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Web application in green infrastructure of cities – co-creativity about trees in Barcelona

Zerek Zhang

Resume– A medida que la población urbana aumenta a su máxima velocidad, la planificación urbana ha sido más desafiante que nunca. En el siglo XXI, una ciudad debe tener en cuenta la sostenibilidad, la igualdad y la inclusión para ofrecer a su población urbana un espacio saludable, cómodo y habitable. Este documento explora las funciones de la planificación colaborativa y cómo se puede utilizar un enfoque de laboratorio vivo para mejorar las infraestructuras verdes de la ciudad, especialmente sus árboles, utilizando el estudio de caso de la ciudad de Barcelona, donde los árboles juegan un papel fundamental en la infraestructura verde de la ciudad.

Paraules clau– web aplicación, árboles, Barcelona, mapas, urbanismo, infraestructuras verdes, ciudad, urbanismo, smart city, medio ambiente, ArcGIS

Abstract– As the urban population is increasing at its highest speed, urban planning has been more challenging than ever. In the 21st century, a city needs to keep sustainability, equality, and inclusivity in mind in order to offer its urban population a healthy, comfortable and livable space. This paper explores the functions of collaborative planning and how a living lab approach can be used in improving city's green infrastructures, especially its trees by using the case study of the city Barcelona where trees play a fundamental role in the city's green infrastructure.

Keywords– Web aplication, trees, Barcelona, maps, urban planning, green infrastructures, city, urban, smart city, environment, ArcGIS.

◆

1 INTRODUCTION

To this day, 55% of the world´s population lives in urban areas already, and according to the projection by UN, this number is expected to increase to 68% by 2050 [1]. The urban population is growing faster than ever, which means a better urban planning is more important than ever.

To make cities a more livable place, urban planning is not just about construction anymore. In the 21st century, city planners need to tackle a more sustainable, equitable and inclusive development. And in order to archive that, involvement of citizens is vital. In recent years, Living Labs operate as intermediaries among cities and citizens to foster innovations and co-creation.

- Author: Zerek Zhang
- E-mail: zhe.zhang2@e-campus.uab.cat
- Branch: Engineering School UAB
- Teacher:Fernando Vilariño (Dep. Computer Science UAB)
- Course: 2020/2021

A city's green infrastructure is just as important as its highway and edifice. The city of Barcelona is facing major challenges in terms of improving its population´s health and comfort in relation to the pollution and the climate change crisis. In a hot summer day in Barcelona, it would be desperate for its citizen if there were no trees in the streets. Trees that are planned in public spaces, under their shades, can moderate the temperature. Other than that, trees also help to clear dust and purify the air its citizens breathe. We also included data from Autonomous University of Barcelona in this project, which is exclusively used for this study.

This paper is to explore the functionalities of web application in planning and learning the green infrastructures of cities by case studying trees in the city of Barcelona and UAB (Autonomous University of Barcelona) campus. Along with the paper, there will be an interactive and co-creative map-based living lab project which allows citizen to learn about the trees of Barcelona while also to participate to make their own contributions.

This paper is structured as follows: In the section 1, all

the technical implementations that we used in the project were explained to offer the insight of the approach of choosing the right tools for the project. In the section 2, the data set we used for this project is detailly explained to offer an understanding of the data we are working on. In the section 3, the results of the study are showcased with interface of the web application explanation and the python function that was developed for this project. In the section 4, we concluded some final thoughts on this project with technical and social dimension. In the section 5, future work will give us a picture of how this project can be carried on in a long run. In the section 6, appendix included the python function code we developed and other results of this project.

2   TECHNICAL IMPLEMENTATION

In order to get the project in the right direction, the selection of tools to be used is vital. In the early stage of the study, ArcGIS was used to visualise and understand the data set. Later for the web application, we used angular for the interface design and two API to be able to offer the services that we wanted to include in the final product. Also python is used to design a function that can find locate nearby trees and return us with information of our interests. They are individually explained as follows.

2.1   ArcGIS

ArcGIS provides a strong set of tools for describing, analyzing, and modeling natural system processes and functions [2]. Like many GIS software, ArcGIS creates maps that require categories organized as layers. When we need to deal with data that contains multiple layers, the program can help us to line them up properly to create a complex data map.

As we are working with spatial information, thus, being able to reflect it on a map is very important. At the early stage of the study, ArcGIS helped us to be able to visualise the datasets that were obtained.After importing XYZ data into ArcMap Point Data Layer by using the CSV file that contains XY geographic information. With display XY Data of ArcGis, I set X field to longitude and the Y field to Latitude with WGS84 geographic coordinate system referenced. Later by adjusting symbology, we can finally visualize the data in a map. This process also can visually help us to understand the distribution, density and many other unique aspects of our data.

2.2   Python

In order to locate nearby trees by any given geographic coordinate information, we need a function to run in the csv to be able to return users with useful information in the dataset. Considering that we are working with a big csv file, I decided to implant the function with python programming [3].

The baseline of the function is to enter an input, with which we will search relative information in the dataset with a certain accuracy then return us with selected information within our interest.

