Development of a GPS module for real-time positioning of radioactive waste drums

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1. Introduction

When radioactive waste drums are transferred to a radioactive waste disposal site, the position of the radioactive waste drum needs to be checked to secure safe transportation of the radioactive wastes [1,2]. However, since the amount of the radioactive waste drums are increasing according to the continuous utilization of the nuclear power plants, the position check of every radioactive waste drums become more difficult to be done by human workers. In this paper, we developed a global positioning system (GPS) module and its software (SW) which can be mounted to each radioactive waste drum to identify its position automatically. The developed SW utilizes Google map application programming interface (API), and it can visualize the current position of the module with respect to constant time or distance intervals for better understandings of the human workers. Also, it can stream its user interface on a web page in real-time, so the transportation status can be monitored by several workers or higher level of management programs.

2. Components of the GPS module

2.1 Structures

The proposed GPS module is composed of a controller (*Raspberry Pi 4B*, Raspberry Pi Foundation, UK), a GPS receiver (*GPS-620*, AscenKorea, Korea), a mount body, an embedded monitor, batteries, and a battery management board as shown in Fig. 1. The mount body was 3D printed using polylactic acid (PLA) materials, and the hardware of the GPS module was assembled and wired for experiments.

2.2 Software architecture

Overall SW framework of the GPS module was developed using QT framework with JavaScript and HTML, and Google map API was utilized to represent the map and user defined figures. Since the user interface should be shared by several workers or higher level of management programs to maximize the compatibility of the developed GPS module, WebRTC framework was utilized to stream its user interface on a web page in real-time.

The configuration of the SW is represented in a usecase diagram of Fig. 2. First, the GPS data obtained by GPS receiver is transmitted to QT application, and

