Demonstrational experiment for the early detection method of wandering dementia patients by using GNSS

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ABSTRACT: Early stage of the research was reported in ACRS2020. This report is advanced research results continuing from last year. 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. Demonstrational experiment has been conducted with the cooperation of elderly people. Examinees are elderly people without dementia. Lending some equipment for examinees and they used it in their daily lives. As a result, it was able to record their behavior pattern. Also, analyzing recorded data, we considered whether it is possible to use that when dementia worsen, saved data can possibly be utilized and split up behavioral route; it could serve as a health index. Also, we have been doing the same experiment with the cooperation of younger people.

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 (FNN, Inc., 2019). 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.
We have conducted preliminary experiment using GNSS logger and smartphone last year (Takumi, 2020). Positional information for indoors was confirmed when the observing person went out the outside of the building. The information in indoors were obtained by simultaneously on GNSS logger and smartphone. Our results showed that each equipment could obtain positional information indoors, but there was some differences in the situation. In addition, it was found that using smartphones made it possible to easily obtain positional information of indoor more than GNSS logger.

3. OUTLINE OF EXPERIMENT

Demonstration experiment with the cooperation of dementia patients were planned at the beginning of experimental research. However, cooperation institution of our research advised that the patient could get into an accident and trouble during the experiment. Because of the advice, the examinees were changed from dementia patients to elderly people. Demonstrational experiment with the cooperation of elderly people was conducted. Examinees are elderly persons who don't have dementia yet. Their behavior pattern was obtained by GNSS and smartphone, and it was analyzed in cooperation with the local special doctor (hereinafter as doctor). Also, we considered effectively using the analyzed result.
Experimental equipment is GNSS logger and smartphone, and GNSS logger name is Type-2. 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-730FL-S	Type2	1	○	—	—
iPhone7	—	5	○	○	○

4. METHOD OF EXPERIMENT

4.1 Confirmation of physical condition

Physical condition of examinees were conducted before the experiment. It was used question sheet created by collaboration with local hospitals. There are about 13 questions in all, for example, frequency of going out, occupation, family structure, etc. Also, HDS-R was utilized for getting the index of cognitive function. HDS-R

means "Hasegawa dementia scale-revised" and is a cognitive function in the examination (Oya, 2019). It has 9 categories, namely calculation and age, time etc. The full score is 30 out of 30. In case of below 20 and out of 30, there is a high possibility of developing dementia (SMS Co., LTD., 2020). However, the exam result is just a references. Even if getting a bad score in the exam, the person might not be diagnosed as a dementia patient (SMS Co., LTD., 2020). All questions and answers were conducted by optional items. Those result was used for analyzing recorded data.

4.2 Demonstrational experiment

First, examinees received experimental equipment from us. The experimental period was about 4 days. Second, examinees lived their daily life as usual while carrying the equipment. Finally, they return the equipment to us and demonstrational experiment are over.
After getting their behavior route, analysis on the data was conducted. Also, we considered effectively using the analyzed result such as whether it is possible to use that when dementia worsen, saved data can possibly be utilized and split up behavioral route etc.

5. EXPERIMENTAL RESULTS

The demonstrational experiment was conducted for two of the examinees this time. Examinees were two women in their 80s who were introduced by the local government. They were named Ms. A and Ms. B in each. They have high results in HDS-R and were less likely of developing dementia. Table.2 shows the details of the examinees.
Two examinees have been using a flip phone and have difficulties to use smartphone, therefore, they used Type-2 in the experiment.

Table.2 Details of Examinees in the Demonstration experiment

Name	Gender	Age	HDS-R result
Ms. A	Female	83	27 out of 30
Ms. B	Female	86	27 out of 30

Using experimental equipment made it possible to obtain their behavior route. A part of the obtained data included positional information, except for going out. So, applicable parts data were removed in the positional information. This research assumed these parts data are an error in measurement. Also, it assume that most data was obtained while staying at home. This is because most positional information was focused on their house. We assume that this is an affected by weather and the COVID-19 pandemic etc. It usually rains a lot in our living area. So, by displaying the route on aerial photography (GSI,2021), it divided the data into two, one with her behavior route and the other without her behavior route. As a result, each examinee's route was found. Fig.2 shows an example of the data without her behavior route.

