ROCSAFE: Remote Forensics for High Risk Incidents

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1 Introduction

Incidents that involve the dispersal of Chemical, Biological, Radiological or Nuclear material (CBRNe) material, although rare, can cause not only material damage, but also can contaminate natural resources as well as being hazardous to humans for long periods of time. For example, the Chernobyl Disaster caused the displacement of 110,000 people from the immediate area, and was estimated to have affected a further 220,000 people [USNRC, 2009]. The hazardous environments created by these incidents impede and endanger any subsequent forensic investigations. The dangers to first responder and forensic teams was highlighted by a recent investigation that found that there were 70 cancers specific to first responders and related workers who attended the World Trade Centre site in 2001 [Goodman, 2016]. A key principle underlying our research is that lives of of forensic teams can be protected if the physical collection of evidence can be automated. The Remotely Operated CBRNe Scene Assessment & Forensic Examination (ROCSAFE) project which is funded by the HORIZON 2020 programme is developing strategies and technologies that will automate the collection of evidence. This paper will provide an overview of ROCSAFE as well as its aims for the future.

2 ROCSAFE Overview

The ROCSAFE project is a three year project. The consortium that is developing the technologies for ROCSAFE contains thirteen partners who are a mixture of public and private organizations. The members are: 1. National University of Ireland Galway, 2. CREO, 3. CNR, 4. Scorpion Networks, 5. Aeorum, 6. Health Service Executive, 7. Inov-Inesc, 8. Department of Defence, 9. University College Cork (Tyndall), 10. Ayuntamiento de Valencia, 11. IBATECH, 12. REAMDA and 13. Microfluidic Chipshop

The central premise of the ROCSAFE project is that automated collection of evidence from incidents that involve CBRNe material is possible through the use of autonomous RAV (Robotic Aerial Vehicles) and RGV (Robotic Ground Vehicles). The strategy that the project will use is that the RAVs will survey the scene. These vehicles will be equipped with infra-red, video and still photography as well as sensors for chemical, biological and/or radiation threat detection. The sensor configuration will be chosen by the scene commander. The information from these sensors and cameras will then be transmitted to a Central Decision Management (CDM). The CDM has as part of its function the ability to use probabilistic reasoning over time to determine the most likely threats, likely locations of hotspots/epicentres, and recommend the forms of forensic evidence that should be sought. The CDM will estimate the best route for the RGVs to collect the previously observed evidence and return it to a mobile laboratory. An overview of the ROCSAFE project is provided in Figure 1.

The diagram in Figure 1 demonstrates the aims of the ROCSAFE project which are to assess the scene, collect evidence, and provide decision support. The scene commander will have access to the infra-red, video and still images as well as sensor information. The graphical user interface (GUI) will be designed to limit the cognitive overload for the scene commander.

A motivation for the development an AI-based decision support system is that the assessment of CBRNe risks and recovery of CBRN-contaminated evidence is not a routine or everyday task. In addition there are extremely large number of variables to consider, which may be beyond an individual or group of experts to evaluate. ROCSAFE's decision support system will highlight key information, therefore reducing information overload on the scene commander, and who then can retrieve the potentially relevant standard operating procedures.

3 Scene Assessment

The scene assessment strategy is predicated upon dividing the incident scene into predetermined subdivisions. At the start of the scene assessment process each of the subdivisions will have an equal probability of containing evidence. The RAVs will assess the scene quickly and relay back information from sensors as well as infra-red and video cameras. It is unlikely that they will relay any detailed information, however the video and infra-red may detect indicators (objects) of evidence, such as: small craters, debris, and damaged buildings. Although object detection is primarily associated with the visible spectrum, it has been used with infra-red imaginary [McClintock *et al.*, 2011]. The individual RAVs will be coordinated with flocking or swarm strategies that have been used in other search based problems [Cimino *et al.*, 2015].

