Using Rapid Prototyping to Link Landform Models to GIS Information

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Abstract

This research aims to create 3D models from several different types of geographic information systems (GIS) data using rapid prototyping (RP) machines. GIS data includes digital elevation model (DEM), census information, watershed data on rivers and streams, information on city services as well as many other categories. If a triangulated computer aided drafting (CAD) model, a model on the computer that used triangular faces to create a 3D shell, was created with this data, then that 3D model could be made on the RP machines. The approach is to first create this triangulated CAD model using DEM data and then add additional types of GIS data for more layers of detail. To start creating the triangulated model, existing software was used to interpret the DEM data. Then new software converted the data into a triangulated 3D model. DEM data and most other GIS data have a different positioning standard. DEM data uses Universal Transverse Mercator (UTM) to describe its x and y coordinates, and most other GIS data uses latitude and longitude. The new software was able to convert from UTM to latitude and longitude. With this conversion a topographical color image was able to be applied to the model. This research concludes that other forms of GIS data could be added allowing for a physical 3D model with multiple layers of detail.
Keywords: Terrain Modeling, Geographic Information System, Rapid Prototyping, 3D

1. Introduction

A majority of the current terrain models are purely digital, with no way of making a physical model out of it. If a physical model was made then it was very time consuming and not an easily repeatable process. Another problem with the current models today is that they are sometimes a surface with no depth, making them not truly 3D. To be able to create an accurate and detailed 3D model quickly would be a step forward in terrain modeling.

1.1. GIS data

Geographic Information Systems (GIS) data can describe county, state, or nation wide information. GIS data can easily be found on the internet. This information comes in several different types and formats. The different types can be anything from digital elevation model (DEM) to information on city services as well as many other categories. DEM data comes in a format which has regularly spaced x, y coordinates of an area with a corresponding z height. DEM data can be found with 30 to 5 meter spacing in between coordinates, providing high accuracy in comparison to the large scale of the DEM [2]. GIS data containing information describing roads comes in tiger line files. Tiger line files contain information such as name, the points that the road lies on, and more. Even though GIS data can be found on the internet with a little searching, understanding the contents of the data can be difficult due to their format.

1.2. rapid prototyping

Rapid prototyping (RP) is a way of creating 3D physical models out of computer aided drafting (CAD) models quickly and accurately layer by layer. The type of CAD models that the RP machine can make is a shell made of triangular faces. There are several different types of RP machines. The main RP machine of interest in this project is

the Z Corporation's 3D Printer seen in figure 1.

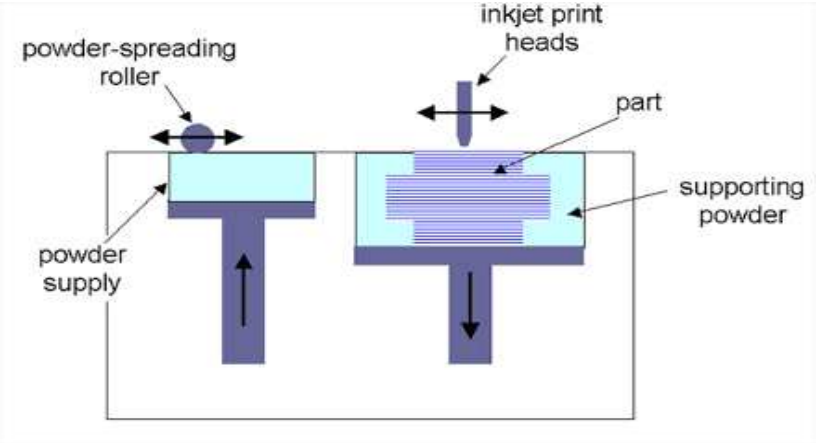

Figure 1 Z Corporation 3D Printer [4].

With its unique use of inkjet technology to spray a bonder to a bed of powder it can create the current layer, lower the bed and then apply the bonder again. The inkjet can also add color, making it the only RP machine that can generate a color 3D model.

2. Objective

To determine a process that can quickly and easily obtain an accurate and detailed 3D terrain model.

3. Hypothesis

GIS data can be converted into a triangulated 3D model. The triangulated model made out of the GIS data could be made on the RP machines, resulting in a physical 3D model.

