Demonstration experiment for the early detection method of wandering dementia patients by using GNSS
- Probability of a positional estimation by GNSS which examinee has in indoor -

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ABSTRACT: Japan has a continuously increasing population of elderly people aging 65 years old and older. At the same time, the number of dementia patients has been increasing. Therefore, the number of missing people among dementia patients has been holding a high record. A lot of reports and information about accidents and troubles in relation to dementia patient has been reported. The patient's family has big problems that the patient may cause an accident and trouble. In the research, we proposed the early detection method of wandering dementia patients by using GNSS logger and smartphone. First step in the research, obtaining their behavior route using GNSS logger and smartphone beforehand, it conducted behavioral analysis based on saved data. Those results are utilized for identification of the main purpose of wandering and a discovery in case of disappearance. We will be doing a demonstration experiment of it with the cooperation of dementia patients. However, it is not possible to conduct the experiment because of COVID-19 now, so this research conducted preliminary experiment using GNSS logger and smartphone. Positional information in indoors are obtained by simultaneously on GNSS logger and smartphone. Our results showed that each equipment could obtain positional information indoors, but there were some differences. In addition, it was found that using smartphones made it possible to easily obtain positional information of indoor more than GNSS logger.

1. INTRODUCTION

Currently, the number of elderly people trends upward in japan. The population of Japan's elderly people in 2019 increased 320 thousand people in comparison with 2018 and became a record high 35.88 million people (MIC, 2019). The ratio of their total population in Japan has been increasing since 1950, and it will expect to increase more. In addition to the information mentioned above, the number of dementia patients has been increasing at the same time. Cabinet office estimated that one out of five people can be a dementia patient in 2025 (Cabinet office, 2017). There has been a lot of reported accidents and cases caused by people suffering from dementia. When dementia worsens, there are increasing patients who happen to be constantly walking around, oblivious to why and where they are going to. As a result, the number of missing people among dementia patients has been increasing every year. Another big problems, there are also a lot of cases wherein the patient's family have to leave a job for nursing care and this has since become a social problem. Many companies and city offices provide a service to serve the patient, but those services have some problems such as expensive equipment, unstable positional accuracy and information leakage to outsiders etc.

2. RESEARCH SUMMARY

This research is conducted as one of K.I.T. Spatial Information Project. Researches are currently conducting the cooperation with the local residents, local government and hospitals. Introducing a patients by local the government and obtaining knowledge of their medical background provided by the hospital, we conducted the experiment. Purpose of the research, we propose the early detection method of wandering dementia patients by using GNSS logger and smartphone. In this research, we propose the early detection method of wandering dementia patients by using GNSS logger and smartphone. The first step in the research is obtaining data of their behavior route using GNSS logger and smartphone beforehand to conduct behavioral analysis based on the saved data. Those results will be used to utilize the identification of the main purpose of wandering person and a discovery in case of disappearance. GNSS logger is a small and cheap device which can be possibly used to record a behavior route and display those using special software on the map. In addition, it will be able to provide with a very low cost in comparison with other search services which is currently being offered in the market for a higher cost. It is worth noting that smartphone ownership in elderly people is increasing every year which means that the usage of smartphone for early detection method has a big potential.

On a previous research presented by K.Kishimoto about the verification of accuracy and demonstration experiment of the method (Kishimoto, 2020), it was founded that measured accuracy has no differences in the position between smartphones and GNSS logger. He also conducted a demonstration experiment of it with the cooperation of healthy elderly people aged from 70 to over 80. As a result, it was found the method is a possible to confirm the feature that they have a trend of wandering dementia patients.

3. OUTLINE OF EXPERIMENT

Demonstration experiment with the cooperation of dementia patients were planned. However, as of this moment, because of the COVID-19 pandemic, we were only able to conduct preliminary experiment using GNSS logger and smartphone. Positional information was obtained by GNSS and smartphone at indoors, and it was compared. GNSS logger has in two types; the wrist watch type and small size type. Wrist watch type was named Type 1, Small size was named Type 4. The smartphone that was used is an "iPhone7" as shown in Fig.1. Smartphone app was used "Geographica” which is a free app that can record the route and create the way to get to the destination, etc. Recording interval for each equipment was set the least interval. Fig.1 shows GNSS logger and smartphone for the experiment. Table.1 shows the types of receiving satellites for each devices and the least indication of recording time.

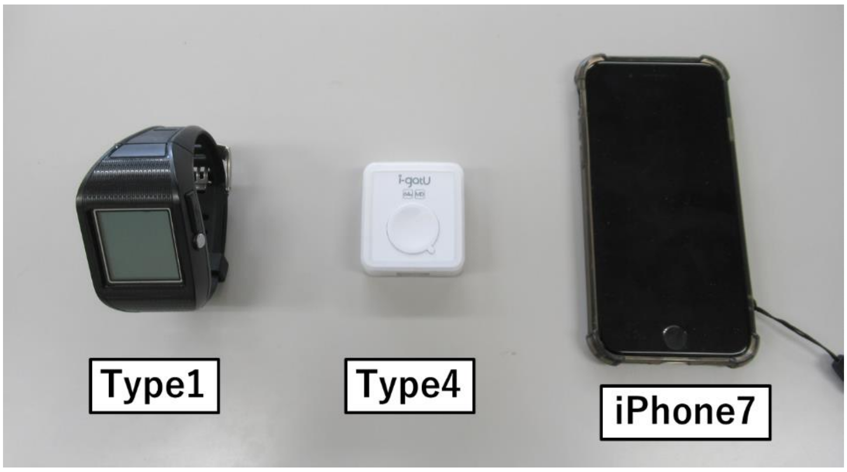

Fig.1 GNSS logger and smartphone

Table.1 Performance of GNSS logger and smartphone

Equipment Name	Equipment Number	Recording interval [sec]	Type of Satellite		
			GPS	GLONASS	QZSS
GT-900	Type1	1	○	―	○
GT-600	Type4	1	○	―	○
iPhone7	―	5	○	○	○

