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D 9.136 - Guidelines/concept for dose measurement apps and tools

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Abstract

The overall aim of SHAMISEN SINGS' WP2 is to **improve the use of plug-in devices and apps** that convert smartphones, tablets and other smart devices into radiation detectors for **self-made measurements** by different sectors of the population. Because citizen and citizen science are likely to use mobile apps to measure radiation exposure, for instance in areas contaminated by previous accidents (Chernobyl, Fukushima), around nuclear plants, or in case of an accident, it is necessary to provide information about the **strengths and limitations** of such devices and apps, as well as on how to **perform and interpret** measurements correctly. For this reason, the main deliverable of WP2 is a **series of recommendations** addressed to different stakeholders: 1) mobile app developers; 2) citizens; and 3) local authorities that can be involved in and benefit from such measurements after a radiation accident.

Content

Scope of the toolkit

This toolkit aims to provide recommendations for the correct use of mobile apps that convert smartphones into radiation detectors through built-in digital camera sensors.

The preparation of this toolkit was considered necessary given that citizen engagement in local decision-making processes in environmental issues is growing; sensor and communication technologies are widely available to the population, especially when emergencies occur; and citizens are increasingly eager to control their own decisions. Moreover, such measurements can benefit both citizens at the individual level and local authorities for collective environmental control and decision-making processes (Liutsko & Cardis, 2018; Liutsko, Sarukhan, Cardis; SHAMISEN SINGS Consortium, 2018).

One of the key lessons from Fukushima was the importance of a rapid characterisation of the radiological situation after a nuclear accident, adapted both to the needs of the public authorities and of the affected people. Radiation self-monitoring "renders radioactivity 'visible', and makes people aware of when, where, and how they are exposed in their daily life" (ICRP, 2019). This may facilitate the communication and develop the radiological protection culture needed to face the consequences of the nuclear accident. On the other hand, the increasing availability of sensing technologies based on smartphones encourages their use even without adequate knowledge or training. As reported in Deliverable D9.133 and in other publications by SHAMISEN SINGS (e.g. RICOMET 2019), these apps have pitfalls and present a potential for misuse and low quality measurements, especially when operated by non-experienced users. Therefore, the development and use of such new technologies should be guided by authorities and experts.

There are different categories of mobile applications for self-made radiation measurements: those that convert signals from built-in mobile phone camera sensors into radiation dose rates; those that collect signals from external portable sensors; and those that are connected to fixed radiation monitors. The former category is the most likely to be used by citizens because it is inexpensive, does not need the purchase of a device, and, in case of an accident, can work without internet connection.

Thus, this toolkit concerns built-in **mobile phone camera sensors** and contains **three series of recommendations**: one addressed mainly to public authorities and decision-makers, on how to deal with the increasing development of sensing technologies; one addressed to citizens who wish to measure their individual exposure; and one addressed to app developers, so that they can make products that meet the needs of both decision-makers and citizens. Overall, researchers can also use the toolkit to improve the quality of data produced by these technologies.

The toolkit is limited to technological aspects of the apps. Discussion on related privacy, ethics and sociological issues is a matter of WP4 and are described in Deliverable D9.135.

Methodology

The toolkit was prepared by partners and experts of the SHAMISEN SINGS project, based on:

- Lessons learned from Fukushima and Chernobyl (SHAMISEN project)
- Lessons learned from other environmental exposure situations and citizen science experiences
- Review of scientific literature on the performance of the apps (D9.133)
- Experimental tests of radiation measurements apps
- Exercise within a EURADOS user group
- Results of the Shamisen Sings survey (D9.130)
- Discussions among experts (EURADOS meetings and CONCERT Stakeholder Group)
- Discussion with app developers
- Input from the S-S Consensus Workshop on related Ethical issues to apps development and use (D9.135)

The toolkit structure

The toolkit is an online interactive tool structured in three parallel sections containing recommendations for i) decision makers/authorities; ii) citizens/users; iii) app developers.

As an example, Figure 1 shows how the section for users is structured.