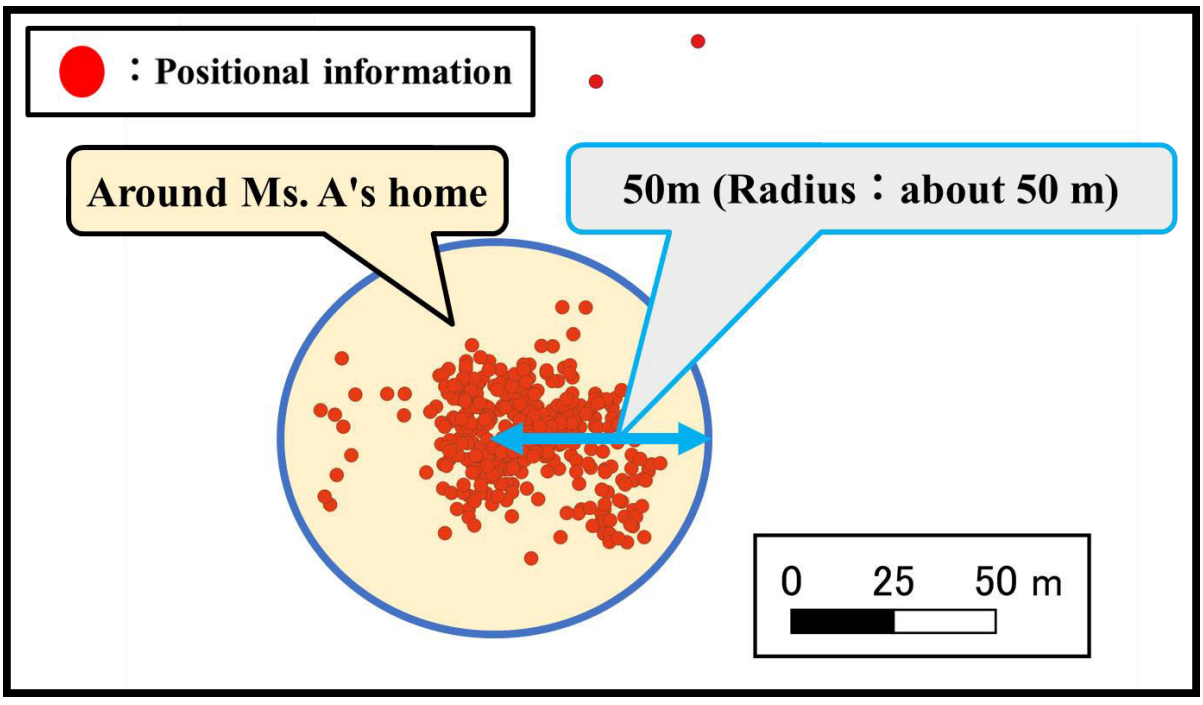


Fig.2 An example of the data without her behavior route

Analysis of examinees was conducted using their obtained data. Calories and total distance, average velocity and so on was calculated used as reference index for the analysis. Can way" and their movement route by them was used in analysis. "Can way" is a free software that allows data to be changed from "txt" format to "GPX" format. When downloading obtained data from Type-2, "txt" format data becomes default format. Also, it is able to calculate used calories by using "GPX" data and setting their weight and age etc. Table.3 shows calculated results of the two examinees.

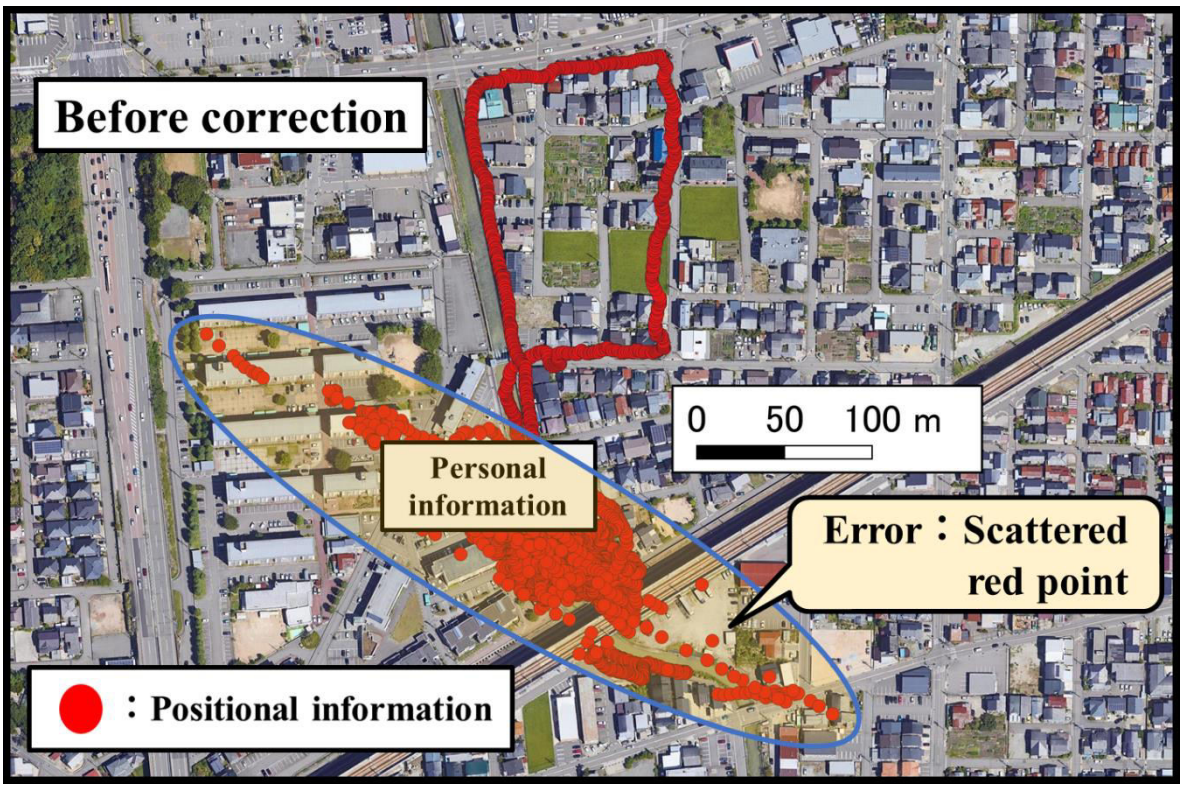
Table.3 Calculation results of two examinees

