Final Publishable Summary Report

SNIFFER FOR CONCEALED PEOPLE DISCOVERY

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Executive summary

The SNOOPY project addressed two major challenges in the field of security that have become increasingly important in the last years: i) detection of people hidden in cargos/containers crossing borders in illegal mode; ii) detection of threats arising from Li-ion batteries transported in airfreight.

To this aim the SNOOPY project has developed an artificial, portable electronic nose, potentially suitable to work in a 24/7 mode, able to detect the presence of hidden people through the identification of molecules produced by human body, e.g. sweats compounds. A second prototype has been developed to detect lithium battery failure at early stages, in order to allow triggering of countermeasures in inaccessible cargo compartments. Common to these two applications addressed by the projects is the adopted sensor technology, based on an array of non-selective sensors, whose collective response is handled through a pattern recognition software. Target search is performed based on (odor) fingerprint recognition.

Goals have been pursued through the consortium merging capabilities in sensors development, system integration and software development, as well as expertise or relationship with end users and authorities involved in the target applications. The consortium consists of six partners: i) University of Brescia (UNIBS, Italy), as coordinator, ii) University of Rome Tor Vergata (UTOV, Italy), iii) Italian National Research Council (CNR, Italy), iv) AIRBUS Defense & Space (AIRBUS, Germany), v) C-Tech Innovation (CTECH, United Kingdom), and Center for Security Studies (KEMEA, Greece).

The SNOOPY project started on 1st of January 2014 and continued for three years, till December 31st, 2016.

In the first period, the project activities addressed the development of basic elements of the SNOOPY sniffer, namely, the pre-concentrator unit, the sensor module, performing a screening over different technologies/approaches in order to select the most suitable ones for integration in the SNOOPY sniffer prototype. In the second period, prototypes' components and their architectures have been optimized, tests have been designed and implemented to check the prototypes' performances in tests as close as possible to real situations.

In December 2016, close to the end of the project, the consortium organized a final workshop in Athens as an event to show the SNOOPY prototypes and their demonstration to authorities, companies, political institutions and academic representatives.

Summary description of the project context and the main objectives

The SNOOPY project has been carried out with the objective to develop technological solutions based on the exploitation of an array of different sensors, whose collective response is handled by means of a proper software to respond to the needs of two target applications: 1) the detection of people hidden in cargos/containers; 2) the detection of failures in Li-ion batteries at early stages in order to allow to take countermeasures, especially in the case of batteries transported in airfreights.

As for the first application, illegal trafficking of people is a major issue in security that has dramatically risen in the last years. The need to face this crime as well as the planning of countermeasures and the identification of missing capabilities has been the subject of several security programmes proposed both at a world-wide and at European level.

In particular, according to the ESRIF final report 2009, one of the major challenges is the detection of people hidden in vehicles or cargos. A common challenge for customs and border control authorities is to accommodate the ever-increasing flow of cargos and people crossing the external borders of the EU, accomplishing the required controls without undue delay and with minimal intrusion.

Nowadays, dogs represent the most effective “tool” to detect the presence of hidden people, but dogs present intrinsic drawbacks that limit their continuous and systematic use: they can’t work in a 24/7 way (24 hours per day and 7 days per week) and they cannot be used by different people, since their performances are strictly related to the bond established with their trainer.

To overcome such drawbacks, systems using non-intrusive inspection (NII) technologies were studied such as CD-2 human occupancy detector; (HOD), a handheld carbon dioxide (CO_2) detector; the RadarVision2, a through-wall motion sensor using ultra-wide band (UWB) radar technology; the advanced vehicle interrogation and notification (AVIAN) heartbeat detector (HBD), a vibration-sensing system; and the MicroSearch human presence detection system (HPDS), a vibration-sensing system (similar to the AVIAN HBD). However, the currently deployed NII technologies all have their limitations and new technologies are needed to fill this gap.

Within this scenario, the SNOOPY project aimed to: i) develop an artificial instrument (the SNOOPY sniffer) that identifies the presence of hidden people through the identification of a plurality of gaseous compounds characteristic of the presence of human beings, arising for example from sweat odor; ii) identify potentialities and drawbacks of the SNOOPY sniffer and trained dogs (K9 units) to integrate these two resources in order to improve the capability of border authorities with respect to illicit traffic of people.

As for the characteristics of the SNOOPY prototype, the goal was to develop an instrument having the following potential features: i) it should be realized using technologies potentially suitable to address low power consumption, weight and size, which are fundamental to develop a prototype that may be optimized to feature portability or even the possibility to be hand-hold; ii) it should have the potential capability to work in a 24/7 way; iii) it should be able to recognize the sniffed atmospheres on its own, providing the information directly to the user through a display in a simple way (in this way the user is not required to have scientific or technical competences to interpret the measurement result); iv) it should be equipped with a small pipe to collect odors in proximity of small apertures, which are present, for example, at lorry/container doors, even if locked, and from which inner odors can be smelled.

