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Mobile Radiation Measuring System using Small Linux box and GPS sensor

Nalin Warnajith[1], Nguyen Cao Thang[2], Sataru Ozawa[3], Atshushi Minato[4]
[1,2,3,4] *Graduate School of Science and Engineering, Ibaraki University, Hitachi, Japan*

ABSTRACT: *The effect of radiation and the measuring the radiation dose rate amount has become as important research topics among the researcher, after the nuclear accident happened in Japan. Several commercial equipments are available that can measure the dose amount but most of them have some limitations. However designing mobile radiation measuring system using PC is generally expensive, and complicated. It also requires electrical power. In this paper, we propose a new technique to combine this type of equipments and GPS sensor using small Linux box. The power consumption and data access are also discussed.*

Keywords: *Dose rate measuring, Raspberry Pi, GPS sensor*

I. INTRODUCTION

With the recent threat of nuclear disaster here in Japan, sparked from the damage inflicted by the massive earthquake and subsequent tsunami, many people have no doubt been caught not knowing as much as they would have liked about nuclear radiation effects, types of radiation, and what a "safe" radiation dose amounts to. The concentration of the radiation is higher than normal in a wide range not only Fukushima area but also in the east part of Japan. Nowadays, there are several commercial equipments are available to measure the radiation dose amount [1, 2, 3]. Most of them are small in size and can be used as a mobile device. But when we think about recording the information it gathered while moving, is somewhat difficult task due to; (1) The cost of devices that can record data while moving is quite high, (2) Most of low price devices are developed for the stand alone usage, (3) Most of them come with a Graphical User Interface (GUI) integrated with Windows OS, so it is hard to use as a mobile recording device due to power consumption etc. This research proposes comparably low cost, a measuring method and portable measuring device that can records the GPS location information, time, radiation, and mapping them.

II. SYSTEM CONCEPT

The proposed system was developed in two structures; (1) Short range or single point dose amount recording via wireless technology (Fig. 2.1), (2) Wide range dose amount recording into USB memory or SD card (Fig. 2.2). The Radiation dose amount was detected via dose meter model TP100 device, produced by TecnoAP Co. Ltd, Japan [3]. And the location information was obtained using GPS sensor. A low cost, low power consuming small computer was included as the main hub of the system.

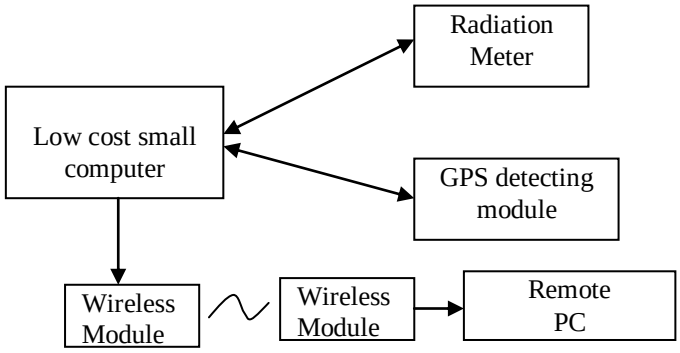

Fig 2.1 Short range or single point measuring system

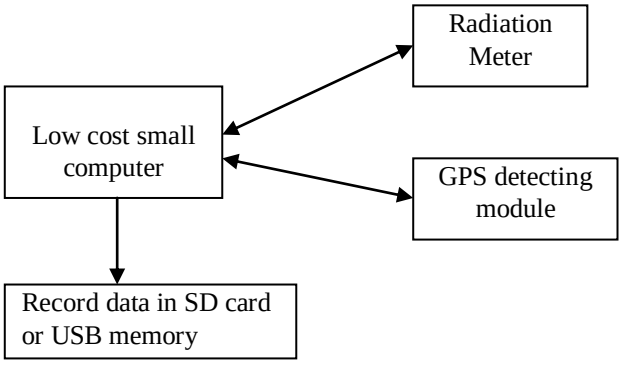

Fig 2.2 Wide range measuring system

Most of the sensors work with the power supply of 3.3V or 5V. They have various outputs: analog outputs, serial communication, SPI interface and I2C interface. It is needed to follow a complicated and complex process to retrieving information from these sensors. In this development, small and low cost microcontrollers were used to get data from GPS sensor. This microcontroller was also connected to USB-serial module. By sending a serial command it requests to the microcontroller to take data from the sensor and returns value.

III. SYSTEM COMPONENTS - HARDWARE

3.1 Raspberry Pi

A low cost, small computer is included in this proposed system as the main hub. The dose meter and the GPS sensor module are are connected and controlled by this computer. Nowadays there are several numbers of these types of small computers are available in the market such as Beagle Bone [4], Banana Pi [5], Intel Galilio [6], Cubieboard [7] etc. Raspberry Pi with Rasbian Linux OS was used for this research considering the intented usage and the price.