Category	Ms. A	Ms. B
Distance	11.85 km	1.15 km
Travel time	3 hr 2 min 59 sec	9 min 41 sec
Average velocity	3.85 km/h	7.12 km/h
Max speed	115.01 km/h	66.16 km/h
Used calories	480.3 kcal	32.8 kcal

First, result of Ms. A were summarized and analysis. Her behavior route data is from 17:10 to 20:13. By displaying the route on aerial photography (GSI,2021), it confirmed that the data has an error in measurement. Also, by removing the error, her behavior route was corrected. Deleted part was from 18:00 to 20:13. Fig.3 shows the data before correction. Fig.4 shows the data after correction. The data of Fig.4 was used for the analysis of Ms. A.

Fig.3 shows that measurement points were scattered. This is because we contemplated that Ms. A did not turn off power of Type-2 after returning to her home. Therefore, Type-2 continued to obtain positional information at her home and caused an error in measurement. In case of obtaining positional information in indoor, most of the time, it is not possible to receive enough number of surveying satellites. Also, obtained position information is scattered. By using the confirmed behavior route of Ms. A, position information was spread out when attention around to her house.

Some result of Ms. A on Table.2 were calculated by using her obtained data with an error in measurement. Therefore, it was difficult to use as reference index for the analysis by using calories and total distance, average velocity etc. Also, it is impossible to calculate using obtain data after correction. This is because it is not possible to redact "GPX" format data to use for calculation.



