Realization and Operations of 3D Data Acquired by Terrestrial Laser Scanner on Web Browsers

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SUMMARY

This paper discusses the offline realization of 3D data acquried from TLS (Terrestrial Laser Scanner) on existing web browsers by grafting widely applied laser scanning and 3D software, which have been utilized in various fields in recent years.

As an illustration of this research paper, this paper will introduce user-friendly application and materialization on various web browsers, including the Internet Explorer from Microsoft, with a 3D scan of South Korea famous historical site, Cheongnyeongpo, using Leica ScanStation C10.
The primary objective of this paper is to establish the groundwork for utilizing quality 3D space information on web browsers, whereas the secondary objective of this paper is to introduce the possibility of sharing and experiencing quality 3D space information anytime and anywhere via wireless Internet access with instruments such as smartphones and tablet computers.

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1. INTRODUCTION

1.1 Background and Purpose of Research

It is a trend to utilize 3D laser scanning for various efficient management of cultural properties and basic data application. The main reason of this is due to the precision which allows people to measure down to the millimeter unit and the possibility of designing the floor plan inversely for assets and buildings which do not have one.

3D laser scanning is a type of laser survey which is the most developed area of terrestrial survey. The principle of laser survey is shooting laser beams to the target and calculating the time taken for the laser to return, and then obtaining the 3D coordination of the target. The previously existing laser survey could only obtain one point per survey, but as survey equipment have developed, it is now possible to shoot and obtain multi points at once.

Utilizing this technology for laser survey is fast and simple like scanning a picture. This method is canned 3D laser scanning and the equipment used is called 3D laser scanner. Especially, it allows rapid continuous scanning so that the artificial error caused by scanning skills or coincidental data loss would be minimal.

For the task related to this research, C10, a Leica Terrestrial Laser Scanner, has been used to observe the site of *Cheongryeongpo*. The observed data has been processed to produce CAD floor plan, modeling data, 3D motion pictures, and web service programs for the production of a management floor plan for national properties.'

The main reason for using Leica's C10 was because of its unique advantage over other terrestrial LiDAR, the traverse feature. As a result, it was possible to obtain a precise location using cadastral control point, and based on this, it is possible to obtain the basic data for reconstruction in case of a destruction of a structure of *Cheongryeongpo*.

Additionally in this research, we have used the latest 3D engine tools to allow people to have access to the 3D modelling data of *Cheongryeongpo* on a web browser.

2. BODY

2.1 3D Survey by Terrestrial Laser Scanner

2.1.1 The Concept of Terrestrial Laser Survey

Terrestrial Laser Survey is accomplished by LiDAR survey system. Terrestrial LiDAR survey system produces high-precision DEM and allows automated handling for fast and accurate acquisition of the location and 3D shape of the target, so it is widely used in various areas. LiDAR shoots hundred thousands of lasers per second to acquire location data of the target, and then provides a 3D expression of the target's surface coordination.

This gives an advantage to work at locations where it is difficult to survey such as a coast or shadowy places like a city, and it guarantees precision down to the millimeter unit. Of course, it can be adjusted to the centimeter unit depending on the purpose of survey.
Terrestrial LiDAR used a digital camera to scan the target and obtain its digital motion picture. These can be utilized as a texture data for 3D modeling which makes them useful for precise 3D spatial data construction. In addition, the applicability is increasing even in 3D spatial data collection and GIS area.

Terrestrial LiDAR laser scanner activates under the same principle of Total Station. It shoots a wave-length range of near-infrared rays or visible rays and calculates the distance with the reflected laser. Simultaneously, it precisely measures the horizontality and verticality of the laser beams to convert them to a 3D point cloud.

2.2 The Present of 3D Survey of Cultural Assets Using Terrestrial LiDAR in Korea

LX Korea Cadastral Survey Corporation has surveyed various cultural assets using terrestrial LiDAR. The most notable works are the *Jungrimsaji* five-story stone tower, and Buyeo *Wangheungsa* Kiln Site. Especially, the work completed at Buyeo *Wangheungsa* Kiln Site proves the time and money efficiency and better precision compared to the work at other kiln sites of the past.

The introduction of these new technologies should be seriously considered as famous foreign cultural assets are being digitalized by LiDAR equipment.

