3D GEOLOGICAL BOREHOLE MODEL USING PYTHON

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64545

Review of Chapter-1

In geoscience, the uses of machine learning technique have been used immensely. It is very difficult to understand the subsurface structures for modeling of geological process. Without boreholes and tunnels, it is impossible to directly access the subsurface and almost all the understanding produce different indirect processes. Boreholes supply information regarding the composition of the earth. It includes holes advanced to collect water sample, soil sample bedrock or rock cores to determine their physical properties. 3D structural modeling is not an end, but it means of developing data interpretation through visualization it can also provide numerical simulations like faults, soil condition, fold structures and unconformities.

There is no available web application to compute the borehole interpolation for determining the soil structure of different location. The interpolation method will be different for every location because the geographical structure may differ with every location. For analyzing the data of borehole interpolation user need to be clearer about the criteria about the interpolation before using it in 3D or 2D visualization model.

For this project there are two main objectives; to project the borehole data into 3D geological representation model and to represent a research on open-source geological software.

Methodology, Borehole data, Interpolation, Outcome

The methodology that we propose is RAD(Rapid Application Development) which is used for creating a system that can be modularized within few months of time. Rapid application development emphasized working software over strict modules and requirements documentation.

Borehole is the term that environmental consultant and engineer use it generally to describe all various types of holes bored or drilled in the earth for geological or environmental site inspection. And this data can be used in interpolation method to demonstrate the soil layer in between the boreholes.

Interpolation is the way toward utilizing points with known values or sample points to assess values at other obscure points. It is used to prognosticate unknown points any geographic point data like noise levels, elevations and so on.

The outcome of this project is the borehole interpolation is a method of finding the subsurface profile between various location to display it in a graph. For geographical structure, a suitable interpolation method needs to be chosen which can show the composition of the soil. Gempy is Python based an open source geomodelling library. It can construct the complex 3D model including various features. Expected outcome will be making a web-based application that can interpolate the boreholes and display the 3D geological model .

Hardware requirements

Hardware Component	Requirements (Recommended)
Processor (CPU)	Inter ® Core™ i7-10750H
Memory (RAM)	8192 MB
Graphic Card	GeForce GTX 1650 Max-Q Design
Operating System (OS) Platform	64 bit

Software Requirements

Software	Requirements (Recommended)
Web Browser	A software application for accessing information on the World Wide Web.
Jupyter Notebook	The Jupyter Notebook is an open-source web application that allows you to create and share documents. It is uses to write the source code for this project.
Creately	It is a online based tools to draw a flow chat for this project.
GitHub	GitHub is a code hosting platform for version control and collaboration

Open source tools or GIS software

Generally, it is quite complex and tiring process to select the right tools or software because to elect a preferred software package that meet the required conditions and requirements. Because of the expanded capability of the software, the costs of cutting-edge GIS software bundles have expanded. GIS software envelops a wide scope of utilizations which include the utilization of a mix of advanced guides and georeferenced information. GIS software can be arranged into various categories. One single software is not able to satisfy all the needs. For further studies, the open source tools and software are :

