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A BIO-INSPIRED 3D OLFACTORY NAVIGATION ALGORITHM APPLIED TO THE SPACE STATION

Abstract

Manned space flight is advancing rapidly, and China's space station has also made remarkable achievements in 2022. However, toxic gas leaks in the space station pose a potential threat to the safety of astronauts and could have catastrophic consequences. There have been several incidents in history where gas leaks occurred in the International Space Station, making the problem of toxic gas leaks urgent to solve. To address this problem, we propose a scheme using a free-flying space robot equipped with gas sensors that can automatically detect leaked gas and locate the source of the leak in an unattended cabin environment. This paper presents a bio-inspired 3D olfactory navigation algorithm to detect the leaked gas in the space station. Generally, the entire process of robotic odor source localization algorithms can be divided into three sub-tasks: plume finding, plume tracking, and source declaration. Focusing on the first two sub-tasks, the olfactory navigation algorithm involves a combination of three strategies, including upwind surge, cross-wind plane spiraling, and klinotaxis (comparing two subsequent concentration samples as the robot moves through space). In the plume finding stage, we use a 3d surge and spiraling strategy inspired by the silk moth. In the plume tracking stage, a bio-inspired klinotaxis strategy is used to locate the gas source. The robot sniffer's sensors can rotate around itself at specific angles in each plane. This body structure enables the robot to detect the concentration of leaked gas at a specific point in a large area in front of it with just two sensors. Simulation results demonstrate that the robot sniffer can successfully find the plume, trace the plume and locate the gas source in the cabin environment using only two bilateral sensors. In summary, the contributions of this study mainly include: 1)A bio-inspired 3D olfactory navigation algorithm was designed to detect leaked gas in the space station and locate the source of the leak, which requires only two sensors and little computing resources. 2)By introducing two attitude angles to represent the pose of the robot in 3D space and the orientation of the sensor in the smell space, we extend the klinotaixs strategy of arthropods on the 2D plane to 3D space.