Detection of hazardous gas dispersion based on sensor equipped micro-aerial vehicles and emergency response modeling

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Introduction

Several air dispersion models are available for the prediction and simulation of the hazard areas associated with accidental releases of toxic gases. The estimation of the source term is crucial for the model result and often affected by large uncertainties in the case of an emergency: the size and location of the leak are difficult to determine and the amount of the released chemical is usually unknown. In these cases, an estimation of the source term based on assumptions is needed.

A possibility to **reduce the uncertainties in emergency response modeling** is the estimation of the release rate ("back-calculation") based on real-time chemical measurements (whenever available).

In the frame of an ongoing **research project SkyObserver**, the usability of airborne measurements conducted with a group of sensor equipped **micro-aerial vehicles (MAVs)** to provide real-time data for release rate estimation is investigated. A modeled first-guess of the hazardous gas dispersion is used for the mission planning. The MAVs are networked and coordinate their routing dynamically within the group so that no collision occurs and the mission area is covered optimally according to a cost function.

On-board computer vision system

An on-board computer vision system is under development as an optional module for the MAV and has to fulfill the following main-tasks:

- detection of persons moving on the ground
- acquisition of an overview image
- live video for the detection of blocked access routes

Source term back calculation

The background idea of the Advanced Back Calculation (ABC; Shahryar and Gilbert, 2003) involves "reverse calculation" with a dispersion model:
Usually the release rate is used as an input to the dispersion model and the results are the concentration field for the affected area, while the ABC utilizes the concentration filed data to estimate the release rate.

The back calculation algorithm takes into account

- measured concentrations (ground-based or airborne)
- meteorological measurements
- release location
- starting time of the release

to estimate the release rate.

References

Shahryar, K. N., E. Gilbert, 2003: Use of real-time measurements for estimating release rate. IChemE Hazards XVII, Process Safety, in the Symposium Series N0. 149, 155-171.

Ambrosch, K., 2009: Mapping stereo matching algorithms to hardware, PhD Thesis, Vienna University of Technology.

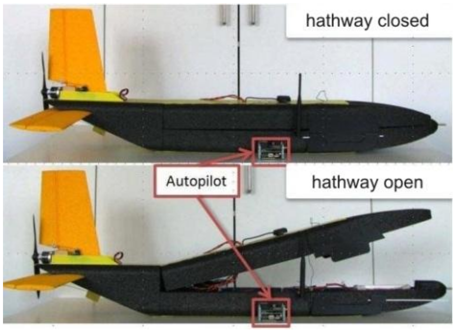

Figure 1: Prototype of the MAV (without wings, with autopilot)

Every micro-aerial vehicle system contains of several MAVs and a ground station. Depending of the operation the MAVs will be equipped with one or more sensors:

- sensors for toxic substance
- camera for obtaining an overview picture
- camera for detection of persons and transfer of live pictures

The ground station serves as a configuration and parameterization, as well as for manual adaptation (by demand) of the system for the real time application.

Figure 2: For the design of this person detection system it is necessary to process the data on-board the MAV in real-time, highly reducing the load for the radio transmission between the MAVs and the base station. Therefore a light-weight embedded vision system is required that comprises image acquisition as well as a processing platform. An embedded vision system that is highly amenable for our purpose is the VCSC4012nano, a so called "Smart Camera" from Vision Components.

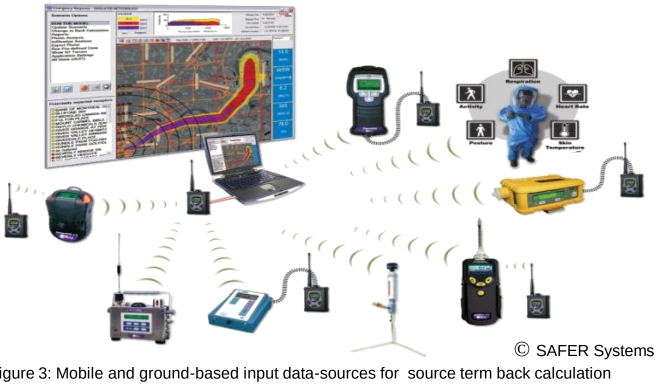

Figure 3: Mobile and ground-based input data-sources for source term back calculation

The ABC approach as implemented by **Safer Systems** (www.safersystem.com) is tested in the SkyObserver project using data measured with MAVs.

This investigation is funded by the KIRAS safety research program of the Austrian Ministry of Transport, Innovation and Technology (www.kiras.at).

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