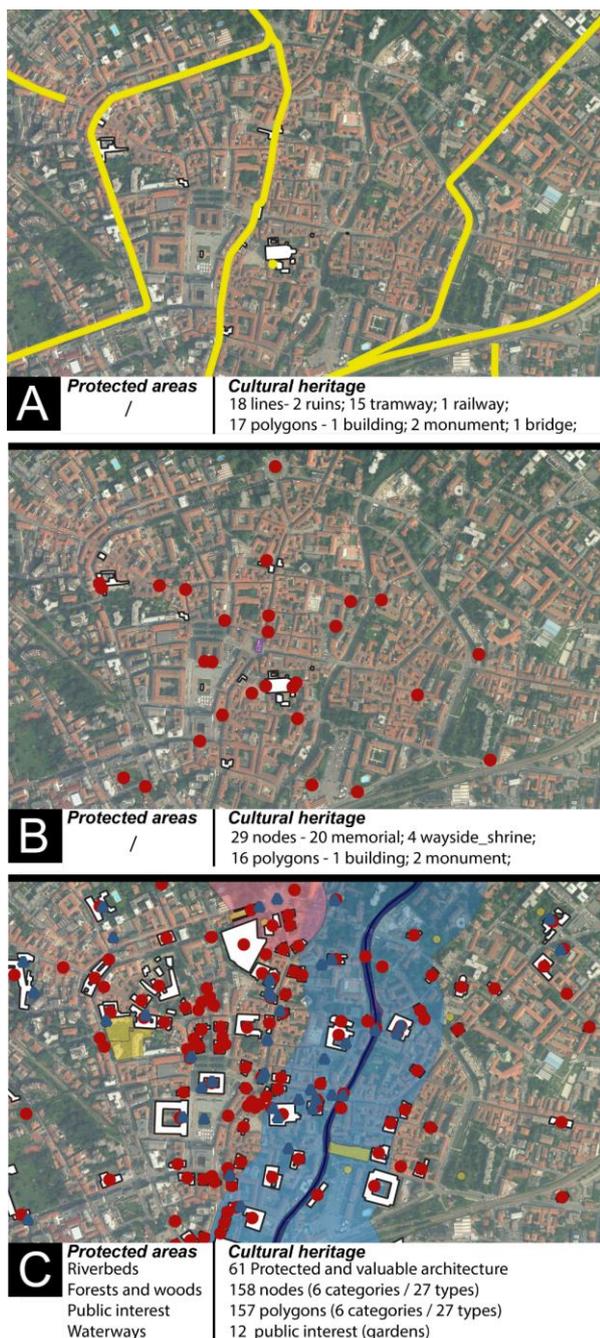

Figure 1. Comparison of the quantity and quality of open data about cultural heritage from A: OSM data downloaded with Overpass turbo; B: OSM data downloaded with QuickOSM; C: Data from Lombardian Geoportal. Background: WMS Orthophoto 2015 (source: Lombardian Geoportal).

5. METHODOLOGY

The methodology is based exclusively on free and open sources, from the collection of data to their processing. In this way, the methodology can be replicable and used by a wider range of interested parties. Each vector file is enriched with the metadata in the attribute table, but the methodology provided a combination of software to obtain other data (e.g. coordinates, area, etc.) and statistical analysis (e.g. ratio, percentage, position, distribution, etc.), which are the initial part of each elaborated cultural heritage project (Portalés et al., 2018). Additionally, the methodology discussed different approaches to reach the desired results and compared their distinctions to choose the most suitable one. This approach shows the importance of the open-source codes and tools that are developed and shared by a community, which creates more possibilities and provides flexibility in the research (Francisci, 2021). The created methodology is divided into two phases: the first one, examined tools for extraction, filtering, and computation of new attributes, and the second one, explored the differences in visualising statistical analysis conducted in the first phase.

5.1 QGIS Integrated Tools versus PyQGIS

The development of QGIS in the past years has been accelerated. Its built-in tools are complex and based on algorithms that are improving with each new version. Moreover, there are many official, experimental and deprecated plug-ins available. To test their capability for the purpose of this study, some of them were selected from a range of possibilities. Each shapefile has an attribute table where the creator inserts values. Additionally, these files have other spatial characteristics which are not directly readable in the tables. Two built-in approaches were used to acquire geometrical attributes and compare the outputs.