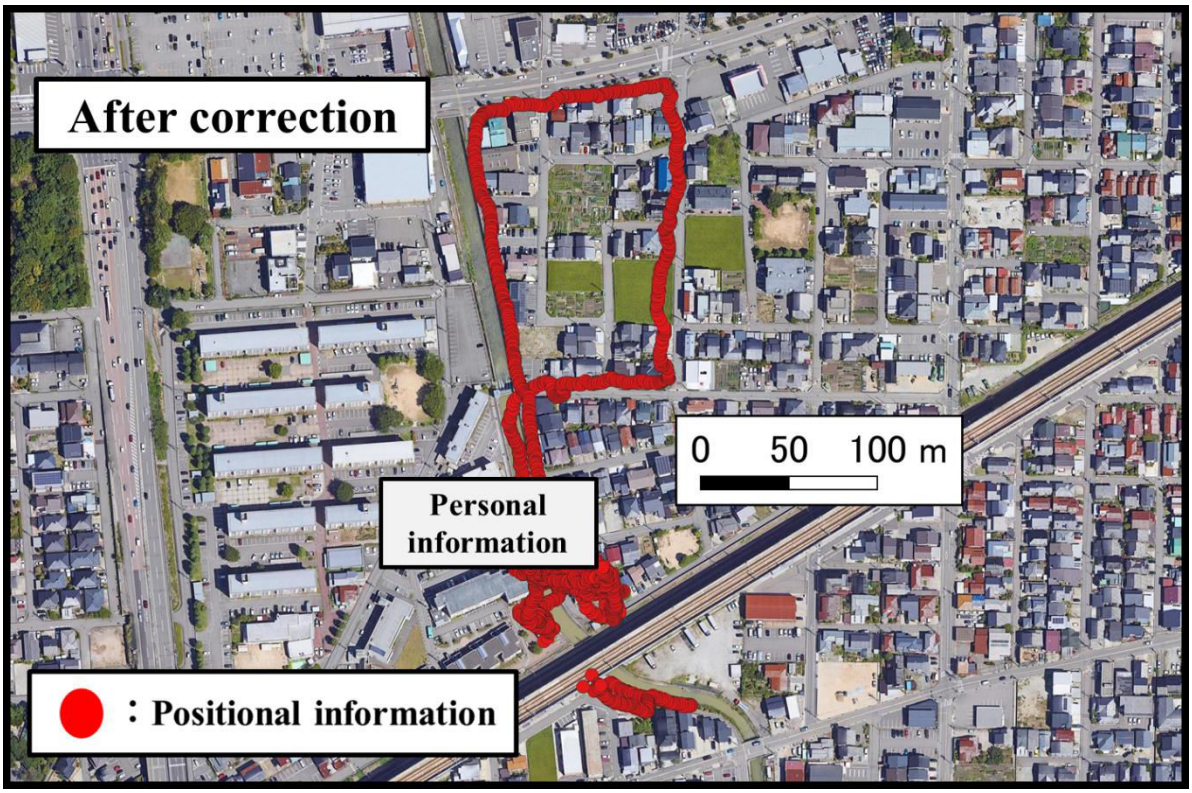


Fig.3 Data before correction（Observation time：17:10 ~ 20:13）

Fig.4 Data before correction（Observation time：17:10 ~ 18:00）

By confirming behavior route of Ms. A, it was found out that she transferred from her house to a road with a lot of traffic by walking. Therefore, she is very active such as walking long distances. Also, doctor who joint work assume that she is healthy. The doctor said that most elderly people likes places where there are a lot of nature like a park. Also, there is less elderly people who walk in road with a lot of traffic. We confirmed that Ms. A took a shortcut through private land during her walks. This has been done among many young people. Therefore, by confirming there result with a doctor, it was possible to again assume that she is healthy. The doctor said that most elderly people have a strong resistance to take a shortcut through private land. Fig.5 shows the location where Ms. A took a shortcut. It has reasons why the location was not judged as an error in measurement. First, it is not easy for an error in measurement to happen in this location. This is because visibility of the sky is good in the location. The main cause of an error in measurement is visibility of the sky. In case of low visibility of the sky because of obstacles such as concrete and tree, this decreases the number of surveying satellites. As a result, the position accuracy becomes bad. There is no obstacle in this obtained location, so it is a good place to obtain positional information. Second, obtained positional information is not scattered before and after the shortcut, and there is no missing positional information. Therefore, it was judged that there is no error in measurement in the location.

It was confirmed that Ms. A walked a bridge over a river. By discussing with a doctor, it was found out that elderly people recognize a bridge and nearby river as dangerous. Therefore, it is unusual among elderly people to walk along the river. However, Ms. A walked without stopping and she did not have a resistance to walk in dangerous places such as bridge and nearby river. Therefore, by confirming the result with a doctor, it was possible to again assume that she is healthy. Also, it could categorize her as a woman who likes water area because of her behavior route. Fig.6 shows the observation situation which Ms. A observed in the nearby places around river.

Second, analysis result of Ms. B were summarized. Her behavior route data is from 11:16 to 11:26. She moved 1.15km for 10 minutes. It was assumed that she moved using electric wheelchair that day. This is because she has an electric wheelchair that in interview for us. By displaying the route on aerial photography (GSI,2021), it was confirmed that the data has an error in measurement before analyzing the data. Fig.7 shows behavior route of Ms. B. There is no aerial photography display on Fig.7. This is because we confirmed positional information of places nearby her house and to protect her positional information.