2.3 3D Survey of *Cheongryeongpo* using Terrestrial LiDAR

[Fig1. *Cheongryeongpo* which has tragic historical story in Gangwon Province

[Fig 1] is *Cheongryeongpo*, the place of exile for the sixth king of Chosun Dynasty, Danjong, which was a project conducted by the writer in person. In the following parts, the process and notable facts of survey will be explained.

2.3.1 GPS Control Point Installation

To express an object three dimensionally, not only X and Y coordinates but also Z coordinate is necessary, so the coordinates X, Y, and Z were acquired by using GPS static survey to install cadastral control points. Korea Cadastral Survey Corporation is differentiated from other private companies by performing precise measurement based on cadastral control points whereas others conduct this based on a random point.

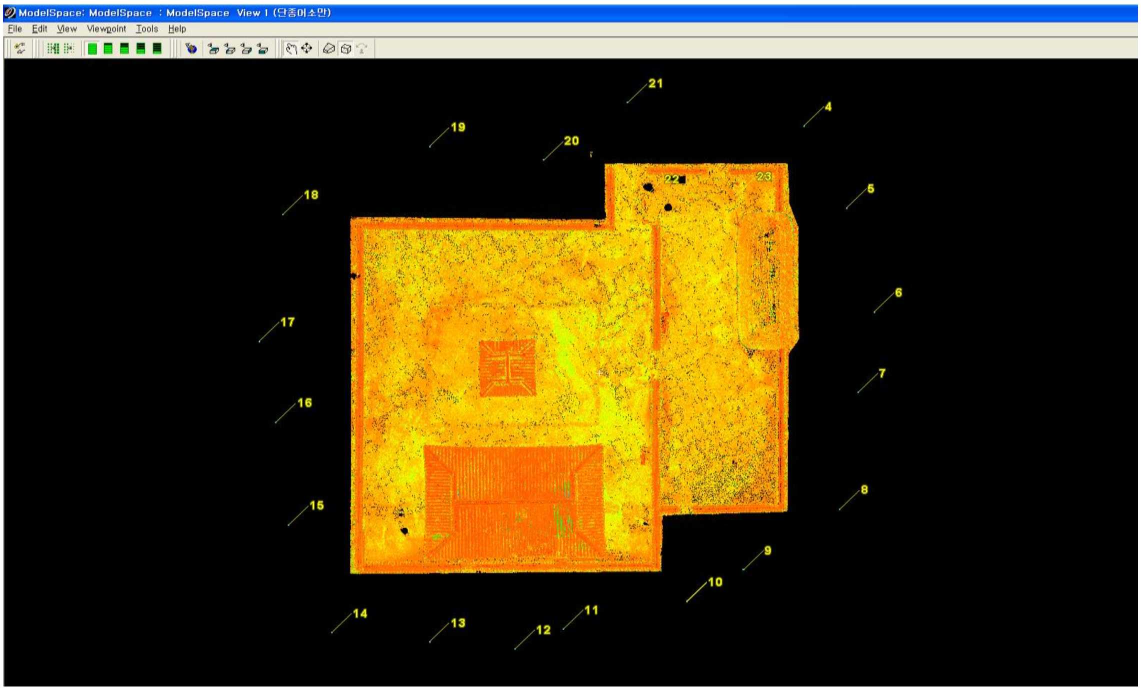
[Fig 2. Three Cadastral Minor Control Points installed by GPS Static Survey

CP No.	X	Y	Z	unit
5881	408281.95	150717.99	191.141	m
5882	408353.86	150690.16	192.904	m
5883	408386.54	150636.10	192.400	m

[Table. 1] The Coordinates of Three Terrestrial Minor Control Points (Bessel Coordinates)

2.3.2 Method of Site Scanning

Site scanning can be processed in two different ways: Traverse survey and random point survey. Traverse survey collimated control point number 5881 from 5882 and initiated to scan the fence, Danjong's house, the tombstone, and monument and arrived at 5883 to reorganize at 5882. For areas that could not be traverse surveyed such as the interior of the house, the roof, and the inside of the monument, we have used random point survey and connected them with the data acquired from traverse survey.
As mentioned above, Traverse survey is one of the main features of C10, and the data acquired from this shows all X, Y, Z coordinates. In other words, the building within *Cheongryeongpo* would be more precisely expressed. As a result, the data can be used as the base data for reconstruction with the exact coordinates in case of destruction.



