An educational cadastral surveying simulator applying a metaverse platform

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Key words: Education, Survey, Metaverse, VR, Simulator, Digital twin, Unity

SUMMARY

In Korea, there are many cases where the boundary on the cadastral map and the actual one do not correspond. Therefore, the boundary needs to be determined by surveyors who have professional knowldege and know-how. However, there are temporal and spatial limitations in terms of capacity building because the cadastral survey is conducted on site. As a result, a host of time and cost for training is needed. This paper is to suggest the development of a cadastral surveying simulator to minimize the limitation. In particular, the simulator is able to contribute to sharing education and know-how and strengthening work skills.

By using VR, cadastral surveyors are able to cooperate with other stakeholders in virtual space for cadastral surveying. Simulator will help observe sites, determine boundaries, and prevent safety accidents by using surveying instruments in virtual spaces. And Furthermore, Simulator will improve to be a metaverse platform that can simulate every action occurring on the land including sectors like construction, civil engineering, firefighting, and traffic.

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1. INTRODUCTION

1.1. Cadastral surveying in Korea

In Korea, there are many cases where the boundary on the cadastral map and the actual one do not match. Therefore, the boundary decision is up to surveyors, which requires a lot of knowledge and know-how. We observe every structure near the site in question and decide on the boundary, comparing it with the cadastral map. This procedure is conducted based on the law.

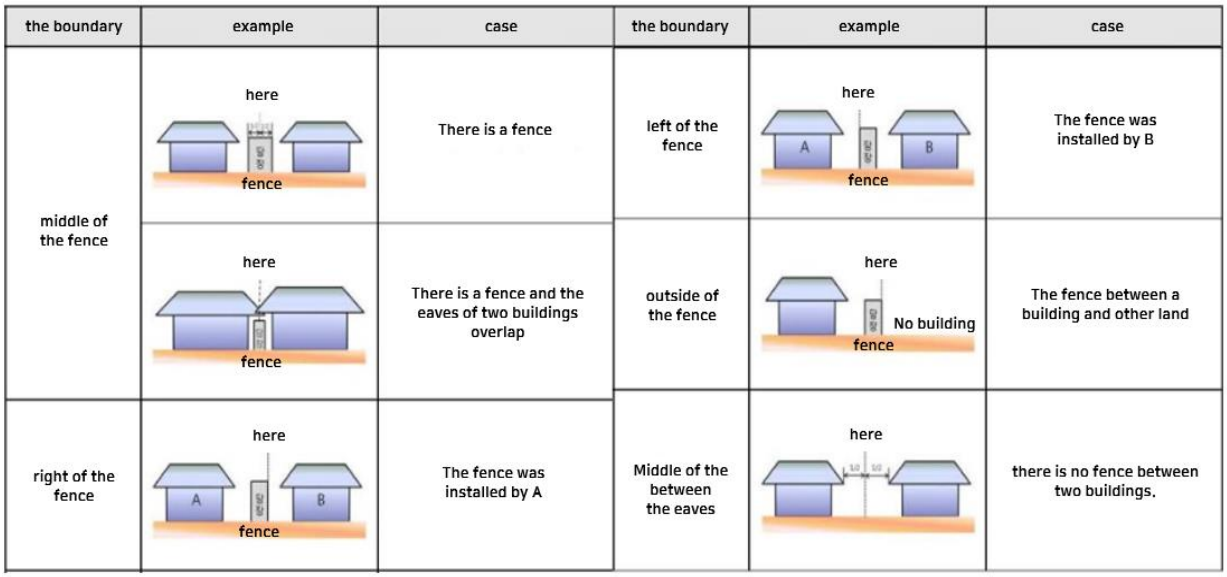

Figure 1 Korean criteria of deciding the boundary of the land

Like the image above, there are many cases when we are to set the land boundary in Korea. This work has to be consistent with the legal basis. Many practices and experiences are required to master this job.

1.2. Cadastral surveying experts in Korea

Korea just started to lack cadastral surveying experts. It is because most of the experts working in this field get to retire. A shift in a generation is proceeding, and the number of young, inexperienced workers are increasing. Our main problem is training them to be experts quickly. But educating cadastral surveying is largely limited to time and space, so we have difficulty training them.

