Journal of Intelligent & Robotic Systems (2023) 109: (2023) 109:75
https://doi.org/10.1007/s10846-023-02012-z

SHORT PAPER

VGR Dataset: A CFD-based Gas Dispersion Dataset for Mobile Robotic Olfaction

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Received: 11 July 2022 / Accepted: 2 November 2023 / Published online: 16 November 2023

Abstract

There are many potential applications for an autonomous robotic agent capable of sensing gases in the environment, from locating leaks in pipes to monitoring air quality. However, the current state of the art in the field of robotic olfaction is not mature enough for most real-world applications. Due to the complexity of gas dispersion phenomena and the limitations of sensors, a great deal of research into the development of techniques and algorithms remains necessary. A very important part of this research is thorough experimentation, but carrying out robotic olfaction experiments is far from trivial. Real world experiments are usually limited to very simplified, wind-tunnel-like environments, as it is impossible to closely monitor or control the airflow in more complex scenarios. For this reason, simulation with CFD offers the most plausible alternative, allowing researchers to study the behavior of their algorithms in more challenging and complex situations. This work presents a CFD-based gas dispersion dataset composed of 120 cases generated under variable environmental conditions, taking place in 30 realistic and detailed models of real houses. All the data is made available in multiple formats, and is directly accessible through ROS, to permit easy integration with other robotic tools.

Keywords Robotic olfaction · CFD · Dataset

1 Introduction

Autonomous robots are a powerful tool, capable of solving real world problems that would be inconvenient, dangerous, or simply tedious to humans. One of the main tools these robots use, and one of the determining factors of which problems they are able to solve, are sensors. Beyond the many sensing tools that are already commonplace for autonomous navigation (cameras, LIDAR, Range sensors, *etc*), which are useful for most application of mobile robots, the robotic agent may also be equipped with more specialized hardware that enables it to interact with the world in different ways and solve a wider range of problems. One such case is robotic olfaction, where the robots are equipped with gas sensors or with devices that measure the presence of other volatile substances [1, 2].

Many tasks can be tackled with this ability to sense gases in the environment: locating gas pipe leaks, detecting contraband or explosives, rescue missions, *etc* [3]. Even though many of these problems involve dangerous conditions that humans and animals should not be exposed to, autonomous robots are not currently a common solution, because the field of robotic olfaction still faces many unsolved challenges. Some of these challenges are directly related to the sensors themselves (long response times, low selectivity, low sensitivity, *etc*) [4]. However, this is not an insurmountable issue, as evidenced by the fact that many of the previously listed problems are currently being solved by human operators that carry handheld versions of those same sensors. Indeed, it seems that robust reasoning and decision-making can make up for these sensing limitations, which suggests that research into developing algorithms and techniques is as important, if not more, as refining the technology used for sensing.

The process of researching and developing solutions for these problems is a challenge in itself. Regardless of the specific application that researchers have in mind, the

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underlying problem that is being worked with is the dispersion of gas throughout an environment. Fluid dynamics is a notoriously complex field, where most problems have no closed-form solution and numerical methods are very computationally expensive and require extensive knowledge about the environment and boundary conditions. For this reason, the research of robotic olfaction often involves developing heuristic techniques that are based more on an intuitive understanding of the problem than on a robust theoretical formulation.

As a result, thorough experimentation is needed, not only to validate proposed solutions, but also as a way to offer insight into the problem and guide the development process. Setting up these experiments is a complicated task, however. In most cases, experimentation is limited to very simple environments, similar to wind tunnels, since controlling and monitoring the airflow in complex scenarios is not feasible. While this can be useful, it is also desirable to test the algorithms under more challenging conditions.

Therefore, simulation with CFD (Computational Fluid Dynamics) is a commonly used tool, offering the ability to run repeatable, controlled experiments in environments of arbitrary complexity. Still, the creation of simulated experiments for testing robotic olfaction techniques is a very time-consuming task that requires a degree of expertise in other fields (*e.g.* 3D modeling) and familiarity with CFD tools. We believe the expertise necessary to set up and carry out this type of simulations, particularly in complex environments, is causing most robotic olfaction research to only be tested under simplified conditions.

In this work, we present a dataset of 3D gas dispersion composed of 120 cases generated under variable environmental conditions, taking place in 30 realistic and detailed scenarios, modeled after real houses (see Fig 1). Its main purpose is to serve as a testbed for the development of mobile robotic olfaction techniques and algorithms (e.g. source localization [5], distribution mapping [6]).