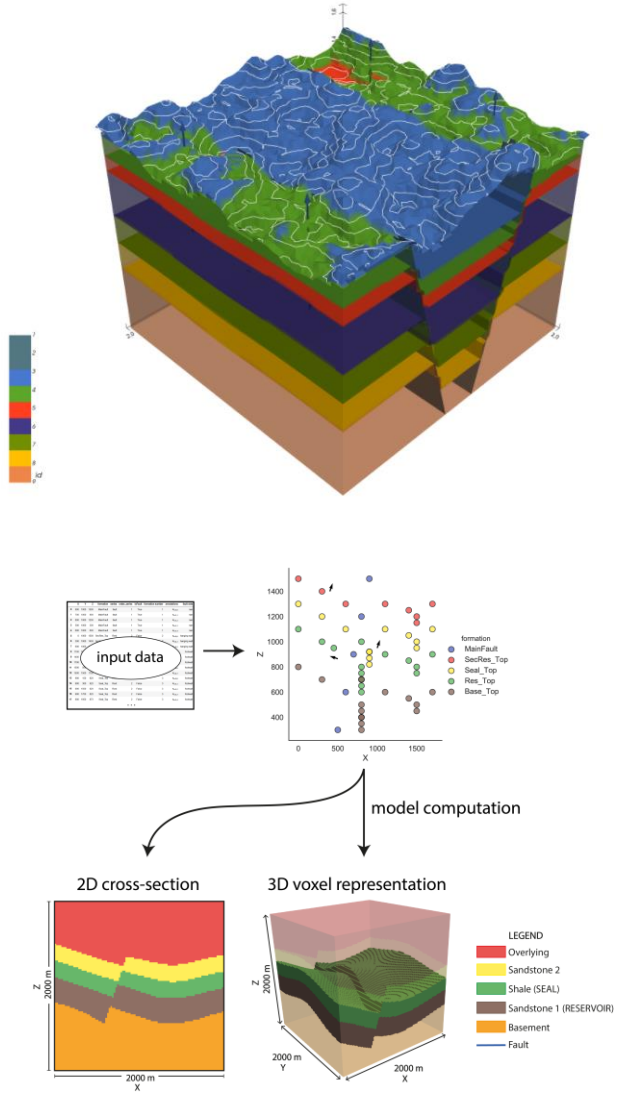
1. Gempy.
2. Leapfrog.
3. QGIS

Software Criteria

The criteria on which the software bundles are assessed are significant in the dynamic cycle. The necessities and wants that the software or tools should meet are set by the criteria. Studies are done portraying techniques and instruments for software choice. There are five main criteria that defined for selecting suitable software or tools. They are functionality, reliability, usability, cost and vendor (Eldrandaly & Naguib, 2011).

