Mobile Robot using different Senses

Michael Wandel[1], Achim Lilienthal[2], Andreas Zell[2], Udo Weimar[1]
[1]University of Tuebingen, Institute of Physical Chemistry,
Auf der Morgenstelle 8, 72076 Tuebingen, Germany, mw@ipc.uni-tuebingen.de
[2]University of Tuebingen, WSI-RA

SUMMARY

An electronic watchman must have the ability to autonomously oversee his target area. This includes to scan the environment for intruders and also for unusual events or other changes of the normal situation. Commonly, seeing with cameras or range finders (laser or ultrasonic) and hearing with microphones is utilized. A gas sensor system was added to enable the robot to detect volatile chemical substances, with a focus on leakage detection and localization. First results in a corridor were presented before. In this paper the results obtained in a 2-dimensional environment are presented. The robot is able to measure a concentration profile in the room, which was constant over the whole measuring time. With this data, the detection of the leak is achieved and even the time of the occurrence can be computed.

INTRODUCTION

After the satisfying results in the one dimensional environment as described in [1], additional experiments in a two dimensional environment were performed. The data set obtained during summer time was already presented in [2]. To confirm the results and to assess the influence of changing environmental conditions, additional measurement were performed in winter time.

EXPERIMENTAL SET - UP

Robot: The sensor system is mounted on an autonomous mobile robot. The robot is about 70cm long, and has a total weight of 55kg. It has a four- wheel drive and a skid steering. Ultrasonic sensors are mounted at a height of 35cm; their main role is collision avoiding. The navigation of the robot is managed with the data of a laser range finder mounted on the top.

Sensors: The chosen sensor system is small, lightweight and can be powered by a 24V DC voltage supply. Eight sensor modules with Figaro TGS2620 metal oxide sensors were connected to the base unit and mounted at different positions on the robot. The usually measured concentrations are in the range of 10ppm ethanol; the only suitable sensors for this concentration range are metal oxide sensors (MOX), because the sensitivity of quartz microbalances (QMB) is not high enough.

***Figure 1**: The robot Arthur, equipped with the gas sensor system. The main unit is inside the robot. Two sensors are mounted on the stiff extension on the front, four sensors are mounted at the vertical rod on the right side, the last two sensors are situated at the back end edges. In the middle of the room, the first version of the automatic source is shown.*

Locations: For the presented experiments normal, unventilated rooms were used. For the experiments a ventilation, e.g. with open windows, should be possible for fast repetition of the experiments. For the first series of experiments personnel traffic was avoided for safety reasons.

MEASUREMENTS

All experiments were performed in a similar manner. At the beginning of each experiment a baseline was measured by driving the robot on a predefined path (usually rectangles with different sizes). The speed of the robot was 20cm/s. After measuring the baseline, the leak was simulated by remotely pouring 40ml of ethanol into a small bowl (surface approximately $100cm^2$) standing on the floor.

RESULTS

Firstly, the same kind of experiments like the once performed in summer time were now repeated. The driving path of the robot was a rectangular helix. Figure 2 shows the results. The difference of the concentration distribution is related to the changed boundary conditions, namely the windows temperature. In summertime the sun was shining on the windows, warming the air and, accordingly, the air stream at the floor level was towards the windows. Now the air stream has an opposite direction with a clear influence on the concentration distribution.

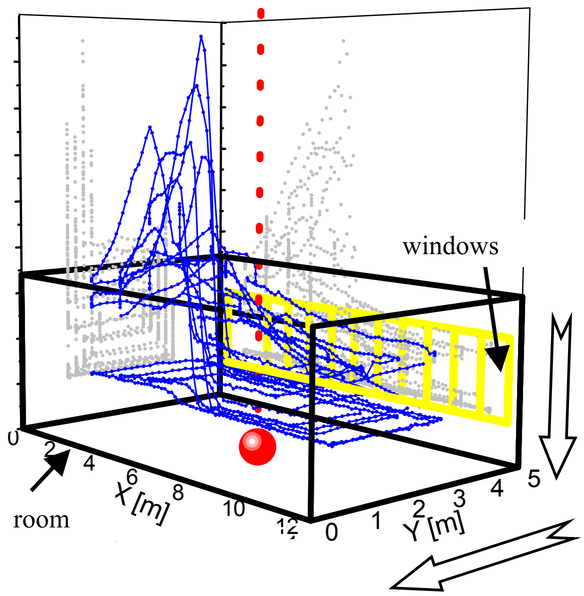

Figure 2: *In winter time, shown above, the windows (yellow at the back wall) were the coldest part of the room, therefore the air stream on the floor has the opposite direction, towards the front wall. The source was in the middle of the room, shown as the red spot on the floor.*

Concentration Profile: A concentration profile was measured in spite of the concerns related to the long response time of the sensors. It could be that this one is not related to the equilibrium sensor signal but is nevertheless constant over several hours. To get a more precise profile, a computing model will have to be established.

Detection of "opening the source": The data evaluation can be divided in two parts: one is the recognition of the event occurrence, the leak in our case. The second task is the localization of the leak. The first part is, of course easier than the second. However, not only the presence of the leakage itself was detected but also the time of the occurrence of the leakage. This was possible, offline, by using a well parameterized peak finding algorithm and a fit to the remaining base line.

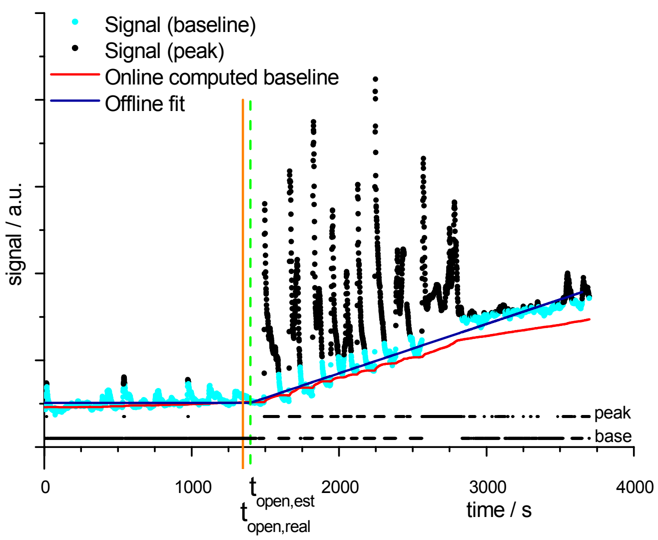

Figure 3: *The first step for the determination of a leak, in this case the opening of the source, is to separate peak and non peak regions. This is done by a straight forward algorithm; results are shown in thin black dots, top means peak, as shown by "peak", and indicates bottom baseline, show as "base" in the figure. A fit to the baseline points (bright blue, in the figure), with a horizontal part and followed by a slope beginning at $t_{open,est}$ results in a good estimation (dashed green vertical line) of the opening time of the source $t_{open,real}$ (red vertical line). The estimated time is about 45 to 90 seconds after the real opening.*

Localization: The direct correlation between the height of the signal / baseline and the distance to the source is only valid in the one-dimensional case. The situation in the 2-dimensional case is much more difficult, but, for example, the plot of the peak maxima in a 2-dimensional map gives hints for the position of the source.

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