GIS data would be used for its availability, accuracy, and multiple types. GIS data is readily available off the internet, making it easy to get several sets of GIS data for the creation of a model. With it being easy to access then it would not make repeating the process difficult. GIS data has high resolution for the large scale that is being dealt with. DEM data has points spaced from 30 to 5 meters [2]. With the versatility of the varying types of GIS data a wide selection of details could be added to a model to make it increasingly detailed.

Z Corporation RP machine has the ability to quickly build a model with a complex geometry. The Z Corporation 3D printer can print at the rate of 25mm (1") vertical per hour [3]. It is a very accurate modeling tool; the error is 0.0035"-0.008" [4]. The Z corporation machine can produce a color model to show additional details. If GIS data and RP were combined a detailed and accurate 3D terrain model could be obtained quickly. If they were combined properly then the process to create a model could also be easy to repeat.

4. Process

To convert GIS data into a model that can be made by RP a shell of triangles needs to be made. Focusing on DEM data to create a basic terrain model that additional data can be added to was the start to this project.

The DEM data that is available on the internet is in a difficult to read format. To read the DEM data AutoDesk Map 3D can import it, and then export the information in a readable format. Then Java programming was used to create a graphical user interface (GUI) to convert that DEM data into a 3D CAD model in the proper format. Then a conversion can be applied to the model so that the global position of a point in the model can be determined. When the global position is determined a satellite image can be applied to the model using the Z Edit software.

4.1. reading DEM

The DEM file type is in a compressed format that is not in text and hard to read. AutoDesk Map 3D 2005 is a program that is able to import the DEM file, because AutoDesk Map 3D is an AutoDesk product; it has the basic functions of AutoDesk including save as an “AutoCAD R12/LT2 DXF” file. This dxf file is a readable text file that is more easily understood.

4.2. java programming

The java code was written to import an “AutoCAD R12/LT2 DXF” file and then interpret the points that are in the file.

4.2.1. base height

The base height function allows the user set the elevation of the bottom face of the model. This function will allow the actual model to have less height to lower the time for the model to build and lower the material cost of the model. This function will also allow for the base to be thicker if the model is too thin, so that it will be sturdier and less likely to break.

4.2.2 z factor

When a model of a large area is scaled down to a reasonable size, the elevation of the model would be scaled down the same amount. This causes slight changes in elevation to be unnoticeable as seen in figure 2. With the “Z Factor” the height could be scaled up so features can more easily be seen.

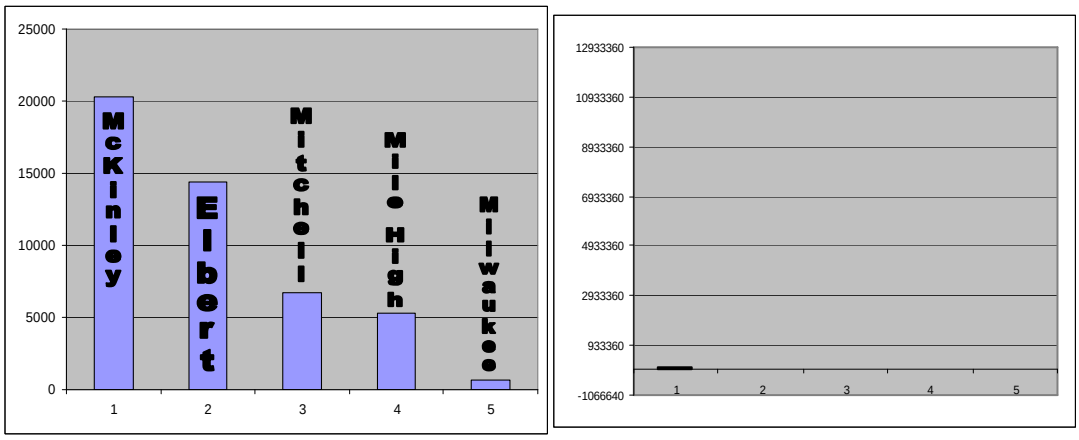

Figure 2 Height of Mountains Scaled to the US [6]

4.2.3. nearest neighbor interpolation

When creating the triangles to make the model, the program emulates four points near each other. To make triangles out of four points, the triangles can be drawn two ways as seen in figure 3.