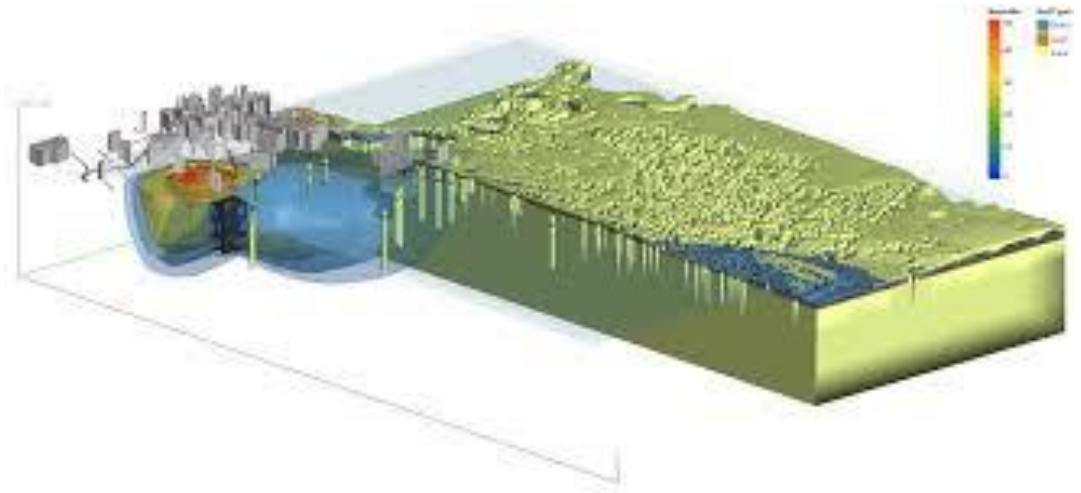
Gempy

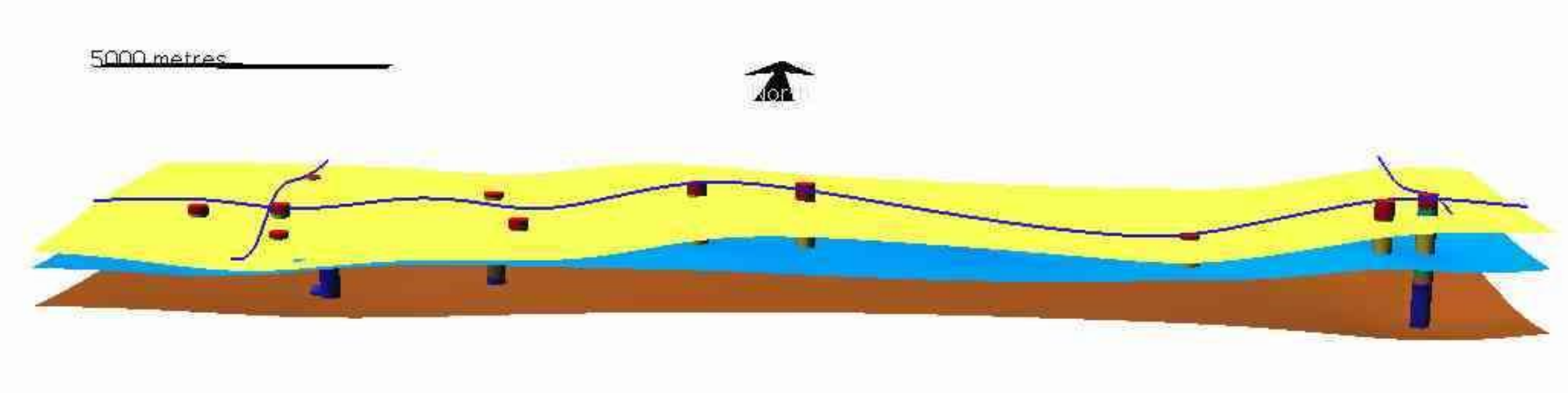
GemPy is a Python-based, local area driven, open-source geomodeling library. It is equipped for developing complex 3D geographical models including different highlights, for example, faults structures, unconformities and fault network, considering underlying powerful implicit approach. From the beginning, GemPy was intended to be handily implanted in probabilistic systems for leading vulnerability analysis with respect to subsurface structures.



Leapfrog Works

Leapfrog is a geological modelling gave by Seequent. Leapfrog offers a few modules, including Leapfrog Geo and Leapfrog Works. Leapfrog Works is explicitly created for the demonstrating of the subsurface and environmental project and gives bits of knowledge into subsurface information inside a 3D environment. The geological modelling software permits quick operation ofgeographical organizations straightforwardly acquired from drill hole data. Leapfrog Works offers a few paid licensing choices for various purposes.





QGIS

QGIS is an open-source GIS where geographic data can be seen, altered and analysed. QGIS is a Free and Open-Source Software (FOSS) and depends consequently on the help of volunteers and benefactors. QGIS offers a developing number of functionalities, in the application itself and just as by the establishment of modules. Since a year, QGIS incorporates a 3D plugin offering instruments for 3D visualization.

Average scores of main software criteria

The average scores of the main software criteria are shown for each alternative. (Meiracker, 2019)

Criteria	Gempy	Leapfrog work	QGIS	MAX
Functionality	18	23	15	25
Reliability	11	11	6	15
Usability	17	17	14	25
Cost	22	20	25	25
Vendor	22	23	21	25
Σ	**90**	**94**	**81**	**115**

Software Installation

Before proceeding to develop the prototype, we need to setup and install various software. For our main software Gempy it has specific hardware requirement, as we are doing this project using Python. So, at the beginning we are going to install python.

As this project is web base so we need to install one web browser like Google Chrome. For our project we use Google Chrome which is simple and can be able to execute the file easily

To run the project, we are using Jupyter Notebook. In jupyter user input programming code or text in rectangular cells in a front-end website page. The program at that point passes that code to a back end 'Kernel', which runs the code and returns the outcomes.