The dataset is based on high-fidelity computational fluid dynamic models for the simulation of the airflow, and the filament dispersion model to recreate the transport of the released volatile through the environment. The data is made available in multiple formats, including ones easily accessible from the Robotic Operating System [7] (with support for both *ROS1* and *ROS2*), alongside the code necessary to parse it. The CFD simulations have been carried out using OpenFOAM [8], and the gas dispersion has been simulated with GADEN [9].

We hope that by making this large repository of data available to the robotics community, we are enabling researchers to evaluate their algorithms more accurately and thus help them to design more robust and sophisticate solutions. The dataset and the instructions for its use can be found in this webpage[1].

2 Dataset Description

To the authors' knowledge, there are very few resources for the testing and development of robotic olfaction techniques. While a number of works can be found that present real-world data about gas dispersion, they are mostly geared towards the validation of atmospheric dispersion models [14]. As such, the scale and spatial resolution of the data are not suitable for robotic tasks. The few datasets that are designed for robotic developments [10, 11] only feature a small number of unrealistically simple environments (*i.e.* wind tunnels), because of the high difficulty of obtaining ground-truth data for the airflow and gas dispersion in real experiments (see Table 1).

We propose the use of high-realism simulation models to avoid this issue, presenting 30 different complex environments (modeled after real houses) with multiple sets of environmental conditions simulated in each of them.

The dataset contains the following data (see Fig. 2):

- 120 simulations of the airflow through these 30 environments (4 configurations per environment), using incompressible, Reynolds-averaged CFD models. The simulations include multiple simultaneous inlets and outlets to generate complex flows (see Fig. 1).
  This data is available in the native OpenFOAM format, as CSV-encoded point clouds, and in the internal binary format of GADEN. The OpenFOAM project configuration files used to generate this data are also included alongside the results.
- 120 gas dispersion simulations, 1000 seconds long each, based on the previously mentioned airflow data. These simulations use the filament gas dispersion model, which can account for the presence of obstacles and time-varying airflow, thus allowing for higher complexity in the gas distribution than would be possible with simple plume models.
  The release sources have been carefully positioned to be coherent with the objects that exist in the environments (sinks, toilets, electrical appliances, *etc.*). The data is available as snapshots of the position of the simulated gas filaments in the internal GADEN format, and in CSV format as "rasterized" gas concentration maps.

1 https://mapir.isa.uma.es/mapirwebsite/?p=1708

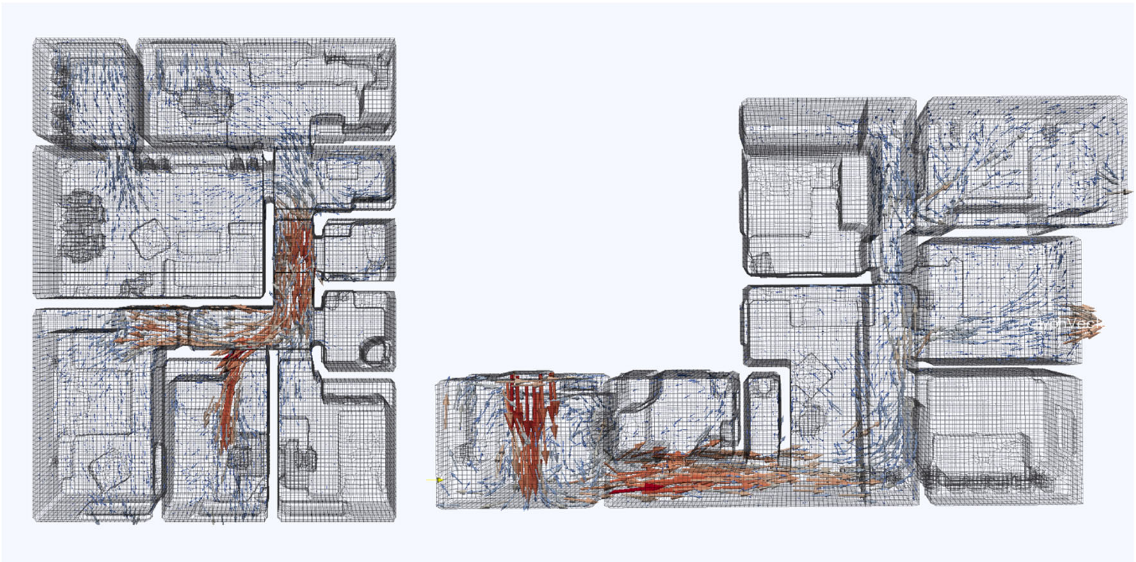

Fig. 1 Examples of the airflows simulated in different environments that are included in the dataset. Having multiple inlets and outlets, as well as many obstacles, tends to produce flows that are more complex than would be possible in a wind tunnel