4. EXPERIMENTAL RESULTS

4.1 Method of experiment

Carrying all of the equipment previously mentioned, the experiment was performed simultaneously indoors. Type 1 was put to left arm, Type 4 was put into left pocket, while the smartphone was put on neck. Positional information for indoors was confirmed when the observing person went on the outside of the building. The observation was conducted in a five story building, specifically in the 2nd and 5th floor, respectively and was divided into three stages wherein having wandering dementia patients is expected. The first stage which we called it short stage last for 10 minutes, the 2nd stage which is the medium stage last for 20 minutes and lastly, the third stage or the long stage needed 30 minutes.

4.2 Analysis of the data

The elevation values in each time were recorded to the equipment, and was able to confirm the situation. Confirmed of elevation values is from the 1st floor, to the ceiling of 5th floor in the building with the height of from 18 meters to 33 meters. Elevation values inside the building grounds was estimated by "Geographical Survey Institute Map (GSI,2020)" to be around about 18 meters while the height of the 1st floor was about 3 meters (LIFULL Co.,2013). GNSS logger measures ellipsoidal height because of satellite navigation system. Calculated elevation estimated geoid height using latitude and longitude of each time by “Survey calculation website (GSI, 2020)” Ellipsoidal height is measured based on reference of the ellipsoid which is a virtual object shaped like a geoid. The standard of height that we are using is elevation. Therefore, Ellipsoidal height converts to elevation by calculating the differences between Ellipsoidal height and geoid height. Elevation is the height from sea level in Tokyo port. Geoid height is the height from reference of the ellipsoid to Geoid. Geoid is virtually an extended surface from sea level to land.Fig.2 shows the relationship between Elliptical height and Geoid height, Elevation. Fig.3 shows schematic views of the experiment. The GNSS logger data could not obtain elevation values within the building, which gave us the result that a positional estimation using GNSS logger is difficult when indoor. However, when observation time is only 20 minutes at each GNSS loggers, it was found that GNSS logger was possible to obtain a lot of elevation values within the building. Fig.4 shows observation data using Type1 when observation time is 20 minutes. Fig.5 shows observation data using Type4 when observation time is 20 minutes. The vertical axis indicates the elevation values while the horizontal axis indicates observation hours. The interval of observation time for each floor is also shown for reference.

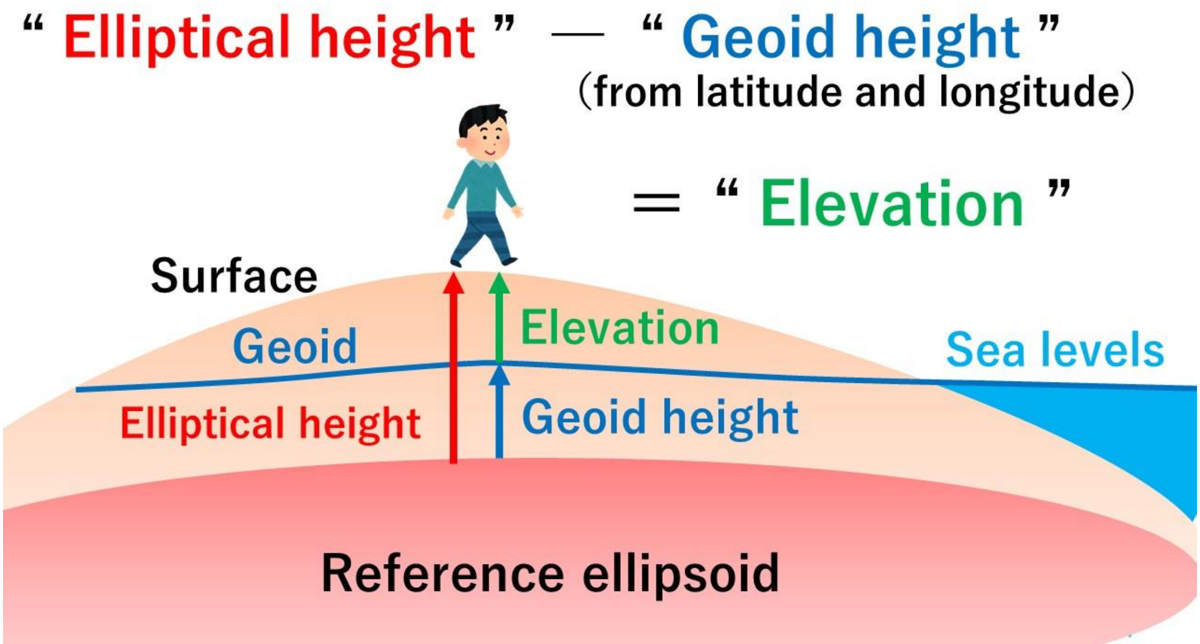

Fig.2 The relationship between Elliptical height and Geoid height, Elevation.

