IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE FOR CREATING MAPS

Diploma Thesis

Artificial Intelligence (AI) has started revolutionizing the field of cartography and geographic information systems (GIS). AI can help in processing huge amounts of spatial data quickly and automatically, reducing manual processes in terms of map analysis, and geovisualization, leading to further development of accurate results. ChatGPT is one of the AI-powered large language models that can be utilized alternatively to create maps. To incorporate ChatGPT with data, it's necessary to understand how prompts can generate the most useful results.

The main objectives of this study are to assess the capability of AI-generated maps from ChatGPT-4 and to compare the quality with a traditional cartographic technique. Map results are developed by Prompt Engineering.

1. Objectives

This master's thesis mainly aims to utilize AI for creating maps by applying different prompt patterns. AI-generated maps are compared to maps created through a conventional cartographic method. The map results are based on Python's script according to prompt engineering techniques.

The study sets the following specific objectives to guide the research:

- To evaluate the functional capability and learning ability of the AI in producing maps, in both static and interactive maps.
- To analyze and evaluate different prompt patterns that influence map outputs.
- To assess the map quality between maps generated by the AI and those produced through a traditional method, aiming to identify strengths and limitations.

2. Case study

The case study in this research is a Wildfire situation in Mainland Portugal during 2002–2022.

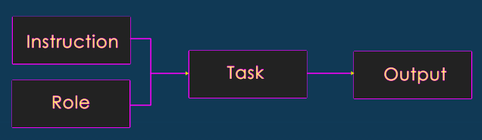
- Average burned area is visualized as a choropleth map,
- Fire spot numbers in each region is visualized as a graduated symbol map.
- Fire spot density is visualized as a dot density map.

The fire data are derived from Global Wildfire Information System (GWIS) and FIRMS NASA.

3. Solution

Basic prompt

Direct instruction pattern is a method that directly instructs the model to follow instructions without providing any examples. This pattern is also known as Zero-shot in prompt engineering.

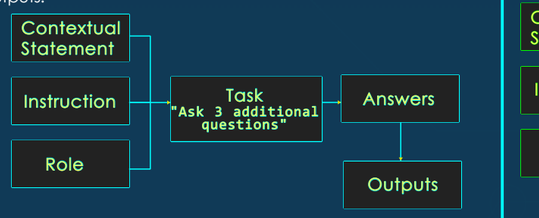


A prompt is the main tool to communicate with ChatGPT-4, then the maps are visualized from AI-generated codes.

The prompt details can affect the level of output quality, this study leverages two different prompt patterns which are indirect prompt as a basic pattern, Cognitive verifier and Question refinement as an advanced prompt.

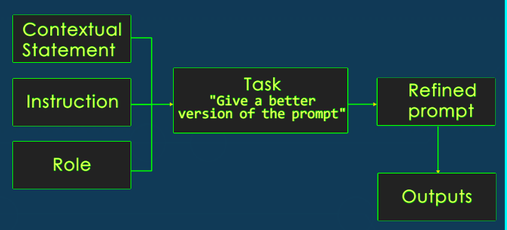
Cognitive verifier

This study applies Cognitive verifier and Question refinement to enhance the quality of the output and details in the prompt which aims to reduce the user's effort in creating a map. The Cognitive verifier can divide sub-questions related to the user's command. Thereafter, the LLM is capable to combine user's answers and process them into the final outputs.