To draw the flowchart, we are using Creately. Creately simplified diagramming so anyone can convert their thoughts into visuals without any difficult steps

To store the data and code we are using GitHub. GitHub is a code facilitating stage for adaptation control and joint effort. It lets you and others cooperate on projects from anyplace

First Cycle of Prototyping

Process of different steps before achieving the 3D model. In figure (a) simple calling the matplotplib where the given extent and the chosen direction; (b) loading the pyvista for 3D plots; fig(c) 2D cross-section come out in matplotlib after plotting three surface point and one orientation point; fig(d) The 3D model pop up in pyvista with two surface layer after plotting after plotting three surface point and one orientation point.

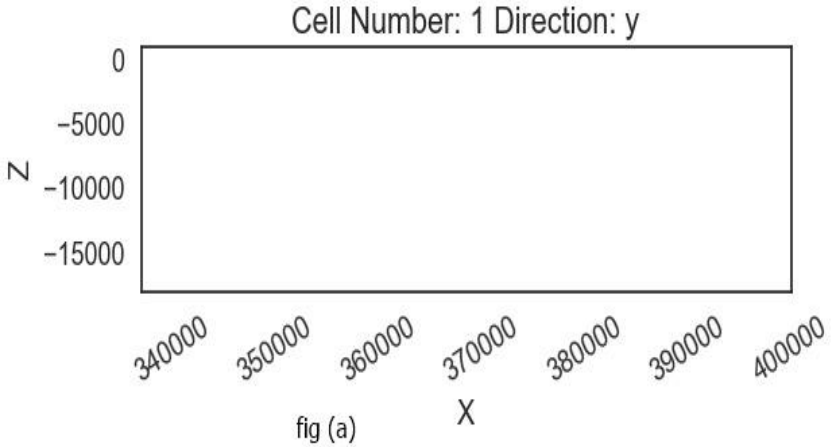


fig (a)

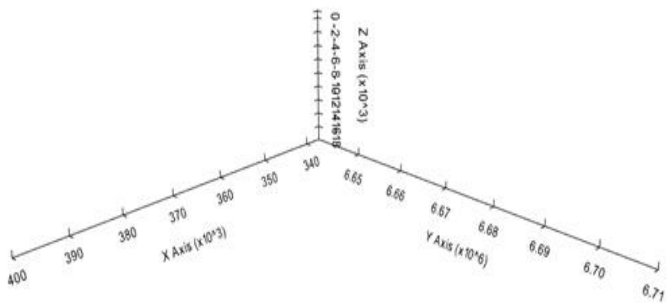


fig (b)

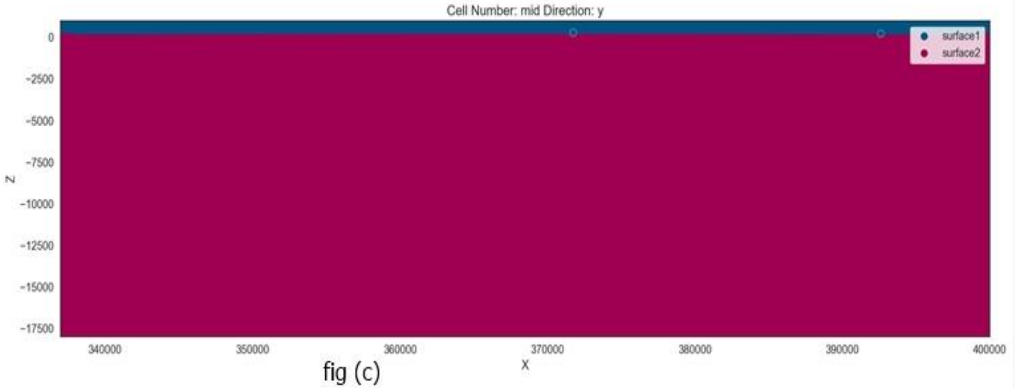


fig (c)