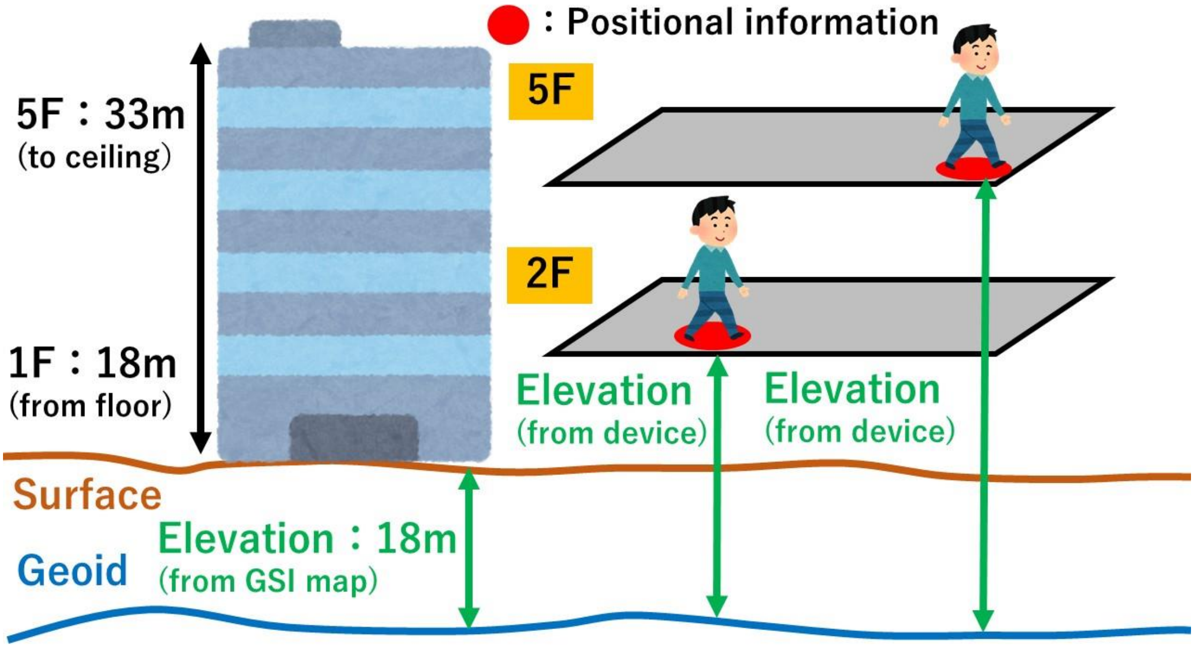

Fig.3 Schematic of the experiment

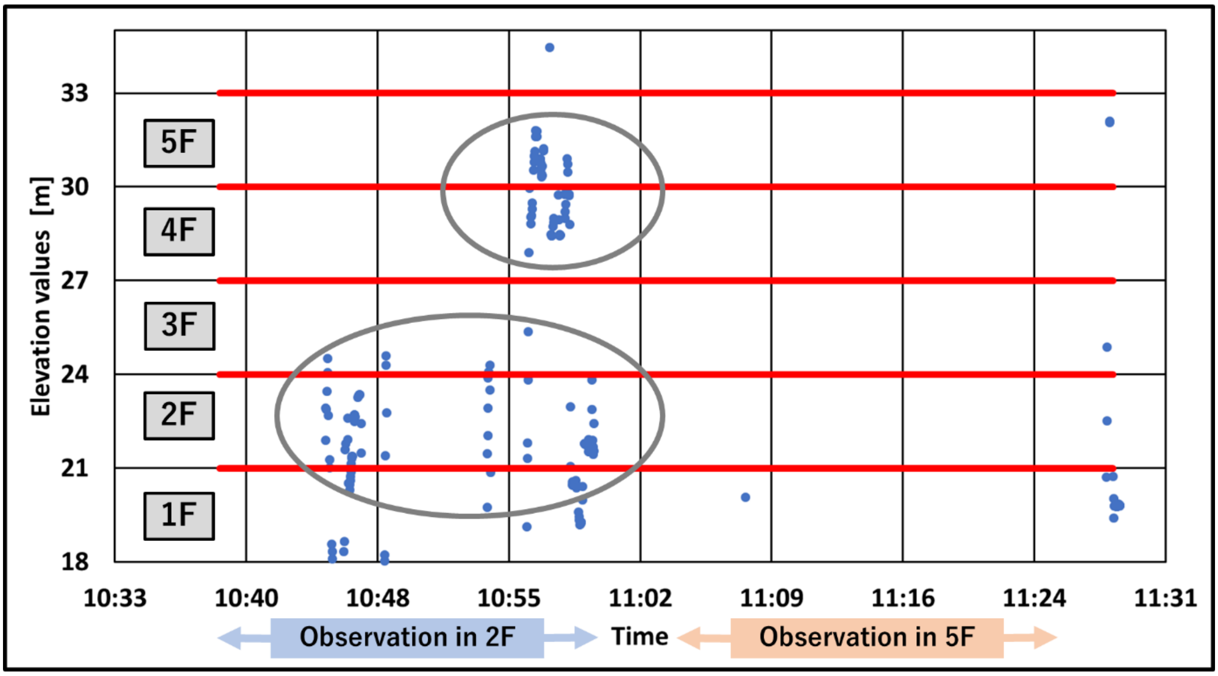

Fig.4 Observation data using Type1 (observation time: 20 minutes)