2.3   Angular

Angular is a platform and framework for building single-page client applications using HTML and TypeScript. We used Angular to code our website interface in order to offer users a versatile dynamic in both desktop and mobile phone.

In the web application, there are 2 services and 7 components that are essential to the project. The main objective of a service is to organize and share business logic, models, or data and functions with different components of an Angular application [4]. Apart from that, in order to use API, we also created a API model which stores all essential code to run API in our web application.

2.4   GitHub

GitHub is a Git repository hosting service. The purpose of Github for this project is to provide access control and several collaboration features to share this project with the community. Git simplifies the process of working with other people and makes it easy to collaborate on projects which is a very important core to this project. Team members can work on files and easily merge their changes in with the master branch of this project to make their own contribution [5].

2.5   API

2.5.1   Carto API

The CARTO Maps API allows us to generate maps based on data hosted in our CARTO account and apply custom SQL and CartoCSS to the data [6]. The API generates a XYZ-based URL to fetch Web Mercator projected tiles using web clients such as Leaflet, Google Maps, or OpenLayers. In this project, we uploaded our data to CARTO server then used a iframe to display our visualization of the dataset on our web application.

2.5.2   YouTube API

With the YouTube API, you can add a variety of YouTube features to your application. Use the API to upload videos, manage playlists and as well as display videos on your website. In this project, on the web application, there's a component that plays an educative role where you can find all the tree related videos and watch them from the web application directly. Thanks to the YouTube API, we are able to do that.

3   DATA

3.1   Data Overview

To support the study that I have been carrying on about the living lab and green infrastructure of the city, I chose Barcelona as the case study and processed related data from OpenData BCN. The data I chose is the trees that have been recorded through out the city. The data is divided into 3 section: Zone tree of the city of Barcelona, Street trees of the city of Barcelona and Park tree of the city of Barcelona. There are in total 229979 registers in these three data sets. Apart from the city of Barcelona, we also collaborated with

TABLE 1: ZONE TREES DATA SET [8]

Data Set	Zone Trees of the city of Barcelona
Description	Name of the species and geolocation of the trees of the city of Barcelona located in areas. This dataset complements of Street trees and Park trees of the city of Barcelona.
Basic Characteristics	Environment dataset. Weekly update with historical information.
Content Formats	KML, XML, RDF, CSV
Register Number	40,633

TABLE 2: STREET TREES DATA SET [9]

Data Set	Street Trees of the city of Barcelona
Description	Name of the species and geolocation of the trees of the city of Barcelona located on streets. This dataset complements of Zone trees and Park trees of the city of Barcelona.
Basic Characteristics	Environment dataset. Weekly update with historical information.
Content Formats	KML, XML, RDF, CSV
Register Number	154,323

Autonomous University of Barcelona to include trees on UAB (Autonomous University of Barcelona) campus [7]. The data we obtained for UAB campus contains geographic information and species information, and this data is yet an open data, which in this case is exclusively shared for this project. In the three Tables (Table 1, Table 2, Table3, Table 4 I respectively offered an quick overview of the data that I have been working on for the investigation.

3.2   Data Selection

After comparing these 4 available data formats through some research, I decided to continue with XML and CSV format for the early stage of my study. Here I will have an explanation on why and how I will process these data for the use my study.

1. XML

   Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. XML is also widely applied in Web application development which will be very helpful

TABLE 3: PARK TREES DATA SET [10]

Data Set	Park Trees of the city of Barcelona
Description	Name of the species and geolocation of the trees of the city of Barcelona located in public parks. This dataset complements of street trees and zone trees of the city of Barcelona.
Basic Characteristics	Environment dataset. Weekly update with historical information.
Content Formats	KML, XML, RDF, CSV
Register Number	35,023

TABLE 4: TREES IN UAB CAMPUS DATA

Data Name	Trees in UAB campus
Format	CSV
Register Numers	4923

for the next stage of this study. We will need to fit available data into an application with GPS [11].

2. CSV

   The CSV (comma-separated values) file offers us more direct and diverse ways to understand the data that we are working on. In the CSV of this data set, they also contain geographic information like latitude and longitude which will be important for our visualization of the data [12].

3.3   Data understanding of BCN data set

In the data set we are working on, there are 229979 trees in Barcelona were being recorded individually with a unique code and other 22 different information. Through a CSV to excel calculate form transformation, we are able to view the data in a table form. I divided this 22 information into different categorized groups and compelled a summarized look at the data.

3.3.1   Geographic Information

1. X_ETRS89: Geo-referenced coordinate measurement

2. Y_ETRS89: Geo-referenced coordinate measurement

3. LATITUD_WGS84: Coordinate measurement

4. LONGITUD_WGS84: Coordinate measurement

5. Green space: Green spaces in the city

6. Address: Address where tree is located

Two different sets of coordinate measurement were stored in the data set. The ETRS89 measurement stands for The European Terrestrial Reference System 1989 which is an ECEF (Earth-Centered, Earth-Fixed) geodetic Cartesian reference frame, in which the Eurasian Plate as a whole is static. The coordinates and maps in Europe based on ETRS89 are not subject to change due to the continental drift [13]. On the other hand, WGS84 stands for World Geodetic System which is an Earth-centered, Earth-fixed terrestrial reference system and geodetic datum. WGS84 is based on a consistent set of constants and model parameters that describe the Earth's size, shape, and gravity and geomagnetic fields [14].