- The 3D models of the interior volume of the 30 environments, in binary STL format. The models have been preprocessed to make them usable in CFD simulation. The preprocessing includes removing self-intersections, making the models watertight, and separating all potential inlets and outlets (windows, doors, *etc.*) as submodels.

Since the simulated environments are based on real houses and feature realistic detail (furniture, appliances, *etc*), the dataset is specially well suited for those techniques that fuse olfaction with object recognition and classification, which is an interesting direction in current research.

3 Tools and Methods

In this section, we will discuss the details of how the dataset was generated. We will also indicate how users may modify the existing data or generate their own simulations with the same methods, in case they require it.

3.1 Mesh Preparation

The 3D models used in this dataset were originally created for the Robot@VirtualHome project [15], and were modeled after real houses. These models feature a high level of detail, which is important for vision-based applications, but do not conform to the base requirements for CFD simulations. In order to be able to run airflow simulations in these environments, they need to be pre-processed.

The main step in this process is making a airtight version of the interior volume of the environment. This includes eliminating self-intersecting geometry and filling any holes that may exist in the model. While this could be done by hand, it is a very time consuming process that requires a certain degree of expertise in 3D mesh manipulation. Instead, we have used an algorithmic approach, generating a voxelized version of the model. Voxelization can be used to guarantee the mesh

Table 1 Comparison with other similar available datasets

Dataset	Nº Scenarios	Data origin	Spatial resolution	Temporal resolution	Environment type
VGR	120	Simulated	0.05m	0.5s	Indoors, multiple rooms
Orebro3DSEN [10]	10	Stationary sensors	1m	0.5s	Indoors, single room
Induced Airflow Testbed [11]	2	Stationary sensors	0.5m	0.2s	Wind tunnel
Mobile Robot Dataset [12]	3	Mobile sensors	0.5m	1s	Indoors and outdoors
Copenhagen Tracer [13]	1	Stationary sensors	10m	10 min	Outdoors

It can be observed that the use of simulation, while intrinsically less accurate than real data, allows for orders of magnitude more resolution and variability, thus providing a valuable tool to researchers

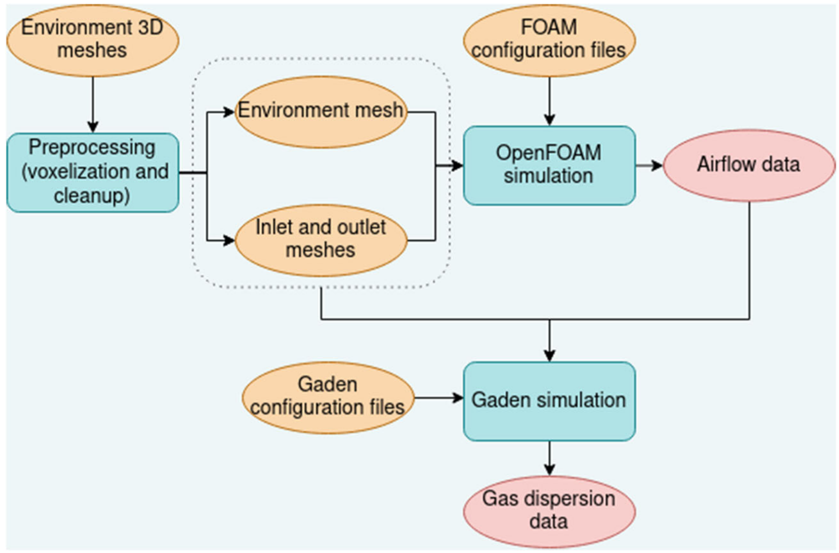

Fig. 2 Diagram of the data included in the dataset and the generation process. In order to use the dataset, only the gas dispersion data is required, but all intermediate data are also available so the users can easily modify the simulations in any way they require. Data marked in red is available in multiple formats to allow for human readability

conforms to the requirements, at the cost of losing some of the most fine details. The data contained in this dataset is based on a 5cm resolution voxelization, although the code included in the project can be used to generate approximations of arbitrary resolution, as per the user's needs.