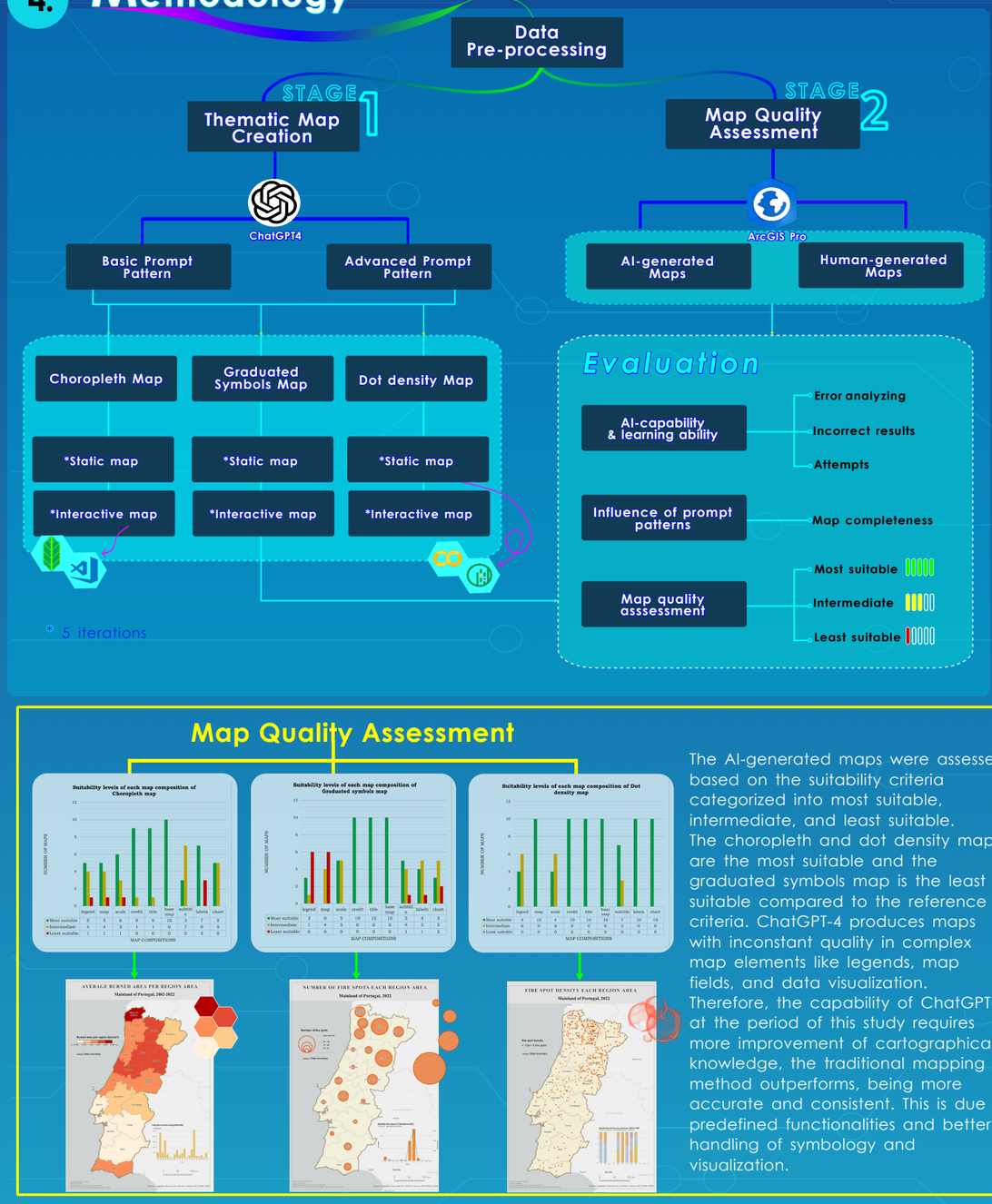


Question Refinement

Question refinement is used for refining map details such as color, placement, and text, including generating map compositions. The advanced capabilities of these prompt engineers enable them to provide refined prompts beyond simple text.