Firstly, the integrated option in QGIS 'Add geometry attributes' was tested. The tool produces a new shapefile, wherein automatically computed attributes are added to existing ones. This geometry tool measures the geometric characteristic depending on the type of vector layer, and the outputs can be different. Material that was examined for this study gave various results. For the polygon features from Lombardian Geoportal, the tool specified area and parameter, already available in the downloaded dataset. For OSM point data downloaded through QuickOSM, it provided x and y coordinates, and for polygon features it yielded area and parameter which did not exist in the initial dataset. Area and parameter which were not initially present were added to the polygon data, downloaded from OSM through Overpass turbo, and length, straight distance and sinuosity were added to the line features (Table 1).

'Add geometry attributes'	Point	Polygon	Line
Geoportal Lombardy	numerical parts (1)	already existing data	/ (no data)
OSM - QuickOSM	x,y coordinates	area and parameter	/ (no data)
OSM - Overpass turbo	/ (no data)	area and parameter	length, straight distance, and sinuosity

Table 1. Built-in tool 'Add geometry attributes' tested on collected material gave different results. "No data" represents that the initial material did not contain those values (source: D. Jovanović).

Additionally, there is a possibility of using another integrated tool 'Add X/Y fields to layer.' This tool does not support multipoint, and therefore Lombardian Geoportal data, and works only with single point features. The tool works perfectly with the data from

OSM. To gain geometrical and spatial values from polygon features, the vector geometry tool 'Extract vertices' was used. The algorithm extracts the nodes which polygons are made of, forming them into a new shapefile. The advantage of this approach is that x and y coordinates can be immediately added by setting geometry on 'AS_XY'. The newly created point features layer can be saved in a comma-separated value file (CSV) for use in Excel or coding applications. To filter the attribute fields, users need to select the appropriate field to be extracted in a layer, while saving the file. Python Console integrated into QGIS was also assessed towards the same purpose.

Secondly, the PyQGIS was evaluated to filter selected values from the shapefile into the CSV, later to be used in Replit for visualisation of results. This will allow researchers that, through a simple extraction of the aimed characteristics, create excel tables, run simple statistical analysis and compare data, without damaging the initial information or creating new shapefiles. Data were taken from the attribute table of point features of cultural heritage, previously downloaded from the Lombardian Geoportal. This dataset was chosen for the study because it is more accurate and complete than that from OSM. The area of interest was Monza and its surroundings. Extracted values are:

- Name (*Nome*);
- Category of the building (*Categoria*);
- Typology of the building (*Tipologia*);
- Municipality where the building is located (*Comune*) (Figure 2).
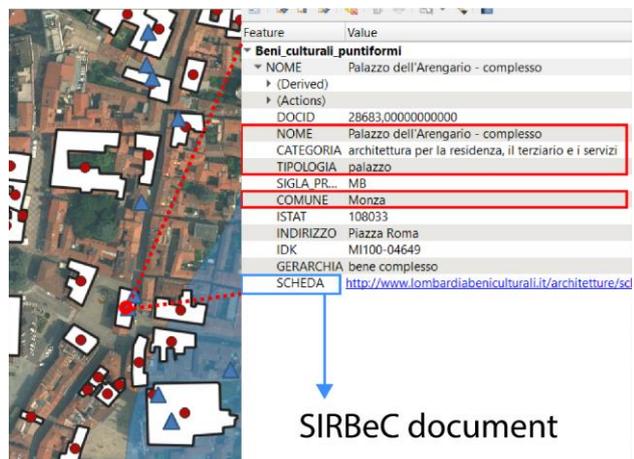
Figure 2. The attribute table of the point features describes cultural heritage. Extracted values are marked in red, and in blue is the hyperlink to access 'SIRBeC' documents online. (sources: Lombardian Geoportal, Lombardia Beni Culturali).