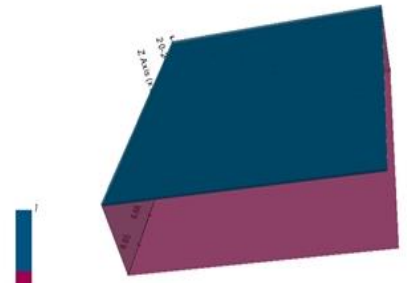


fig (d)

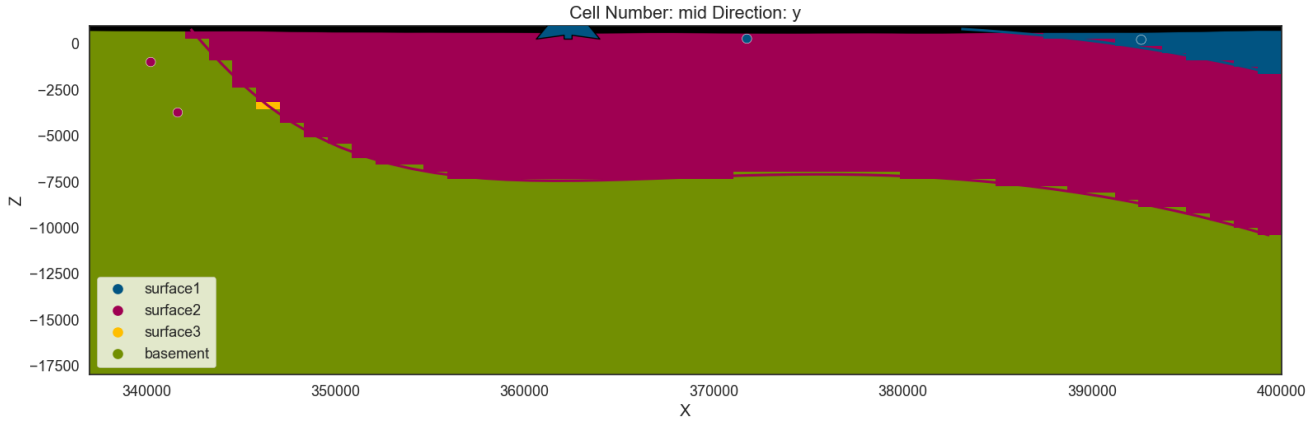
Refine the Prototype

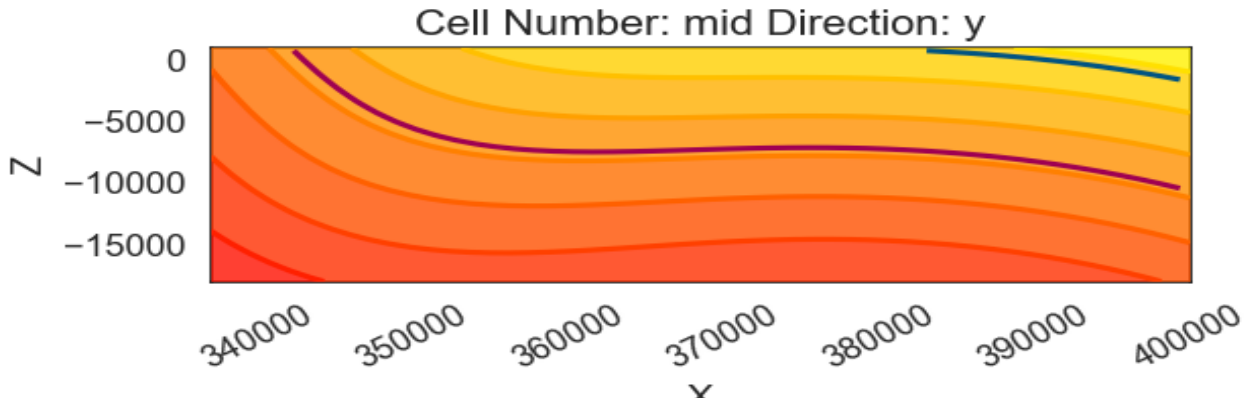
After considering the feedback, start changing the function because in the beginning the function was to import the data from the github but now we add the surface points and orientations measurement according to the need. In this prototype we add one more layer.