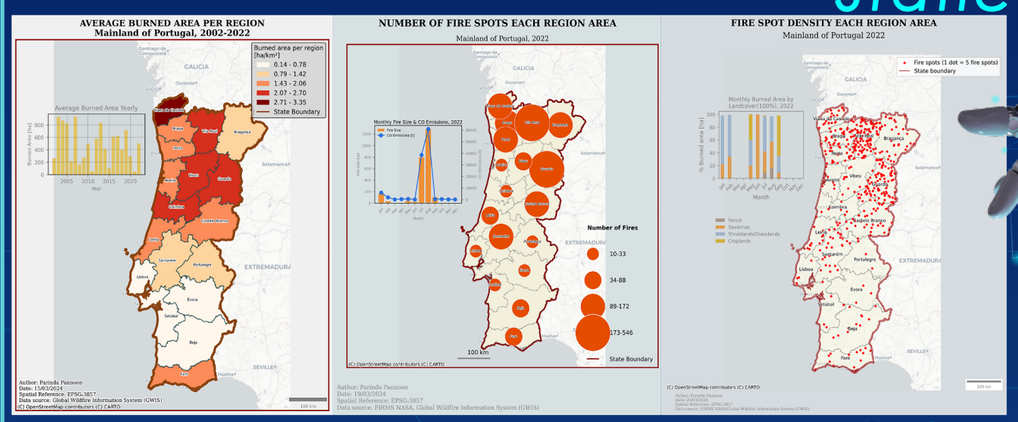


4. Methodology

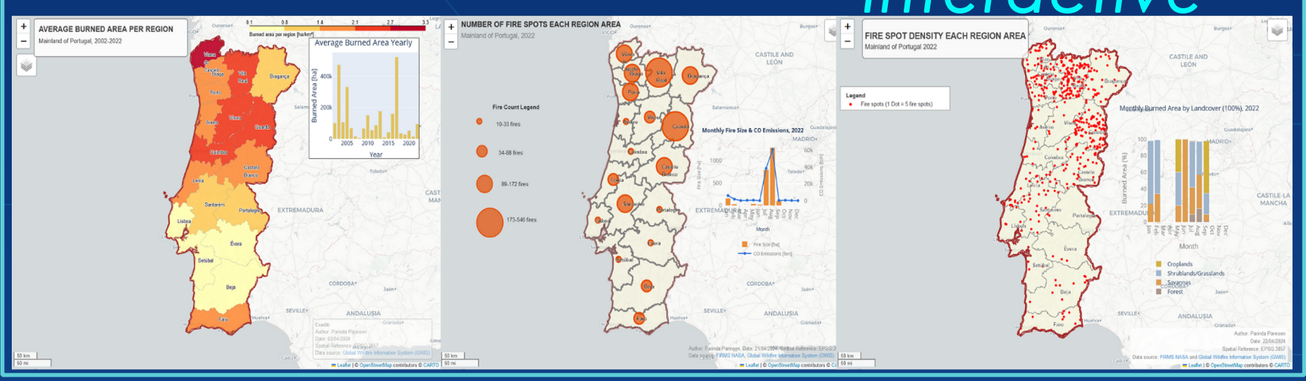


5. Results

Static

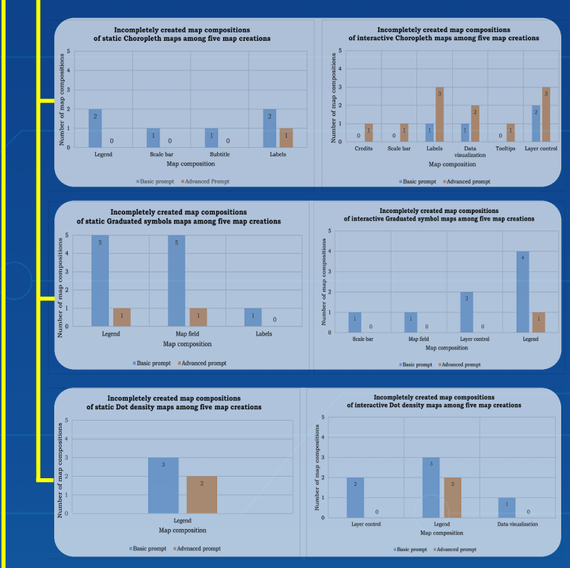


Interactive



6. Evaluation

Completeness of Map compositions

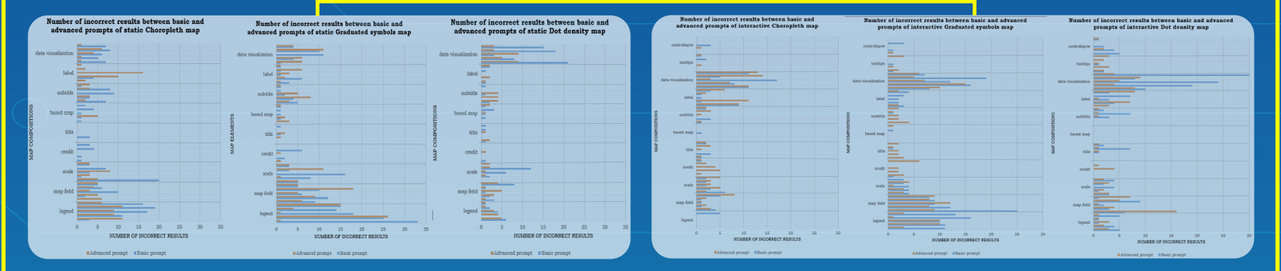


Number of Attempt

The study reveals ChatGPT-4 can achieve all the map compositions according to cartographic rules. The advanced prompts generally can create most of the map compositions successfully more than basic prompts, particularly in complex elements like legends, map fields and data visualizations. However, both prompt types still face challenges, particularly in maintaining consistency and achieving complete map compositions across all map types.

The number of attempts is a factor to evaluate how map results are affected by different types of prompts. The advanced prompts generally reduce the number of attempts in most of the elements, their effectiveness is more pronounced in complex scenarios such as creating interactive graduated symbols maps. However, when considering only the map fields of the choropleth and dot density map, both basic and advanced patterns do not have a large difference of an average number of attempts.

Number of incorrect results



AI-generated maps using ChatGPT-4 can produce hallucination or incorrect map outputs due to the limitation of cartographic knowledge. The advanced prompts reduce the number of incorrect results for certain map elements, but the prompt does not consistently improve all components. Considering map fields from five iterations, the advanced prompt returns more inaccurate results for interactive maps. For static maps, there are no significant differences between the basic and advanced prompts.

Map Quality Assessment

The AI-generated maps were assessed based on the suitability criteria categorized into most suitable, intermediate, and least suitable. The choropleth and dot density maps are the most suitable and the graduated symbols map is the least suitable compared to the reference criteria. ChatGPT-4 produces maps with inconstant quality in complex map elements like legends, map fields, and data visualization. Therefore, the capability of ChatGPT-4 at the period of this study requires more improvement of cartographical knowledge, the traditional mapping method outperforms, being more accurate and consistent. This is due to predefined functionalities and better handling of symbology and visualization.