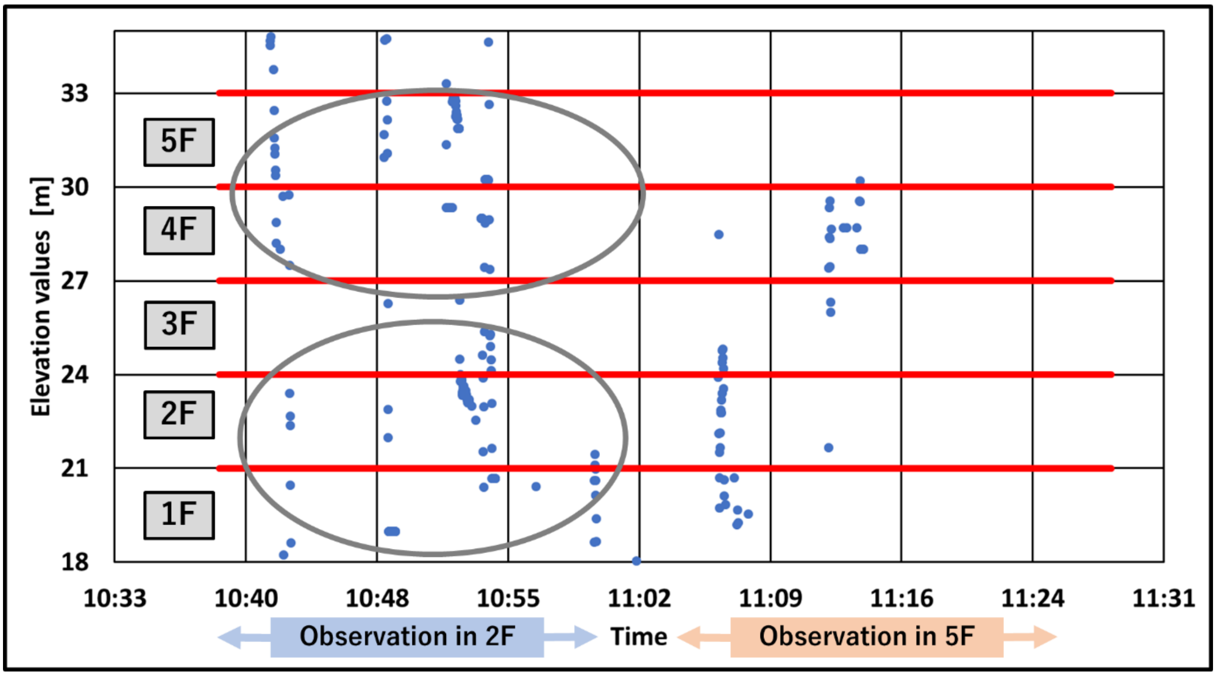

Fig.5 Observation data using Type4 (observation time: 20 minutes)

Confirming the obtained situation from 10:41 to 11:04 which was measured in 2nd floor, it was found that a measurement point could be obtained at the 2nd floor. However, it was found that some measurement points are disturbed on 4th floor and 5th floor from 10:55 to 11:02. The same tendency was appeared on Type4. Type1 could not obtain a measurement point from 11:05 to 11:25 which was measured in 5th floor. However, Type4 was possible to obtain the point at the probably 5th floor from 30 meters to 33 meters.
Smartphone was similarly confirmed the same measurement points. The height which is measured by geographica with smartphone is elevation values and it omitted the estimating geoid height. Using smartphone is possible to measure the elevation values of current location using air pressure sensor. In case of smartphone with air pressure sensor, it is possible to measure an

air pressure of current location by the sensor. Smartphone data was able to obtain many elevation value data of the building in each floors in comparison with GNSS data (GNSS logger). Fig.6 shows observation data using smartphone with observation time is 20 minutes.