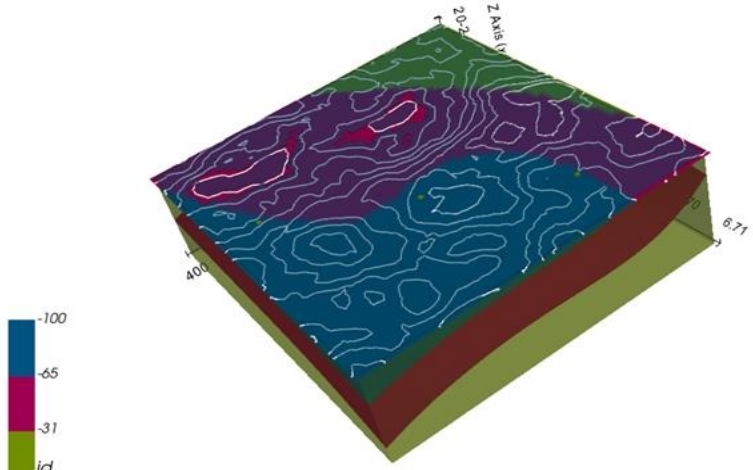
First figure is the direct visualization of 2D cross section model using matplotlib. In 2D cross section there is a prospect to display all the possible locations of the interfaces.

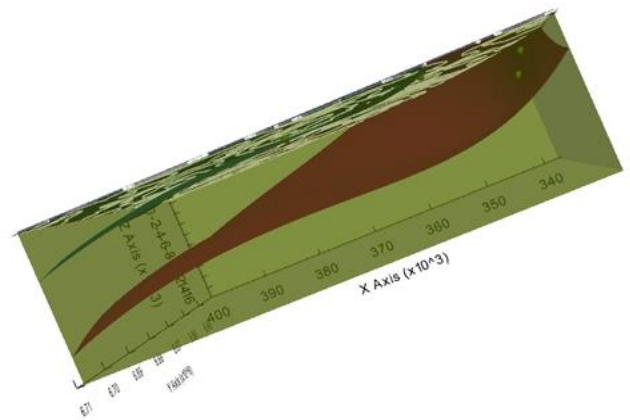
Second figure is the lithological scalar field structure that is generate through Gempy.

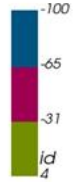
Third figure is the direct visualization of 3D geological model including topology. In this model there are slits, two surfaces layer and basement.











Project Outcome

The main objectives were to project the borehole data into 3D geological representation model and to represent a research on open-source geological tools or software. After completing the project, the outcomes are stated below:

- Show the 2D cross section borehole model
- Adding the surface point on real-time
- Show the lithology scaler field of the borehole data
- Show the 3D geological borehole model

Project Limitation

Due to latest update of Gempy there is a conflict between Anaconda and gempy's compatibility. For this reason, mini conda need to use for further progress.

- Gempy uses VTK (Virtual Toolkits) to demonstrate the 3D geological model but the outdated version of VTK become conflictive regarding Theano installation. Because there are some compatibility problems with python and VTK.

- As gempy is new and still under developing so to construct the geological model it need minimum specific data and they are: - surface points and one orientation layer. Without this minimum data gempy will not execute the model.

- In gempy, the borehole data is used to demonstrate the geological subsurface only it will not display the model of borehole.

Project Future Work

- Allow users to input the data in both in the system and on Github to retrieve the data.
- Gempy not only show the 3D geological model it also has different type of features like showing the full faults network and Folds on single layer or all the layers.
- Showing more probabilistic 3d model with the help of topology.
- In near future gempy is planning for the visualization of the models using virtual reality so with the help of this algorithm we can demonstrate the model in virtual reality.