To be able to access the selected layer in QGIS, the command *>>> layer=iface.activeLayer()* was introduced. This command fetches the reference to the currently loaded layer and stores it in the layer variable. Next, command *>>> dir(layer)*, was used to show all the available methods for the object. This is useful when the source and consistency of data are unfamiliar, or Web Map Service (WPS) is called by the user. To access all the features in the active layer, the command *>>>getFeatures()* was applied, followed by for-loop to collect all features *>>>for f in layer.getFeatures ():*. The variable *f* is employed to access the values through the attribute table, and extract the aimed features listed previously:

print (f ['NOME'], f ['CATEGORIA'], f ['TIPOLOGIA'], f ['COMUNE'])

Since the attribute table contained no information about the longitude and latitude coordinates of the features, these were added through code. Coordinates are important for remote studies, from the GPS connection of photography to the georeferencing of point clouds. Applied function *geometry()* returned the geometries of the object and stored them in the variable. All collected data were composed and extracted in a single document in the CSV file, to be used later in Replit for simple statistical analysis and graphical representation of results. After stitching information together, the desirable output was set, using the function *.format()* to print multiple variables.

print ('{}, {}, {}, {} , {: .2f}, {: .2f} \n' .format (f['NOME'], f['CATEGORIA'], f['TIPOLOGIA'], ['COMUNE'], geom.asPoint().y(), geom.asPoint().x()))

This approach is convenient because the attribute fields remain untacked, and PyQGIS extrapolates selected data into a new external file. However, the process can be complicated for non-professionals, even if the used code is simple (Figure 3).
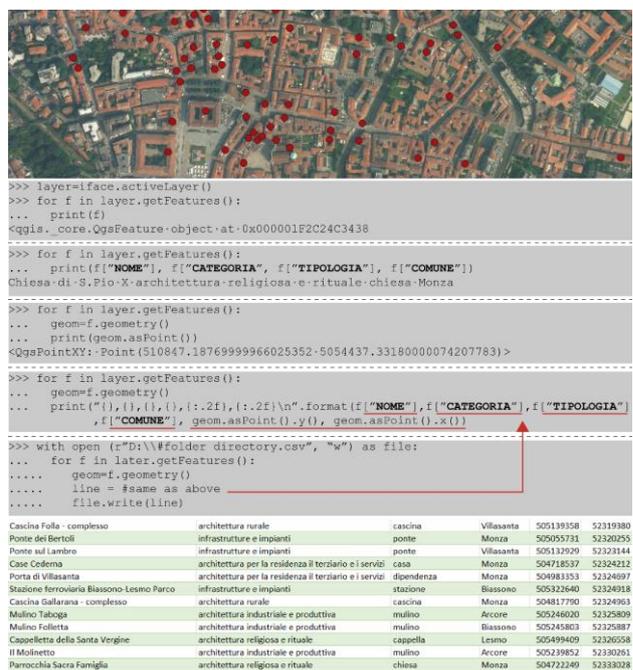
Figure 3. Code is written in PyQGIS to filter values of point features (source: Lombardian Geoportal) and add coordinates. Results were saved in external CSV format (source: D. Jovanović).

5.2 Representation of Results : QGIS tools versus Replit

The second part of the analysis discusses other two methods that were assessed for the creation of statistical analysis of previously extracted data and visual representation of the results. Firstly, the QGIS built-in functions in the Plots Toolbox were evaluated. The automatic production of graphical representation is not very flexible and cannot directly calculate the sum of the same text values to create a chart. It works only with numerical values which need to be available in the attribute table. The output is an HTML link and can be downloaded only as a PNG image file, which quality is insufficient. On the plus side, graphs viewed in the browser are interactive, and display values simply by moving the mouse over the desired part. Another option in QGIS is using plug-in DataPlotly, which is a widely used and suggested plotting tool. The plug-in can create several types of plots and automatically calculates the numerical sum or percentage of

selected text values. It has an integrated field calculator, so other conditions can be set manually. It was designed as a simple tool, which can be easily customised for simple graphs. Moreover, it has an option for multi plots and subplots. The plots can be saved as HTML (for interactive use, but once saved cannot be used on other systems) or in PNG.