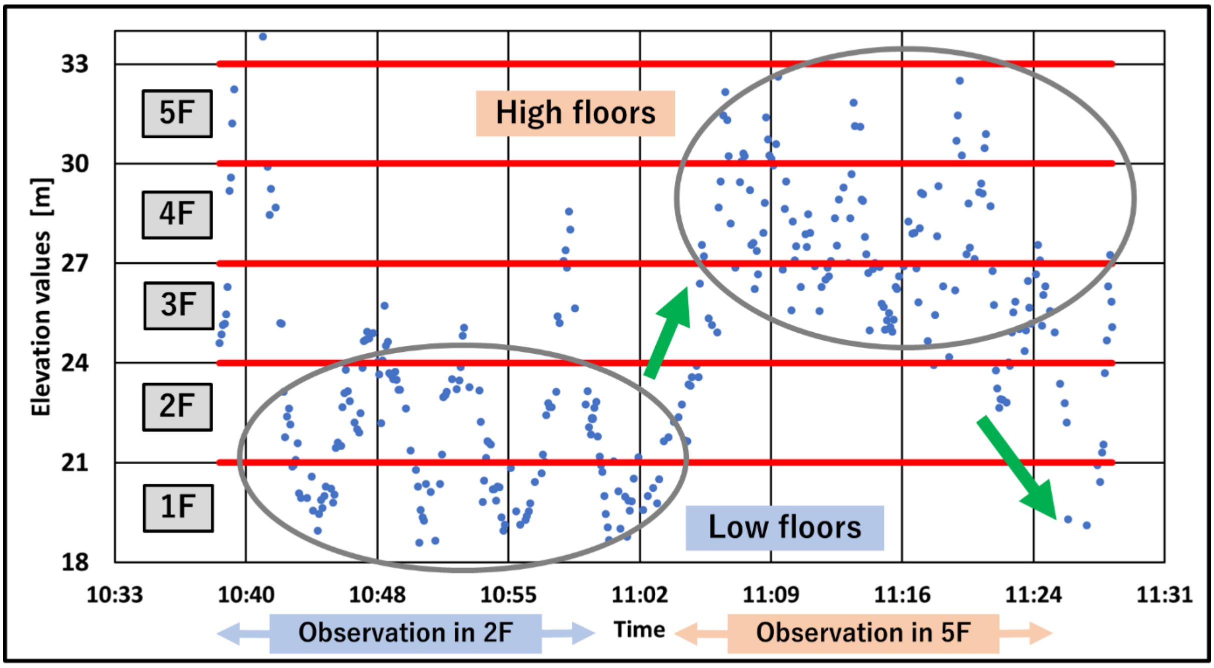

Fig.6 Observation data using smartphone (observation time: 20 minutes)

Confirming the obtained situation from 10:41 to 11:04 which was measured in 2nd floor, there was different elevation values, but it was found to be going through low floors. The same tendency was appeared from 11:05 to 11:25 which was measured in 5th floor. It was also possible to read the change of elevation value from about 11:03 and estimated to be moved floors, and the time matched actual observation time (arrow symbol of upper right of Green as shown in Fig.6). The same tendency was appeared from about 11:25 (arrow symbol of lower right of Green as shown in Fig.6).

Another experiments showed similarly results confirmed. It was found to be going through low floors and high floors. When observation time was around 10 minutes, there was a little different elevation values and it was difficult to read a time when moving from 2nd floor to 5th floor in the building (arrow symbol of upper right of Green as shown in Fig.7). The actual time was from 13:57 to 13:58. However, it was possible to read a time when moving from 5th floor to 2nd floor in the building (arrow symbol of lower right of Green as shown in Fig.7). The time was about 14:09 and matched actual observation time. Fig.7 shows observation data using smartphone when observation time is 10 minutes. When observation time was around 30 minutes, elevation values was most varied. However, there has been an evident big change of elevation value which is estimated to be moved floors from about 14:09 (arrow symbol of upper right of Green as shown in Fig.8). The time was matched the actual observation time. There is also a big change of elevation value which is estimated to be moved floors from about 14:24 (arrow symbol of lower right of Green as shown in Fig.8), but the time did not match in comparison with the actual observation time which is from 14:40 to 14:43. Fig.8 shows observation data using smartphone when observation time is 30 minutes.

Confirming the observation which acquired positional information indoors on "Geographical Survey tile (GSI,2020)", it was found that smartphone could obtain more information than the GNSS logger. On smartphone, some measurement points were disturbed up to about 50 meters from within the limits of the building. On Type4, measurement points were disturbed up to about

100 meters from it. On Type1, measurement points were disturbed up to about 1 Kilometers from it which means that Type1 was inaccurate in gathering data. Fig.9 shows the observation situation which acquired positional information indoors on smartphone. Fig.10 shows the observation situation which acquired positional information indoors on Type1. Fig.11 shows the observation situation which acquired positional information indoors on Type4.