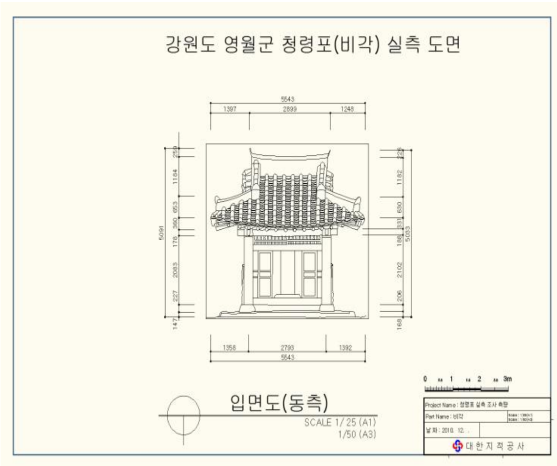
[Fig. 3] The exterior of Traverse-surveyed *Cheongryeongpo*, 3D precise survey conducted in numerical order

2.4 Post Process

The data scanned above in Body 2.4 was 55 stations and the data size was around 30 gigabytes. Based on this data, CAD floor plan and 3D modeling was possible after post processing. There were two main reasons of this process, and the first one was that minification of data size while maintaining the information of location and shape of the vast point cloud, and the second was loading and administrating the GIS tool and management system so that the data can be converted to a managerial form. The post processing for *Cheongryeongpo* was mainly registration, filtering, planar auto-abstract, polygon modeling, and texture mapping.

2.4.1 CAD reverse-Engineering Floor Plan Preparation

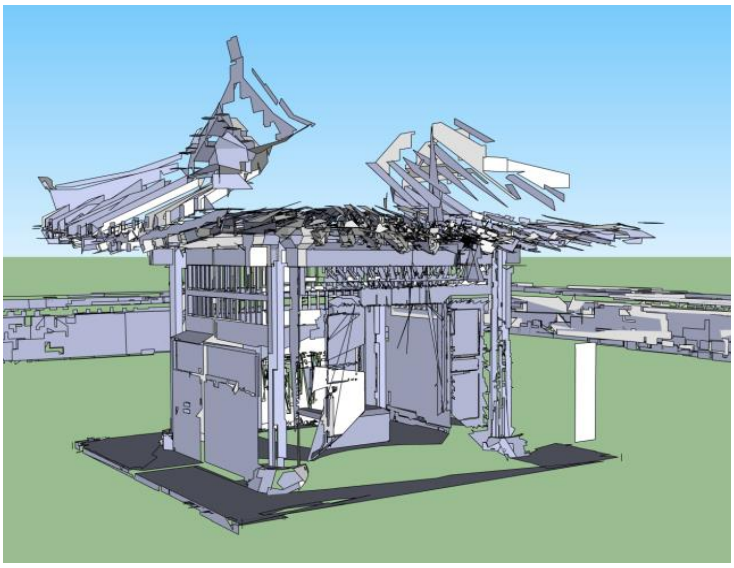
[Fig. 4] High-Resolution Image of Elevation of the Monument



[Fig. 5] CAD Floor Plan of Elevation of the Monument

The data of Elevation of the Monument which has been registrated and filtered was converted to PTS format, a type of ASSKII, with the program Cyclone, and then it was loaded from Points tool 1.5 for precise resolution revision, and lastly save as JPG format to go through color revision with Photoshop. After extracting a clear image with the JPG file, we acquired a high-resolution image file like [Fig. 4]. We loaded this file from CAD to produce a floor plan with commands such as blur, line, circle, arc, and square, and then entering the lengths of each parts in millimeter units results with a survey floor plan like [Fig. 5]. Even if a distance is not marked on the floor plan, it can be checked on CAD with the DI command if the CAD original data is present. The main reason why cultural assets like *Cheongryeongpo* are surveyed is because it is possible to produce a floor plan for a building which does not have one, so in cases of destruction, it can be an essential data for Reverse Engineering. This recent feature of reverse engineering is not limited to buildings, but is also applied to everyday life such as jewelry crafting, production of F1 racers' helmets, and comparison with benchmarked or competing items.