Another approach was examined to test if production of better-quality graphs, with more flexibility in computations and custom representation, are possible. In the first part of the paper, integrated Python Console was studied. Thus, for the second part, another coding application was selected to access the best results and combinations of tools. In-browser coding application Replit, which uses Python language, was analysed for the same purpose.

```
6   data = pd.read_csv ("dataCH.txt")
7   print (data)
8
9   #PERCENTAGE OF CATEGORIES IN SELECTED MUNICIPALITY
10
11  mask = data["municipality"].values == "Monza"
12  data_new = data[mask]
13  print(data_new)
14
15  cat_new=data_new["category"].value_counts()
16  print(cat_new)
17
18
19  labels = "architettura per la residenza il terziario e i
    servizi", "architettura rurale", "architettura religiosa e
    rituale", "architettura industriale e produttiva",
    "infrastrutture e impianti", "architettura fortificata"
20  sizes = cat_new
21
22  fig1, ax1 = plt.subplots(figsize=(10, 10))
23  explode = (0.2, 0.2, 0.2, 0.2, 0.2, 0.2)
24  colors=( "orange", "red", "yellow", "green", "blue", "purple")
25
26  ax1.pie(sizes, explode=explode, autopct="%1.1f%%", shadow=True,
    colors = colors)
27
28  patches, texts, auto = ax1.pie(sizes, colors=colors,
    shadow=True, explode=explode, autopct="%1.1f%%" )
29  plt.legend(patches, labels, loc="best", title="Categories")
31  ax1.axis("equal")
32  plt.title("Percentage of different categories in
    Monza",fontsize=25)
```

```
[352 rows x 6 columns]
architettura per la residenza il terziario e i servizi    214
architettura rurale                                        50
architettura religiosa e rituale                           46
architettura industriale e produttiva                      25
infrastrutture e impianti                                  15
architettura fortificata                                    2
Name: category, dtype: int64
```

Figure 4. Screenshots of code in Replit calculating how many dissimilar categories of cultural heritage buildings there are in Monza and surroundings, in percentage, and presenting them in a pie chart (see Figure 6, source: D. Jovanović).

Creating charts through the Python packages such as *matplotlib* or *pandas* showed a better degree of control over a graph. The main advantage is that graphs can be exported as many different files, such as PDF and SVG. Additionally, filtering of the information and visual representation of charts is almost limitless. The coding program is easier to use than PyQGIS, and there is an option to save each graph individually for later use. It was possible to explicitly implement the list of fields of cultural heritage which were obtained in the previous step through PyQGIS and saved in an external CSV file. This file was called in the Replit coding panel so that other statistical analyses can be conducted. Counting of the number of the particular value field of architecture in each municipality (e.g. category or typology) was performed with the function

cat=data["category"].value_counts(). The counted values were stored in the created variables containing the numerical value necessary for statistical analysis and the design of a plot afterwards. Moreover, it is possible to rearrange the data, regardless of their order in the original file (Figure 4).

6. DISCUSSION OF RESULTS

The process of data extraction and addition of new spatial characteristics (e.g. coordinates, geometry, etc.) to the vector layer was done with QGIS built-in tools and integrated PyQGIS. Firstly, the output of geometry tools that are integrated into QGIS depends on the type of file that the user is working with. Conditioned by the algorithm, the tool 'Add geometry attributes' gives different results varying on a type of vector file. Every time, it creates a new shapefile, where the existing attributes are added to new ones. Another integrated QGIS tool tested was 'Add X/Y fields to layer' to provide coordinates of point features of cultural heritage. The tool is not suitable for all types of files, which creates another restriction and additional steps for the tool can be used effectively. Acquiring coordinates of buildings, for potential direct georeferencing of point clouds, creation of orthomosaics, and linkage of architectural models is important in cultural heritage studies. To extract nodes from the polygon features, the vector geometry tool 'Extract vertices' was used. The advantage is that in each node the properties of the polygon they are extracted from, with added coordinates, are stored. Applying this tool is simple and yields fairly accurate results. The disadvantage is that in making the polygon shapefiles, authors are drawing nodes which do not belong to the building volume. There is a need to revise achieved results before using extrapolated nodes for further analysis.

On the contrary, the Python Console is a precise tool and it is based on a code that the user writes. It can better target the aim of the research, and for the purpose of this study, extract the information in an external file for further use in statistical analysis. In PyQGIS immediate filtering of attributes was possible through a code, and these were saved in a temporary memory. Reordering of fields was also feasible. Moreover, the console was able to create a new table of attributes with the information that users need (e.g. coordinates) without changing the initial set of data or adding new shapefiles, in order to avoid overloading layers. This file can be saved externally to be used subsequently.

On the one hand, these integrated tools can perform automatic computations, they are a much faster and easier solution for a wider range of users, but the results will not always be precise. On the other hand, PyQGIS can appear complicated for non-experienced users, but provides greater flexibility and generates custom made extracted data in an external file (Table 2).

QGIS - Built-in geometry tool	PyQGIS
Does not work with all types of geometries	Works with all types of geometries
Easy	Precise
Automatic	Complex
Output is internal (new shape file)	Output is external
Not flexible	Flexible
Does not require previous knowledge	Requires basic coding knowledge
Filtering of fields (during saving)	Filtering of fields (before saving)

Table 2. Comparison of built-in geometry tools and PyQGIS coding console. Advantages and disadvantages in terms of data extraction, coordinates' addition, and filtering (source: D. Jovanović).

