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AI PLANNING TOOL FOR COMMUNITY SHARED URBAN GARDENS

ARTIFICIAL INTELLIGENCE PROJECT

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1 Introduction

Community shared urban gardens are collaborative spaces where individuals from a community can come together to cultivate and maintain gardens within urban areas. These gardens provide a shared space for growing fruits, vegetables, herbs, and flowers. Urban gardening promotes sustainability as they allow communities to produce their own food locally, reducing the need to transport food for long distances. It improves health as gardening is proved to be a good way of exercising and improving mental health, also they give access to healthy fresh produce to consume promoting a healthier diet. Community shared urban growing gardens provide a space for community members to come together and work towards a common goal. In an urbanized world, community gardens connect urban residents and constitute spaces for a commons management of urban resources. Urban gardening also have many environmental benefits, it decreases some pollution caused by food transportation, it combats the urban heat island effect by absorbing sunlight and providing shades, and decreases water runoff by absorbing rainfall. These gardens can also be an opportunity to educate people on food production and consumption, while transforming unused urban spaces into beautiful green areas. There are however some challenges that have to be considered like water resource availability or sunlight and weather conditions. But the main one is the limited amount of land available for this use inside of a city. This last challenge is the one this project focuses on. The aim of this project was to build an Artificial Intelligence tool capable of choosing the best plots of land to be used for urban gardening whilst minimising the necessary amount of land area used. It also must satisfy a minimal produce goal and minimize the distance of the plots to the assigned community. To do so it will take into account the city size, population and geographical location. The idea is that this tool could be used by a city government to help plan and optimize the construction of many urban gardens inside of a city. In addition it create a list of plants which are best considering the geographic location.

2 Model

To solve this problem a model to optimize is needed. The idea is to do so as a constraint satisfaction model. Firstly we assume that each city has a certain number of plots that are available to be chosen for this purpose, each one of these in a different location and of different sizes. For this project these are randomly generated, however the idea is that in a real application a city government draws up a list of plots with location and size. This is also the case for the neighborhoods, in which case the number of neighborhoods generated depends on the city land size and the number of people in each neighborhoods depends on the city population. Taking for example the city of OSLO 45 different neighborhoods and 122 possible plots were generated.

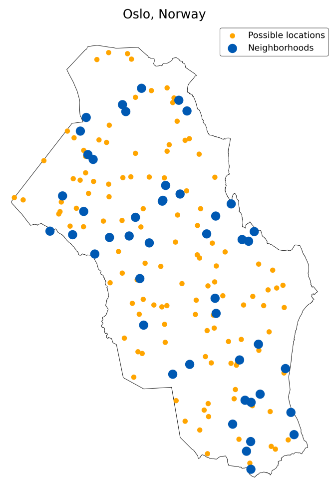

Figure 1: Generated plots and neighborhoods for the city of OSLO

Finally a produce goal is set, this will be a percentage of the yearly quantity of vegetables consumed by each community from their assigned plots of land. For every city a different yield per square meter is computed to obtain the land area needed for the urban gardens. In addition to finding the least number of plots to be assigned, another goal was also to create a program that would offer residents reliable guidance for choosing the best vegetables to plant for their areas, considering the climatic conditions of the previous year. The first step was to create a database of plants, where some of their characteristics like average yield are present, from which we will choose the most suitable plants for the selected city. The focus was on day-by-day temperature, which we used to calculate an approximate monthly average. Based on this information, the optimal growth temperatures for each species was considered and the plants best suited to those the specific climatic conditions were selected. However there are many other variables to consider in agriculture, and climate is only one factor influencing crop success, but this can be a good starting point to improve. For example a future improvement could be to implement another artificial intelligence system to monitor the plant's health and pathologies through various sensors and computer vision to recognize signs of disease or nutrient deficiencies.

