Technical Note

An Approach for Robot-Based Odor Navigation

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Received 24 Apr 2011; Accepted 4 Nov 2011; doi: 10.5405/jmbe.924

Abstract

Environment pollution has pushed an increasing interest in the development of automated and intelligent systems for monitoring and analysing environmental variables. Odor sensing is generally applied to security, elderly care, food quality control, and domestic gas leakage or fire detection. In this field, recent applications of mobile robotics systems are being considered, more specifically, the detection of an odour source by a mobile robot. In this paper, an ethanol odor field, coming from a source, is measured using Metal Oxide Semiconductors sensors. An explore- exploit-based algorithm, which makes use of this environment information, is implemented in a mobile robot by combining the spiral and the plume-centered upwind search algorithms. Simulation results validate the robot performance during an odor detection task.

Keywords: Odor detection, Plume tracing, Infotaxis, Mobile robot

1. Introduction

The goal of odor localization is to find the source of a chemically volatile substance in the environment, which is vital for many life forms on Earth [1]. Some common applications are finding the source of dangerous substances, detecting drugs, searching for survivors in natural disasters, detecting fires in their initial stages, and locating unexploded mines and bombs.

Mobile robotics are increasingly used in medical applications, such as robotized wheelchairs [2]. Humanoid robots have been developed to help educate and socialize children with special needs, and mobile assistive devices have been developed for monitoring, coaching, and motivating prescribed exercise therapy [3]. Powered exo-skeleton robots have been employed for medical care, in particular to help nurses lift and carry patients. Step rehabilitation robots can reduce the number of therapists needed for training [4,5]. They also allow the training process to be customized for each patient.

Odor sensing is generally applied to security, elderly care, food quality control, and domestic gas leakage or fire detection [3]. A survey device with odor sensors that can detect the degree of human fatigue has been reported [6]. Odor localization is not as simple as sensing variations in a chemical concentration due to diffusion [7]. Several problems concerning mobile robot odor detection in various environments (i.e., diffusion- dominated fluid flow, turbulence-dominated fluid flow, and turbulence-dominated weak fluid flow) have been reported [1].

Numerous algorithms have been developed for finding an odor source and for determining a robot's path. These algorithms commonly mimic the chemotactic behaviour of biological organisms, for example, zigzag or spiral [8]. Some algorithms also consider other parameters besides chemical information, such as air flow or temperature. Other tracing techniques are based on analytical odor distribution models. Ishida et al. [9] presented a mobile robot comprising chemical and air-flow sensors. Starting from the sensory data and knowing the position of the odor source in advance, the behavior of the plume was described with an odor distribution model.

Marques et al. [10] computed a goal vector for guiding a robot towards the odor source using a concentration gradient. This gradient was obtained from an analytic gas distribution model and the measured upwind airflow direction. Lilienthal et al. reported an odor localization method based on an analytical model [11,12]. They used an experimental grid map which was obtained by measuring concentration values. Their method is suitable for turbulence-dominated weak fluid flow environments.

An infotaxis navigation approach was proposed by Martin-Moraud [13]. This method considers the odor plume not as a continuous cloud, but as comprising intermittent odor patches which are dispersed by the wind. Far from the source,

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