Summary

In conclusion, the methodology will bring the clear view how to complete and carry the process with the help of rapid application development. This method is easy and fast processing which will help to finish the project early.

This research is aimed to 3D functionalities among software or tools to support 3D geological model.

Gempy is user friendly python based can do complex 3D geological model and most importantly gempy is open source and easily accessible and does not any cost .

The main objectives of this 3D geological borehole model are to show the 2d cross section, lithology and 3D realistic model. With the help of 2D cross section model user can be able to identify the soil structure. With the help of borehole data lithology will demonstrate the differences of soil layers.

And with the help of 3D model user can be able to detect the probabilistic soil structure, soil layers, surface points, soil condition and basement.

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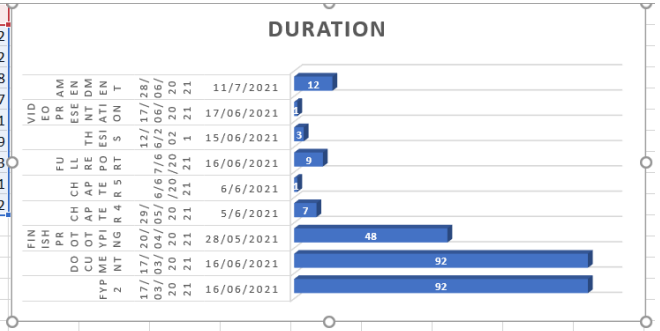
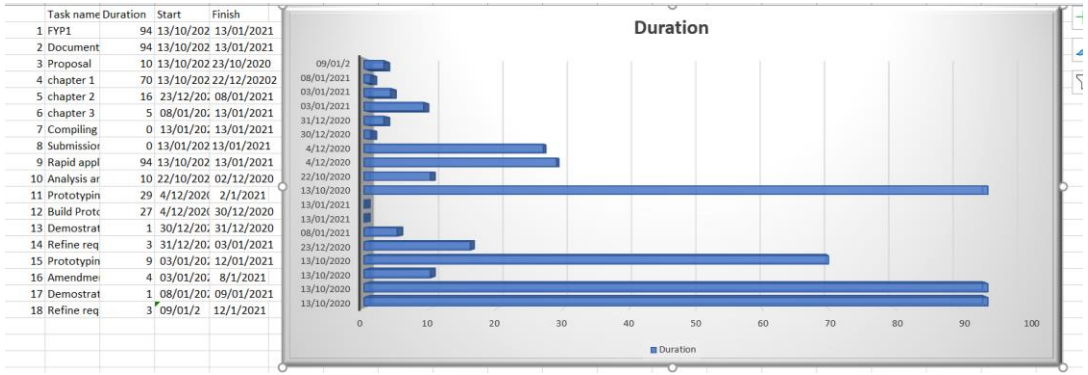
Features of QGIS Retrieve from https://docs.qgis.org/2.8/en/docs/user_manual/preamble/features.html