3.3.2   Characteristic information

1. **Element type**: For a well-organized the maintenance work that needs to be done on the trees, 4 element types are identified in Barcelona. Road tree: trees that are in located urban plots, predominantly in nursery and in alignment, located in an environment close to buildings and/or roads, which requires a more frequent maintenance pruning than the other types. Zone tree:

tree in urban fabric, especially in parterre or sauló, which due to its location does not affect buildings or the passage of vehicles, so pruning is different in frequency and shape from that of road trees [15].

2. **Size**: The size of the trees is classified into 4 categories. Apart from 11506 trees have no record on its size, most of the trees are identified as medium size, huge size and exemplar size.

3. **Tree category**: In order to facilitate maintenance work, in Barcelona the trees are grouped into four categories according to the perimeter of the trunk (measured at 1 meter from the ground). In the case of palm trees, this classification is determined by the height of the stem (trunk). In this data set, 88300 of the trees are in the second category which consists about 43%, 22% in the first category, 20% in the third category and 10% in the exemplary category [15].

4. **Data of plantation**: The year when the tree was planted

5. **Width**: The measurement through all the way around the middle of the tree.

6. **Scientific name type**: there are 342 scientific names of the trees were identified in the data set.

7. **Spanish name type**: Tree names that are called nationally in Spain and there are 285 Spanish type names were identified.

8. **Catalan name type**: Tree names that are called locally in Catalonia region and there are 326 Catalan named types were recorded.

9. **Catalan species ID**: an ID that was given by the region of Catalonia by the tree's species.

3.3.3 Environment Information

1. **Water Type**: Even though most of the water types are not being recorded in the data set, there are 3 main water types. Phreatic(deep-rooted plant that obtains a significant portion of the water that it needs from the phreatic zone); Portable(trees that are being watered from a portable water source); Regenerated(recycled water for trees that are located in places where the supply of the natural water resources are insufficient).

2. **Watering method**: there are 7 major watering methods being used. Aspersion, Dissemination, Dropping, Damaged dropping, Gardener, Hose and Rotator.

3. **Surface type**: The surface type where the tree is planted

4. **Tree pit support type**: Tree pit support is a support that surrounds the initial hole a tree is planted in.

5. **Tree neck covering**: A covering that is placed in the middle of the tree.

6. **Tree pit support edge**: The edge of the pit support of the tree.

7. **Tree pit support size**: The size of the pit support of the tree.

3.4 Data understanding of UAB data set

In the data that was shared for this project, we have in total 4923 registers. And there are 4 different information were recorded in the data.

1. LATITUD_WGS84: Coordinate measurement.

2. LONGITUD_WGS84: Coordinate measurement.

3. Latin Specie name: Specie name in Latin. There are in total 120 Latin specie names were recorded.

4. Specie name: Specie name in general term. There are in total 42 general specie names were recorded.

3.5 Data Visualization

To have a closer look at the data, I started with importing XYZ data into ArcMap Point Data Layer by using the CSV file that contains XY geographic information. With display XY Data of ArcGis, I set X field to longitude and the Y field to Latitude with WGS84 geographic coordinate system referenced. Later by adjusting symbology, we can finally visualize the data in a map. Barcelona has more than 150,000 trees planted on the streets, the management of which is a priority of municipal policies in order to structure a global green system that contributes to improving the quality of life of citizens.

3.5.1 Result of the visualization

Through computer program ArcGis and web aplication Carto, I used 4 CSV files individually to make three maps (Figure 1, Figure 2, Figure 3, Figure 4) to have a basic learning of the data visually.

Fig. 1: Map of Trees in Barcelona - Zone trees

3.5.2 Problems with the visualization of the data

As the geographic position of Catalonia, the official geographic coordinate reference is ETRS89 31N. In the coordinates system ETRS89 31N of Catalonia, The X values are always 300000 or 400000 and the values of Y are million between 4,000,000 and 4,500,000. Fields 1 and 2 represent these X and Y data.

The values of X and Y I got from the dataset are much larger than expected. Possible cause of this is that decimals

Fig. 2: Map of Trees in Barcelona - Street trees
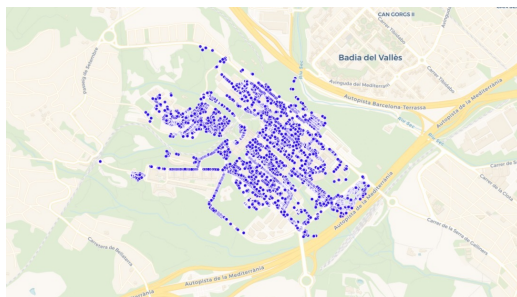

Fig. 3: Map of Trees in Barcelona - Park trees

Fig. 4: Map of Trees in UAB campus

have been removed while importing the data due to the big number we are dealing. On the other hand, In Spain, the use of comma (,) and period(.) are different from most English-speaking countries or are the opposite usage to most English-speaking countries. (Example: twelve and thirty-four hundredths in English number writing is 12.34 while in Spanish is 12,34. And 1,258 means one thousand two hundred thirty-four in English and respectively one and two hundred thirty-four thousandths in Spanish)

With some help, I quickly found the solutions to these problems

1. Re-downloading the data set.

   The simplest solution is to re-download the data then carefully export and import them for later data processing.

