



5th Intercontinental Geoinformation Days

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MCDM: A new Quantum GIS Plug-In for multi criteria decision making analysis

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Keywords

Geographic Information System
Python
QGIS
Plugin

Abstract

Today, open-source software is free and reliable, and its use has increased. The fact that closed-source software is designed for commercial purposes and its reliability is debatable has encouraged free software developers worldwide to develop alternative software. The number and users of GIS (Geographic Information System) software written in open-source code worldwide and our country is increasing daily. QGIS software is a GIS software developed by free software developers, which is growing in popularity with its new versions and allows plug-in development with the python programming language. The fact that the plug-ins developed with QGIS software can be shared with other users brings together users of open-source geospatial software worldwide for common goals. This study aims to create a plug-in design in which multi-criteria decision-making methods (MCDM) can be used directly and shared with other world users with a plug-in to be developed with QGIS software. For this purpose, a plugin named MCDA has been created.

1. Introduction

Software known as closed source (CSS) is non-free software for which the publisher reserves certain license rights, and the user pays a fee for other people to use, modify or share the software. The expression word free is used in the sense of freedom that the word freedom carries. In this respect, open source software is defined as free software and its users as free software users (Hanbay-Tiryaki and Balaman, 2021).

The first organizational initiative for the development of free software was the establishment of the Free Software Foundation by Richard Stallman in 1985. Another foundation established for free software development is the Open Source Geography Foundation (OSGeo), established in 2006. QGIS is a user-friendly open-source Geographic Information System (GIS) software distributed under the GNU General Public License. QGIS is the official project of the Open Source Geography Foundation. It runs on Linux, Unix, Mac OSX, Windows, and Android and supports many vector, raster, and database formats and functions (Kuka ve Bushati, 2014).

The general purpose of Multi-Criteria Decision Making (MCDM) is to assist the decision maker in choosing the "best" option among the many possible

options in the presence of multiple selection criteria and different criteria priorities. A site selection decision is made in 4 steps. These steps are; determining the criteria to be used in evaluating site selection alternatives, defining critical and practical criteria, developing site selection alternatives, evaluating the alternatives, and making the site selection decision (Erden and Coşkun, 2011).

Although developers worldwide have developed plug-ins for many different purposes, there are a limited number of plug-in studies in the field of MCDM that will help decision-makers make decisions about space. Today, it has become common to make spatial analyzes using MCDM methods in public and private institutions. However, it is still a problem for users to perform these operations after a complex series of processes in the GIS software. Although the number of theses, articles, and publications using MCDM methods in our country has increased considerably in recent years, when the studies in the literature are examined, two main problems have been identified for those who do the study. First, the cost problem arose because the GIS software used in the first place was CSS. The other problem is that many tools and processes using open-source or closed-source GIS software and MCDM methods need to be clarified for the user. In this

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Cite this study

Yılmaz E & Bilgilioğlu S S (2022). MCDM: A New Quantum GIS Plug-In for Multi Criteria Decision Making Analysis. 5th Intercontinental Geoinformation Days (IGD), 90-93, Netra, India

context, it is aimed to develop a plug-in design where users can analyze using MCDM methods without learning the use of a GIS program.

2. Method

2.1. QT

Qt was developed in 1990 by developers Eirik Chambe-Eng and Haavard Nord to design a C++ database application for ultrasound images. Thanks to the Qt library developed over the years, Qt Designer has enabled users to design fast and effective graphical user interfaces (GUIs) without writing long codes (Rischpater, 2013).

2.2. Python

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Highly built-in data structures combined with dynamic typing and dynamic linking make it very attractive for rapid application development and for use as a scripting or glue language for interconnecting existing components (URL-1).

2.3. PyQGIS

PyQGIS is an adapter developed by the QGIS community and required to develop a new GIS software using the Python language and the QGIS API and to make a new plug-in QGIS (Karataş & Kirbaş, 2015). By converting Qt to PyQt and QGIS to Pyqgis, the SIP tool uses Qt and QGIS libraries with the Python

programming language. When PyQt or PyQGIS classes are used with the SIP tool, the codes in C++ classes work using python.