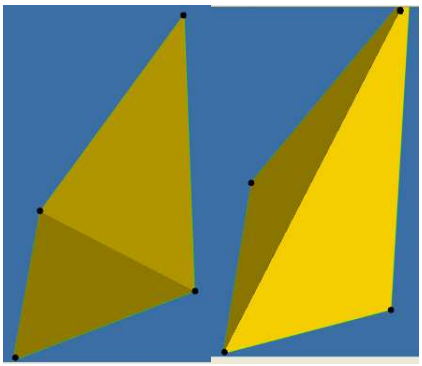

Figure 3 Drawing Triangles with Four Points

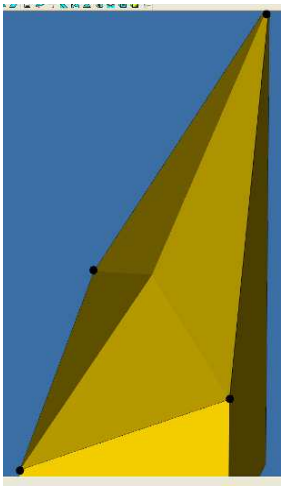

Figure 4 Nearest Neighbor Interpolation

Instead of choosing one of the two ways to draw the triangles, the four points were averaged and then created four triangles as seen in figure 4. This nearest neighbor interpolation is a combination of the two triangle faces. This provides a better approximation of the shape of the landform.

4.2.4. STL file format

The main purpose of this program is to create a stereolithography (STL) file. An STL file is a triangulated CAD model. When the STL file is created the points are converted into triangles using the nearest neighbor interpolation. The STL file created is the file that the RP machine's software will use to generate the physical model.

4.3. global positions

The DEM data comes in an x and y coordinate format called Universal Transverse Mercator (UTM). The UTM format can be converted into latitude and longitude. With latitude and longitude associated with the model, the global position of the model can be determined. Most other types of GIS data use latitude and longitude to describe their positioning, so with the latitude and longitude of the model, those other types of GIS would be able to be added in the right place on the model.

4.3.1. adding models together

If the latitude and longitude of a model where known its position on the globe would be known. Allowing for different models to be placed together properly so that large areas could be modeled in pieces and then put together. An example of two models put together is shown in figure 5, with Waukesha and Milwaukee county put together.

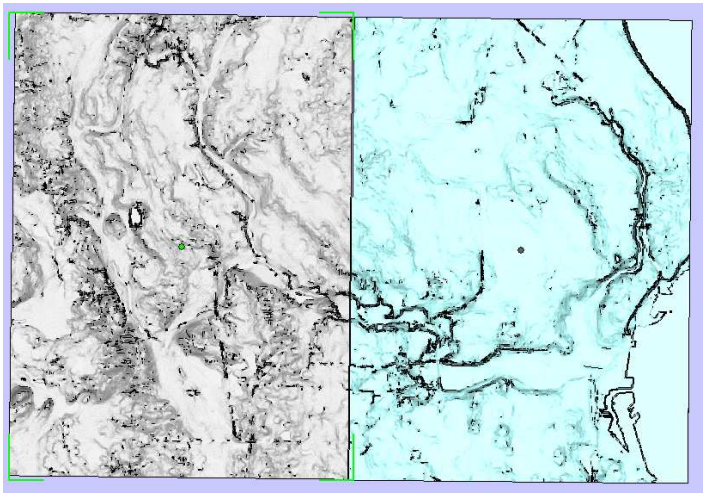

Figure 5 Waukesha and Milwaukee County Models

4.3.2. color satellite image

In addition to adding multiple models together, with the global position other GIS data can be added. A topographic satellite image was able to be added to the model. As seen in figure 6 a matching satellite image could be obtained. The color image was applied to model using the Z Edit software, the software made by Z Corporation for direct use with the Z Corporation RP machine.