2. Changing manually.

   Through excel or text programs to visualize the CSV file in order to find the problem then change the data error manually.

4   RESULT

The final results of this project are a fully functional web application and a python language based tree locator which we at later stage we can integrate it into our web application interface.

4.1   Web application

The web application we developed with Angular can adapt both mobile phone and desktop users as we can see at Figure 5. However, the interface layout is exactly the same. There's a navigation bar on the top and a footer on the bottom floating on the interface. The web application contains 7 different components which will be individually explained.
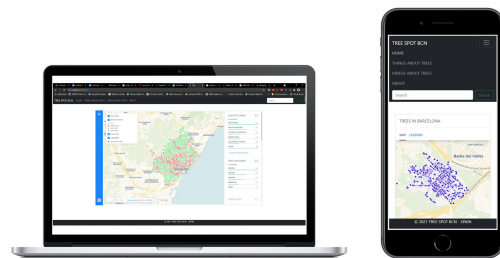

Fig. 5: Web Application interface on desktop and phone

4.1.1   Homepage

On the homepage of the web application(see Figure 6, a map that was made with Carto specifically for this project is positioned in the center. On the map, people can interact with data statistics by tapping on specific points on the map (see Figure 7). You can also put in your address in the search bar to look up all the information about the trees around you.

4.1.2   Things about trees page

Things about trees page is a component where users can look up information and fun facts about trees in Barcelona. (see Figure 8) It was integrated with Angular pipe commands. This is a page that we can regularly update or even in future we can use it as a platform to collaborate with citizens to post things about trees in Barcelona.

4.1.3   Videos about trees page

On the videos about trees page, this is where we implanted the YouTube API. (see Figure 9) On this component, users can receive the latest videos about trees from YouTube. People can not only learn about tree but also learn knowledge about identifying pests and possible diseases. The root of the videos update is a admin managing a YouTube playlist which at later stage of the project can also be collaborative with citizens.
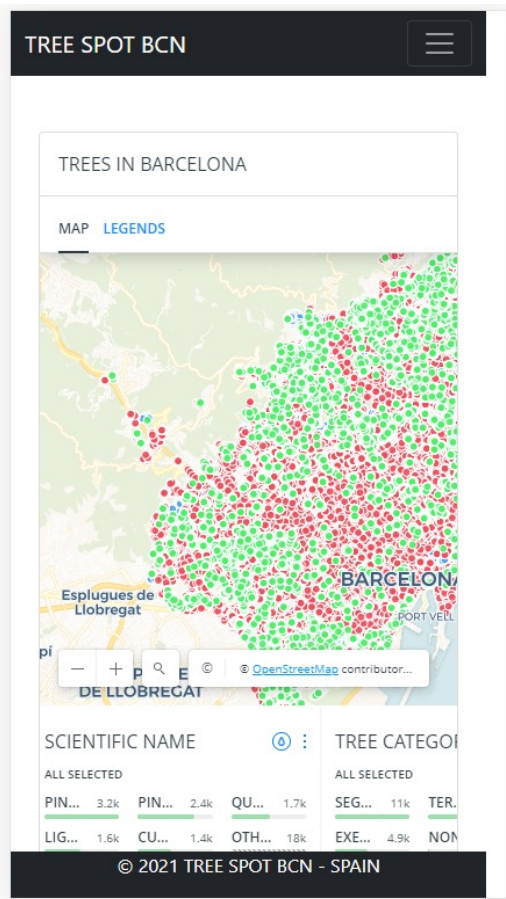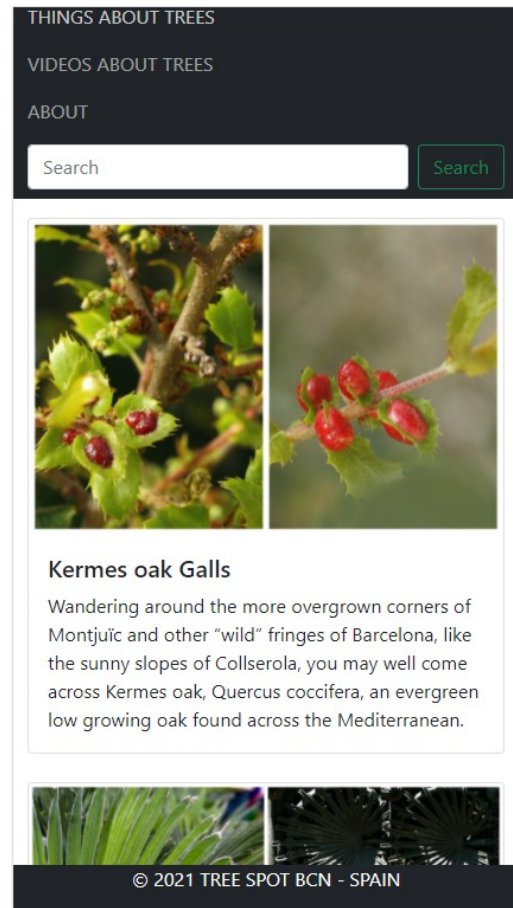
Fig. 6: Homepage of the Web Application