The same technological approach (merging different sensor technologies to increase the selectivity and reduce false alarm rates) has been used to develop a second prototype dedicated to detect early stage of Li-ion battery failure, focusing in particular on battery transported in air cargo containers.

Indeed, in case of a fire arise in only one container of the cargo department, the fire growths until the active fire protection system of the whole cargo department is activated. This includes fire detection as well as fire extinguishing equipment. Fire extinguishing actions in the form of halon flooding of the whole cargo for fire suppression and an emergency landing takes place. Nevertheless, current fire detection is performed by smoke detectors and the false alarm rate is about 200 false alarms per one real alarm, which is issued by the Federal Aviation Agency (FAA).

Nowadays 100 Million of lithium primary (non- rechargeable) and lithium-ion (rechargeable) cells are transported by air cargo per year and this number will increase. Li batteries belong to the dangerous goods because they consist of a flammable electrolyte and an own energy source, as dramatically confirmed by recent years events.

The SNOOPY idea is to equip each cargo container with a Sniffer detector to allow more precise localization of possible ignition source and to provide a halon injection into the affected container to allow a better fire suppression with much smaller amounts of halon.

Description of the main S & T results/foregrounds

The main hardware results of the SNOOPY project are the two prototypes developed for the two target applications, i.e. the detection of hidden people and the detection of Li-ion battery failure at early stages.

The core of the two prototypes is represented by sensors. Two different kind of gas sensors were developed ad hoc by the consortium for the project. These are chemiresistors (i.e. gas sensors that transduce the presence of target analytes through a modulation of the device electrical resistance) based on metal oxide nanowires and quartz crystal microbalances (i.e. mass-sensitive devices that transduce the adsorption of gaseous molecules through a change of the crystal resonant frequency) coated with layers of either porphyrins or corroles. To have different sensors, each one showing its own response spectra, suitable to develop the sensor array that represent the core of the prototype, metal oxide materials were functionalized by means of different catalytic nanoparticles, specifically selected to enhance the respose to key compounds of sweat odour. Similarly, different kinds of porphyrins and corroles were synthesized by tuning the molecular structure, in particular changing the metal atom at the center of the aromatic rings, to tune the selectivity according to the project requirements.

Moreover, functional substrates suitable to exploit metal oxide nanomaterials according to different transduction mechanisms (i.e. surface ionization, catalytic heat development) and measurements protocols (i.e. temperature profile protocols) were specifically developed with the aim to obtain different functionalities suitable to increase the selectivity of the sensor array and thus reduce the false alarm rate.

As for the detection of Li-ion battery failure, digital cameras have also been used in combination with gas sensors with the aim to merge the two main technologies nowadays in use for fire-detection and thus potentially reducing the false alarm rate of the whole system.

Another important component of the prototype is the enrichment unit, this is necessary to increase the concentration of analytes when these are too small. The working principle of this unit is the absorption, at room temperature, of the volatile compounds on a sorbent material for a pre-defined time, and the following desorption at high temperature.

Due to the different target atmospheres of the considered applications, two enrichment units have been developed. Moreover, a system for remote sampling based on a similar working mechanism has been developed in order to collect real samples of atmospheres and store these in the sorbent material, which can be sent elsewhere for a detailed chemical analysis.

Pneumatics, electronics, software have been developed ad hoc to produce the two SNOOPY prototypes and handle in the optimal way all the components. For each application, the respective final prototype has been realized into two steps: first, a non-optimized prototype has been prepared and tested, then, based on the output of these tests, an optimized instrument has been realized.

The prototypes were first tested in lab and then in field. Measurement and validation protocols have been decided considering the advises received from border authorities and air transport experts in order to approach as much as possible the scenarios and needs of real applications/customers.

In particular, for Li-ion battery failure application, the prototype has been tested in battery overheating and battery overcharging experiments. A setup suitable to carry out such tests in secure and safe conditions has been realized. The setup allows simultaneous measurements with the SNOOPY prototype and analytical techniques to properly characterize the optical and chemical signals developed during the different stages that underwent Li-ion batteries while approaching their failure.

Concerning the detection of hidden people, lab-tests have been carried out with real sweat samples (collected from volunteers that worn t-shirts during physical exercises). These tests allowed to study the performance of the SNOOPY prototype to detect the presence of t-shirts impregnated by human sweat in a confined space (a box provided with a small hole to smell the inside odor from outside) against situations where dry t-shirts or t-shirts impregnated simply by water were lodged in the box. Effects arising from gender, type of physical exercise, presence of interfering substances were investigated during these tests. Further measurements were carried out working directly with volunteers staying inside a small room (in order to tests not only the sweat odor but all the volatile released by a person). These last tests were also carried out in collaboration with the K9 units of the Hellenic police force to compare the capability of the SNOOPY sniffer prototype with trained dogs and identify possible protocols suitable to integrate these two resources.