2.4. PyQt

PyQt is a GUI module developed by the British company Riverbank Computing Limited, combining the Qt library and the cross-platform interpreted Python programming language. PyQt4, PyQt5, and finally, PyQt6 were released in January 2021. PyQt has many modules for developing interfaces.

2.5. QGIS

Free and open-source GIS software has increased its popularity as it allows the creation and customization of various spatial applications by meeting the specific needs of its users. QGIS is one of the most flexible of this software. Thanks to the use of python, where users can develop in the GIS software environment, spatial applications are allowed (Oxoli et al., 2016). QGIS also includes a "plug-in" architecture where extensions to the application's core functionality can be developed and used with existing plug-ins (Khan & Mohiuddin, 2018).

3. Results

The Flow Diagram, which includes the menus of the plug-in developed in QGIS software and the steps to be followed when analyzing with MCDM methods, respectively, as a geographical tool, is shown in Fig. 1.

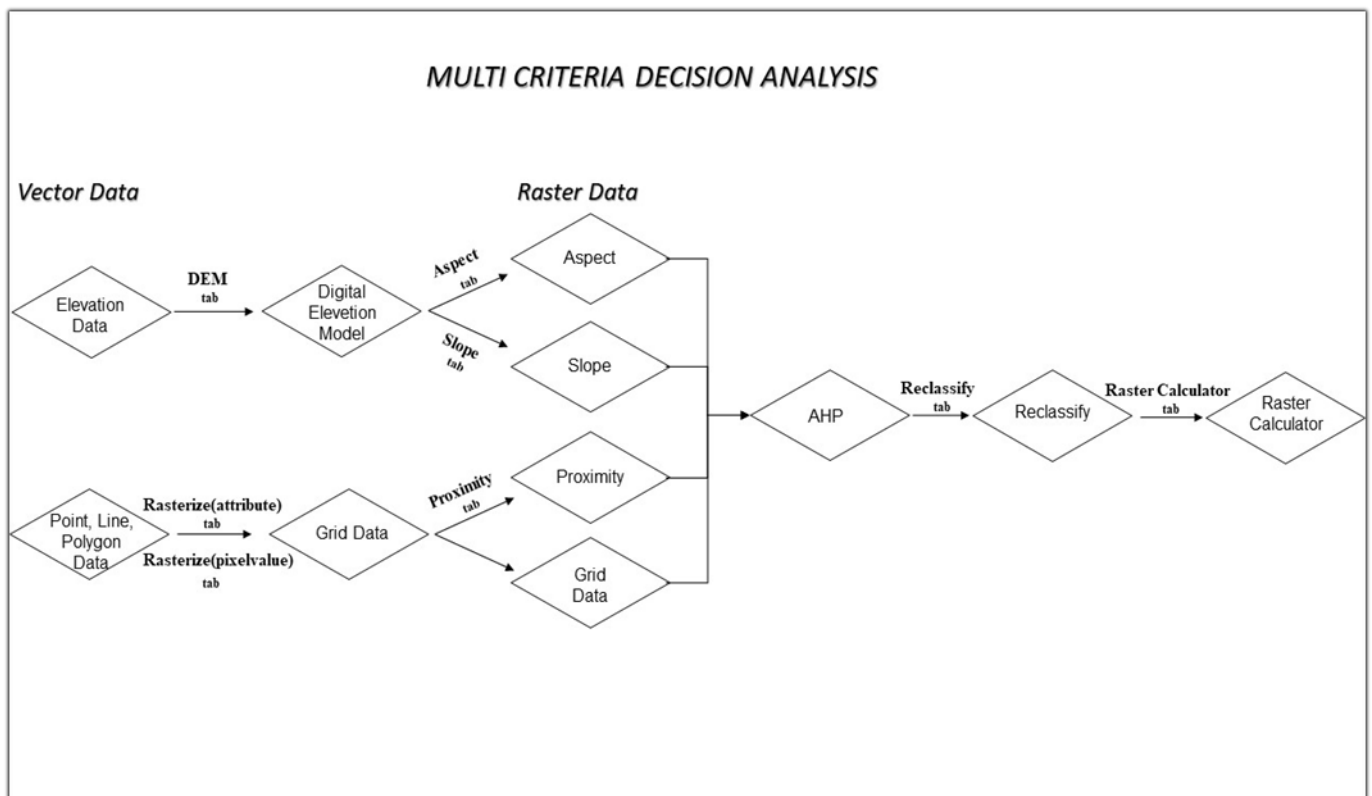


Figure 1. MCDA plugin's menu flows diagram.