Once this step is complete, the model needs to be divided into separate sub-meshes, as a way to indicate where the possible air inlets and outlets are. This step has to be done manually, since it is necessary to identify the appropriate parts of the model (*i.e.* doors and windows). The models included in the dataset already have all inlets and outlets separated and numbered, even those that are not used in the included simulations.

3.2 Airflow Simulation

The simulation of the airflow through the environment is done with CFD tools. Specifically, we rely on OpenFOAM [8], a well-established open source software.

While setting up CFD simulations can be a very challenging process that requires extensively studying the specifics of the problem (*e.g.* boundary conditions) it should be noted that, for the purposes of this dataset, this is not a major issue. The intention here is not to obtain precise results about how the system evolves over time under certain conditions, but instead merely to generate a plausible situation, featuring an airflow as complex as one might find during real experimentation with a robot. As such, the specific values of the boundary conditions and other simulation parameters can generally be assigned arbitrarily, so long as they are kept within the ranges of what would be reasonable in a real scenario.

A brief summary of the parameters used to configure the simulations can be found in Table 2. Steady-State, incompressible flow is simulated using Reynolds-averaged Navier-Stokes (RANS) models –specifically, the k-ω SST turbulence model. The boundary conditions are specified as a fixed flow velocity at the inlets and a static pressure at the outlets, which is a commonly recommended configuration for incompressible flow-driven analysis [16]. The project configuration files, which contain the specific values assigned to the parameters of the simulation in each of the individual scenarios, can be found alongside the results in the dataset.

3.3 Gas Dispersion Simulation

The last step of the process is simulating the dispersion of the transported gas throughout the environment. To do this, we use the filament dispersion model [17], where the dispersion of a patch of gas is modeled as a number of discrete packets of gas (filaments) that follow the flow field of the previously simulated airflow. Each of these gas filaments represents in turn a 3D distribution of gas molecules, with a higher concentration near the center of the filament. In GADEN, the tool used for this work, the filaments are modeled as 3D gaussian distributions of concentration.

Table 2 Configuration used for setting up the OpenFOAM simulations

Parameter	Configuration
Flow type	Incompressible
Time	Steady-State
Turbulence model	$K - \omega$ SST
Environment geometry	Fixed Wall, no-slip condition
Inlets	Fixed Velocity, 0.1-1 m/s
Outlets	0 gauge static pressure

Note that each simulation has a different setup, and the specific values of any parameters can be found in the files included with the dataset

The gas patches that the source emits move according to the vectors of the airflow data that was simulated through CFD in the previous step, as a way to model advection. Diffusion is modeled through several mechanisms, including having every gas patch be composed of multiple filaments that can drift away from each other, slowly increasing the spread of the concentration distribution of a given filament over time, and applying small random movements to the filaments to simulate sub-cell scale turbulence.

The features of the environments were taken into consideration when designing the gas simulations. The simulations presented here have been carried out in the environments of the Robot@VirtualHome dataset, which is designed for visual sensing tasks. Therefore, it is easy to synchronize the data presented here with the original dataset, providing a convenient way of designing and testing sensor fusion techniques (Fig. 3). We wanted to enable such uses of the dataset, and therefore it was important to make it so that the source is placed at points of the environment where there is an object that could realistically emit the kind of smell being simulated. For example, the source may be at a sink when the simulated volatile is sewage gas, or near an oven or other similar appliances when it is smoke. All the simulations included in the dataset observe this consideration.

Once again, the configuration files of each of the simulations, which include all the parameters (*i.e.* gas type, release rate, filament mean concentration, *etc*) are included in the dataset, in case the users need to check any values or modify the configuration to run their own version of the simulation. All included simulations are 1000 seconds long and feature multiple simultaneous airflow inlets and outlets, in order to generate scenarios of interesting complexity.

4 Project Structure and Usage Instructions

The data resulting from these simulations is most easily accessed though GADEN itself, as it is designed to read and play back the results, making the data accesible through ROS and offering a simulated-sensor interface for querying data at specific points. There also is an implementation of GADEN for Unity [18], which can also easily read the gas dispersion data, and offers more options for the visualization of the gas plume (Fig. 4). Users who prefer to access the data directly will find, included with the dataset, a small program to convert the results of the simulations to discrete-time rasterized gas concentration and wind vector maps in human-readable CSV format.

