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Using game engine for 3D terrain visualisation of GIS data: A review

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Abstract. This paper reviews on the 3D terrain visualisation of GIS data using game engines that are available in the market as well as open source. 3D terrain visualisation is a technique used to visualise terrain information from GIS data such as a digital elevation model (DEM), triangular irregular network (TIN) and contour. Much research has been conducted to transform the 2D view of map to 3D. There are several terrain visualisation softwares that are available for free, which include Cesium, Hftool and Landserf. This review paper will help interested users to better understand the current state of art in 3D terrain visualisation of GIS data using game engines.

1. Introduction

In recent years, a lot of research has been conducted with regard to 3D terrain construction. Most of the research has developed new applications for viewing and creating in 3D. Eventually this helps in promoting tourism and future planning for disaster and security [1]. It has been proven that the 3D terrain can be perceived a lot better compared to normal 2D map which requires certain level of comprehension in map reading. Currently, there are few categories of 3D terrain visualisation engines that are available on the internet using the game engine and open source. Each of these categories has advantages and disadvantages. Therefore, the aim of this paper is to provide a comprehensive review of 3D terrain visualisation of GIS data generated from the game engine. This paper begins with a brief history of game engine and continues with the detail of game engines such as Torque 3D, Unreal Development Kit (UDK), Unity3D and CryEngine. The second section covers the available 3D terrain visualisation software. The third section explains terrains visualisation using game engine and shows the terrain created using the game engine. The fourth section discusses on 3D terrain visualisation and 3D terrain visualisation using game engine and finally the fifth section concludes this paper.

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2. Game engine

Game engine refers to a set of tools that help the developers to create games a lot faster and easier using commands that used to require a lot of coding through plug-in or asset provider of the game engine [2]. In the earlier days, game was limited to hardware capabilities. The earliest development of arcade games started in 1966 [2], and one of the most well known arcade game known as Pong was introduced [3]. This game utilised the advancement of technologies of arcade games which ported into the consoles. As the technologies grew, the game was then ported into the PC platform around 1990. During this time, the term “game engine” was introduced. Since then, many different types of game engine have been introduced including Torque 3D, UDK, Unity3D and CryEngine. Figure 1 shows the architecture of game engine that was introduced by Lewis and Jacobson [4].

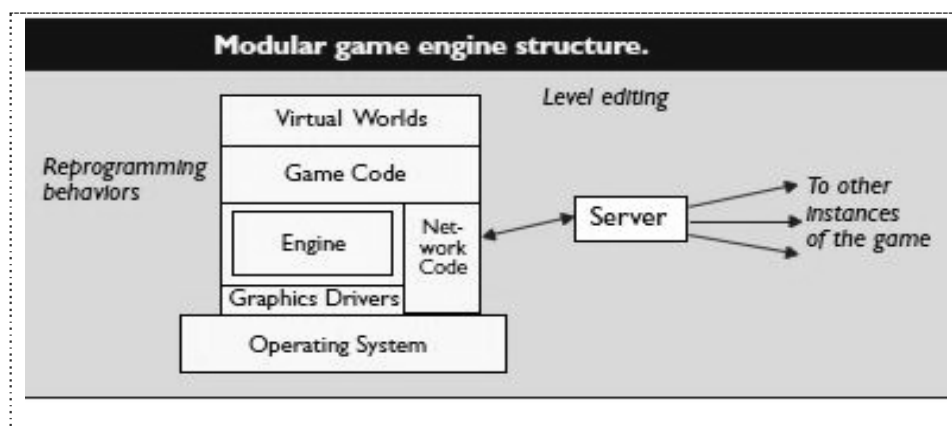


Figure 1. The architecture of game engine (Source: Lewis and Jacobson [4]).

2.1 The Torque Game Engine (TGE)

TGE is a game engine published by GarageGames [5]. Torque started around as a company by the name of Dynamix, then later after acquiring the tribes 2 source codes from Source, it have been changed to Torque 3D. The engine uses C++ as its main script which allows the user to have a better editing of the engines. Torque 3D supports PhysX, modern shader features, and advanced deferred lighting mode. TGE runs on most windows platforms, Mac and Linux. TGE also provides documentation for the users in creating and designing their own games. The database of this game engine supports MySQL and uses Torque script.