1.3. Application of the game simulator on cadastral surveying

We deliberated on how to train the new generation efficiently. As mentioned, the young are flowing into the cadastral surveying field. This generation has been familiar with various digital devices from childhood, called digital natives. We considered them to be well-trained in the digital environment because of this familiarity.

So, we are to lay the ground for education free to temporal and spatial limitation, combining cadastral surveying and game simulator. Because cadastral surveying work is done by a team, we are to replicate the work by making the team online. It will help users operate together and learn the job.

Using the metaverse system that started to draw attention these days, we aim to make it able for users to be connected, get trained together, and simulate the cadastral surveying work in virtual space.

2. DEVELOPMENT

2.1 Unity and VR

We used Unity as the software for this project. Unity is a prominent game engine and has features that there are many individual developers as well as corporations because of broad users and abundant related materials. Recently, Unity started to draw attention as a metaverse platform, and the company is fully supporting this trend by developing related packages and suggesting guidelines. Unity has various target platforms, and this is followed by the strengths that they can apply the developed software to several environments like PC, mobile, gaming devices, and VR.

We used Meta Quest of Meta as the VR device for this project. This device includes a headset viewing the screen and hand controllers operated by both hands. It makes users feel like they are in real, virtual space by tracking functions with sensors. Initially, it had a limitation that we must connect it to a PC, but new VR device models with built-in PC are now releasing. Thanks to this, we come to use it without temporal and spatial limitations, expecting it to be the core device of a metaverse age.

2.2 Designing simulator process

Now we are to replicate the process of boundary relocation surveying, which is the most conducted work in Korea. We composed the flow of simulation as below.

1. (condition replication) Via VR, accessing the virtual world where the work site is replicated on DB
2. (surveying) Assuming the condition and doing surveying work.
3. (deciding boundary) Observing the work site and deciding boundaries.
4. (installing boundary point) installing the stakes on the boundary point of the land.

Based on the order above, we developed a prototype software with Unity that is compatible with VR devices.

2.2.1 Condition replication for cadastral surveying

We used graphics close to the live actions to represent the work site realistically. In the case of Unity, we can use assets (graphics, sound, script) needed for production for free or with

money, through the opened data forum called asset store. We used asset called Suburb Neighborhood House Pack (Modular) in this project.

Figure 2 Virtual site replicated on Unity

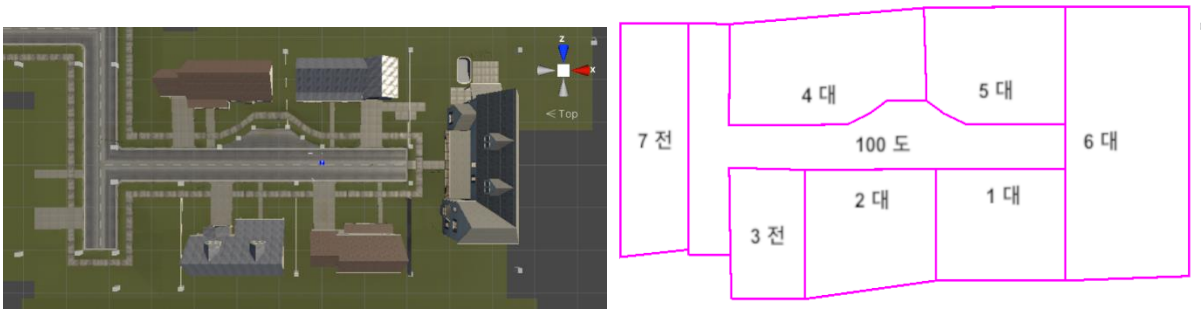

Figure 3 Left: the bird's-eye view of the site, Right: the cadastral map of the site.

Parcel number	Land catrgory	Number of points	Building	Area
1	Land	4	Y	545
2	Land	4	Y	598
3	Dry paddy-field	5	N	369
4	Land	7	Y	756
5	Land	6	Y	605
6	Land	6	Y	1271
7	Dry paddy-field	16	N	596
100	Road	4	Road (curbstone)	993