Figure 5 shows the structure of the dataset. Directory *models_FBX* contains the original 3D models of the environments, without any preprocessing, in case the users need to generate a higher-precision voxelization of the environment than is provided with the simulations.

The *utils* directory includes several programs to aid with the process of generating new simulations, along with their source code and written instructions for how to use them. Users who do not intend to create their own simulations, but only to use those included in the dataset, will not require these tools. Still, the previously mentioned program for generating the rasterized concentration maps is also included here.

The *OpenFOAM_files* directory contains all the configuration files for the CFD simulation, as well as the already voxelized 3D models of the environments in STL format, and the results of the CFD in the format of OpenFOAM. The data is organized by environments, with a separate folder for each one. Inside each of these folders, there is a subfolder for each of the simulations. The simulations are named according to the inlets and outlets that are active in them, based on the way the inlets and outlets are numbered in the split 3D model.

The *GADEN_files* folder contains the gas dispersion data. This is the only part of the dataset required for using the simulations we have carried out. Once again, the data is organized first by environments, and then by simulations. The simulations are named following the same rule as in the OpenFOAM directory, using the numbered inlets and outlets, but, in this

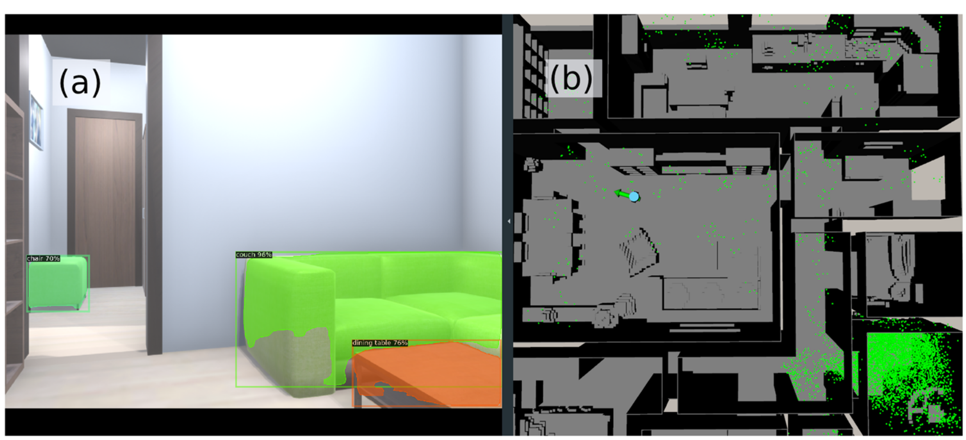

Fig. 3 Since the environments in which the simulations have been carried out were originally modeled for vision applications in the Robot@VirtualHome project, this dataset is particularly well suited for olfaction-vision fusion algorithms. (a) Object recognition algorithms running on the image captured by the robot's camera. (b) View of the gas concentration in the environment

Fig. 4 Using the GADEN plugin for Unity, the gas and wind simulations can be played back in the same simulation environment the Robot@VirtualHome dataset uses. This option also offers more realistic ways to visualize the gas plume, further enabling the testing of vision-related techniques

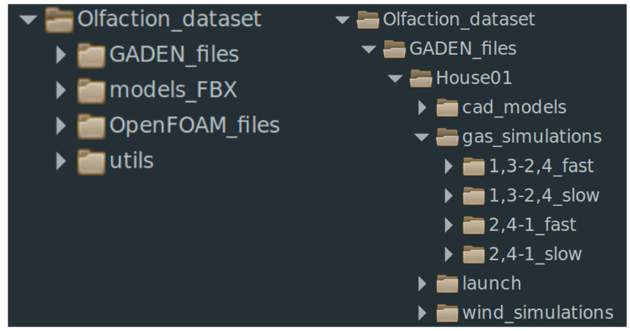

Fig. 5 File structure of the dataset. The result data and configuration files of the OpenFoam and GADEN simulations are separated and organized by the environment used in each simulation

case, the name of the simulation also includes the 3D coordinates of the gas source and the type of gas that was simulated.