The Raspberry Pi is a single board credit card size of computer [8] (Fig. 3-1). It runs on special versions of Linux distributions like Raspbian, Pidora, Rasp BMC, OpenELEC, RiscOS and Arch. The importance of Raspberry Pi is, it can be used for several purposes such as general purpose computing, learning program, project platform etc. Raspberry Pi is available relatively very low price (around US$35) but it is a full computer that can run Linux. That means servers, used for home automation, video streaming, electronic device. Raspberry Pi needs only 5V power supply. The Model-A Raspberry Pi draws at most 2.5W, and the Model-B draws at most 3.5W [9].

3.2 Radiation dose rate meter

TA100U (By TechnoAP Co. Ltd, Japan) is a handheld small dosimeter which shows gamma ray nuclide by spectrum (graph) in addition to displaying general dose rate (μSv/h) (Fig 3-2) [3]. Also data can be transmitted to PC via USB. It consists CdTe (Cadmium Telluride) semiconductor, which has larger atomic number (48, 52) than silicon semiconductor has, has high energy radiation absorption ability and can operate at room temperature. With up-to-date electronic circuit, energy compensation is achieved. Accurate dose rate is displayed in wide range of 0.01 μSv/h to 10 mSv/h. This has built-in lithium-ion battery and is capable of 15 hours of continuous operation [3].

Fig 3.1 Raspberry Pi - Model A

Fig 3.2 Radiation dose rate meter- TA100U

Fig 3-3 GPS Module GT-723F

3.3 GPS Sensor (GT-723F)

The GT-723F is a compact all-in-one GPS module solution intended for a broad range of Original Equipment Manufacturer (OEM) products, where fast and easy system integration and minimal development risk is required. The receiver continuously tracks all satellites in view and provides accurate satellite positioning data. The GT-723F is optimized for applications requiring high-performance, low cost, and maximum flexibility; suitable for a wide range of OEM configurations including handhelds, sensors, asset tracking, PDA-centric personal navigation system, and vehicle navigation products [10].

3.4 Microcontroller (R8C/M11A, M12A)

This experiment has been utilized with 16-bit CISC microcontroller of the R8C Renesas family platform. The role of this microcontroller is making the communication between GPS sensor and the Raspberry Pi. The R8C/M11A group and R8C/M12A group of single–chip microcontroller (MCUs) incorporate with the R8C CPU core, which provide sophisticated instructions for a high level of efficiency. With 1Mbyte of address space, the CPU core is capable of executing the instruction at high speed with 20MHz and it consists with 2Kb EEPROM, AD converter and serial interface [11]. The low power consumption feature of this microcontroller is also highly considered in this development.

3.5 XBee-PRO S2B wireless module

For wireless system implementation, XBee-PRO S2B wireless module (By Digi International® Inc.) was used. This module consume very low power and available at low cost. Also it is able to communicate 60m indoor/urban range, 1.5km outdoor range very efficiently [12].

IV. SYSTEM COMPONENTS - SOFTWARE

4.1 Main controlling program

The Raspberry Pi system application is programmed in Python that comes built-in with Raspbian OS. Serial communication method is developed using Python package PySerial 2.7. When the main Python program starts, it continuously obtains required information (Fig 4-1) and average of ten readings of the dose meter with date, time, latitude and longitude information was send via XBee to the remote computer or save in the SD card or USB memory.

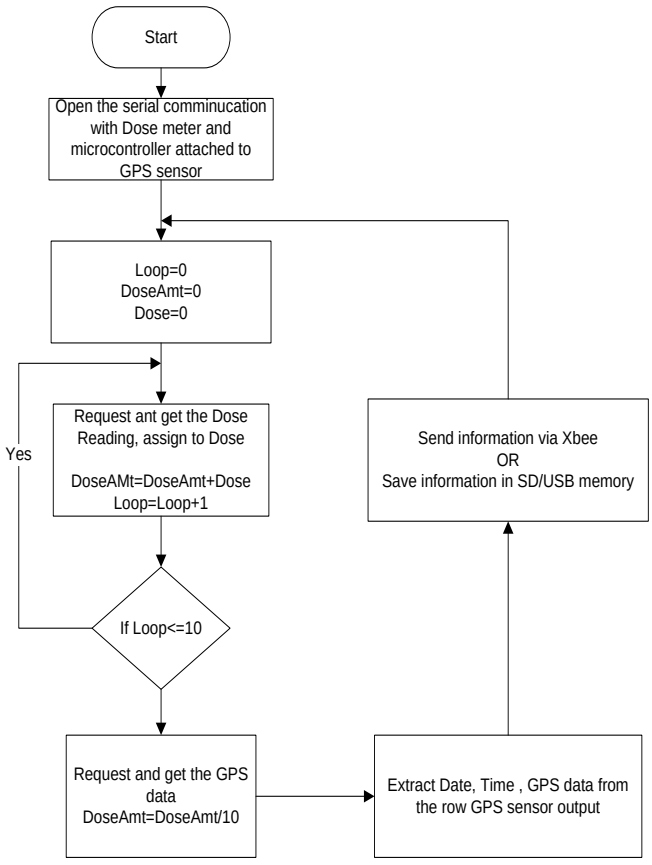

Fig. 4-1 System flow chart of the Python program.