Figure 1. Recommendations for the use of mobile apps for dose measurements

The Toolkit

Recommendations for decision makers/public authorities

Section 1. Preparatory steps

1. Make a preparedness plan

Public authorities and Decision makers should be prepared to answer to the citizens' needs and requests of informal sensors before, during and after an emergency. Therefore, they need to develop a "get ready" plan to inform, educate and guide. It should be implementable in different scenarios and at different times of the emergency: in the preparadness phase, during the emergency and in the recovery phase. It should consider the use of sensing technologies both for citizen science projects and for citizens wishing to measure their individual exposure. It is particularly important that citizen science projects are designed to train citizens in normal times and prepare them to emergencies.
The plan should be set up with the involvement of experts, scientists, decision makers, citizen associations and app developers.

2. Explore the available apps and tools

Get to know the available apps and their limitations as well as technologies different from the built-in cameras. If possible, develop a plan to test the sensors and the mobile apps available on the market. Also explore new outcomes of scientific literature, since this is a rapidly evolving field of research.

3. Explore private public partnerships, but preserve independence.

The independent role of public authorities during or after the emergencies should be preserved. Therefore, any collaboration with app producers, which are normall profit-oriented, must be transparent in its terms, including the use and property of data collected.

4. Update the plan

The plan should be updated as often as new technologies and mobile apps appear- or disappear- from the market. Even this toolkit, made for today's apps and technologies will probably not be valid in e.g. one year..

Section 2. How to prepare citizens.

5. Be transparent. Communicate Effectively with Citizens. Increase trust.

List and explain the various technologies available for self-made radiation measurements and clearly the pros and cons of each technology.
The messages should be understandable by the untrained public, with attention to children and digitally-challenged people, while providing adequate information to skilled adults.

Section 3. How to guide citizens

6. Guide the user in the app choice

Provide citizens sufficient information to make an informed choice while encouraging the choice of existing reliable apps and devices. For instance, provide a "check list" of minimum parameters or criteria the app should comply with. This could prove beneficial for individual users and boost data sharing and use by authorised research organisations or other institutions.

7. Guide the user in the app use

Provide support to populations who wish to make their own measurements. These guidelines should be simple and short. Provide also a list of typical errors (including those due to human factors).

8. Guide the user in the data interpretation

The apps should allow collected data to be understandable by untrained citizens. To this purpose the app's output should be in dose rate units. Instead, most existing apps provide counts per minute which cannot be directly related to the environmental dose by official sources or documents.

9. Continue supporting the citizens

Offer citizens adequate expert counselling resources to perform and interpret radiation measurements. Set up a unit (e.g. a toll-free phone number) to answer citizens' questions. Experts should also be willing to communicate and answer doubts raised by the public through multiple channels (e.g. mass media or social media).

Section 4. How to guide the developers

10. Set a minimum standard through stakeholder consultation

Establish a minimum standard that apps for citizen's use should comply with by consulting with stakeholders (experts, scientists, decision makers, citizen's associations and developers) to agree on reliable, achievable, feasible and desirable minimum performance requirements. For this, the following issues need to be considered:

- Product performances required to meet the needs of both decision makers and citizens.
- Benefits vs risks of providing scientific content about the meaning of the measurement and possible health or radiation protection implications.
- Type of information provided: some provide dose rate (by a calibration factor), others the counts per minutes, and others just provide a green, yellow or red light. In particular, for those models that only provide counts per minutes and for which calibration factors are not available, the user should be alerted that the measurements cannot be taken as a real indication of the radioactivity level.

11. Make the standard available for all developers

The minimum standard for apps to comply with should be made available to developers so as to ensure a fair competition and increase the quality of products in the market.

Section 5. Quality of data

12. Explain uncertainties

Individual measurements are affected by uncertainties, especially when performed by untrained persons and in real scenarios with multiple radiation sources. Authorities should be aware of this and explain it clearly to the public in order to avoid misinterpretation and panic.