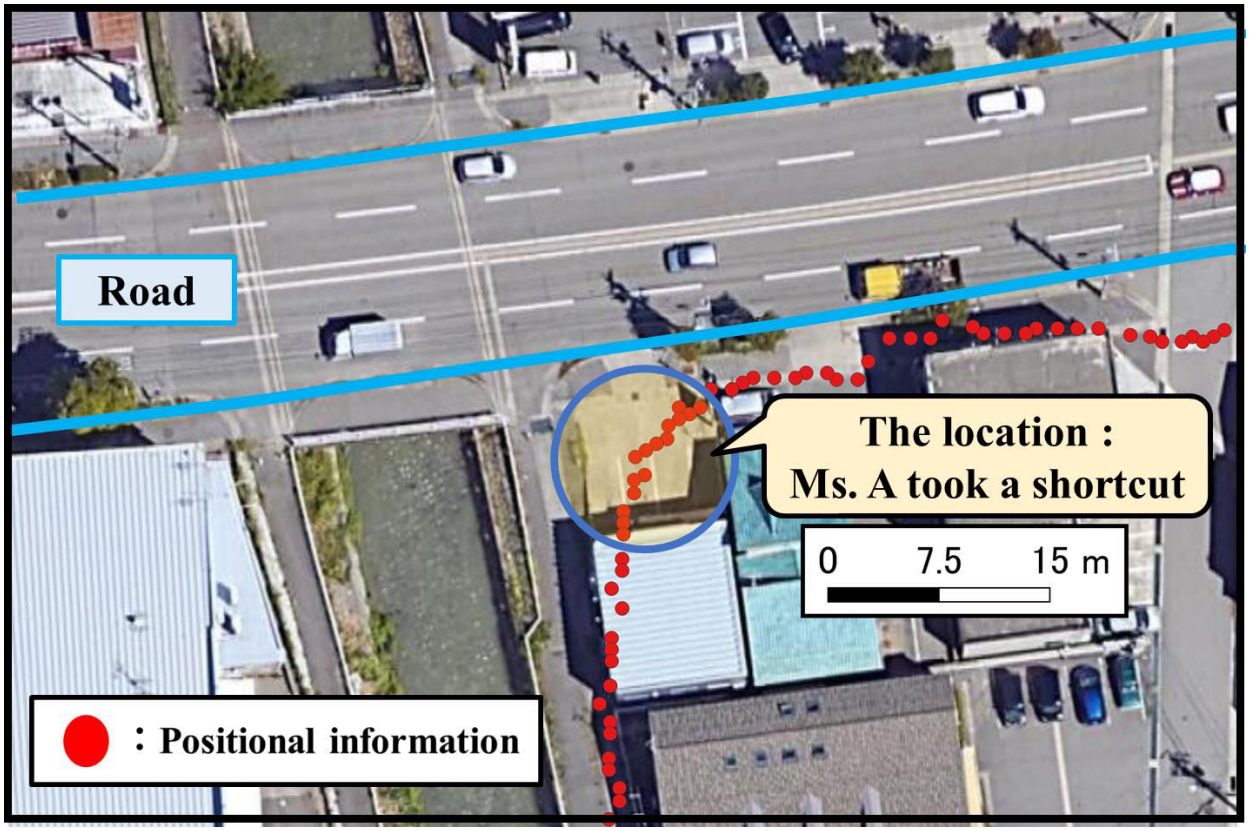


Fig.5 Location where Ms. A took a shortcut

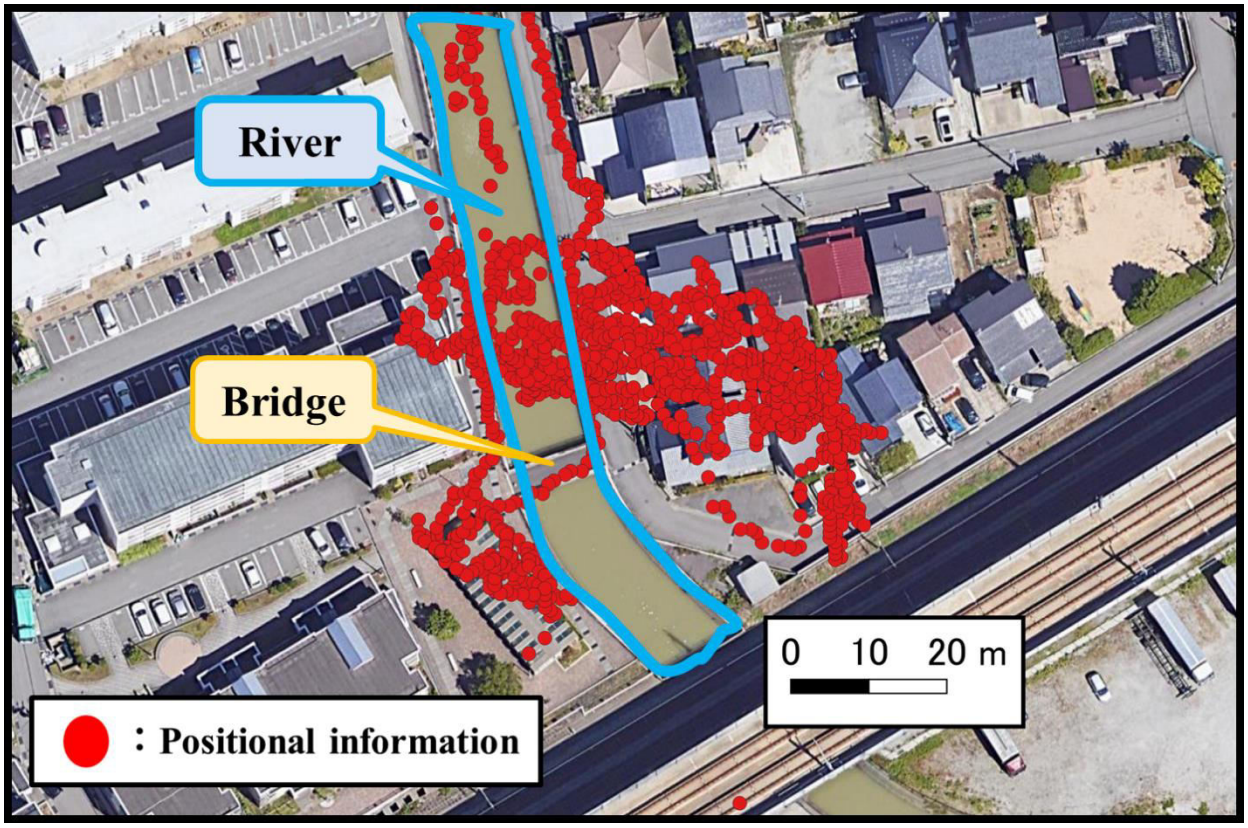


Fig.6 Observation situation which Ms. A moved at the nearby around river

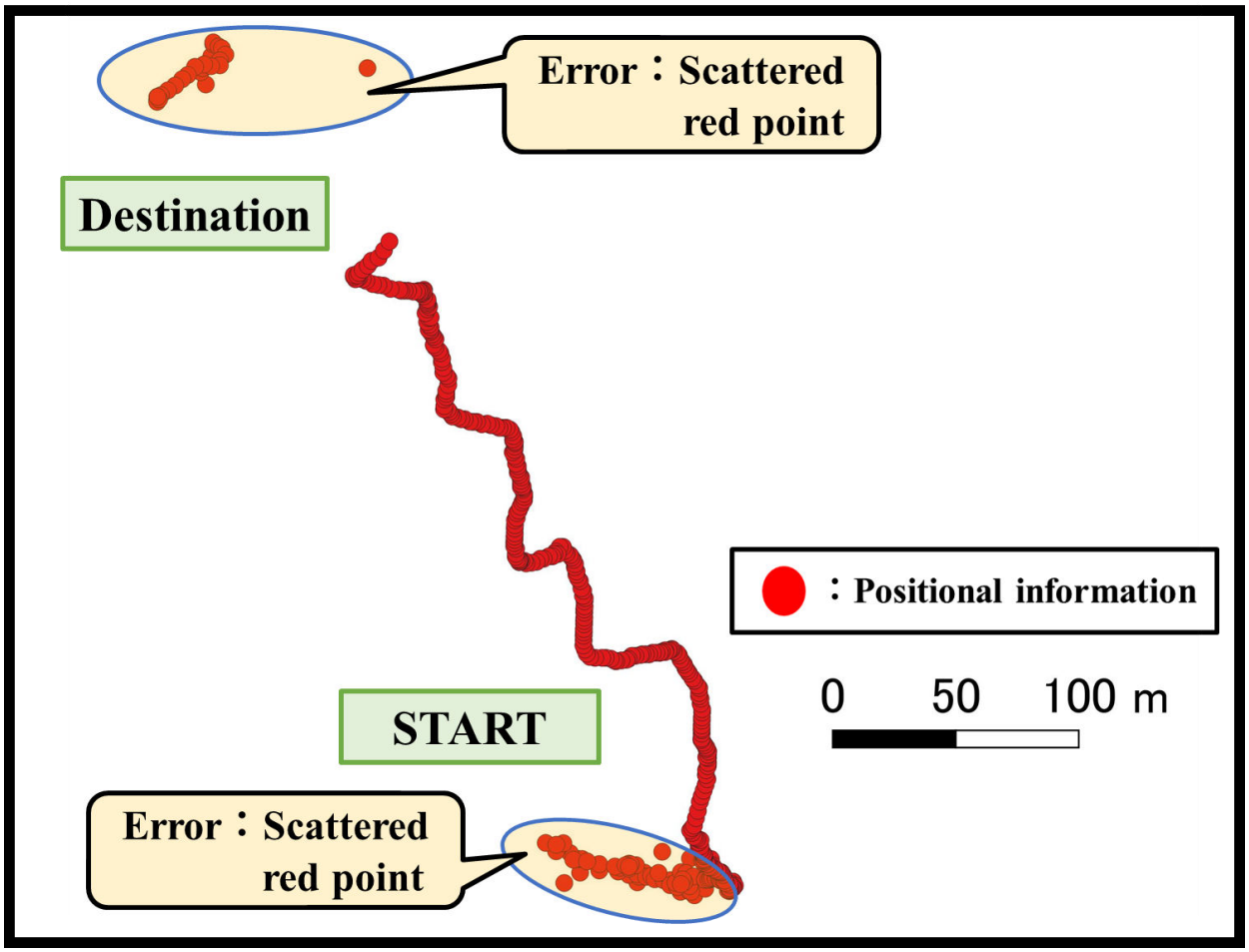


Fig.7 Behavior route of Ms. B

By confirming behavior route of Ms. B, it was found out that start was her house and destination was amusement place. Its amusement place is a one of Japanese gambling store. That measurement points were scattered in the start point and destination point.

A part of the measurement points at the start point were scattered in different directions compared to proceeding directions. It assume that this phenomenon is an error in measurement during receiving from surveying satellites. Also, these errors were happened because of not receiving enough number of surveying satellites. This happened as soon as she went out of her house.

The error in measurement in goal point happened nearby the amusement place. Fig.8 shows the observation situation in goal point; Fig.8 enlarges the top left part of Fig.7. Also, the time of obtained positional information is shown on Fig.7.

Two locations from 11:25 and 11:26 were errors in measurement. The first location at 11:25 had only one measurement point and there is no other point around the location within a 50m radius. Therefore, it assume that obtained positional information was scattered in the first location. However, it is difficult to assume that the second location at 11:26 is an error in measurement. This is because the location has some measurement points. So, it considered whether the location is the error. Ms. B moved like blue arrows based on time of obtained positional information. As a result, some measurement points scattered in the location are errors in measurement. This is because the direct distance between 11:24 and 11:26 is about 160 m and it was assumed that Ms. B is difficult to move only in about 2 minutes. Also, the error happened when obtaining positional information in the amusement place where it is difficult to receive enough number of surveying satellites.

Ms. B probably went to the amusement place. This is because her destination was probably the amusement place. Therefore, she likes gambling and crowds of people, and doctor advised us that it is possible this was influenced by her previous occupation and educational background. Also, it was found that she did not go through any nearby river around her house. Therefore, she does not like places near a river. Also, it was found that Ms. B went to farther places compared to Ms. A. This is because Ms. B return her license last year.