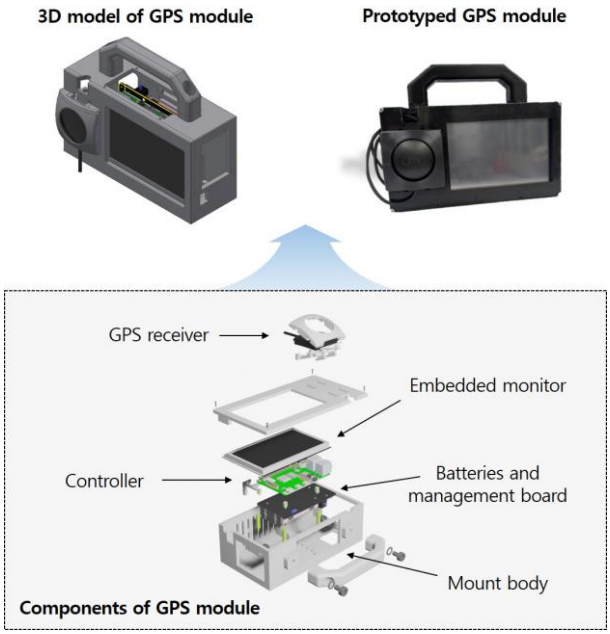

Fig. 1. Structures of the proposed GPS module

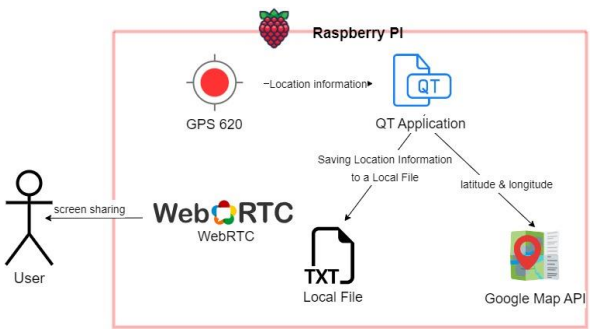

Fig. 2. A usecase diagram of GPS module SW

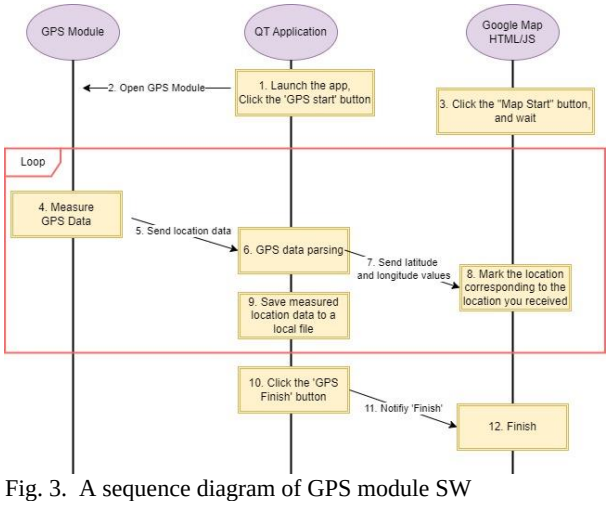

Fig. 3. A sequence diagram of GPS module SW

the data is continuously written as a file of text format in the local drive and transferred to a visualization part using Google map API. Then, the visualization part represents the point on the map based on the measured GPS data with respect to the visualization policies. Finally, the map and visualized points which represents the current position and transportation locus of the radioactive waste drum are displayed in the embedded monitor and shared on a web page by using WebRTC framework. The detailed logical procedures processed in the GPS module during the operation are represented in a sequence diagram of Fig. 3.

3. Measurement functions and experiments

3.1 Constant interval measurements

The GPS module can measure its position by two types of constant interval modes as shown in Fig. 4: time and distance. In the constant time interval mode, the measurements are conducted by a constant period, and it has advantages of representing the velocity change of the GPS module during the transportation. On the other hand, in the constant distance interval mode, the measurements are conducted when the distance from the previous position becomes larger than the predefined level of distance. It can uniformly represent the locus of the GPS module, and it has advantages of representing the path and status clearly.

3.2 Map adjustment and data management

The center position and scale of the displayed map are important parameters in visibility and usability of the SW. Therefore, the center point of the display is matched to the position which is obtained by averaging the latitude and longitude values of measured points. The scale of the map is adjusted when the measurement is finished to maintain an enough margin at every side of the display for better visibility.

The measured data which includes the time stamp, date, latitude, longitude of each measured point is continuously written to a local text file sequentially, and the writing process is finished when the GPS FINISH button is clicked by the worker to finish the data measurement.

3.3 Experiment result

Real demonstration to verify the developed GPS module was conducted in KAERI, and the pseudo-mission was assumed that the radioactive waste is transported from the start position to the finish position as shown in Fig. 5. The measurement was conducted by using the constant distance interval mode, and the measured points were displayed as a red-colored circle with diameter of 2 m. The whole procedures were streamed on a web page by using WebRTC, and the proposed GPS module successfully measured and displayed its positions in real-time.

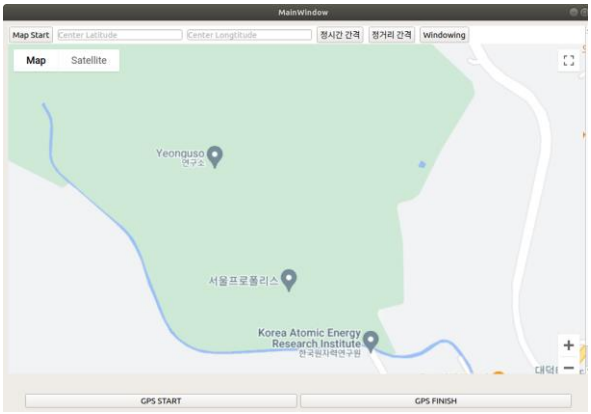

Fig. 4. User interface of the GPS module

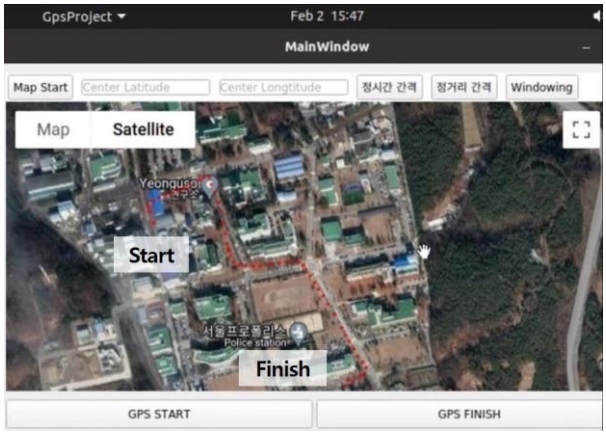

Fig. 5. Experiment result of pseudo-transportation mission and locus of the GPS module

4. Conclusion

In this paper, the GPS module is proposed to measure and monitor the position of the radioactive waste drum during the transportation operations. The hardware of the GPS module was developed and prototyped, and operating SW was developed with the architecture using QT, Google map API, and WebRTC. The constant interval measurement methods, automatic map adjustments, and data management protocols were also developed, and the GPS module and its SW were verified by real demonstrations.

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