13. Implement a process to validate data

When data are shared and used for decision making, a quality validation process should be set up in collaboration with experts. Calibration remains a main issue. Despite efforts to explain the importance of calibration factors to developers and users, it is undoubtly difficult to have accurate calibration for all available mobile phone models. This is especially true considering the fast turnover of models. It is important that public authorities encourage scientific research to develop methods to calibrate data *a posteriori*, or to allow users to calibrate their devices.

14. Take advantage of the citizens' data

Use of the measurements performed by public bodies and citizens remains a sensitive issue, due to interpretation and confidentiality aspects (ICRP 2019). However, if guided and validated by experts, the data collected by citizens can be a valuable source of information for authorities and academia. Citizens' data could be collected by crowdsourced platforms developed and managed by public and research bodies. Thus, authorities or radiation protection institutions, possibly coordinated at the European level, should develop tools and strategies to manage large amounts of data, especially considering that big data can smooth possible errors derived from individual measurements and partly resolve the problem of data quality.

Recommendations for citizens/users

Step 1: Choose and download an app

There are many commercial apps on the market. However, keep in mind that some are not updated, expensive or have different versions (basic/pro). Make a choice based on the recommendations provided by public authorities.

Step 2: Set up the mobile phone

Cover the camera with a black, thick adhesive tape. This protects the image from visible light.
If the mobile phone is white, then place the mobile in a black sachet.
Do so even if you are in a dark room.

Step 3: Set up the app

Set up the app following instructions given by the producer. Be sure you have understood correctly. The setup step typically involves the downloading of a conversion factor from the producer site and is necessary to obtain accurate measurements.

Step 4: Measure

Measurements are carried out in video mode. The minimum measurement duration should be about 20 minutes. Take several measurements to obtain a mean value. If possible, place the mobile phone always in the same positions when measuring.
Be aware that:
Battery discharge in 20 min is about 10%.
Mobile temperature increases up to 40 °C.
Some apps do not allow the use of the phone while measuring.

Step 5: Log the data

Typically, several types of data can be registered: gamma dose rate, geolocation, time of the measurement, indoor/outdoor location during measurement, weather, sensor temperature and mobile phone model.

Step 6: Share the data

Most apps let you share these data with family and friends, your email contacts, authorities, and crowdsourcing radiation maps.

Recommendations for App developers

The current apps seem to be at the same time too difficult for the public and not professional enough for use by authorities. It is advisable to develop both basic and professional versions.

Basic version

1. Adapt the instructions to the potential user

Provide instructions that are as simple and clear as possible for all types of users, including skilled and digitally-challenged adults and children. Use illustrations, when possible.

2. Adapt the type of data to an unskilled user

Provide the dose rate, which can be compared to official data. If feasible, integrate results with understandable graphs. If providing a traffic light scheme, then specify the corresponding dose rate range.

3. Simplify the app setup

Extend the list of the mobile models for which the calibration factors are available. Maintain the calibration factors updated.

If a calibration factor is not available, alert the user that the measurements may not be reliable. Facilitate calibration set up process. Opt for the automatic upload of the calibration curve.

4. Provide protocol to achieve quality of data

Provide the minimum recommendations for a correct measurement: minimum acquisition time and minimum number of measurements to have proper statistics and more robust data. Specify clearly how the mobile has to be protected from visible light. If possible, propose set up tests.

5. Make the app interactive

Provide the user with the possibility to write comments, add information on the situation, upload photographs or ask questions. This can help improve the quality of data.

<u>Pro version</u>

1. Adapt the instructions to an experienced user

Provide technical instructions. Include details that help understand how the hardware and software work.

2. Adapt the type of data to an expert user

Provide raw data and access to calibration factor and background setup. Allow access to data about sensor temperature and battery percent charge.

3. Allow access to set up of app parameters

Extend the list of the models for which the calibration factors are available. Allow manual calibration for all models.

4. Provide protocol to achieve quality of data

Clearly explain the sources of uncertainty when measuring. Recommend a minimum acquisition time and a minimum number of measurements to have proper statistics and more robust data.

5. Make the app interactive

Provide the user with the possibility to write comments, add information on the situation, upload photographs. This can help improve the quality of data.

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