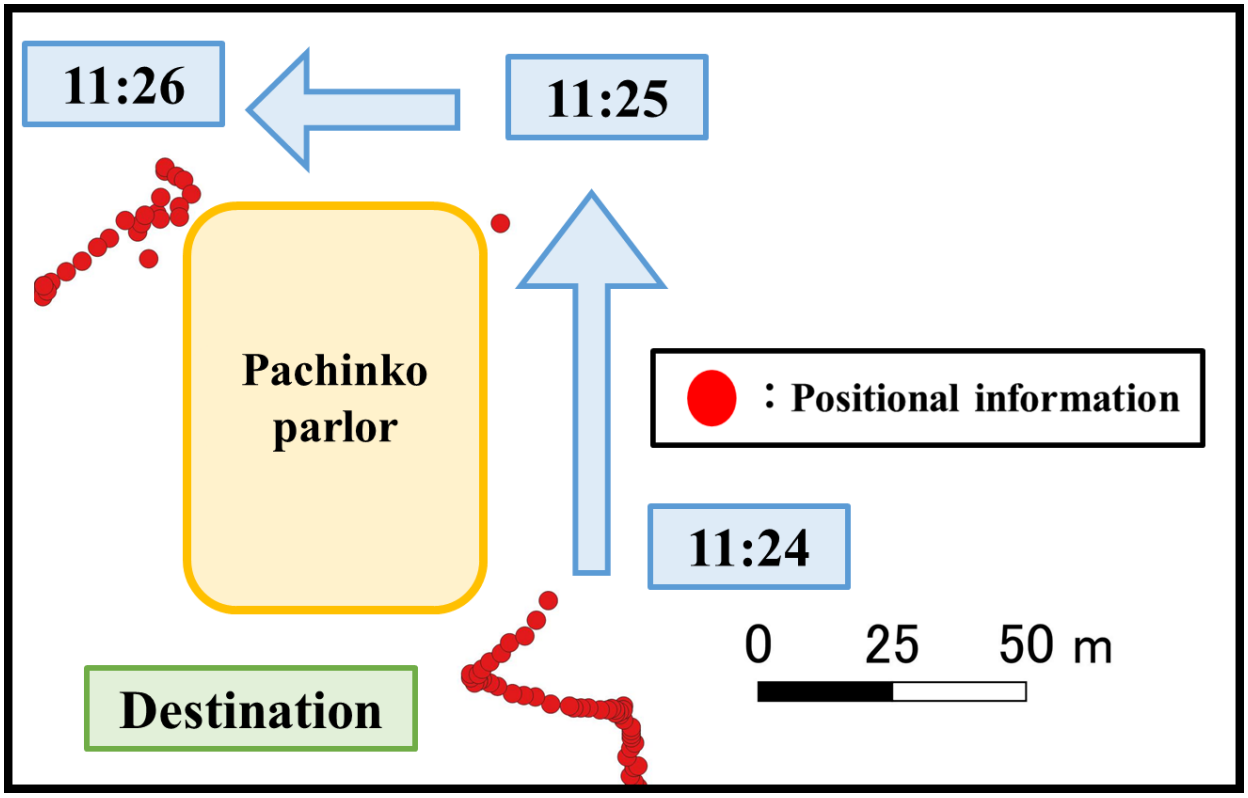


Fig.8 Observation situation in goal point

We have been conducting the same experiment with the cooperation of younger people. Most of experiment method are the same as demonstration experiment with the cooperation of elderly people. There are three difference points between experiment with younger people and experiment with elderly people. One of difference point is that the contents of question sheet. There are about 14 questions in all including hobby, major, exercise routine, etc. This is because generation of examinees are different. The other difference point is that there is no HDS-R. This is because younger people have enough cognitive function. Another difference point is that smart phones are the only experimental equipment. Younger people are used to using smartphone compared to a GNSS logger. Also, examinees are obtaining positional information get only when going outside by walking, and going out time is more than 30 minutes. They only go out during sunny days. This is because in case of obtaining positional information all the time, cell phone bill becomes high. Also, transportation is only focused on walking to compare younger people with elderly people. Doctor advised that it is necessary to have more than 30 minutes of going out time. Examinees can do anything when they are going out. The demonstrational experiment was conducted for two of the younger examinees this time. It has not finished analyzing the data yet.

Examinees were two men in their 20s who goes to our university and their obtained behavior route are under analysis. They were named Mr. A and Mr. B each. Behavior route data of Mr. A is from 11:56 to 12:24, Behavior route data of Mr. B is from 12:00 to 12:35.

Their behavior routes will be under analyzing now. In case of displaying the route on aerial photography (GSI,2021), it is difficult to read the route in the right order. Therefore, by dividing the route into each observation time, we displayed their behavior route in the right order. Also, it was divided into two individual ways. One pattern is moving route, other is without moving route such as a short break, staying indoor and stopping. Table.4 shows the details about the divided routes of Mr. B. Fig.9 shows behavior route of Ms. B after the divided routes.

By displaying behavior route of Mr. B, one route was from his house to the entrance of supermarket and finished obtaining positional information once in the entrance of supermarket. Other route was from the entrance of supermarket to his house and started obtaining positional information from the entrance of supermarket again. Therefore, it was assumed that his routes were from house to supermarket and from supermarket to house. Also, it was found that the starting point was form his house and the destination was supermarket, in addition, it was assumed that he went out of the supermarket at 12:21 and arrived in his house at 12:35. Using the same method, we were able to easily see the behavior pattern of Mr. A and the error. By confirming Table.3, it was not possible to obtain positional information from 12:13 to 12:18. This is because he went indoor, it was not possible to receive enough number of surveying satellites. It was possible to receive some surveying satellites from a smartphone, only two positional information was obtained at 12:18. In case of receiving position information indoor, the position accuracy becomes bad. In spite of him being indoor, the obtained information showed that he was outside, so we

assumed that the obtained information from outside as an error in measurement. By dividing the behavior route of Mr. A in the same way as the behavior route of Mr. B, it was possible to easily see the behavior pattern of Mr. A and the error too.