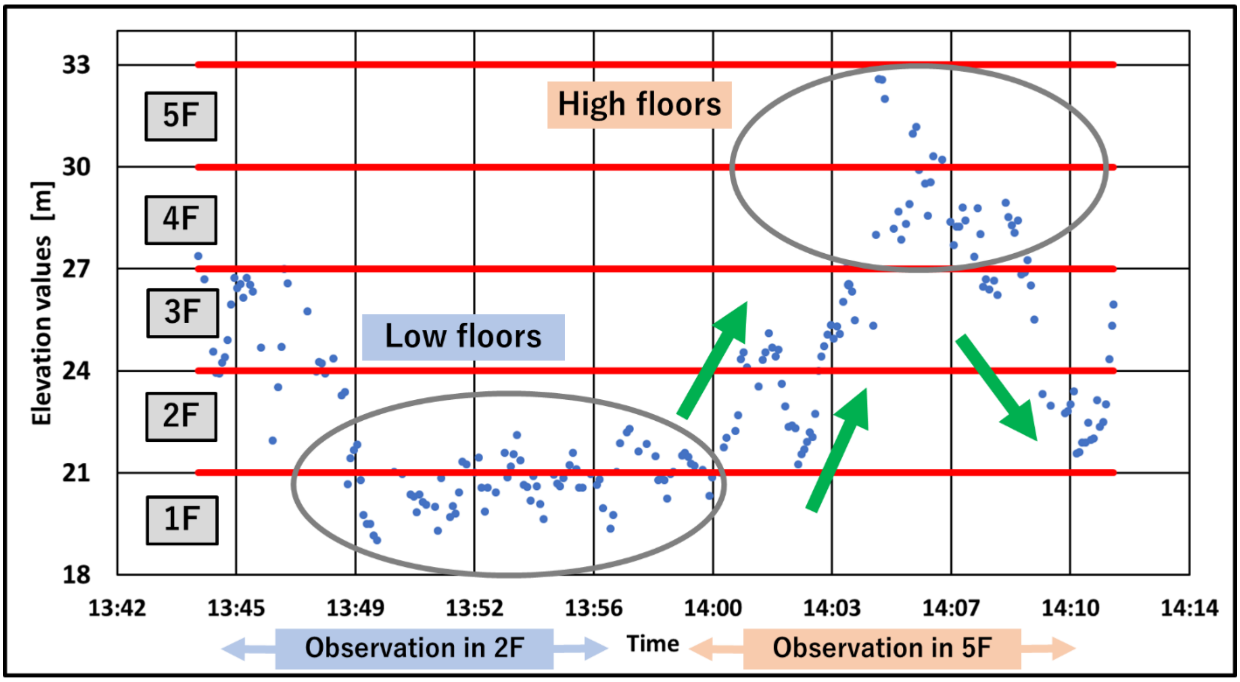

Fig.7 Observation data using smartphone (observation time: 10 minutes)

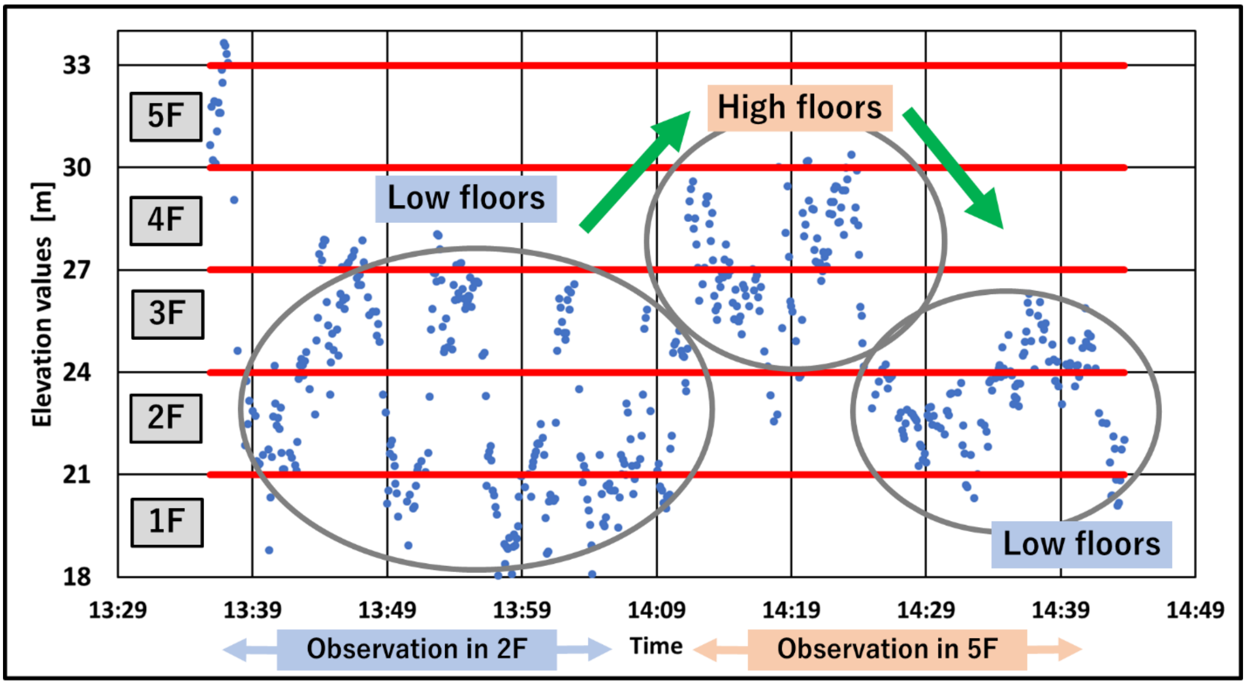

Fig.8 Observation data using smartphone (observation time: 30 minutes)