Shiratuddin and Thabet [6] discussed details on how TGE could be utilised to develop Design Review System from manual to 3D complete visualisation system. Besides that they also utilized this engine for application such as a Southern Miss’s Innovation and Commercialization Park [7]. Figure 2 shows the architecture of Torque 3D game engine as explained by Nilson and Söderberg [8].

2.2 Unreal Development Kit (UDK)

UDK was released by Epic Games Inc. and it is a free version of Unreal Engine 3 [9]. It has been used by professional studios and indie developers to create well known games such as Gears of Wars, X-men Origins and many others. UDK provides the developer with same functionality as paid version. UDK allows for visual scripting using Unreal kismet and its main script is called UnrealScript. Navarro et al. [10] explained that UDK has a lot of functionalities including skeleton animations. It uses NVidia’s PhysX and UDK behaviour editor. Shiratuddin and Thabet [11] explained the architecture of UDK in their research on “Virtual Office Walk-through Using a 3D Game Engine” as shown in figure 3.

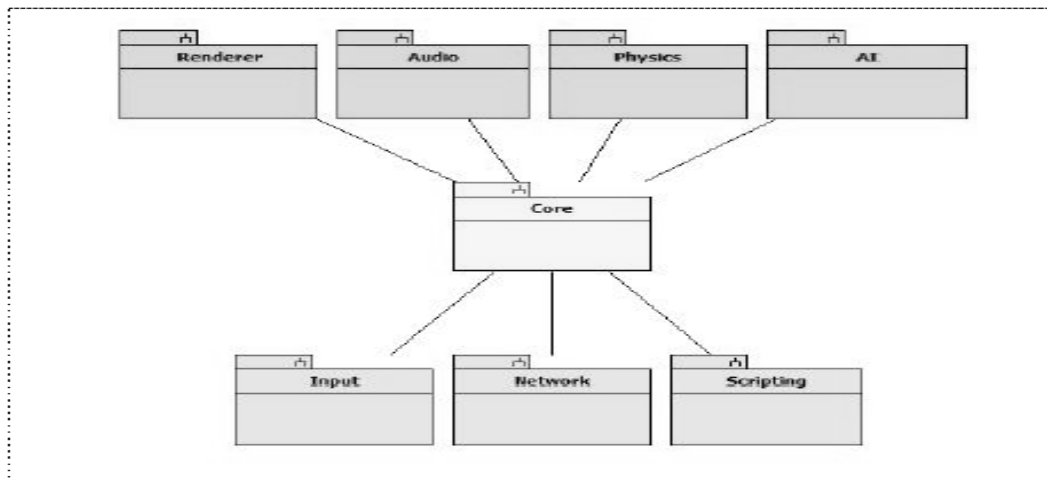


Figure 2. Torque game engine architecture (Source: Nilson and Söderberg [8]).

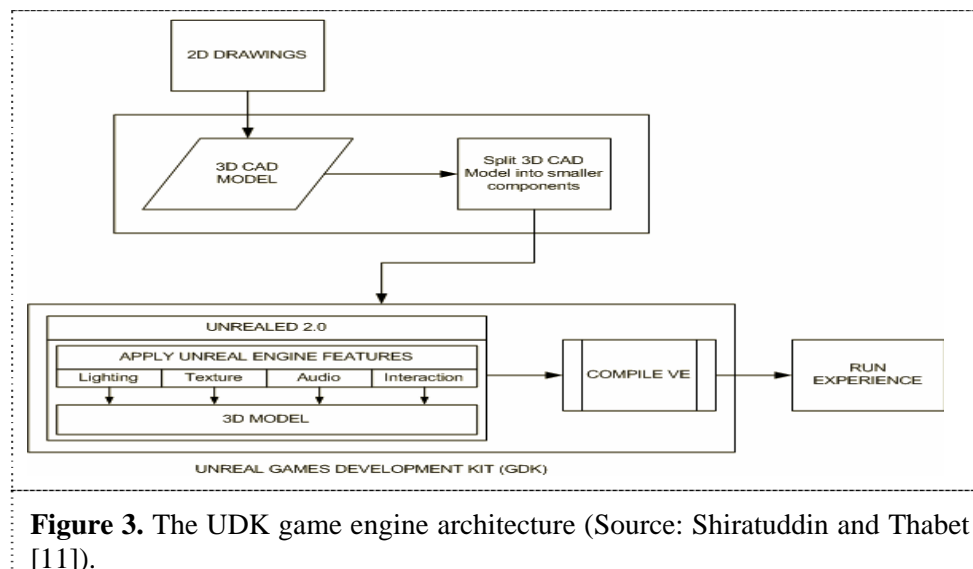


Figure 3. The UDK game engine architecture (Source: Shiratuddin and Thabet [11]).