Positive and promising results have been obtained for both applications.

The two prototypes and a video showing their performances in the aforementioned tests have been shown during the final SNOOPY workshop organized in Athens (Greece) in December, 14-15, 2016.

Description of the potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and the exploitation of results

The SNOOPY prototypes realized and tested for the two target applications (detection of hidden people and detection of Li-ion battery failures) have been developed till a Technological Readiness Level (TRL) of 5.

As for the first application (detection of hidden people) the SNOOPY prototype, featuring the potential capability to work in a 24/7 mode, is expected to improve the capability of border authorities to inspect the large number of vehicles and cargos transported every day through border checks and customs. During normal operation the SNOOPY sniffer can be operated as a stand-alone instrument, i.e. it will perform the entire task of sampling, pre-concentration and detection, including decision-making. Moreover, the instrument has been designed to be as simple as possible to use: the operator can control the instrument through a touch screen, a few buttons and lights are enough to control the instrument, start the measurement and reads the output result, in particular, the display provides a 3 level output (presence/absence of people and uncertain case). These features are useful to allow the operator to work with it with no special training. So far, the instrument shows potential features that are complementary with respect to trained dogs that can be combined to enhance the capability of border authorities. In particular, the SNOOPY sniffer has been thought to work continuously (potentially in a 24/7 way) and by different users, so it allows to screen cargos/containers, allowing to save K9 resources, whose employment can be scheduled only when necessary as complementary/further check after the sniffer use. Moreover, a technological solution such as the SNOOPY sniffer can resolve ethical problems related to dogs approaching those people that for cultural or religion reasons may be afraid or may refuse the act of coming in contact with or in proximity of dogs.

Concerning the prototype developed for Li-ion battery failure, results showed the capability of the SNOOPY prototype to detect the failure on the basis of both electrolyte leakage and flame development. The former is of particular interest since, in several situations such as battery short-circuiting or overcharging, the battery failure event takes place through the expulsion of the electrolyte followed by the development of fire. So far, the capability to detect the electrolyte expulsion event allow to trigger countermeasures to prevent the development of any flame. The synergic combination of gas sensors and differential digital camera allows the exploitation of different signals thus reducing the false alarm rate that may be induced by interfering gases (for traditional systems working with gas sensors only) or light spikes/shadows (for traditional systems working with cameras only).

Societal impacts are foreseen for both applications, each one benefitting from the technological advances produced by the SNOOPY project, due to the increased capability of authorities to guarantee a more efficient surveillance in two sensitive sectors whose needs have dramatically increased in the last years.

From a policy perspective, the operational experience gained with the SNOOPY sniffer technology is expected to stimulate the development of a set of best practices and blueprints for the building, deployment and operation of novel border security procedures. From a science and technology perspective, the SNOOPY concept is exciting as it involves an element of “learning from nature”. This leaded to the development of several results suitable for exploitation and dissemination.

In particular, basic aspects of fundamental science have been addressed during the project, resulting the in the publication of 6 peer-reviewed articles (including 4 open-access articles) and 27 dissemination activities, including oral and poster communications at scientific events, interviews and articles dedicated to non-specialized audience and the organization of two workshops. With the aim to meet the proper, broad audience, the SNOOPY mid-term workshop took place during the FRONTEX “Workshop on European funded border security research projects” in Warsaw (Poland), June 15-16, 2016. The second workshop was organized as a stand-alone event for the demonstration of the SNOOPY prototypes to police and border authorities, representatives of European countries government, companies (both small, medium industries and large enterprises).

Results were suitable for exploitation too. Indeed, thanks to the SNOOPY project (and to the background of the University of Brescia and CNR in the field of gas sensor and electronic noses), the University of Brescia (in collaboration with CNR) funded the spin-off company NASYS S.r.l., dedicated to the preparation of metal oxide chemiresistors for application in environmental, food-quality control, security fields.

Moreover, possible exploitable results/products have been identified as follows: i) UNIBS, UTOV and CNR developed a mixed sensor array combining the technologies of metal oxide chemiresistors and quartz crystal microbalances functionalized by means of metalloporphyrins/metallocorrols to enhance the selectivity capability of the array with respect to traditional array composed by sensors based on a single technology; ii) AIRBUS has developed a method combining gas sensors and digital camera signals for fire detection.

Project web-site and contact details

Project web-site: http://www.snoopy-project.eu/

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