Table.3 Details about the divided routes of Mr. B

Ms. B		
Measurement point	Category	Observation time
No.1 Red point	Moving route	12:00 ~ 12:13
No.2 Yellow point	Error	12:18
No.3 Blue point	Moving route	12:21 ~ 12:35

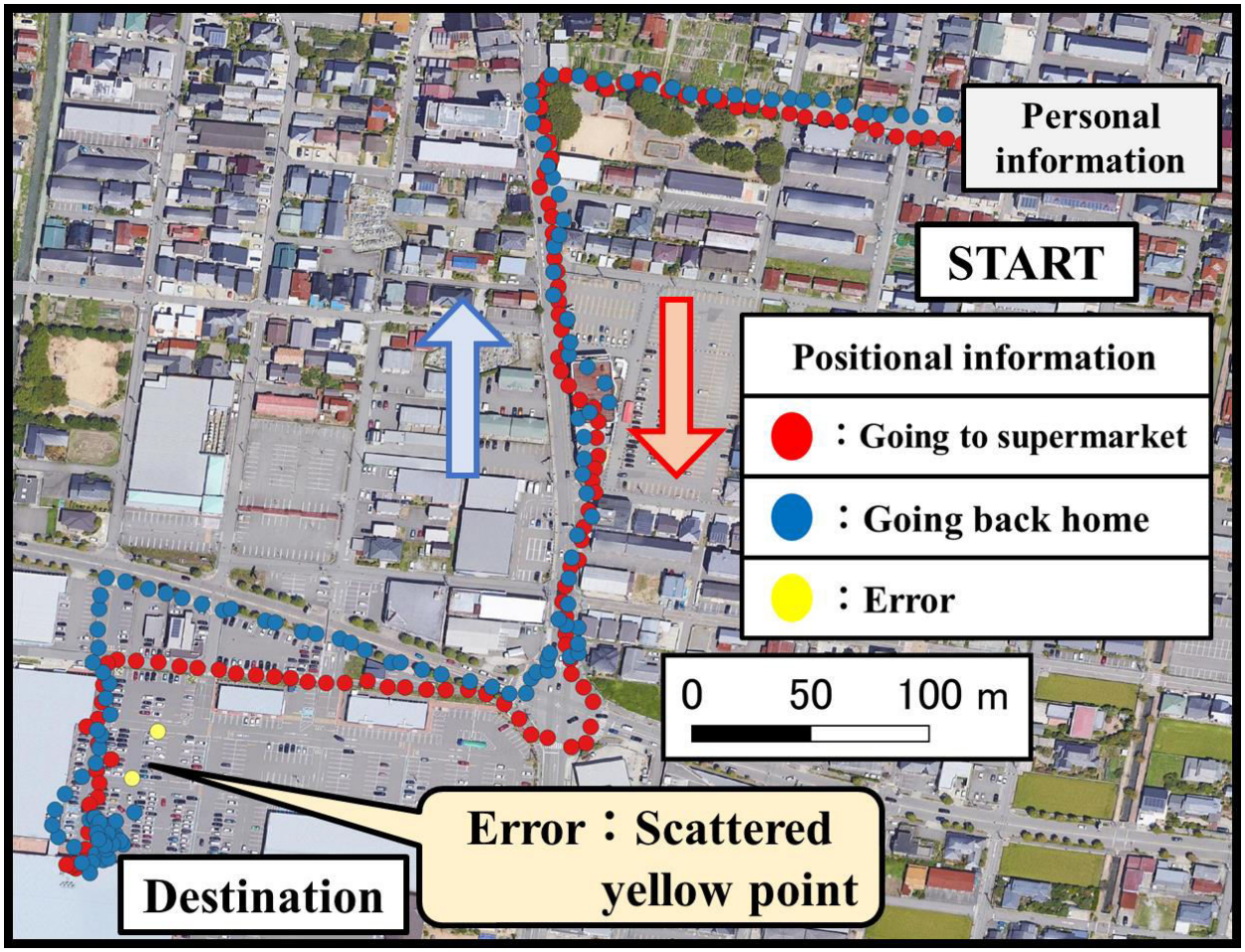


Fig.9 Behavior route of Ms. B after the divided routes

6. 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.

Experimental results showed that it is possible to confirm health condition of examinees. This method makes it possible to obtain a health index of elderly people including dementia patients. Also, by being able to divide their behavior pattern, in case the dementia patient can't be found, it is possible to utilize this method to search for the

patient. In the experiments, two examinees who are women with the cooperation of a local hospital, were reported. One examinee moved around nearby her house. She walked to a road from her house with a lot of traffic which elderly people usually do not want to go. Also, it found that she took a shortcut which there use many among young people. Therefore, she is healthy. Also, she likes going to a nearby river, and she was possible to categorize her as a woman who likes water area. In case of having bad health as a dementia patient and missing, we assume that she may be wandering a nearby river. Other examinee transferred from her house to a far place called an amusement place. Therefore, it was possible to categorize her as a woman who likes amusement place. Also, it categorized as a woman who does not like water area.

By dividing the route into each observation time, it could easily display behavior route of examinees of younger people in the right order. Also, it could find out an error in measurement in the location. This method can easily be done by the patient's family. By dividing the route into each observation time, the family can easily find out the error without specialized knowledge. Also, it is possible to check each observation time using free software "Excel" and "QGIS".

7. ACKNOWLEDGEMENTS

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