# Crowd-sourced citizen-driven mobile sensing of radiation

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## Summary

Amid the Fukushima triple meltdown disaster of 2011, the lack of independent, accurate radiation measurement has been a concern. As a response, concerned citizen have started to take upon themselves this challenging task.

We present the design of an affordable mobile radiation sensor system for independent citizen monitoring and cartography of radioactive contamination. Historically radiation measurements has had a high entry barrier for technical, financial, and political reasons. We show how the tremendous advances in information technology have been a game changer in this field. Notably, we leverage the open-source software and hardware paradigm can to dramatically accelerate the development and deployment time of the system.

Our design methodology allowed to prototype and deploy the system in one month following the Fukushima disaster. Our sensors have been since driven by volunteers, covering most of North-East Japan with a fine spatial resolution.

## Motivation

Due to the recent triple meltdown at Fukushima Dai-ichi plant that followed the Great Tohoku Earthquake and Tsunami, radiation fears dormant since Chernobyl were suddenly awaken. During the early time of the crisis, all the radiation measurements were done by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) as well as the operator of the plant, Tokyo Electric Power Company (TEPCO), both having a vested interest in controlling the value of the measurements published. In addition to that the measurement data was published in a format unsuitable for machine reading and the data was not released free of rights, making it difficult to use for academic purposes.

Another drawback of this data set is that it is collected by fixed sensors. Fixed sensors offer a really good temporal resolution, making it suitable for early detection of new radioactive pollutant release detection. However, it has a very poor spatial resolution. Since radioactive plume fall-out is notoriously spotty because of the airborne travel mode[1], a high spatial resolution is needed in order to precisely assess the contamination at the level of houses. This is necessary for multiple reasons, including, first of all, to assess the health hazard and plan evacuation areas accordingly, plan efficiently decontamination work, identify areas still suitable for farming. To add to the challenge, during a crisis, the availability of Geiger counters, not normally mass produced, is not guaranteed. A mobile sensing scheme allows to efficiently use a reduced number of sensors to cover a large area.

Mobile radiation measurements have been done in the past, notably for Chernobyl[2]. However, dramatic advances in localization and information technology have both increased the performance and lowered the

[1] H. Terada/M. Chino: Development of an atmospheric dispersion model for accidental discharge of radionuclides with the function of simultaneous prediction for multiple domains and its evaluation by application to the Chernobyl nuclear accident, in: Journal of nuclear science and technology 45.9 (2008), pp. 920–931.

[2] H. Arvela/M. Markkanen/H. Lemmelä: Mobile survey of environmental gamma radiation and fall-out levels in Finland after the Chernobyl accident, in: Radiation protection dosimetry 32.3 (1990), pp. 177–184.

cost of mobile sensing, making it affordable for communities of concerned citizen.

Recently, such community-driven mobile sensor networks has emerged as a very efficient way to cover large areas in detail using much fewer sensors than a fixed network, at the expense of time resolution[3]. In the case of radiation contamination with Cesium 134 and Cesium 137, with respective half-lives of 2 and 30 years, this is a fair trade-off.

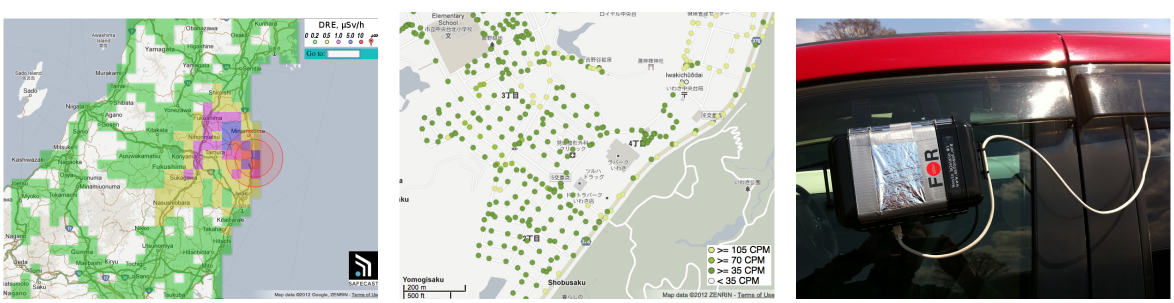
## Results

Because of the citizen-driven and privately funded nature of the project, the design needs to be very cost-efficient. Off-the-shelf hardware was used to create a first system composed of a Geiger counter, a commercial GPS USB dongle, a micro-controller board and netbook. The audio output of the Geiger counter was plugged to an Arduino board outputting the count-per-minute (CPM) every five seconds over serial port. The netbook then aggregates the geographic location obtained from the GPS and the radiation count and writes it to a file every five seconds.

The Geiger counter chosen is the Inspector Alert[4] that uses an industry standard[5] LND7314 two-inch pancake tube. The Geiger counter, the Arduino board and the GPS are housed in a waterproof box. This box is fixed to the side of a car using a simple system of straps that can be easily fixed on any car by winding up a window on the strap as shown in Fig. 1 (c). A long USB cable then links the box to the netbook inside the car. Suction cups on the back of the box ensure that the box is firmly attached and do not vibrate, even driving at higher speed on the highway. Combined to its small form factor, this allows the sensor to be used in an unobstusive manner on most cars.

The sensor is the workhorse of Safecast[6], a volunteer project for the mapping of radiation in Japan. The driving of the sensors was crowd sourced to volunteers based in the contaminated areas in Tohoku. The sensors unique design allowed it to be used during daily activities, simplifing the collection of data. As can be observed in 1 (a), the spatial resolution allows to finely measure residential areas.

After collection, the data file produced is manually (as of now) uploaded to an online database. From this database, comprehensive maps as shown in Fig. 1 (a) are created and released. Finally, it is worth noting that the raw data collected is released in the public domain in machine readable format, allowing it to be easily reused for further research.




(a) Global map (b) Individual drive map (c) The sensor

Figure 1: (a) Global map of collected data for the Fukushima prefecture. Each square is color coded according to the average dose rate in the area covered. (b) Individual drive map. Every point correspond to a single measurement. We can observe how it is possible to densely cover residential areas. (c) The sensor fixed on a car. The box contains the Geiger counter a micro-controller to count the pulses from the counter, a GPS USB dongle and small USB hub. We can see the USB cord that links to the netbook in the car.

[3]K. Aberer et al.: Opensense: open community driven sensing of environment, in: Proceedings of the ACM SIGSPATIAL International Workshop on GeoStreaming, ACM, 2010, pp. 39–42.

[4]International Medcom: Inspector Alert, `http://medcom.com/products/inspector-alert`, May 2012.

[5]Radiological Worker II Study Guide, SLAC National Accelerator Laboratory, Nov. 2001.

[6]Safecast, `http://blog.safecast.org`.