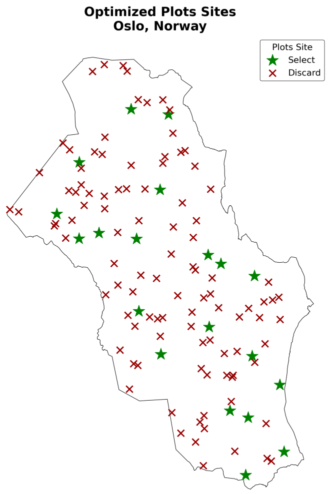

Figure 2: Selected and discarded plots

Finally the constraints can be discussed. Firstly every neighborhood must access only 1 plot:

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad \forall i \in \{1, ..., m\}$$

Where $x_{ij} = 1$ if and only if the neighborhood i is connected to plot j. Another constraint is that the demand of each neighborhood assigned to plot j must be lower than it's yield:

$$\sum_{i=1}^{m} r_i x_{ij} \leq \text{yield}_j \qquad \forall j \in \{1, ..., m\}$$

Every neighborhood must also be connected only to an activated (chosen) plot:

$$x_{ij} \leq y_j \qquad \forall i \in \{1, ..., n\} \ j \in \{1, ..., m\}$$

Where $y_j = 1$ when the plot j is selected. The objective function to be optimized is then written as follows:

$$min \sum_{j=1}^{n} d_j y_j + \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

Where d_j is the size of plot j and c_{ij} is the cost associated with the distance between neighborhood i and plot j. This was all implemented in a python script, the output of which can be seen in the Figure 2 where, for the example of Oslo, only 20 plots were needed and chosen from the 122 possible. The final assignment of each plot to every neighbor is shown below.

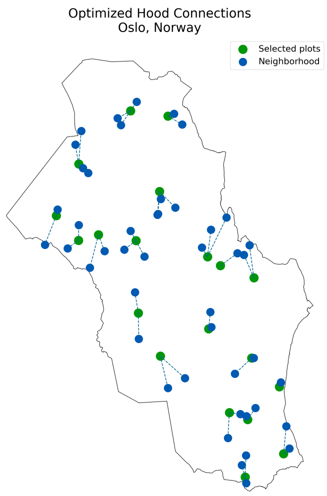

Figure 3: Optimized solution

3 Conclusion

In conclusion our AI tool was able to select the best plots of land to be used as a community shared urban garden and give the best assignments to every neighbor given the selected constraints. The optimization of the objective function was carried out in a python script written in a joint effort of our team members. This tool was tested with 6 different cities (Padua, Naples, Oslo, Montreal, Sao Paolo, Singapore) with success. An advantage of this solution is that it is highly customizable to fit the different use cases, just changing the average yield per square meter can give highly different results, so it could for example be updated yearly with the statistic gathered the previous year to better learn the real possibilities of urban gardening. The code and other result images are left in the appendix for the reader.