2.4.2 CAD reverse-Engineering Floor Plan Preparation



[Fig. 6] Monument Loaded from Google Sketch Up after planar auto-abstract from Edge Wise

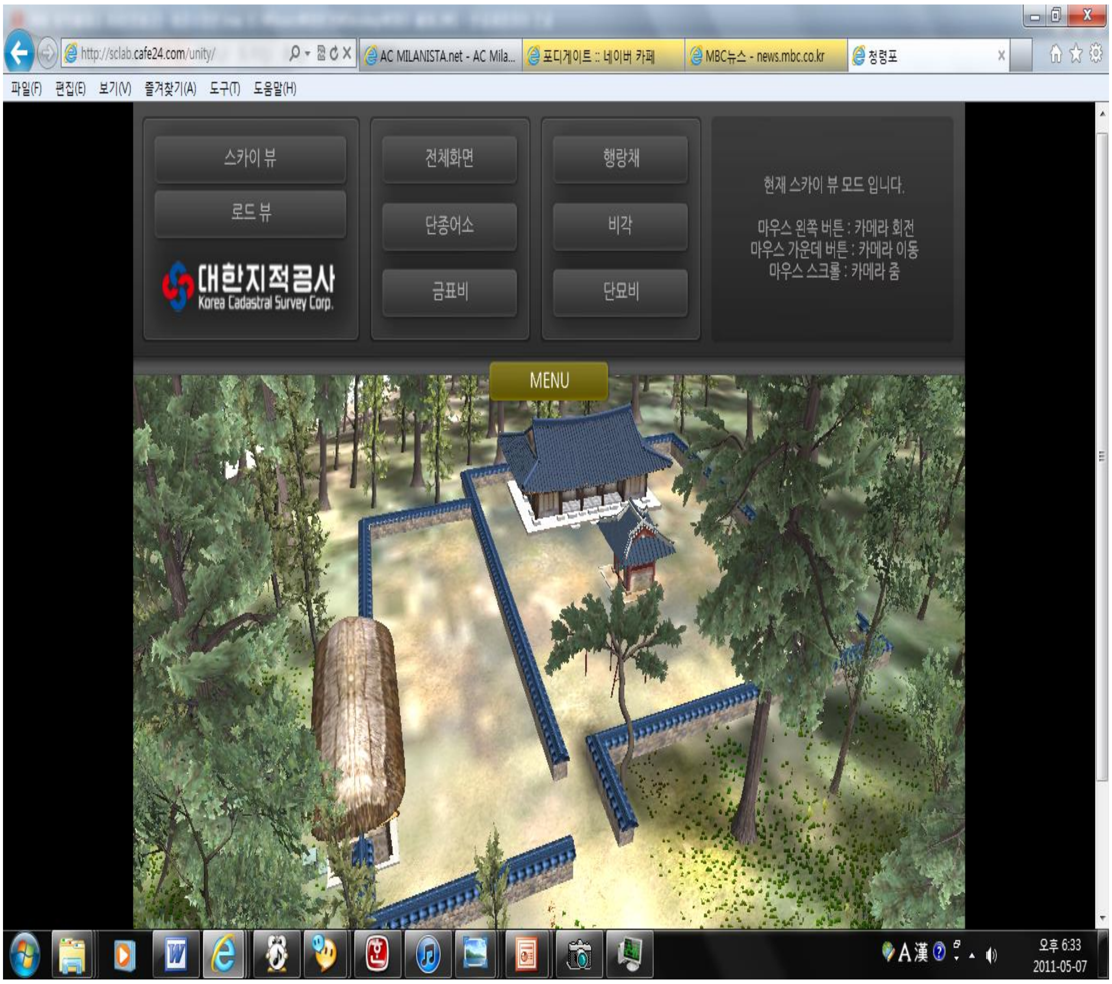
Planar auto-abstract is the process of building the base for polygon modeling. [Fig. 6] shows the extraction of connection surface of the filtered point clouds using Edge Wise and how it is loaded on Sketch Up. As you can see in the picture, curves like the roof tiles have a notably low extraction rate compared to walls or planar surfaces, even though it is an automated abstract. Currently, a plug-in that allows you to load surveying stations on Sketch Up is developed, so it is possible to directly model based on surveying stations.