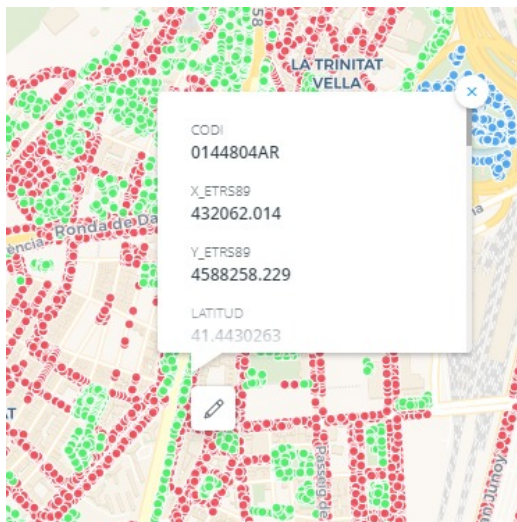Fig. 8: Things about trees page of the Web Application

4.2 Python Function

4.2.1 Input

We need to create a way to allow python to read our inputs. To achieve that, we need to create 3 arguments named latitud, longitud and accuracy. Arguments in python allow us to send values or information to a function when it is called. After defining what arguments our function requires, argparse will figure out how to parse those out of sys.argv. The argparse module also automatically generates help and usage messages and issues errors when users give the program invalid arguments. The first step to apply argparse into our function is creating an ArgumentParser object, and we name it tree finder.

Filling an ArgumentParser with information about program arguments is done by making calls to the add_argument() method. Generally, these calls tell the ArgumentParser how to take the strings on the command line and turn them into objects. This information is stored and used when parse_args() is called [16].

After we have all the arguments as strings, importantly, we need to convert them into floats and int. This is important since we later need to perform mathematical operations on the string that contains the float number in order to compare information that is in the dataset.

4.2.2 Information selection and Output.

We need a algorithm to select information of our interest in a spatial sense. When the inputs are read by python, we

Fig. 7: Onclick information about each point

4.1.4 About page

About page consists a formula where users can contact the admin by email to send us feedback about the experience of the application.(see Figure 10) For a later stage, we can add more features to this component where users can report possible tree diseases or pests to us and we can share the report with city hall so they can send over maintenance team to look up the tree that was reported.
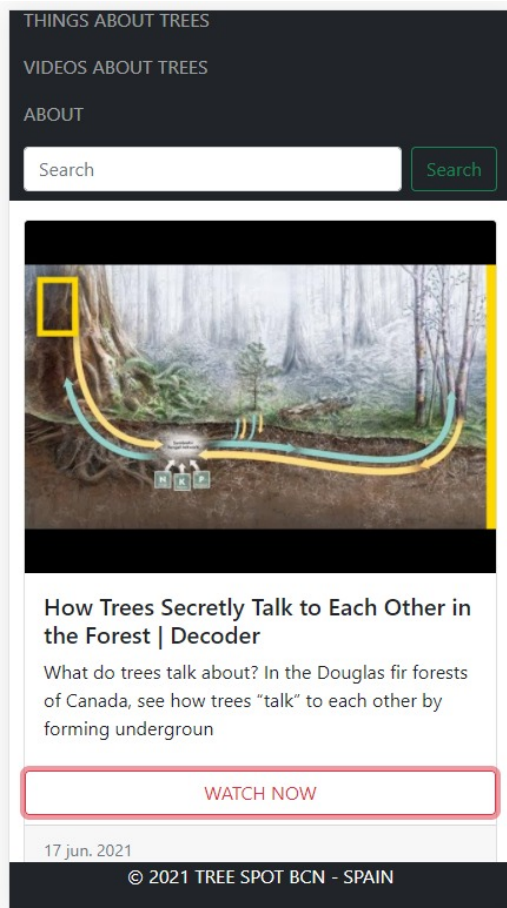
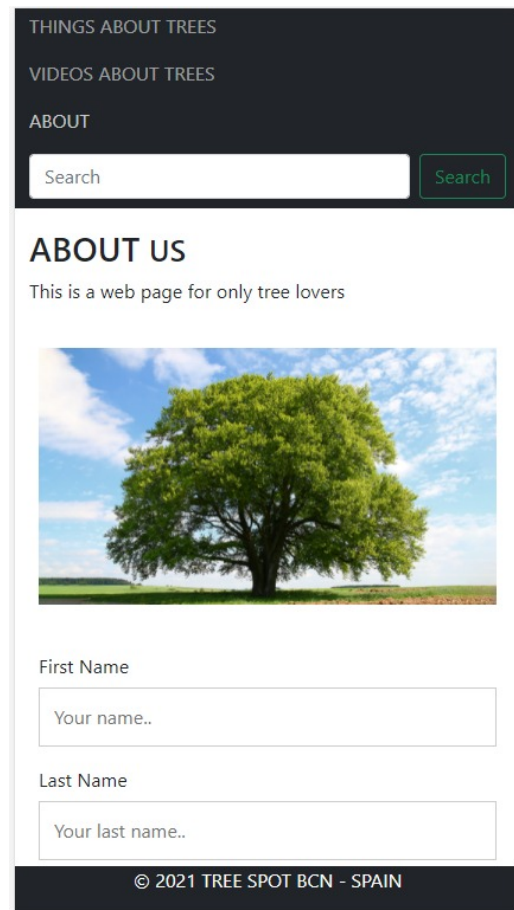Fig. 9: Videos about trees page of the Web Application