In the second part of the study two other methods were evaluated for performing statistical analysis and graphical representation of results. Work started with the built-in plot tools of QGIS, that use numerical values, while direct calculation methods were not applicable. The study continued with the use of the plug-in DataPlotly that offers several types of charts. However, it is weaker in terms of the variety of visual representations. Nevertheless, one constraint is that there is no option for exporting graphs in a vector file, and graphs can only be saved in PNG format. Graphs are interactive while they are in preview, but once they are saved their interpretation is difficult since the numerical data are not readable. Another drawback is that the order of data cannot be adjusted in the DataPlotly and is conditioned by the order in the existing attribute table. These problems cause plot tools to underperform with a large dataset containing a substantial number of field varieties (Figure 5).
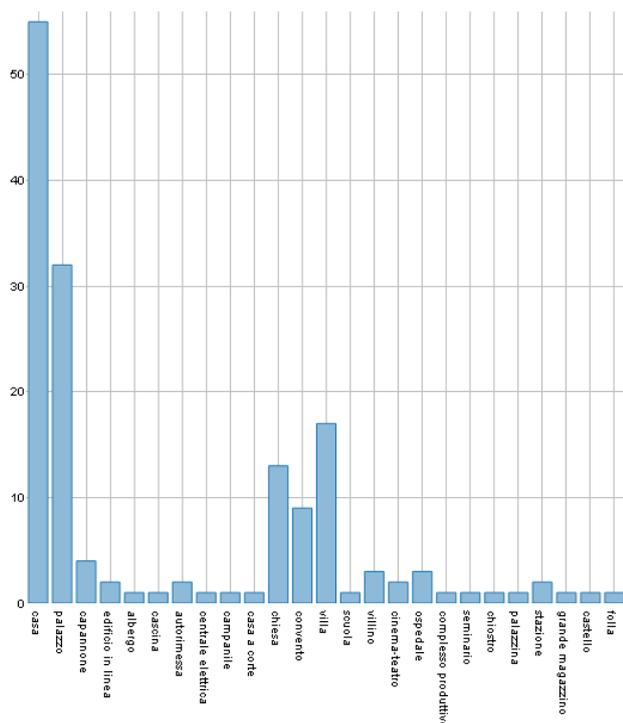
Figure 5. Histogram of typologies of cultural heritage in historical centre of Monza made with plug-in DataPlotly. Low-quality resolution and not presented numerical values are the main shortcomings of this approach (source: D. Jovanović).

The Python coding language application Replit showed a higher degree of flexibility: charts were adjustable and export was available in several formats, most importantly as vector files. The variety of charts and their customisation required coding knowledge but offered more options. Additional advantage is that Replit is an online application and there is a possibility for sharing code with users in real-time, where they can upload their own set of data in CSV or TXT. In this case, it is sufficient to change the value the user is interested in for graphical visualisation. Through a written algorithm, Replit can calculate percentages of typologies and categories of diverse cultural heritage in the selected municipality and present them on the selected graphs (Figure 6). This can be a useful solution for other professionals to directly access statistical data which are previously processed and distributed by the GIS experts. Additionally, users do not need to know how to code. They can make their analysis and charts by inserting CSV information into

a pre-written code, without actually visualising spatial data (Table 3).
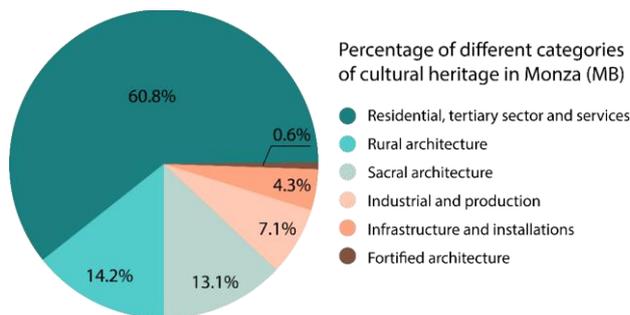

Figure 6. Pie chart made in Replit and exported as PDF file. Numerical values are presented in percentages (see Figure 4, source: D. Jovanović, second variation).