2.3 Unity3D

Unity3D is a game engine created by Unity Technologies [12]. It can be used to create online and offline games. Unity3D provides a wide range of assets that help developers to create games as well as documentations and tutorials. It utilises the concept of assets which work like a plug-in where the user can import or just copy the asset file into a specific folder. Unity3D uses JavaScript, C# and Boo as the main programming languages. The main advantage of Unity3D is that it can run on multi-platform OS including Windows, Mac, Linux and also mobile. It is capable of importing other 3D models in fbx, sbx and obj formats. Wang et. al. [13] presented the architecture of Unity3D as shown in figure 4.

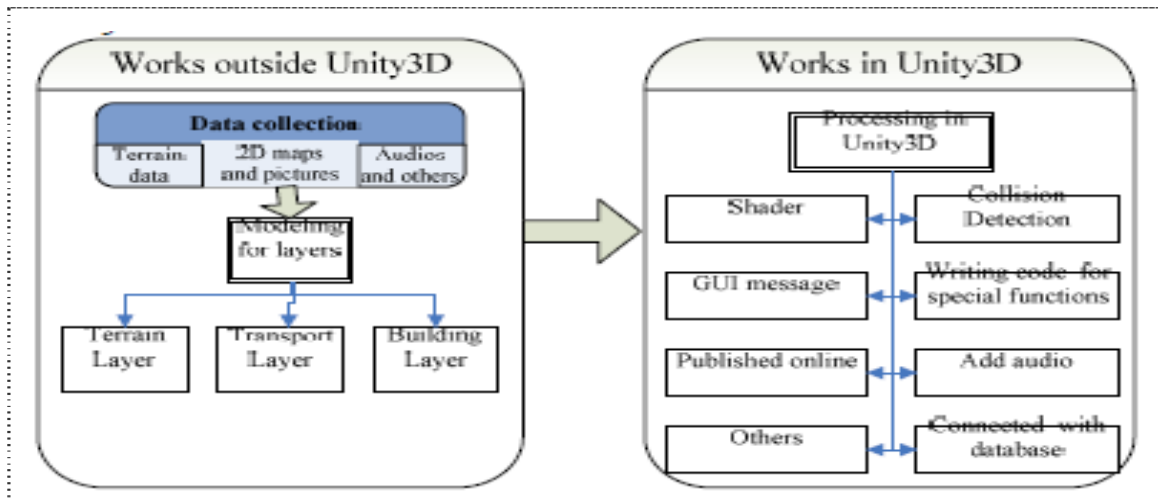


Figure 4. Unity3D game engine architecture (Source: Wang et. al. [13]).

2.4 CryEngine

CryEngine is a game engine created by Crytek, a developer based in Germany [14]. CryEngine provides a much rich environment to create games in a sandbox using “WYSIWYG” method. There have been four releases for CryEngine and each release is an improvement to the others. CryEngine is free for non-commercial development which allows developers to have first hand on the game engine. CryEngine itself uses sandbox editor to add objects into the world terrains. Trenholme and Smith [15] explained the detail functionalities of the CryEngine. Meanwhile, Herrlich [16] explained the features of CryEngine. Figure 5.0 shows the sandbox editor view of CryEngine.