The saved information on SD or USB memory is in two formats; (1) Text format that can be used for analyzing via Microsoft Excel or any software that can import text based data, (2) SQL query file format that can be used to upload data to MySQL web server in KISSEL web server developed by KISSEL group of Ibaraki University, Hitachi, Japan.

4.2 KISSEL Server System

The Knowledge Integration Servers System for E-Learning (KISSEL) is a knowledge sharing system which is designed to cater to teachers' communities in Asian Pacific countries. Aim of this system is to provide resources (especially in multimedia), tools and techniques essential for student-teacher communication and self-learning. This online courseware management system was developed by the research group of the Ibaraki University, Japan and it was upgrading time to time with recent advancements [13, 14, 15]. The point is that the contents of the KISSEL are developed cooperatively by the effort of all the members of the communities. The KISSEL servers have already been settled in Japan, Samoa, Sri Lanka, Bangladesh, Vietnam, Indonesia and Poland. The server will be installed also in New Zealand, Australia and Cambodia etc., in near future [16]. The point is that the contents of the KISSEL are developed cooperatively by the effort of all the members of the communities [17]. At present, the contents of the KISSEL are concerned to E-learning techniques and early warning, preparedness and mitigation of natural disasters.

4.3 Database Development

The Google Maps Application Program Interface (API) is useful for providing users with an interface that can freely access map and satellite information, and also allow users to grasp a clear concept of space and distance. So the findings of this research are presented using this Google map API. MySQL database is used as the backend and using this database XML (Extensible Markup Language) codes are generated and transfer to the Google Map API (Fig 4-2).

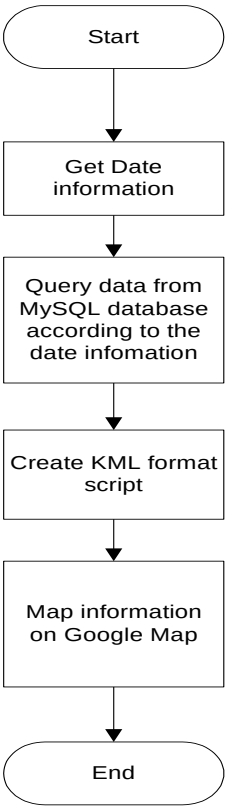

Fig 4-2 Flow chart of the web application

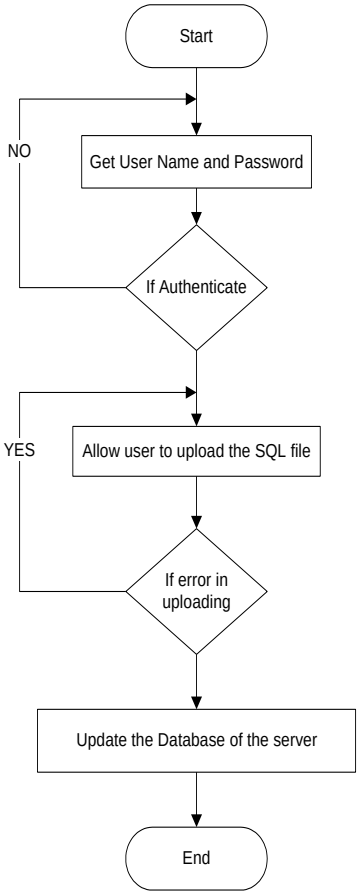

Fig 4-2 Flow chart of the SQL files uploading

Also an interface for uploading new data sets to the server is developed. An authentication process also adopted before uploading the data (Fig 4-3).

4.4 Automation of the system while booting the Raspberry Pi

Initially, at the development stage of this system, a display unit was used. When data gathering in actual field, it is impossible to use a video display due to the difficulty providing the power supply. So, the main program of the system need to run automatically when the Raspberry Pi is switched on. So, the automation of system process was carried out by crontab method which comes with Linux distributions. It can execute command in periodically and adding by following entry, the system can be executed automatically while booting.

```
# @reboot sudo python DoseWithGPS.py &
```

V. RESULTS

5.1 Data obtained from wireless method

Fig 5.1 shows a sample output comes using XBee wireless data transferring method.