Table 1. Land list of the site

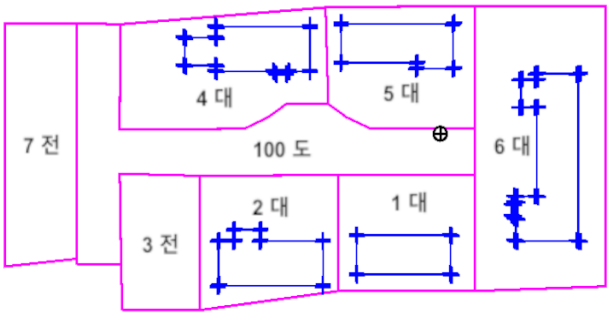

Figure 4 Buildings represented on the cadastral map

Figure 5 Real instruments used in surveying

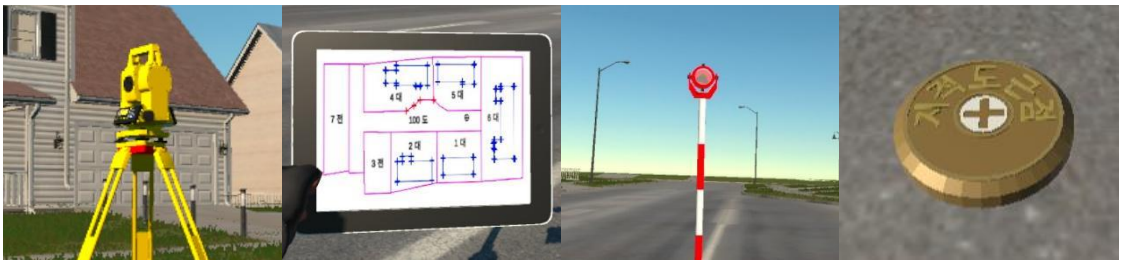

Figure 6 Instruments replicated in the virtual space

2.2.2 Observation using Total station

We performed the surveying work in the virtual space identically with the practical cadastral surveying method. We move to the observing point with a prism-installed pole, and then we observe the prism by Total station. This is the method that represents the point on the floor plan by calculating coordinate value with distance and angle. We realized the real-world process in the virtual world as below. We arranged structures that are criteria for boundary decision, including, curbstones, fences, and buildings, in the replicated work site. This will replicate an environment where users can practice the observation. We expect this to help enhance work skills by users understanding the criteria of boundary decisions and practicing the process of determining the result.