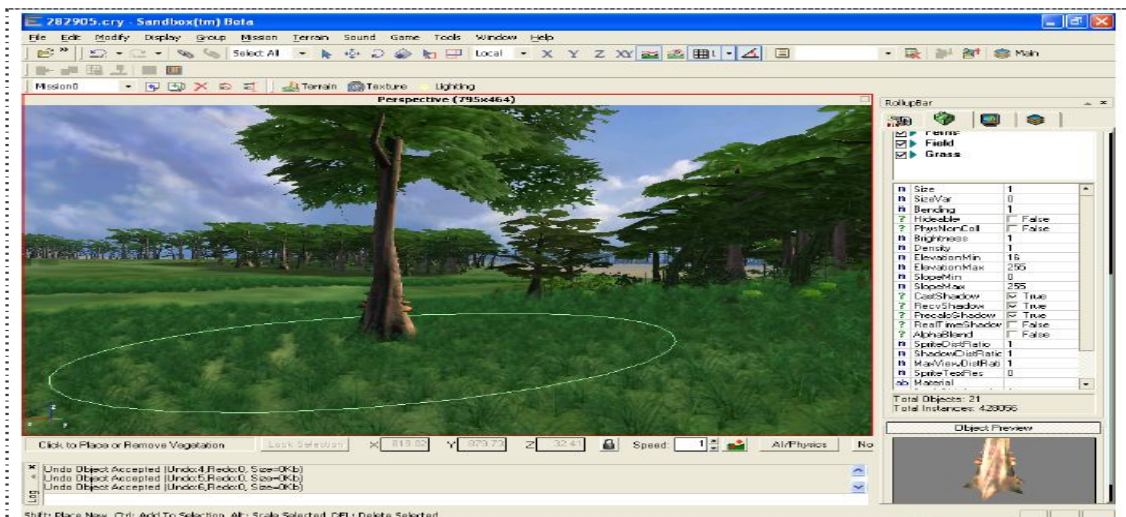


Figure 5. The sandbox editor view of CryEngine (Source: Herrlich [16]).

3. 3D terrain visualisation software

In recent years, a lot of 3D terrain modelling software as well as terminologies have emerged. The terminologies which include digital elevation model (DEM), triangular irregular network (TIN) and digital terrain model (DTM) are normally used for terrain data type and they are frequently used in software that have the capability to read and display 3D terrains. Ruzinoor et al. [17] reviewed the

techniques and software for 3D terrain visualisation of GIS data and explored different types of techniques for visualising 3D terrain [18]. The VRML technology has been used by Ruzinoor et al. [19] for visualising terrain online. Horne [20] the original author of 3DEM created the software for commercial market and after a few years of development, he halted the project but still share the full version of the software for public used. The software has the capability of importing and generating 3D terrain from DEM data. This software also provides a surface view of Mars terrains. Zuse Institut Berlin & Lenné3D [21] created the BioSphere3D. This software has the capability to display the landscape of globe terrain by using data such as DEM, satellite and aerial images, 3D models (Collada), 3D plant models (Lenné3D Flora3D) and shapefiles. Cesium is a 3D terrain visualiser that uses globe view concept which has the capability to zoom and explore the whole world terrain. It uses WebGL libraries to load the shapefiles in producing the terrain. It is based on entire cloud and fully dependent on scripting [22].

Besides that, Earth3D was developed by Dominique Andre Gunia [23] using Java and C++ as its core programming codes. The data for this software is generated from NASA, USGS, CIA and the city of Osnabrück. GenesisIV is a landscape software created by Geomantics [24]. The advantages of this software is the capability in generating the photorealistic terrains. G3DGMV (3D Graphical Map Viewer) was developed by Yost [25] for terrain visualisation which uses DEM and DLG as its main data source. It also provides the functions for saving as image and creating guide based on user preferences. Hftool was introduced by Stock [26] which is a Unix based terrain viewer and the output from this software can be converted into different types of file formats. Integrated data viewer (IDV) was created by Unidata [27] and is based on java programming. The software is able to create an animation of satellite images, viewing a grid view of terrain plot and also displaying a data based on globe.

LandSerf a terrain visualisation software was created by Jo Wood [28] and it is also a Java based terrain visualisation. It can handle multiple files of GIS format and also provides high interactivity visualisation. This software also able to import and export raster format and able to integrate with Garmin GPS receiver. Guth [29] has introduced MicroDEM which is a portable terrain viewer where it can view DEM data and also able to merge the data. Virtual Globe was created by Sintef, a research organization in Scandinavia that cover a lot of research area until it was taken over by Norkart for further development. This software uses globe as its main view and data such as SRTM, GLOBE and GTOPO30 to display terrain model. This software was also developed using Java [30]. OpenEV was originally developed by Atlantis Scientific Inc. [31], which is currently known as Vexcel. As of 2006, it was acquired by Microsoft and has ceased involvement in the project. OpenEV is a terrain viewer that uses OpenGL for rendering and it supports various types of raster and vector formats to create elevation.