In order to access the data through GADEN, users will find that each scenario includes a ROS launch file with the appropriate configuration to play back the simulation in real time, and different types of simulated sensors (gas sensors and anemometers) that can be used to access this data from the position of a simulated robotic agent. For details on how to use GADEN, we refer you to the user guide in the GADEN online repository[2].

Similarly, other configuration files for generating the simulations themselves are included, so the users can modify any aspect of it (*e.g.* the source position or release rate) without having to set up the rest of the project.

5 Use Cases

In this section, we will briefly discuss other works which make use of VGR dataset to carry out robotic olfaction experiments. We hope these examples will serve as an indication of how the data presented here may be utilized in the context of research.

PMFS [19] is an algorithm for source localization designed to operate under indoor, structured and human-centered environments (*i.e.* multiple rooms, furniture, etc.). The latter implies turbulent dispersal of the gases being released, and autonomous navigation to avoid obstacles and perform path planning. *PMFS* is validated by running multiple experiments under different conditions, including four scenarios (two different environments) from the VGR dataset. These environments were appropriate testing scenarios because the number of obstacles and walls they feature poses the kind of challenge that PMFS attempts to tackle.

GadenTools [20] is a toolkit and programming API to access detailed CFD and gas dispersion simulations through standalone Python code. Its primary purpose is to ease the development and integration of mobile robotic olfaction applications by enabling convenient and user-friendly access to Gaden gas dispersion simulations.

In its accompanying demo, available online through a Jupyter Notebook[3], some scenarios from the VGR dataset are utilized to demonstrate the capabilities of the toolkit and to implement and test a simplified version of the Surge-Cast algorithm.

6 Conclusions and Future Work

In this work we have presented a new CFD-based dataset of gas dispersion that is designed for the development and testing of mobile robotic olfaction techniques and algorithms. We hope this tool enables researchers working on this field to make faster progress and design more robust solutions than would be possible without these resources.

The dataset itself can be further extended in the future with more scenarios and more variety of environmental conditions. The feedback of the community of robotics olfaction researchers would be an invaluable tool for refining and extending this resource, and thus simplifying the process of future research and experimentation.

Author Contributions All authors contributed to the conceptualization of the project. Pepe Ojeda carried out the development and wrote the first draft of the article. Javier Monroy and Javier Gonzalez-Jimenez supervised the development of the dataset and revised and corrected the article.

Funding Funding for open access publishing: Universidad de Málaga/CBUA. This work was funded by the Andalucian Government (Junta de Andalucía), under the HOUNDBOT project (P20_01302) and the grant for the formation of pre-doctoral researchers (24653).

2 https://github.com/MAPIRlab/gaden

3 https://colab.research.google.com/drive/1Xj7rrsmeDa_dS3Ru_UIhhzlaifGH6GS4

Data Availability The data is made available online, and is accessible through the following URL: https://mapir.isa.uma.es/mapirwebsite/?p=1708

Declarations

Conflicts of interest The authors declare no conflicts of interest.

Ethics approval The authors declare that this study does not pertain to a subject that requires approval by an Ethics committee.

Consent to participate The authors declare that this is not applicable to this work.

Consent for publication The authors declare that this is not applicable to this work.