2.4.3 Materializing 3D Cheongryeongpo on Unity3D Engine

[Fig. 7] Platforms supported by Unity3D Engine

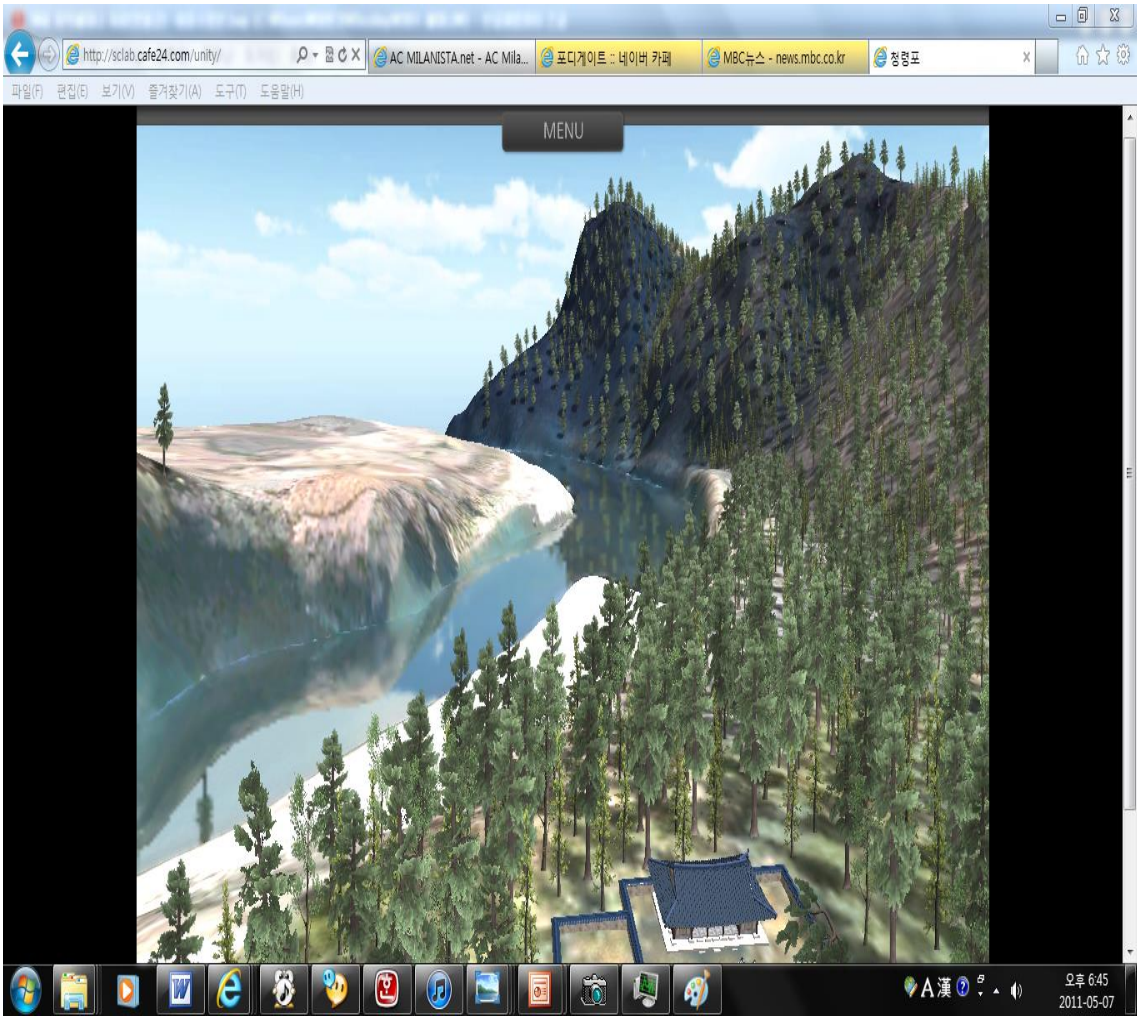
Unity3D is a 3D gaming engine produced by Unity Technologies which is not only used for making games, but can also be used as an editing tool for 3D contents. It can be run on Windows and Macintosh OS, and it can develop various contents for Windows, Mac, Wii, IOS, Android, etc. and 3D web games with Unity Web Player plug-in. It is relatively obscure in Korea, while it is well known as IPhone game developing program in the United States. It is simple and stable compared to other developing programs, which allows it to have a very high success rate of development. In short, it is possible to export 3D contents developed with Unity3D to various platforms such as smart phones and console games.