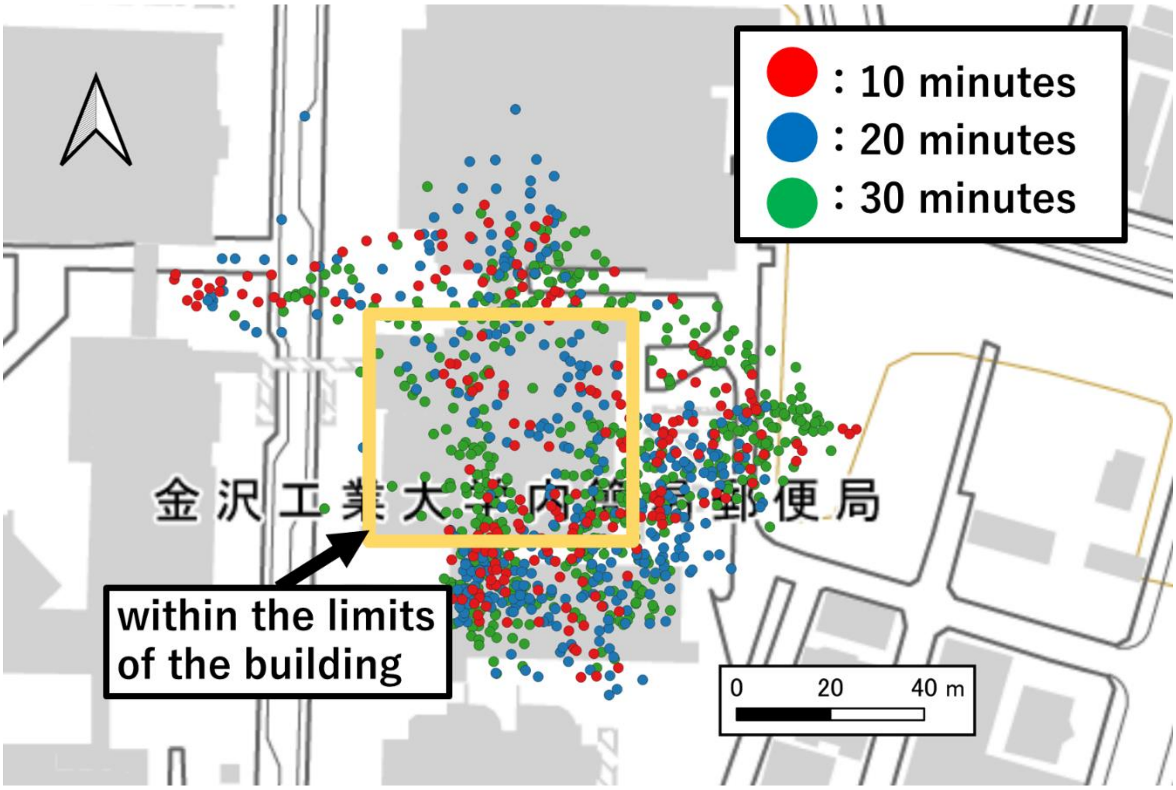

Fig.9 The observation situation which acquired positional information indoors on smartphone

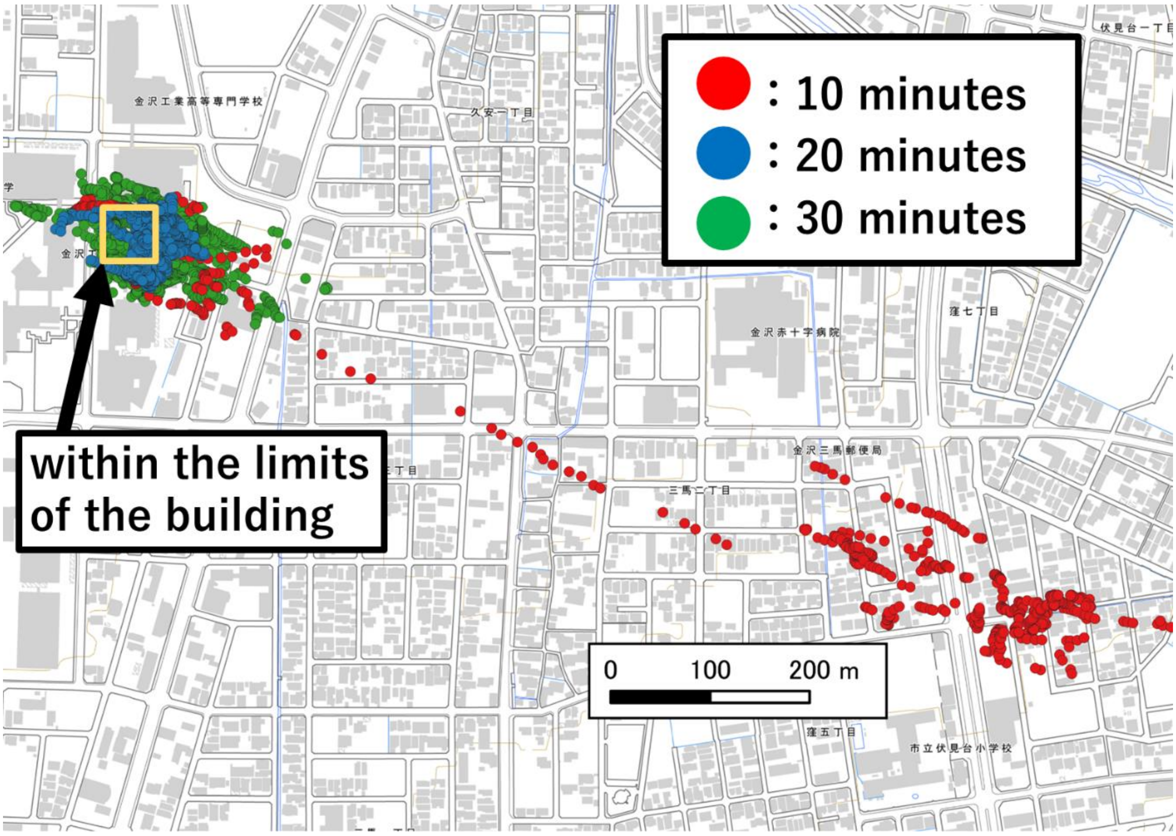

Fig.10 The observation situation which acquired positional information indoors on Type1

