Thesis subject

Hybrid AI for the prevention of toxic smoke inhalation risk among firefighters

Francis Faux[1], Romain Guillaume[2], Florence Dupin de Saint-Cyr[3], Eric Carayol[1]

[1] Université de Toulouse, INUC, IRIT/ADRIA
[2] Université de Toulouse, UT2J, IRIT/ADRIA
[3] Université de Toulouse, UT3, IRIT/ADRIA
[4] Université de Toulouse, INUC ISIS/Connected Health Lab

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1 Context

In their fire-fighting activities - both urban and forest fires - firefighters are exposed to fire combustion products (polycyclic aromatic hydrocarbons [PAHs] and particules), to chemicals contained in fire-fighting foams (perfluorinated and polyfluorinated substances) and flame retardants. In France, the ANSES in its 2019 report [1] highlights the "Health risks associated with the occupational exposure of firefighters". In 2023, the International Agency for Research on Cancer classified the firefighting profession in group 1 - the highest risk [2]. Absorption of fire-fighting effluents or other chemicals may occur through inhalation, skin absorption and possibly ingestion, even by firefighters wearing personal protective equipment (PPE). In June 2022, twenty-five scientists from eight countries met at the International Agency for Research on Cancer (IARC) in Lyon, to finalize their assessment of the carcinogenicity of occupational exposure in firefighters. On the basis of the epidemiological evidence available, this study published in Lancet [3] concluded that there is a causal association linking occupational exposure as a firefighter with mesothelioma (asbestos-related cancer, 58% higher risk for mesothelioma among firefighters compared with the rest of the population) and bladder cancer. There is also "limited" evidence in humans of a link with colon, prostate and testicular cancers, as well as with melanoma and non-Hodgkin's lymphoma. It is therefore essential to take individual, contextualized readings (depending on the type of fire) of firefighters' inhalation of certain toxic products (acrolein (C3H4O), aldehyde (CH2O), benzene (C6H6), hydrocyanic acid (HCN) and carbon monoxide (CO)). Thus, in the literature, several health monitoring systems based on wearable connected sensors have been proposed [4, 5, 6, 7, 8].

The originality of this thesis is twofold :

— to provide an individualized history of a firefighter's exposure to toxic products throughout his career. A study of the parameters characterizing exposure situations will have to be carried out by means of an adapted state of the art in order to propose a protocol for acquiring and storing this history.

— Then, using the data thus recorded (possibly supplemented by other datasets from the literature), the aim will be to study models based on hybrid artificial intelligence combining on-line learning and formal reasoning under uncertainty, which will make it possible to target people at risk, for different types of fire.

In the long term, this project could be useful for confirming the classification of certain pathologies as "occupational diseases" by means of a statistical study.

2 Objectives

The aim of the project is to trace the toxic products "inhaled" by firefighters during their various interventions. The first stage of the thesis will be to make the real-time acquisition system operational and reliable (calibration of sensors, securing of recordings), and to contextualize it according to the type of fire (apartment, forest). The second objective of the thesis will be :

— to study hybrid online and multi-source learning models [9,10] for modeling the toxicity of different types of fire, in order to infer the duration of exposure to different toxic products (taking into account the randomness of the context)

— to develop a medical decision support tool under uncertainty to identify at-risk firefighter profiles. Given a firefighter's history, it will be possible to deduce the arguments that point to a certain level of risk associated with the development of different diseases. To this end, work on Bipolar Layered argumentative Frameworks [11, 12, 13] could be adapted to temporal data and, if necessary, enriched.

3 Local environment

The person recruited will carry out the internship at the CHL (https ://isis.univ-jfc.fr/le-connected-health-lab), a usage laboratory for experimenting, innovating and designing solutions for tomorrow's Digital Health, located within the ISIS engineering school in Castres.

This thesis is part of the Sainte Barbe project. It is financed by the Ecole Nationale Supérieure des Officiers Sapeurs Pompiers (ENSOSP). The doctoral student will be provided with an office, a powerful, up-to-date computer, and all the resources required for his or her work.

The theme of the CHL is the patient pathway in the broadest sense, based on a systemic approach involving well-being, prevention, diagnosis and monitoring.

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4 Expected candidate profile

Master's degree in computer science with a strong AI background, particularly in machine learning, knowledge of uncertainty modeling in AI will be highly appreciated.

5 Références

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(p.138) - absence de système de traçabilité (p.140) - le problème de toxicité des fumées semble bien là (p. 140) - certains sapeurs-pompiers ont mal compris la nécessité de se raser (p.140)

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