4. 3D terrain visualisation software using game engine

As game engine development progresses, several new add-ons have been included such as terrain editor. Most game engines have their own terrain editor which helps in creating realistic terrains. In Unity3D, the developer is able to design a realistic terrain using terrain editor which can be viewed using the first person view. The terrain editor in Visual 3D allows the user to import DEM data to generate the terrain [32]. Torque game engine also provides the terrain editor as explained by Yang et. al. [33] on how the terrain can be created using TGE. Figure 6.0 shows an example of terrain generated using TGE. Besides that, UDK also provides a terrain editor that supports DEM data that can be manipulated using Unreal engine [34]. The DEM of TGE allows GIS data to be loaded but the data must be in a compatible format in order to generate the terrain. While Unity3D also has the capability to load GIS data and generating the terrain from the data and uses script to control the data to be more interactive. CryEngine requires a bit of works to get the GIS data into the game engine. Figure 6-9 show the images of terrain generated from different types of game engines which include Torque, UDK, Unity3D and CryEngine.

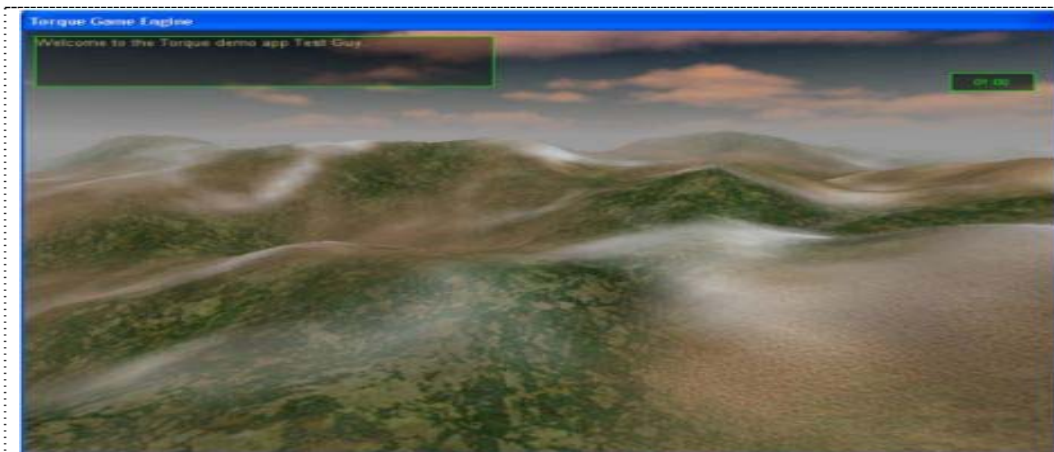


Figure 6. Images of terrain created by Torque engine. (Source: Yang et. al. [33]).



Figure 7. Image of terrain created by the UDK game engine. (Source: Epic Games Inc. [9]).



Figure 8. Image of terrain created by Unity3D game engine.



Figure 9. Image of terrain created by CryEngine (Tracy & Tracy [35]).

5. Discussion

Terrain visualisation software was first introduced in the early 1990's whereby during this time the computing capability of the hardware was still limited. Table 1 shows a list of terrain visualisation software where most of them use C++ and Java as their core programming tools. Most of these software (Biosphere3D, GenesisIV, IDV, Landsarf, MicroDEM, Norkart Virtual Globe and OpenEV) has their own graphical user interface (GUI) tools. Besides that, G3GDMV and Hftool use other tools such as GTK, GNOME and SGI with improved GUIs. All of these software was developed to load data locally. Some of the software does not read the data, but uses OpenGL technology for their rendering. Figure 10 shows the evolution of terrain visualisation software from 1995 till now.

Table 1. Terrain visualisation software.

Terrain software	Year	Language used
IDV	1997	JAVA
Hftool	1998	Linux/SGI
G3GDMV	1999	GTK/ Gnome/Linux
Norkart Virtual Globe	2001	JAVA
OpenEV	2001	OpenGL, C ,GTK
Landserf	2004	JAVA
GenesisIV	2005	C++
MicroDEM	2007	C++
3DEM	2009	SGI/Microsoft OpenGL libraries
Biosphere3D	2007	C++, OpenGL 2.0
Cesium	2012	JavaScript/WebGL