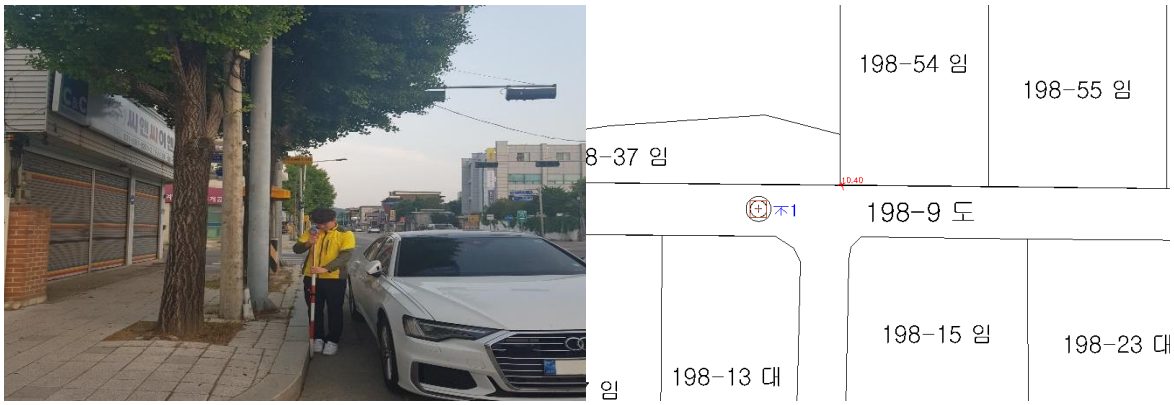

Figure 7 of the real work site

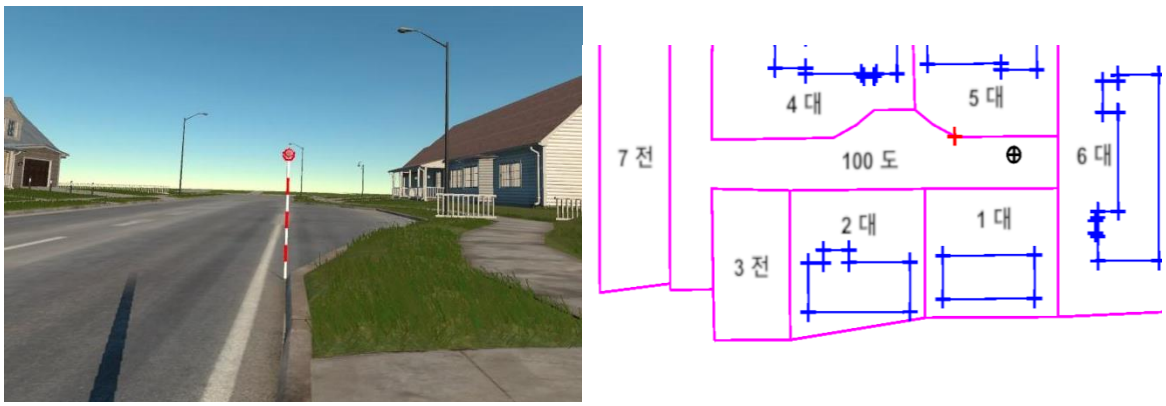

Figure 8 Process of the virtual site

2.2.3 Team composition by multi-play

Usually, in Korea, a team of three people conducts the cadastral surveying work. Teamwork is critical because each member has a role. We developed this project using a networking engine called Photon to enable multi-users to experience the same work site with a concurrent connection. Photon provides free and paid servers, and in the case of small projects, we can realize them in a free-of-charge server (highest access: 100). This project provides two roles - engineer and pole man.

The pole man moves to the observing point with a pole, and the engineer observes it and represents the point on the floor plan. The engineer aims a prism by the crosshairs middle of the screen and observes.

Figure 9 Left: the perspective of the engineer, Right: the perspective of the pole man

2.2.4 Replication of the error

Error is an inevitable element of cadastral surveying. Every survey has an error and minimizing this error is the surveyors' mission. It is difficult to identify the error in a real survey because there are various cases of error - errors due to the machine, the habit of individual surveyors, etc. Meanwhile, we can access every coordinate value in the virtual reality environment. Therefore we can simulate how many errors occur.

2.2.5 Boundary decision

We decide on the boundary by observing every structure near the site and comparing them to the cadastral map. This is a process to align the cadastral map with the structure on site, giving correction value from all directions.

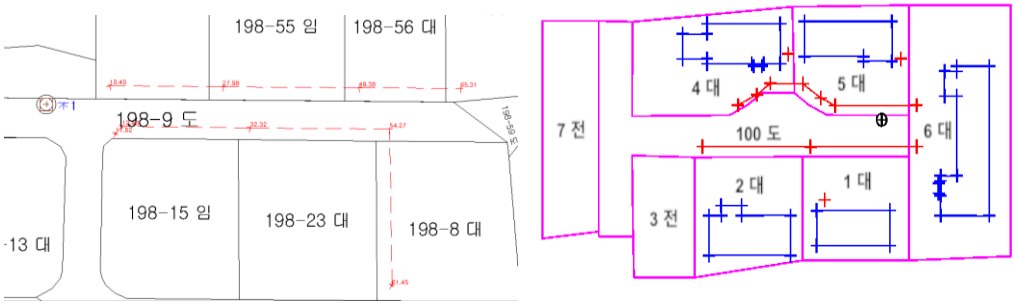

Figure 10 plan before the boundary decision, Left: real floor plan, Right: virtual one.

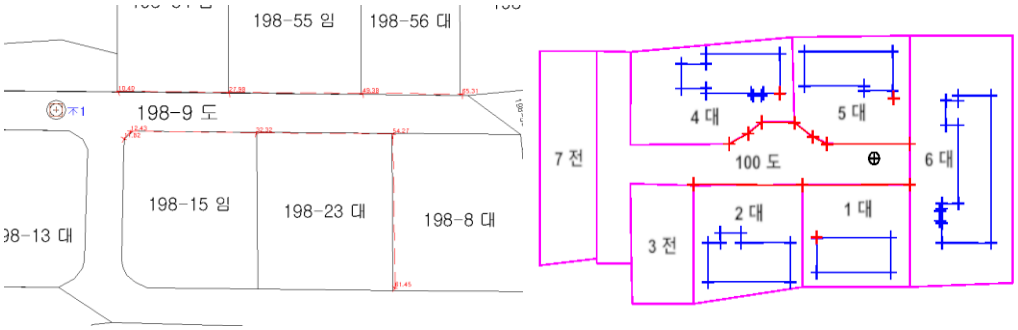

Figure 11 Floor plan after the boundary decision Left: real floor plan, Right: virtual one.