The modeling data of *Cheongryeongpo*, texture mapped with 3D MAX, can be saved as FBX format. The reason of saving in FBX format is because it has the best compatibility with Unity3D. We can now load *Cheongryeongpo* 3D modeling data on Unity3D by dragging the FBX file into the assets folder after running Unity3D. To revive the terrains of *Cheongryeongpo* area, we convert the DEM file of the area to FBX and then drag it into the assets folder. Then with the data, complete the regional terrain by using Terrain menu of Unity3D. After completion, export it for web browser view, and you can see it as [Fig. 8]



[Fig. 8] Unity 3D based *Cheongryeongpo* Run on Internet Explorer

The Unity3D file based *Cheongryeongpo* was around 55 megabytes. The original data which was around 30 gigabytes was converted to a data file which is portable after optimization. It actually took about 20 seconds to watch 3D *Cheongryeongpo* on the internet, and it was not difficult to run on computers manufactured after 2008. The previously existing 3D data were heavy, required a high performing hardware and certain programs to run, and a long time to download. On the other hand, Unity3D had overcome these disadvantages and allows various web browsers to run. It had no problems running on Explorer, Chrome, and Firefox, and it also runs on computers with Windows and Mac. In short, it has a great compatibility in general.

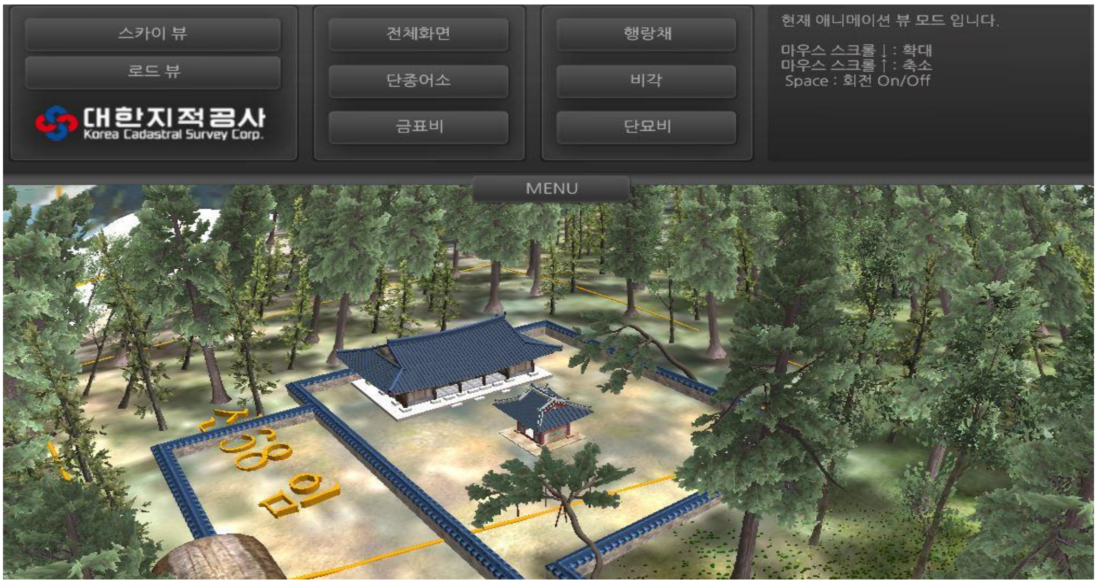


[Fig. 9] DEM of *Cheongryeongpo* Area Made with Aerial Photograph

With 3D data like this, people can have some experience of *Cheongryeongpo* and can even be used as a great educational reference. If internet is available, the data can also be available to foreigners living across the world, and could be a method of publicizing Korea.

2.5 Application Plans with the Cadastral System

In Body 2.4.3, the ground track of 3D *Cheongryeongpo* made with digital elevation model of its area was converted into yellow polygons to overlap to make a cadastral map like [Fig. 10] by overlapping. During the process of inserting the ground track, we have failed to result with a perfect positional matching with the digital elevation model, but we have found the possibility of the conversion of a 2D cadastral map to a 3D cadastral map. In the next research, fusing high resolution satellite photograph, digital elevation model (DEM), terrestrial LiDAR data, and ground track to raise the precision would be the key point.