Before the functions in the flow chart were coded, the functions that each function would use in common were determined, and the coding process was started. In this context, functions named `dosya_ac()`, `vector_sec()`, `raster_sec()`, `projection_check()`, `name_check()`, `progress()` were written first.

1. `dosya_ac()`: This function will create a new folder named AHP on the desktop when any function in the plug-in is run and save all the files to this folder.

2. `vector_sec()`: Written to import data in vector data format (.shp, .geojson, and .gml) into QGIS 3 software. It is coded to work when the tool buttons of Clip, Dem, Rasterize (attribute) and Rasterize (pixel value) functions are clicked.

3. `raster_sec()`: Import raster data format (.tif, .tiff) into QGIS 3 software. It is coded to run when the tool buttons of the Aspect, Slope, Proximity, Reclassify, and Raster Calculator functions are clicked. 4. `projection_check()`: It gives the information of which projection system the data used in Clip, Aspect, Slope, and RasterCalculator functions belong to, with LineEdit.

5. `name_check()`: It checks whether there is a previously saved file with the same name in the AHP folder.

6. `progress()`: Shows the time-dependent change of the ongoing process with the ProgressBar tool to the user.

7. Then, the functions of the "Grid Data Conversion" and "Weighted Sum" menus in the flow diagram; It is written in the order Clip, Dem, Aspect, Slope, Rasterize (attribute), Rasterize (pixel value), Proximity, Matrix_Calculator(), Reclassify, Raster_Calculator.

8. `Clip()`: Performs the split operation. It is coded to determine the working limit.

9. `Dem()`: It is coded to generate digital terrain model data in raster data format from elevation data in vector data format.

10. `Aspect()`: It is coded to generate a raster data type aspect map from the generated dem data.

11. `Slope()`: It is coded to generate a raster data type slope map from the generated brew data.

12. `Rasterize (attribute)`: It is coded to generate raster data to be created by selecting the desired attribute information from the .dbf file as the numerical value of the pixels from the line and polygon data in vector data format.

13. `Rasterize (pixel value)`: It is coded to generate raster data. The desired numerical value can be assigned as the numerical value of the pixels from the line and polygon data in vector data format.

14. `Proximity()`: Coded to generate proximity state maps.

15. `Matrix_Calculator()`: It is designed as an AHP Calculator tab. From the available comparison matrix values using Multi-Criteria decision analysis techniques, The normalized matrix was coded to calculate the random index, weight, consistency vector mean, consistency index, and consistency ratio values.

16. `Reclassify()`: The generated raster data is coded to assign new pixel values.

17. `Raster_Calculator()`: It is coded to perform mathematical operations on the pixel values of the

raster data in order to obtain a single raster data with new pixel values by multiplying and summing the consistency ratios of the criteria and sub-criteria and the pixel values.

The designed plug-in consists of two menus named Grid Veriye Dönüşüm (Grid Data Conversion) (Fig. 2) and Ağırlıklı Toplam (Weighted Sum) (Fig. 3).