Number of error analyzing

Another factor in evaluating the capability of ChatGPT-4 is "Error Analyzing" issue, highlight the limitations of the AI in processing spatial data since the error often shows when manipulating the given shapefiles and CSV. The "Error Analyzing" issue in ChatGPT-4 significantly impacts two elements which are a map field and data visualization. For static maps, the advanced prompt generally reduces the number of errors, but this pattern does not eliminate the error in interactive maps which means more refinements is needed for the interactive version to solve the data processing issues.

Making a map with GIS software can be complicated for nonexperts, and the software could be costly leading to the exploration of alternative approaches. The growth of AI has been implemented in the field of cartography, however the accuracy remains to be evaluated and developed. This leads to the assessment of the capability and accuracy of AI in creating maps as well as the map quality compared to a map created by traditional method.

In conclusion, this study reveals the potential of ChatGPT-4 in the field of cartography and GIS but also highlights several limitations. ChatGPT-4 is useful for a basic map without containing so many elements such as plotting an overview visualization of the data. The results can be improved based on the prompts. The thesis can be a guideline for further studies related to ChatGPT-4's functionality in map creation. Also, the results show the insights of the strengths and weaknesses of AI in cartography. In addition, the map outputs based on Geopandas and Folium pave the way for more visual and mapping improvement in the future development of Python libraries for geovisualization.

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Appendix to diploma thesis number 4

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