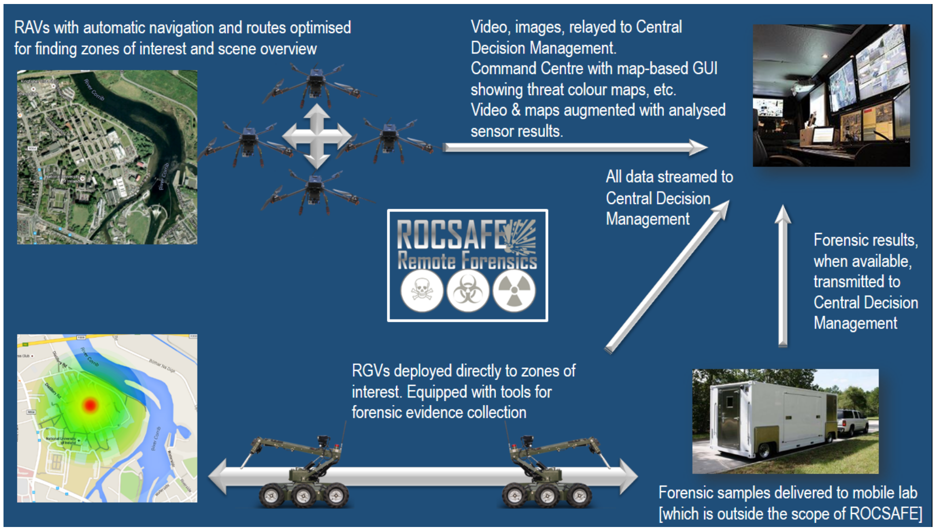

Figure 1: Overview of ROCSAFE Project

4 Central Decision Management

A key component of the CDM will be a Dynamic Bayesian Network (DBN). A DBN has been chosen because it is able to reason with multiple data streams. The initial structure of the DBN will be created from outside sources such as standard operating procedures from expert end-users. In addition to the DBN, there will be image analysis of the video, still and infra-red images. The proposed method of analysing images is Convolutional Neural Networks that will highlight regions of interest in the aforementioned images. Algorithms that analyse sensor information are also being developed. Finally, intuitive Graphical User Interfaces (GUIs) are being developed to display the relevant information from which the scene commander can make informed decisions.

There are a number of challenges that the DBM will have to face. For example the differing time frames of data-streams. The video and infra-red streams are likely to be constant, data from other sensors may suffer from lag and will transmit data for short periods. In addition the data gathered from video and infra-red cameras mounted on the RAV from differing altitudes will need to be accounted for in the structure of the Bayesian Network. This will build upon the work of [Aleks *et al.*, 2009; Enright *et al.*, 2010; 2013].

5 Conclusion

The ROCSAFE project is designed to advance the automated collection of evidence. In addition to the described advances, there will be advances in sensor technology. It is hoped that this project will develop technology that will protect forensic teams as well as guaranteeing the chain of evidence. This research has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 700264, ROCSAFE (Remotely Operated CBRNe Scene Assessment and Forensic Examination).

References

[Aleks *et al.*, 2009] Norm Aleks, Stuart J Russell, Michael G Madden, Diane Morabito, Kristan Staudenmayer, Mitchell Cohen, and Geoffrey T Manley. Probabilistic detection of short events, with application to critical care monitoring. In *Advances in Neural Information Processing Systems*, pages 49–56, 2009.

[Cimino *et al.*, 2015] Mario GCA Cimino, Alessandro Lazzeri, and Gigliola Vaglini. Combining stigmergic and flocking behaviors to coordinate swarms of drones performing target search. In *Information, Intelligence, Systems and Applications (IISA), 2015 6th International Conference on*, pages 1–6. IEEE, 2015.

[Enright *et al.*, 2010] Catherine Enright, Michael G Madden, Norm Aleks Stuart Russell, Geoffrey Manley, John Laffey, Brian Harte, Anne Mulvey, and Niall Madden. Modelling glycaemia in icu patients a dynamic bayesian network approach. *College of Engineering & Informatics*, 2010.

[Enright *et al.*, 2013] Catherine G Enright, Michael G Madden, and Niall Madden. Bayesian networks for mathematical models: techniques for automatic construction and efficient inference. *International Journal of Approximate Reasoning*, 54(2):323–342, 2013.

[Goodman, 2016] Leah McGrath Goodman. 9/11s second wave: Cancer and other diseases linked to the 2001 attacks are surging, 2016.

[McClintock *et al.*, 2011] Joseph McClintock, Mark Saxon, Jennifer Forsythe, James Rascoe, and James Risser. Development of the adaptable, gis-based, multi-threat detection system. In *Technologies for Homeland Security (HST), 2011 IEEE International Conference on*, pages 507–511. IEEE, 2011.

[USNRC, 2009] USNRC. Backgrounder on chernobyl nuclear power plant accident. Technical report, United States Nuclear Regulatory Commission, 2009.