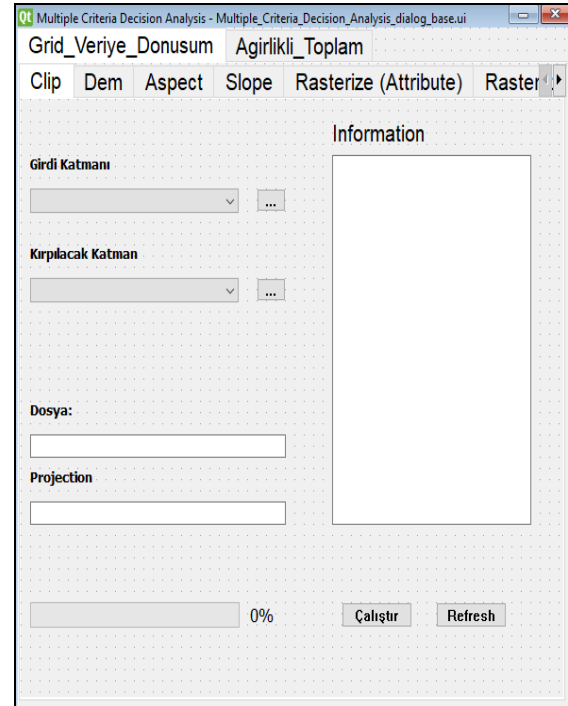


Figure 2. Grid data conversion menu.

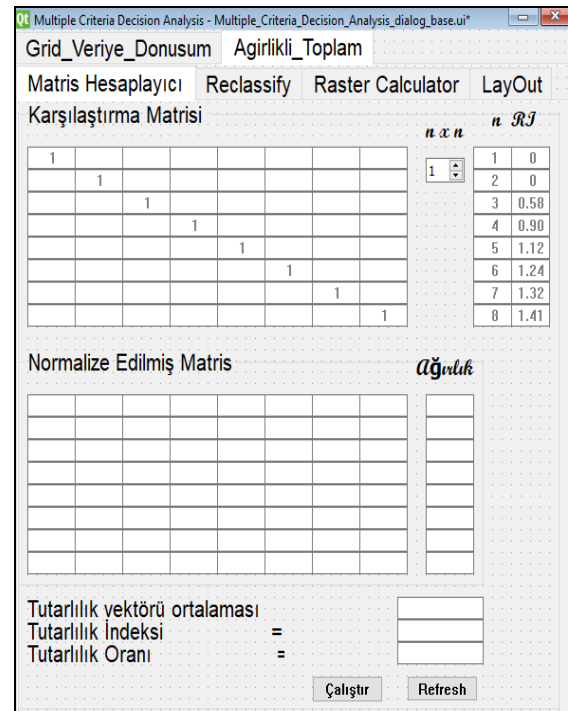


Figure 3. Weighted sum menu.

When the interface design is completed in the Qt Designer program, the functions of the geographical tools to be used for geographical analysis are coded with the help of Python and PyQGIS. After the coding of the functions is completed, it is possible to establish a

relationship between the functions and the menus in the interface design by establishing signal-slot connections. Button, Combobox, etc., in the interface design. The tools emit a signal when clicked. The connection of the broadcast signal with the function (slot) is established by coding with the python programming language. An example of function code shown in Fig. 4 and function signal-slot connection shown in Fig. 5.

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Figure 4. Slope function codes.

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Figure 5. Slope function signal-slot connection.

4. Discussion

In the literature research, it has been determined that open source GIS software is preferred over commercially licensed software in order to make spatial analyzes thanks to its advantages such as free, reliable, changeable, distributable and easily accessible in recent years. In the examinations, it is seen that the work done with the QGIS software, which is the open source GIS software, has increased in the last fifteen years. In addition, another result of the research is the increase in GIS projects using MCDM methods.

5. Conclusion

The study consists of a QGIS plug-in design that will enable geographic analysis. The purpose of the application is to design an open source, free, simple to learn and use plug-in for users who will analyze using MCDM methods. Since the plug-in is designed with open-source codes, it can be further developed by its

users in the future. As a result, a GIS plug-in has been developed, and it is aimed to be presented to the user with all the design phases. The interface design of the plug-in was completed with the Qt Designer software. Geographic tools are coded using the open source python programming language and the QGIS API, and the PyQGIS adapter used in plug-in development. Geographical tools have been designed considering the interface designs of GIS software used in MCDM applications. Thus, it is aimed to be easy to understand for the user. The plug-in that has been prepared has been presented to all users of the world at the address <https://github.com/mreilmzz-hub/MCDA-Plugin>.

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