QGIS - Built-in Plot tools	Plug-in DataPlotly	Replit online IDE
Numerical values need to be pre-calculated in the attributes	Values are calculated automatically	Numerical values can be calculated with a code
Limited flexibility	Field calculator	Flexible
Order not adjustable	Order not adjustable	Adjustable order
Extract file only as .png	Extract file only as .png	Extract file in vector format
Not sharable in real-time	Not sharable in real-time	Real-time sharing
Easy use	Easy use	Medium difficult use

Table 3. Comparison between built-in plot tools of QGIS, plug-in DataPlotly, and online coding application Replit for making simple statistical analysis and graphically present results (source: D. Jovanović).

7. FUTURE WORKS

The primary role of OSM is not collecting historic material. Even if there are some examples of using OSM for historic purposes, such as Open Historical Map (OHM)[8], their work lies in creating an out-of-date map and they are not particularly interested in the state of cultural heritage nowadays. On the other hand, there are initiatives that can turn into collaborative mapping projects. One inspiring talk was delivered at the conference 'State of Map 2021' by Anne-Karoline Distel, titled 'Mapping Heritage in Ireland: A Journey'[9]. The speaker gathered a small group of people interested in history and open data, and they collected and uploaded data to OSM, regarding historical features and their descriptions. Together with the locals, they managed to provide information about historically important landscapes and buildings. Additionally, she stressed that the community must start collecting these data as soon as possible before they are lost.

Mapped cultural heritage in OSM is usually visible on the field survey or on the satellite imagery, but usually, its description is treated as any other building, without additional attributes. Those results are conditioned by the tagging system and a diverse community of mappers. Marking protected areas or cultural heritage values, which are not directly visible, are not present in OSM for the investigated area. This is happening because these historical areas or buildings need to be valorised by groups of professionals in the field and special administrations that are in charge of their protection. From the example above, it is evident that the OSM community can be involved and have an impact with help from the local community, using field papers for mapping the condition of built heritage at the local level. Public administrations are very slow in updating their documentation as is evident on 'SIRBeC' catalogues (some surveys were

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[8] https://www.openhistoricalmap.org

[9] https://2021.stateofthemap.org/sessions/ZCUPCF/

conducted for the last time in the 1990s, while for some valuable buildings still in use, surveys have never been carried out). The extent of patrimony is great and there is a need for involvement by a local community which will recognise the state and dangers of neglected built structures which are often found in smaller historical centres. In this way, professionals, institutions and citizens can work together through open data.

Additionally, involvement of students, integration of basic coding courses in study plans, and familiarisation with open data can accelerate the production and information quality in the future. Innovative teaching methods involve education about open access information and FOSS for various purposes (Gaspari et al., 2021). The code developed in this study has been shared with students on the master's degree in architecture at Politecnico di Milano, who showed interest in discovering more about the topic and being able to create custom statistical analyses on their own.

8. CONCLUSION

In the past years, many students, researchers, and professionals were not able to continue their work because of the inaccessibility to the site and unavailability to perform the field survey, which is necessary when it comes to the investigation of cultural heritage. The process of using and combining open and free software, including those which can be used off- and online, can provide, to a certain degree, some information that is not visible in attributes. They can perform automatic calculations, initial statistical analysis, and basic spatial geometry. In this way, the research can be continued and conducted also remotely. The methodology, processes and tools used in this paper are simple, yet they are setting clear guidelines to be followed, especially for non-experienced users. Used built-in QGIS tools, plug-ins and coding applications gave different results depending on their aim. This paper examined the simple addition of coordinates in the attribute tables, extraction of CSV files, and their use for basic statistical analysis and graphical representation. In the conclusion, the tools developed through and for QGIS are many, easy to use and available to everyone. Coding applications can be integrated into the process for more complicated calculations and refined results. This nurtures interdisciplinarity and opens up a range of opportunities.

In summary, this paper stresses the importance of freely shared data and the power of geographic information tools in urban, architectural and heritage analyses. The free and open QGIS software has wide applicability on various scales in cultural heritage projects: from mapping materials to evaluating territories (Adamopoulos and Rinaudo, 2021). Citizens and experts can be involved in the decision-making processes of administrations, and public bodies can use open data provided by the local community (Roued-Cunliffe and Copeland, 2017). Collaboration between these two sides, in the interdisciplinary environment, potentially produces the best results for evaluating contemporary built environments and their intrinsic cultural heritage.

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