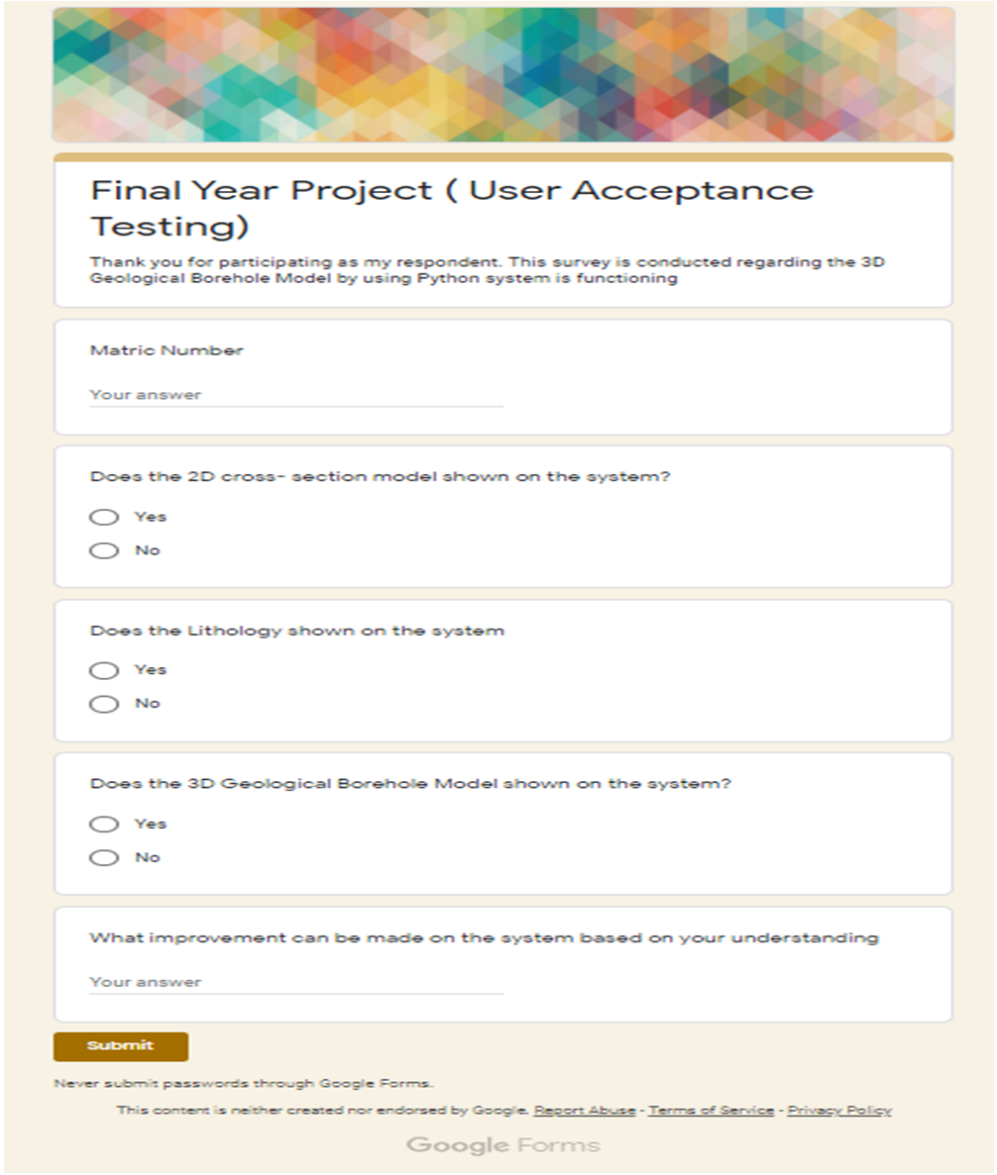
Task Name	Start	Finish	Duration
FYP2	17/03/2021	16/06/2021	92
Document	17/03/2021	16/06/2021	92
Finish prototyping	20/04/2021	28/05/2021	48
Chapter 4	29/05/2021	5/6/2021	7
Chapter 5	6/6/2021	6/6/2021	1
Full Report	7/6/2021	16/06/2021	9
Thesis	12/6/2021	15/06/2021	3
Video presentation	17/06/2021	17/06/2021	1
Amendment	28/06/2021	11/7/2021	12





Appendix-A

Appendix-B



Final Year Project (User Acceptance Testing)

Thank you for participating as my respondent. This survey is conducted regarding the 3D Geological Borehole Model by using Python system is functioning

Matric Number

Your answer

Does the 2D cross- section model shown on the system?

- Yes
- No

Does the Lithology shown on the system

- Yes
- No

Does the 3D Geological Borehole Model shown on the system?

- Yes
- No

What improvement can be made on the system based on your understanding

Your answer

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