Appendix

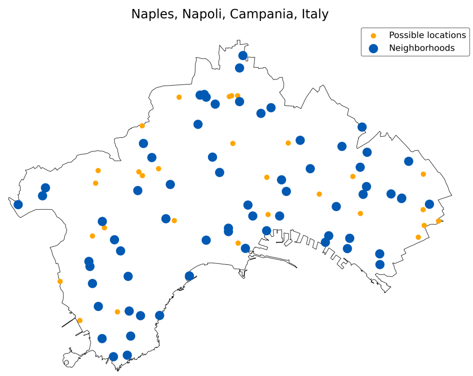

Figure 4: Possible plots and neighborhoods - Naples

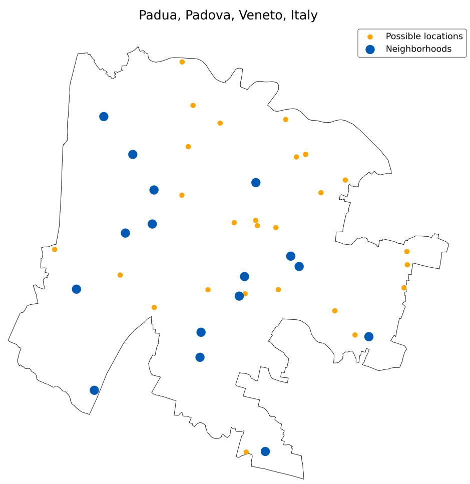

Figure 6: Possible plots and neighborhoods - Padua

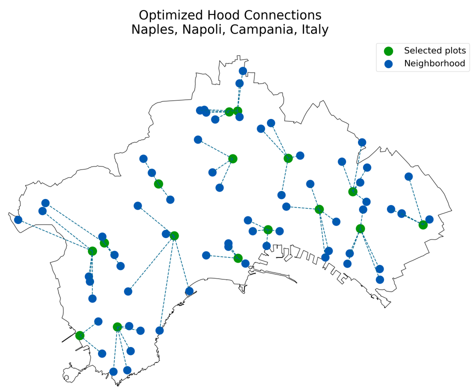

Figure 5: Optimized solution - Naples

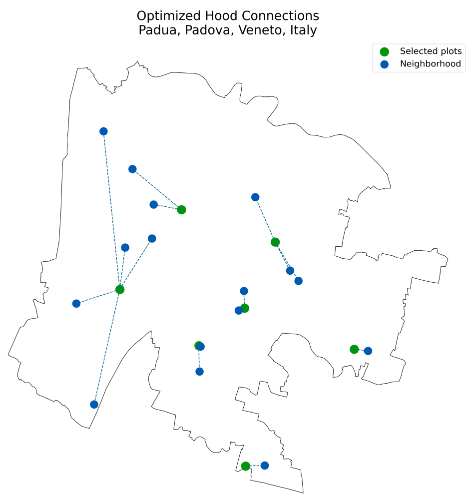

Figure 7: Possible plots and neighborhoods - Padua

	Piante	MESI interramento	MESI interramento 2	TEMPO PRODUZIONE (settimane)	TEMPERATURA MINIMA	TEMPERATURA MASSIMA	RESA PER MQ
16	ZUCCA	Marzo-Giugno	NaN	15	15	40	13.0
8	MELANZANE	Marzo-Giugno	NaN	9	15	35	4.0
2	CAROTE	Febbraio-Settembre	NaN	10	15	35	4.0
12	PEPERONE	Marzo-Giugno	NaN	8	15	40	4.0
10	PATATE	Febbraio-Marzo	Settembre-Ottobre	16	10	25	4.0
9	MELONE	Marzo-Giugno	NaN	10	15	40	3.0
14	RADICCHIO	Maggio-Luglio	NaN	8	-5	25	3.0
17	ZUCCHINE	Febbraio-Agosto	NaN	6	10	40	3.0
7	LATTUGA	Aprile-Luglio	NaN	6	10	25	3.0
6	INDIVIA	Febbraio-Marzo	Luglio-Settembre	8	5	25	3.0
5	FAGIOLINI	Gennaio-Dicembre	NaN	7	10	35	3.0
4	CIPOLLE	Ottobre-Novembre	Marzo-Maggio	12	0	30	3.0
15	SPINACI	Febbraio-Ottobre	NaN	8	10	30	2.0
1	BROCCOLI	Marzo-Aprile	NaN	16	5	35	1.0
13	PISELLI	Ottobre-Aprile	NaN	8	0	30	1.0
3	CAVOLO NERO	Aprile-Settembre	NaN	8	5	35	1.0
0	AGLIO	Ottobre-Febbraio	NaN	16	-5	25	1.0
11	PEPERONCINI	Aprile-Luglio	NaN	8	15	40	0.5

Figure 8: Plants selected - Naples

	Piante	MESI interramento	MESI interramento 2	TEMPO PRODUZIONE (settimane)	TEMPERATURA MINIMA	TEMPERATURA MASSIMA	RESA PER MQ
16	ZUCCA	Marzo-Giugno	NaN	15	15	40	13.0
8	MELANZANE	Marzo-Giugno	NaN	9	15	35	4.0
2	CAROTE	Febbraio-Settembre	NaN	10	15	35	4.0
12	PEPERONE	Marzo-Giugno	NaN	8	15	40	4.0
10	PATATE	Febbraio-Marzo	Settembre-Ottobre	16	10	25	4.0
9	MELONE	Marzo-Giugno	NaN	10	15	40	3.0
14	RADICCHIO	Maggio-Luglio	NaN	8	-5	25	3.0
17	ZUCCHINE	Febbraio-Agosto	NaN	6	10	40	3.0
7	LATTUGA	Aprile-Luglio	NaN	6	10	25	3.0
6	INDIVIA	Febbraio-Marzo	Luglio-Settembre	8	5	25	3.0
5	FAGIOLINI	Gennaio-Dicembre	NaN	7	10	35	3.0
4	CIPOLLE	Ottobre-Novembre	Marzo-Maggio	12	0	30	3.0
15	SPINACI	Febbraio-Ottobre	NaN	8	10	30	2.0
1	BROCCOLI	Marzo-Aprile	NaN	16	5	35	1.0
13	PISELLI	Ottobre-Aprile	NaN	8	0	30	1.0
3	CAVOLO NERO	Aprile-Settembre	NaN	8	5	35	1.0
0	AGLIO	Ottobre-Febbraio	NaN	16	-5	25	1.0
11	PEPERONCINI	Aprile-Luglio	NaN	8	15	40	0.5

Figure 9: Plants selected - Padua