Fig. 10: About page of the Web Application

have longitude and latitude information and also accuracy ratio. As we can see longitude and latitude are not in line (Figure 11) so we have to filter twice to be able to get all the geographically fit points and to return to us. The input accuracy defines the matching numbers after decimal points. The function we use is to first filter the latitude with the latitude argument input then filter again with longitude argument input in order to get the most precise spatial matching points. Then the function will return us with the rows that match. Although not all the information of one row is in our interest, so we need a print command to return us with the tree specie and its coordinate position.

5   CONCLUSION

5.1   Technical aspect

After the study, we summarised a conclusion from a technical aspect. We analysed all technical tools that were used in this project from its pros and cons to learning curve to offer an insight on how these technical implantation can be applied in the process of research.

5.1.1   ArcGIS

For this particular project, spatial data is the core of this study. And spatial analysis goes beyond locations on the map which is one of the most powerful features in GIS. It integrates spatial and tabular analysis not only with maps, but also with tables and charts. ArcGIS offers a very easy
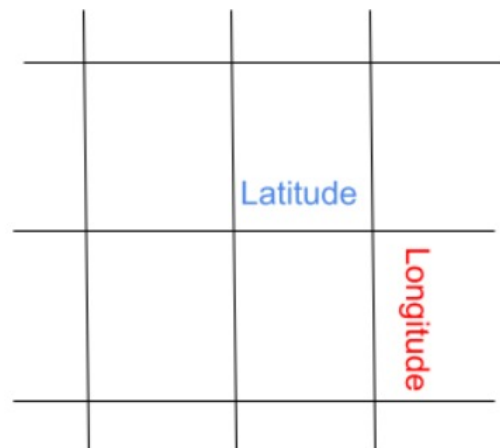

Fig. 11: Longitude and Latitude simulation

to use and advanced analysis tools across the program and its platform. ArcGIS is the top program to work with whether your analysis requires a simple online map viewer, a powerful desktop application, a drag and drop interactive approach, a dynamic scripting environment, or all of the above.

However, ArcGIS is a very pricey tool and you will not be able to get an access to the program until you pay for the license. Another disadvantage of ArcGIS is that is not open source [17], this can be the reason why its not preferred in academia studies. The interface of ArcGIS program is not very friendly, it can be very hard to know where the specific

tools are.

5.1.2 Carto

As mentioned before, ArcGIS is a very powerful tool but it's not open source. To be able to display the map on our web application, Carto enabled us to display it using spatial data through an iframe. Carto is very user friendly and has a very huge variety of tools that are not only suitble for academic research but also for business. For example that you can use Carto to design a more efficient delivery routes, a better behavioural marketing, a strategic store placements, and much more.

5.1.3 Angular

We used angular as the web application's framework, and it suits the project perfectly since it is an open-source typescript-based framework. To be able to work with Angular, it totally depends on your knowledge and learning of JavaScript. So if you have a basic knowledge of JavaScript, it would be easy for you to sail through [18]. Angular is a complex and verbose framework with many ways to solve a single problem. It has intricate component management that requires many repetitive actions. But at the same time, they are not well versed with your basics then indeed learning Angular will be an uneven hilly patch for you. And I made a learning curve to represent the using of angular for this project (see Figure 13). The amount of time required to produce the first unit (T1): 6.00 hours, the improvement factor (m): 0.5 and the unit number (n'th unit): 5.00. And we get the result as The amount of time required to produce the 5'th unit: 2.68 hours (6 * 5-0.5).
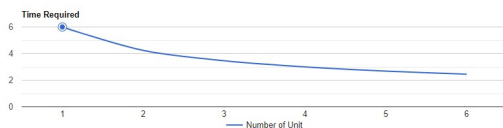

Fig. 12: Angular Learning Curve

5.1.4 Python

Python is easy to learn with a steady learning curve. Especially when compared to other programming languages that have a very steep learning curve. Python is considered the easiest language to learn and should be one of the first languages that you should learn when considering programming, and this has a huge reflection on this project that we were able to code our own function after 2 weeks with only very basic entry knowledge of python.