References

1. Karakaya, D., Ulucan, O., Turkan, M.: Electronic nose and its applications: A survey. Int. J. Autom. Comput. **17**(2), 179–209 (2020). https://doi.org/10.1007/s11633-019-1212-9
2. Feng, S., Farha, F., Li, Q., Wan, Y., Xu, Y., Zhang, T., Ning, H.: Review on smart gas sensing technology. Sensors **19**(17), 1–22 (2019). https://doi.org/10.3390/s19173760
3. Bobrovnikov, S.M., Gorlov, E.V., Zharkov, V.I., Panchenko, Y.N., Aksenov, V.A., Kikhtenko, A.V., Tivileva, M.I.: Remote detector of explosive traces. In: 20th International symposium on atmospheric and ocean optics: atmospheric physics, vol. 9292, pp. 92922–92922 (2014). https://doi.org/10.1117/12.2074055
4. Monroy, J.G., Gonzalez-Jimenez, J., Blanco, J.L.: Overcoming the slow recovery of mox gas sensors through a system modeling approach. Sensors **12**(10), 13664–13680 (2012). https://doi.org/10.3390/s121013664
5. Wiedemann, T., Shutin, D., Hernandez, V., Schaffernicht, E., Lilienthal, A.J.: Bayesian gas source localization and exploration with a multi-robot system using partial differential equation based modeling. In: ISOEN 2017 - ISOCS/IEEE international symposium on olfaction and electronic nose, proceedings (2017). https://doi.org/10.1109/ISOEN.2017.7968884
6. Visvanathan, R., Kamarudin, K., Mamduh, S.M., Toyoura, M., Ali Yeon, A.S., Zakaria, A., Kamarudin, L.M., Mao, X., Abdul Shukor, S.A.: Improved mobile robot based gas distribution mapping through propagated distance transform for structured indoor environment. Adv Robot **34**(10), 637–647 (2020). https://doi.org/10.1080/01691864.2020.1748900
7. Quigley, M., B., G., K., C., J., F., T., F., J., L., E., B., R., W., Ng, A.: ROS: An open-source Robot Operating System (3.2), 5–5 (2009). https://doi.org/10.1109/IECON.2015.7392843
8. OpenFOAM. Available Online: https://openfoam.org/ (accessed 26 April 2022)
9. Monroy, J., Hernandez-Bennetts, V., Fan, H., Lilienthal, A., Gonzalez-Jimenez, J.: GADEN: A 3D gas dispersion simulator for mobile robot olfaction in realistic environments. Sensors **17**(7), 1–16 (2017). https://doi.org/10.3390/s17071479
10. Orebro3DSEN. Available Online: https://github.com/jburgues/Orebro3DSEN (accessed 26 April 2022)
11. Mamduh, S.M., Kamarudin, K., Visvanathan, R., Yeon, A.S.A., Shakaff, A.Y.M., Zakaria, A., Kamarudin, L.M., Abdullah, A.H.: Gas dispersion with induced airflow in mobile olfaction testbed. AIP Conference Proceedings **1808**(1), 020051 (2017). https://doi.org/10.1063/1.4975284
12. Wada, Y., Trincavelli, M., Fukazawa, Y., Ishida, H.: Collecting a database for studying gas distribution mapping and gas source localization with mobile robots. The Abstracts of the International Conference on Advanced Mechatronics?: Toward Evolutionary Fusion of IT and Mechatronics?: ICAM **2010**(5), 183–188 (2010). https://doi.org/10.1299/jsmeicam.2010.5.183
13. Gryning, S.-E., Lyck, E.: The copenhagen tracer experiments: reporting of measurements. Denmark. Forskningscenter Risoe. Risoe-R, vol. 1054 (rev.1)(EN) (2002)
14. List of Atmospheric Dispersion Datasets by the ADMLC. Available Online: https://admlc.com/datasets/ (accessed 26 April 2022)
15. Fernandez-Chaves, D., Ruiz-Sarmiento, J.R., Petkov, N., González-Jiménez, J.: Robot@VirtualHome dataset. Zenodo (2021). https://doi.org/10.5281/zenodo.4610098
16. Tu, J., Yeoh, G.H., Liu, C.: Chapter 6 - practical guidelines for cfd simulation and analysis. In: Computational fluid dynamics, pp. 224–276. Butterworth-Heinemann, Burlington (2008). https://doi.org/10.1016/B978-075068563-4.50008-2
17. Farrell, J.A., Murlis, J., Long, X., Li, W., Cardé, R.T.: Filament-based atmospheric dispersion model to achieve short time-scale structure of odor plumes. In: Environmental fluid mechanics, vol. 2, pp. 143–169 (2002).https://doi.org/10.1023/A:1016283702837
18. Ojeda, P., Monroy, J., Gonzalez-Jimenez, J.: A simulation framework for the integration of artificial olfaction into multi-sensor mobile robots. Sensors 21(6) (2021). https://doi.org/10.3390/s21062041
19. Ojeda, P., Monroy, J., Gonzalez-Jimenez, J.: Robotic gas source localization with probabilistic mapping and online dispersion simulation (2023). https://doi.org/10.48550/arXiv.2304.08879. (Preprint)
20. Ojeda, P., Ruiz-Sarmiento, J.-R., Monroy, J., Gonzalez-Jimenez, J.: Gadentools: A toolkit for testing and simulating robotic olfaction tasks with jupyter notebook support. In: Tardioli, D., Matellán, V., Heredia, G., Silva, M.F., Marques, L. (eds.) ROBOT2022: Fifth Iberian Robotics Conference, pp. 166–177. Springer, Cham (2023)

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