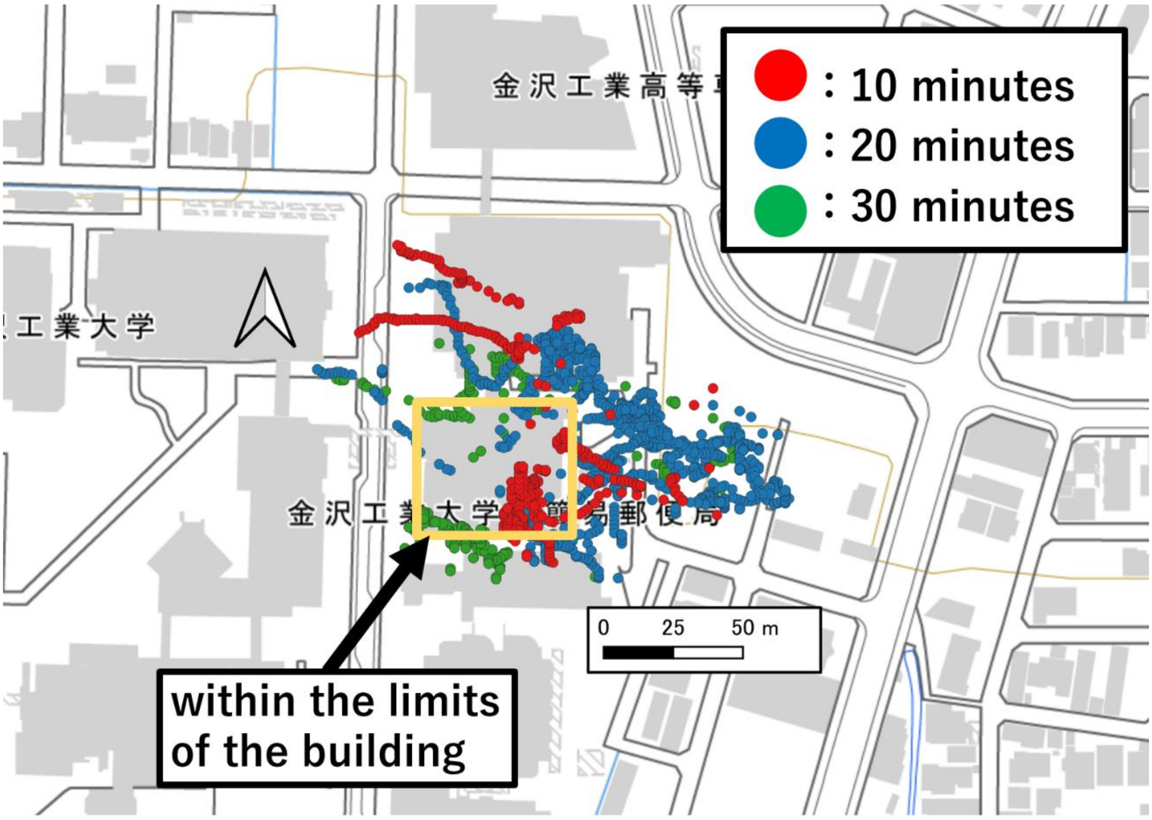

Fig.11 The observation situation which acquired positional information indoors on Type4

5. CONCLUSION

The research has been carrying out since 2016. Pioneers who led the research conducted an experiment about the verification of accuracy and demonstration experiment of the method. As a result, it was found that GNSS logger and smartphone is possible to obtain high accuracy in mountainous areas and in coastal strips wherein dementia patients are often wandering. Also, on the demonstration experiment with the cooperation of healthy elderly people, it was found that the obtained data is possible to confirm a means of transportation and which side of the road wherein walked, going outside is a long time or a short time.
Our results showed that each equipment could obtain positional information indoors, but there was some dissimilarity in the situation. It was found that for the GNSS logger, it is difficult to obtain positional information at an estimate position indoor. Almost GNSS logger data could not obtain positional information within the building. However, when observation time in 2nd floor is only 20 minutes at each GNSS loggers, it was found that GNSS logger could obtain positional information of low floors starting from 1F (18 meters) to 3F (24 meters), and some measurement points were disturbed where high floors beginning from 4th floor (27 meters) to 5th floor (33 meters). Also, while observing from the 5th floor, it was difficult to obtain positional information of 5th floor (from 30 meters to 33 meters). In addition, when using smartphone, it is easier to obtain positional information of outdoors and can also possibly estimate position even indoors. On all smartphone data, in the case of observation in 2nd floor, it was found that smartphone could obtain positional information of low floors wherein it is from 1F (18 meters) to 3F (24 meters). Also, in the case of observation in 5th floor, it was found that smartphone could obtain positional information of high floors even from 4th floor (27 meters) to 5th floor (33 meters). From the experimental results now, we were not able to confirm a trend about difference of observation time. Therefore, there is a need to conduct extra experiment to confirm the trend.

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