In the real work site, there are various structures, and the criteria of the boundary decision differ depending on the condition. Surveyor's knowledge and experience play a critical role in this process. This project will provide an environment replicating various sites and conditions for users to have enough practice in advance.

2.2.6 Installing boundary point stake.

Most of the cadastral surveying in Korea is Boundary Relocation Surveying. It is a survey that relocates the boundary point in the cadastral map to the real location by installing stakes. In Korea, there are many cases where the boundary on the cadastral map and the actual one do not match. Because of this, many people request boundary relocation surveying to execute their property rights. We can specify the location of the boundary point only when we have done the boundary decision process properly before.

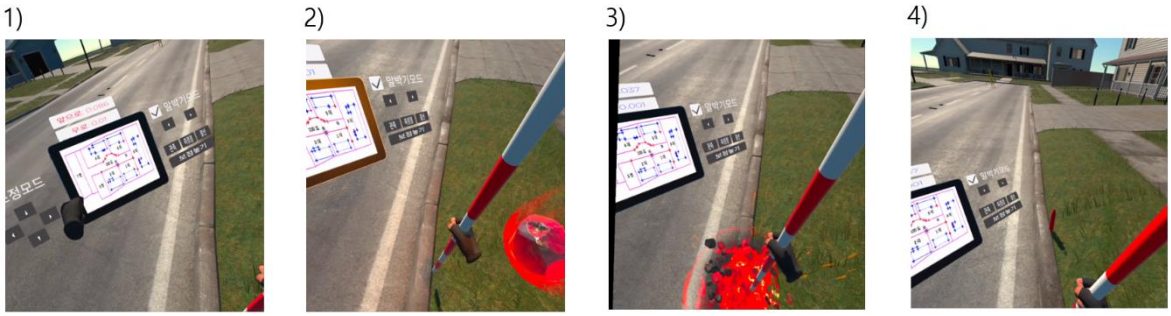

Figure 12 Process of installing stakes by tracking the boundary points

We find the accurate location of the boundary point using distance and angle and then indicate the stake in that location. After indicating every location of the boundary point, the simulation wraps up and the software autonomously assesses it based on the users' behaviors and judgments. It gives feedback about surveying errors and boundary decisions. Users can share and debate their results with those who had the same simulation, joining together in a virtual reality environment

3. CONCLUSION

3.1. Map making using digital twin

We tried a method that replicates the work site existing in the real world into virtual reality and surveys there. We selected the site that will be replicated, shot the site by drone, and generated 3D files to use in Unity. If we can realize the real site, then we can connect it to the existing survey data, making our project to be a utilizable education platform.
However, shooting by drone has limitations: it makes many blind spots. We need to examine using MMS instruments together to make up for it. Further, we expect to cut the data construction cost if we combine this simulator with the digital twin platform that our company is developing.

Figure 13 Left: real work site, Right: replicated virtual site (Unity)

3.2. Conclusion and expected effects

We investigated the development probability and orientation of the cadastral surveying simulator using VR through the pilot development. One of the main features of this project is that it obtains reality through VR and provides various experiences to users. If we complete this project, this simulator will help users learn the cadastral surveying work and enhance their competence in coping with diverse conditions. We expect it to be applied to other sectors as well as cadastral surveying, and to settle as a working manual.
As the metaverse started to draw attention nowadays, new paradigms are emerging, and the cadastral surveying field is trying to get on this trend. If we connect this project to a digital twin platform, it will be more scalable and suggest the expected effect in three sectors:
First, the construction of a cadastral surveying simulation based on a metaverse platform. By accessing a digital twin space where the work site is identically realized, we can survey in the virtual space without having to visit the site personally. This virtual space provides simulations for civil engineering and construction as well as surveying, giving much more information to the survey applicant.
Second, the provision of data for the inspective survey of the government agency. Regulation rules that cadastral surveying shall get the inspective surveying of the government agency. With our project, the inspector does not have to visit the site in person and can examine it through the virtual environment. It will save time and cost. Also, it will help process the civil complaint related to land without visiting the site, when utilized as references.

Third, the expansion to other fields. We developed this simulation mainly aiming at cadastral surveying, but it can be applied to any tasks occurring on the land. It can simulate construction, civil engineering, firefighting, and traffic fields, and many institutions and organization will be able to utilize it.

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