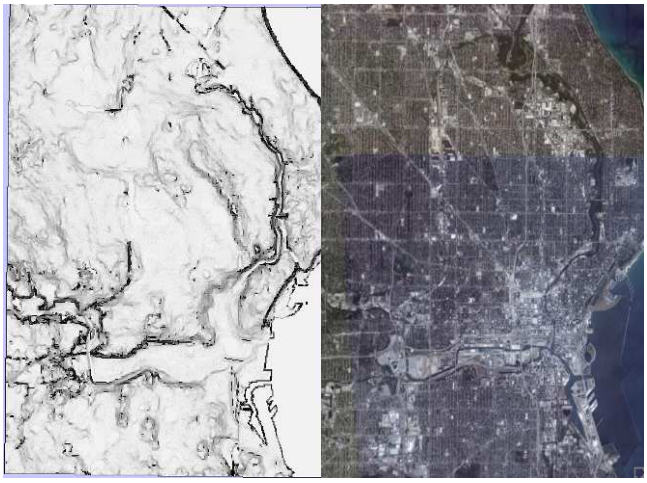

Figure 6 Milwaukee County and Matching Satellite Image [5]

5. Results

The process was used on Milwaukee County. The resulting model is seen in figure 7. This model is an accurate 3D model of the terrain with a color satellite image. This model had a 5 hour build time, the time it took for the Z Corporation RP machine to make it. The CAD model was made from downloading the data to putting the color on

it in an hour. So the model above could be made in 6 hours. Another model could be reproduced easily, because the steps would work for any other area.

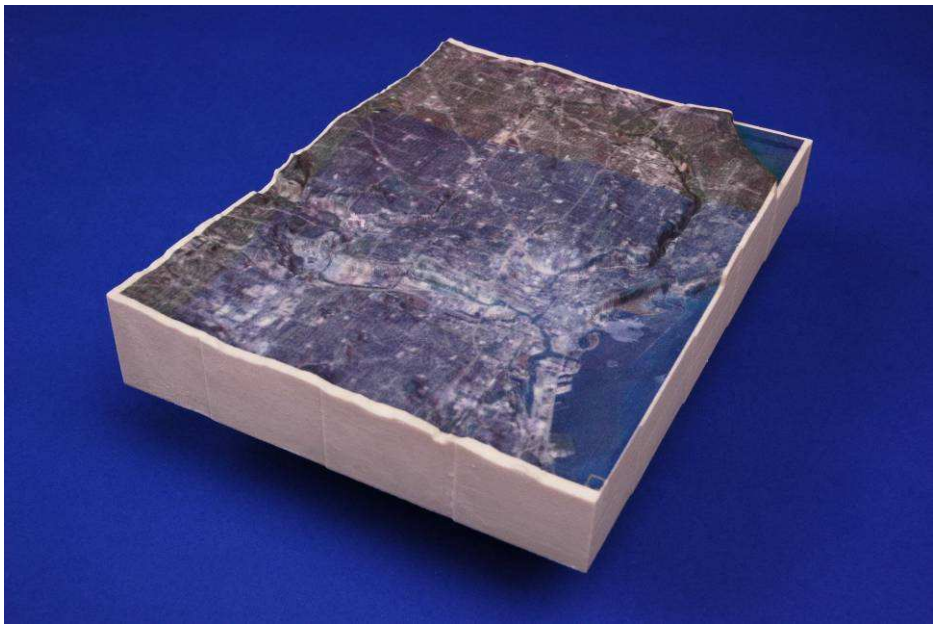

Figure 7 Final Model of Milwaukee

6. Conclusion

An accurate geographical 3D model can be made quickly and easily. The process to create it can be repeated easily. The model can have multiple types of GIS data added to the base GIS elevation model.

This research is a step towards obtaining an accurate and detailed 3D terrain model. It was able to use DEM data and a satellite image to create an accurate model. Although adding the additional information is possible it will take more work to do so.

7. Further Work

This research was only able to use DEM data to construct a model. Adding additional GIS information would be needed for this process to be fully useful, so there can be an adequate amount of detail. Further work would be needed to add these other types of GIS data to the model.

8. Acknowledgements

The author would like to thank to the Milwaukee School of Engineering for hosting the Research Experience for Undergraduates (REU) program, and the Rapid Prototyping Center. The author would also like to thank the National Science Foundation for funding this research program. Finally the author would like to thank all the people who helped on the project: faculty advisor Michael McGeen, Gunnar Vickburg, Ann Bloor and Betty Albrecht for their work in the REU program.

"This material is based upon work supported by the National Science foundation under Grant No. EEC-0139142. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation."

9. References

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