[Fig. 10] Inserting Cadastral line (yellow color) inside 3D *Cheongryeongpo*

2.6 Application Plans of 3D Data of Cultural Assets And Expected Effectiveness

Application plans of 3D data of Korean cultural assets and expected effectiveness is as following.

2.6.1 <u>3D Cultural Asset Spatial Information Service Via Smart Phones</u>

As of January 2015, Korea's Smart Phone Distribution has surpassed 40 million. It means that almost every citizen of Korea has a smart phone. In addition, due to the new generation wireless service initiated in 2012, the transfer speed of smart phones have drastically increased. The maximum transfer speed was around 1 megabyte per second under 3G network, whereas the current 4G LTE transfers around 4 megabytes per second. Therefore, downloading a 100 megabyte 3D spatial information data under 4G LTE network takes only about 25 seconds, and downloading *Cheongryeongpo* takes only about 12 seconds. If we can survey more cultural assets, more people can indirectly experience and learn about them. This is a byproduct of a uniquely fast wireless network service.

2.6.2 3D Cultural Asset Guide Video

When the asset data surveyed with a cadastral LiDAR is combined with a software called Points Tool, it is possible to produce a 3D motion picture, which can be developed into a lively cultural asset guide video with an addition of captions and voice guide. Picture 18 is a scene from the guide video of '*Solmoe* Shrine' which was produced for the Pope Francisco's visiting Korea. Of course, informational voice guide is included to make the watchers feel as if they are listening to an actual guide.

[Fig. 11] Screenshot of ′*Solmoe* Shrine′ Guide Video

2.6.3 <u>Production and Distribution of Educational Contents</u>

If the numerous Korean cultural assets are surveyed with Terrestrial LiDAR and produce as education contents like [Fig. 12], students will be able to study with a more lively and stereoscopic educational tool.

[Fig. 12] An example of Educational Contents of Historical/Cultural Asset Quiz

2.6.4 3D Museum Application for Smart Phones

[Fig. 13] 3D Cambodian Museum Application Surveyed with Terrestrial LiDAR

One expected effectiveness of surveying a cultural asset with terrestrial LiDAR is the development of an application. Picture 20 is a Cambodian Heritage Museum 3D application for Android-based smart phones. The object in the screen is Vishnu, surveyed with terrestrial LiDAR. The objects in the 3D museum can rotate, enlarge, or reduce with the user's touch. At the top left of the screen locates a pop-up screen explaining about the object. In addition, this application is also registered on Google Play Store as a free application, so allowing anyone to download it anywhere is a great advantage. As a result, 3D museum applications are an effective method to publicize one country's cultural assets with a low budget.

3. CONCLUSION

Mentioned before, terrestrial survey is under great interest due to its effective management and recent restoration of cultural assets. The Statue of David in Europe, St. Elizabeth Hospital in America, and Chongqing Great Hall of People in China are all precedents of the world's interest in terrestrial LiDAR for restoration and management.

Following this trend, Korea Cadastral Survey Corporation has adopted terrestrial LiDAR survey technology since 2006 and has surveyed *Naksan* temple, *Chotdaebawi* rock, *Gochang* Dolmen, *Myeongdong* Catholic Church, *Cheongryeongpo* kiln site, etc.

For various reasons, a number of cultural assets in Korea are under conditions which make them unavailable for experience. As a result, we can only experience those through books or photos. So, we should try our best to bequeath our great assets to our descendants with the latest technologies like terrestrial LiDAR. In addition, the 3D *Cheongryeongpo* made with Unity 3D is light and easily played online, which makes it an accessible 3D spatial information prototype a new type of machine or device which is not yet ready to be made in large numbers and sold. People will be able to access 3D spatial information whenever they want to if LiDAR and wireless network are engrafted.

However, terrestrial LiDAR survey takes a long time as it requires a lot of man labor and uses different software during every step of process. It is also not popularized due to the high price of LiDAR equipment and software. As a result, simplifying the post process and researching about automating technology should be focused on.

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