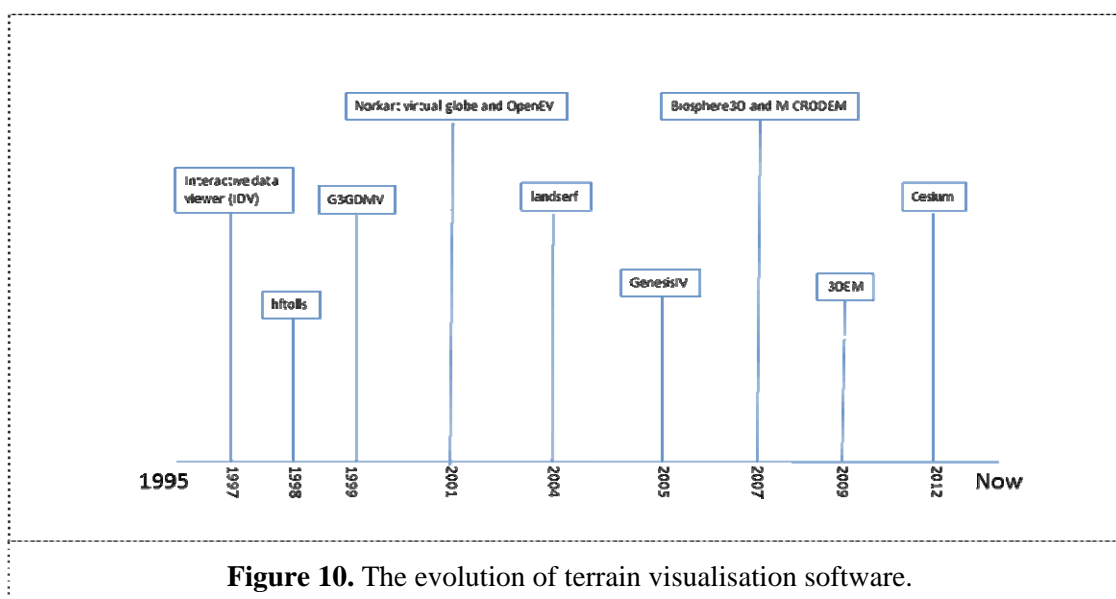


Figure 10. The evolution of terrain visualisation software.

Based on the game engines that have been discussed in this paper, most of them have built-in terrain editor. It is easier for the user to generate the terrain without intensive coding, although using GIS data in game engine would require a few works on coding itself and some of the game engines provide plug-in which can be used by the user to create the terrain. An article by Green [34] looked at how DEM can be used inside UDK to view its data, Unity3D also allows GIS data to be viewed in specific format. The script written by Jeff Craighead allows Unity3D to be used with GIS data [12]. TGE also allows loading of GIS data but it requires the data to be loaded into a compatible format. Cryengine also requires a bit of works to get the GIS data into the game engine. This shows that most of the game engines have the capability in generating the terrain from GIS data. Table 2 compares the different types of game engines. It shows that most of the game engines were developed a few years ago and until now they can still be used for developing new applications.

Table 2. Comparison on different types of game engine.

Game Engine	Year created	Level Editor	GIS support	Source code and SDK	Documentation
Torque 3D	2001 Originate from Tribes 2 game	World Editor Material Editor Terrain Editor Shape Editor Forest Editor River Editor Decal Editor Decal Road Editor Mesh Road Editor	Custom imports	https://github.com/GarageGames/Torque3D Available version 3.5	Available at http://docs.garagegames.com/tge/official/
CryEngine	2004	Sandbox Terrain editor Sound Editor	Custom imports	Available as a package	Available at http://freesdk.crydev.net/dashboard.action
Unity 3D	2005	Game object Mesh Effect Physics Terrain Asset can be imported into a single scene, also uses plugin with editor	Custom imports	SDK available for free as Unity3D source codes is available for purchase	Available at http://wiki.unity3d.com/index.php/Main_Page
Unreal Development Kit	2009 originate from Unreal 3 game engine	Geometry Mode Terrain Mode Mesh Paint Mode Static Mesh Mode Landscape Mode Foliage Mode	Custom imports	http://wiki.beyondunreal.com/UnrealScript_source_code Available in multiple versions.	Available at http://www.unrealengine.com/en/udk/documentation/

6. Conclusion

As the technologies march forward into the future, several new technologies and new software to visualise terrain emerge and that include game engines. These software allows editing and creating of 3D terrains which can be a reliable source of reference to all. Game engines provide different approaches to the GIS data. Game engines also provide vast potential for customization in making GIS data useful in various applications such as tourism, future disaster planning, security and many others. With the help of game engines, GIS data can be viewed from different types of perspectives and angles.

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