5.2 Social impact

This project can play an important role in citizen science with the approach in contributing to tree health engagement which can be applied on many other aspects of the green infrastructure of the city. It also has a huge impact in terms of inspiring a large number of people, especially young people to care more about trees and the environment in general. Users can not only learn something new but also can positively change their attitudes to mother nature.

5.2.1 Application on city of Barcelona

On the scale of the city, the web application can be used by all the citizen. The participation of citizen is very important in this project. This project can help the city not only to address concerns about the pests and diseases that are threatening trees and woodlands, but also addressed the Government's objectives to raise public awareness of tree and green infrastructure health and empower people to work with officials to monitor trees. The environment and nature is the responsibility for everyone, and this web application can be a perfect respond to get everyone involved protecting the green infrastructure of Barcelona.

5.2.2 Application on campus of Autonomous University of Barcelona

This web application can be used as a base for a lot of other meaningful researches around the campus. However, the data we obtained from trees in the UAB campus is consisted with very simple geographic and specie information, We can use this app application to motivate students to do tree census on their own on the campus then send their data to corresponded admin to update new information into our data. Also this web application can help other students to locate and learn more about trees on the campus, and we on the web application, people can also learn how to identify and report trees diseases to help the tree health.

6 FUTURE WORK

The final products we get from this project can really contribute something good to our city. We are creating a platform that is tightly linked with trees and green infrastructure of the city. The web application can be an enabler for citizen science projects that are oriented by green infrastructure. In the future, there is possibility that we can integrate GPS (The Global Positioning System) into our web application to offer users a more real-time interactive experience. Also there are much more aspect to dive in about trees. We can include allergies information in our data which can help citizen to avoid certain locations in the city thus reduce the risk of allergic reactions.

7 ACKNOWLEDGMENTS

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A   APPENDIX

A.1   Annex. Python Code

```python
import csv, time, argparse
#import csv and nesassery libery

#using parser to create argument reader, arguments that are inputs that are passed
into script
parser = argparse.ArgumentParser(description="tree finder")
parser.add_argument("latitud",help="input your latitude")
parser.add_argument("longitud", help="input your longitude")
parser.add_argument("accuracy", help="select accuracy of results")
args = parser.parse_args()
#convert arguments into floats and int
myLatitude=float(args.latitud)
myLongitude=float(args.longitud)
accuracy = int(args.accuracy)
#to check the delay of running the data
start_time = time.time()
#open the csv file as binary
with open ('mapdata.csv',"rb") as a:
    #convert the binary data into utf8 in order to handle all the special
    characters in spanish
    acsv = [x.decode('utf8').strip() for x in a.readlines()]
    csv_reader = csv.reader(acsv, delimiter=',')
    #the csv_reader is to create an csv object with the delimiter ,
    treesInLatitude = []
    #this is list, this needs to be outside of the loop since the input will
    be accesible in the next loop.
    for row in csv_reader:
        #we can see, I did once for the raw data filtered for latitud
        then appended it to treesInLatitud
        rowFloat = float(row[3])
        if round(rowFloat,accuracy)==round(myLatitude,accuracy):
            treesInLatitude.append(row)
            #for loop through treeInLatitud printing out all trees found in latitud
    for row in treesInLatitude:
        rowFloat = float(row[4])
        if round(rowFloat,accuracy)==round(myLongitude,accuracy):
            #print the result which is the output of this script
 print(
 f"found tree species: {row[5]} at address: {row[7]} with coordinate {row[3]}, {row[4]} "
     )
end_time = time.time()

print("Read time: ", (start_time-end_time), "seconds")
```

A.2   Annex. Tables about characteristic of Barcelona data set

TABLE 5: ELEMENT TYPE IN BCN DATASET

Element Type	Number of trees
Road Tree	154970
Zone Tree	41813
Road Palm Tree	5539
Zone Palm Tree	2025
Total	204347

TABLE 6: TREE SIZE IN BCN DATASET

Size	Number of trees
Exemplar	7925
Big	49714
Medium	81008
Small	54194
No Record	54194
Total	204347

TABLE 7: TREE CATEGORY IN BCN DATASET

Category	Number of trees
Exemplar	21081
First	46611
Second	88300
Third	42258
No Record	6097
Total	204347

TABLE 8: F. TREE PIT SUPPORT EDGE IN BCN DATASET

Edge	Number of trees
Others	7750
Without Edge	69333
Concrete	63251
Metal	39088
No record	24925
Total	204347

TABLE 9: YEAR OF PLANTING IN BCN DATASET

Year	Number of trees
<01/01/2006	177443
2006	1
2007	459
2008	886
2009	2175
2010	2915
2011	2428
2012	1754
2013	1987
2014	2171
2015	1175
2016	2162
2017	1962
2018	2052
2019	2432
2020	1609
2021	736
Total	204347

TABLE 10: WATER TYPE IN BCN DATASET

Type of water	Number of trees
Phreatic	863
Potable	4951
Regenerated	38
No record	198495
Total	204347

TABLE 11: WATERING METHOD IN BCN DATASET

Watering Method	Number of trees
Aspersion	2362
Dissemination	980
Dropping	11148
Damaged Dropping	1612
Gardener	1
Hose	5924
ROTATOR	87
No record	182233
Total	204347