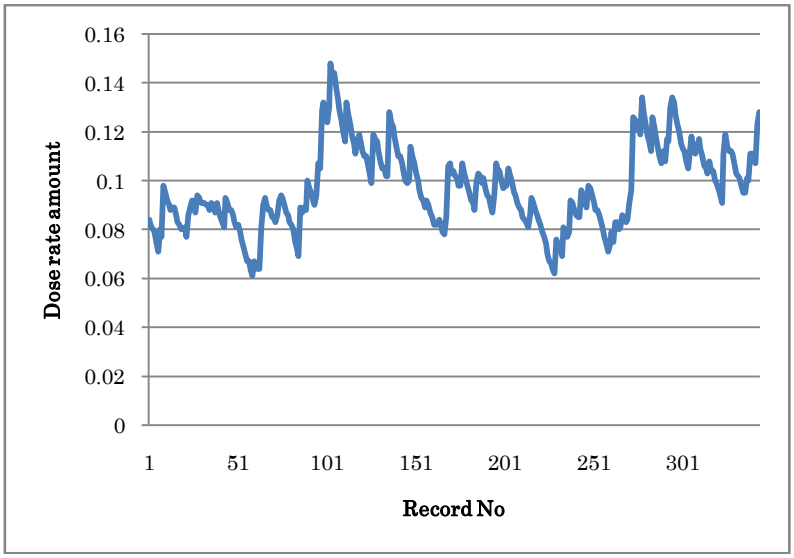

Fig 5-1 Dose amount using XBee

5.2 Mapping on Google Map

Fig 5.2 shows a sample output comes using KISSEL web server (http://kissel.base.ibaraki.ac.jp/intl/apps/sensor/)

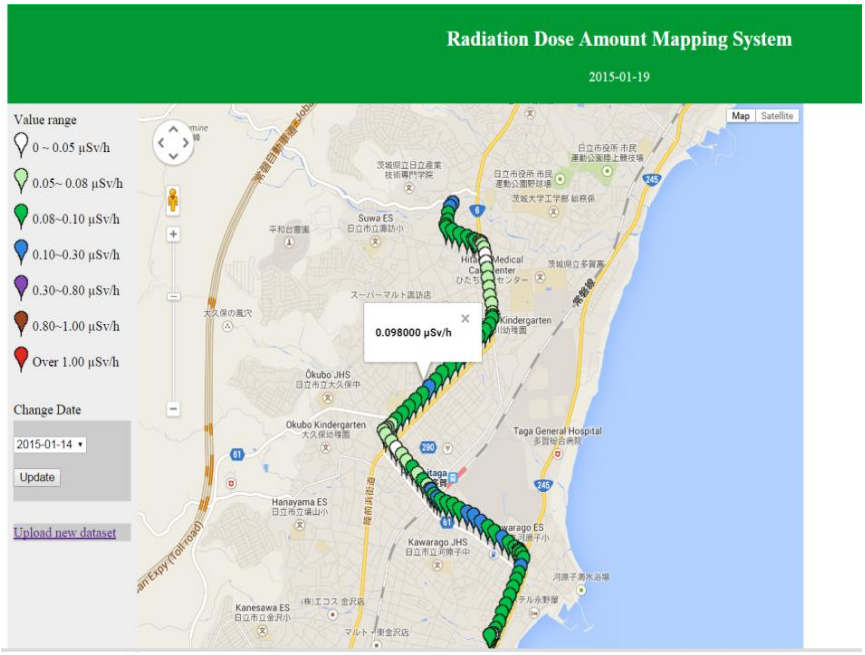

Fig 5-2 Mapping dose rate amount in Google Map

VI. CONCLUSION

A new concept for mobile radiation measuring system with GPS sensor module system is presented in this paper. The main target of developing such system with low cost and low power consuming is successfully obtained using Raspberry Pi and GPS sensor. The following table shows cost and power consumption of the available alternatives for this developed system.

Table VI-I Cost and power consumption comparison of available alternatives

	Expected Cost (USD)	Power consumption
Desktop PC	275~1600 (depend on the configuration)	60-250 W
Notebook	250~ (depend on the configuration)	15-60 W
Beagle Bone	50~	2.3 W
Raspberry Pi	35~	2.5 W

The GPS sensor and all other equipments (except dose rate meter) are very low expensive and all of them can be obtained lower than 10 USD cost. So, it is clear that by using Raspberry Pi, the system can be developed at lowest cost. Regarding the power consumption, it can be powered using a 5V power supply when the system based on the Raspberry Pi. For example; the testing data colleting was carried out in Hitachi area, Ibaraki Ken, Japan by using motor vehicle 5V power supply unit. So, developing a mobile data collection system is easy and manageable as the system that proposed in this paper.

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