TABLE 12: SURFACE TYPE IN BCN DATASET

Type of Surface	Number of trees
Others	2266
Grass	19039
Grass with vegetation	3236
Pavement	146384
Sandstone with vegetation	11276
Sandstone without vegetation	13562
No record	8584
Total	204347

TABLE 13: TREE NECK COVERING TYPE IN BCN DATASET

Type of Covering	Number of trees
Others	557
Padding	2909
Gravel	847
Cobblestone	173
Drained Pavement	1848
Contrate Grid	338
Metal Grid	3670
No Covering	158806
No Record	35199
Total	204347

TABLE 14: TREE NECK COVERING TYPE IN BCN DATASET

Type of Support	Number of trees
Others	4522
Elevated	167
Square	102365
Rectangular	31344
Round	11454
Triangular	165
Garden	1101
Ground	43472
Elevated Ground	1473
No record	8284
Total	204347

A.3   Annex. Maps
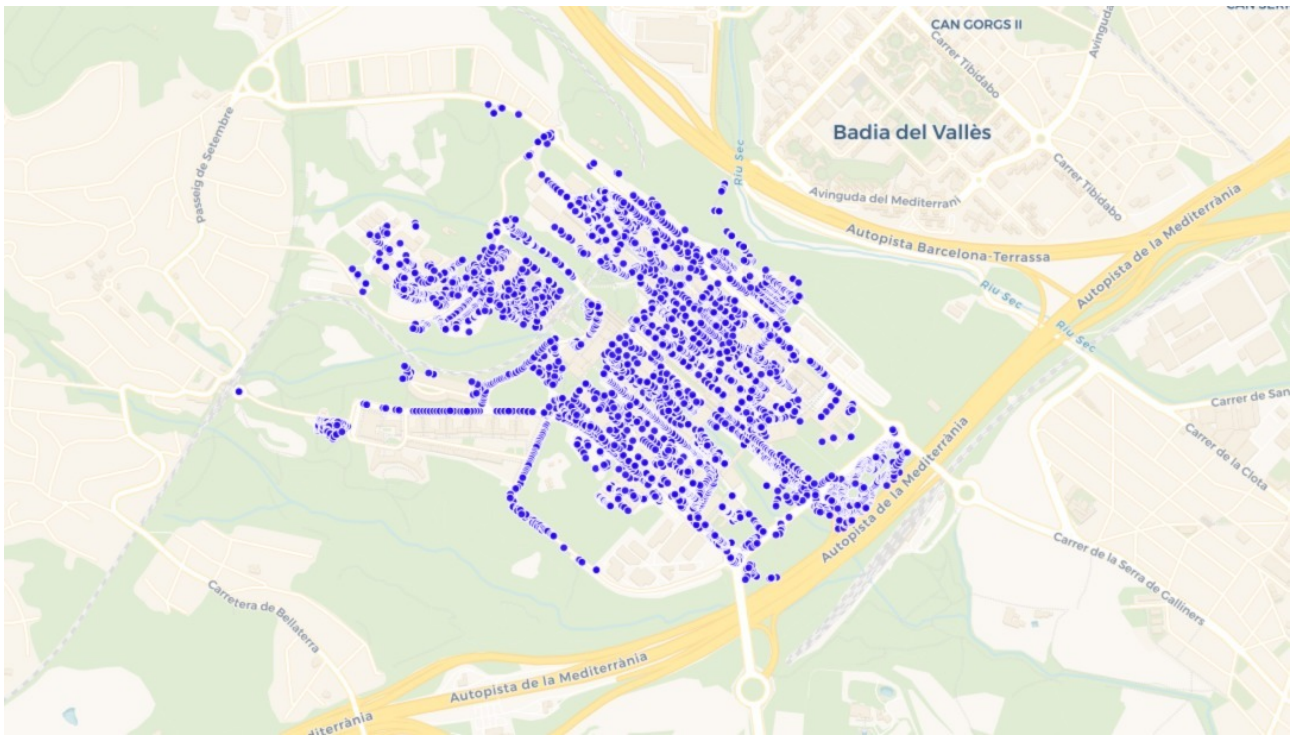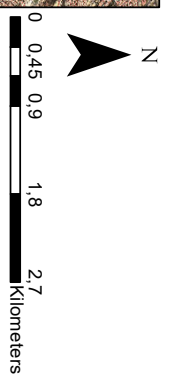

Fig. 13: MAP OF TREES IN UAB CAMPUS

Fig. 14: MAP OF TREES IN BARCELONA - PARK TREES

Legend

• Park Trees

Map of Trees in Barcelona Park Trees 2020

Author
Zerek Zhang

Reference:
1. 2021_1T_Arbrat_Parcs_BCN.csv
OpenData BCN
2. WMS server:
ICGC

N

0   0,45 0,9   1,8   2,7
                           Kilometers

Fig. 15: MAP OF TREES IN BARCELONA - STREET TREES

Fig. 16: MAP OF TREES IN BARCELONA - ZONE TREES