Flying odour tracking robot with insect antennae

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1 Introduction

Odour tracking is one of the difficult navigation task of robots. Since odorants are intermittently distributed in the air [1], fast response and recovery time of sensors are important to track the patchy distribution [2]. However, conventional sensors are too slow to catch the temporary changing odour information [3]. Insect antennae have fast response and recovery time, which are suitable for this kind of usage. Furthermore, low power consumption is another advantage while measuring electroantennogram (EAG), and genetic tools are available to alter the response to different odorants [4]. Combining insect antennae and flying robots enable us to find odour source more quickly. Nevertheless, it is necessary to eliminate noise from recorded EAG to get the correct odour information. In this study, we analysed EAG during flight of a drone, and developed simple algorithm to extract odour-evoked signals from noise.

2 System Design Concept

In EAG recording experiments, we used antennae of a adult male hawkmoth (*Agrius convouvuli*). The antenna was isolated and stainless steel electrodes (ϕ 0.1 mm) were inserted into the ends of proximal and distal. To immobilise and prevent drying of the antenna, small pieces of grass capillary(ϕ 1 mm) was filled with saline and was attached at both two sides as shown in Figure 1, which were further sealed with conductive gel (Spectra 360, Parker laboratories, NJ, USA).

As shown in Figure 2, the isolated antennae were mounted onto the drone (AR.Drone 2.0, Parrot, France), trying to capture the odour of pheromone. We used the major component of the homogeneous female sex pheromone [(E,E)-11,13-hexadecadienal] as a test odorant. The signal

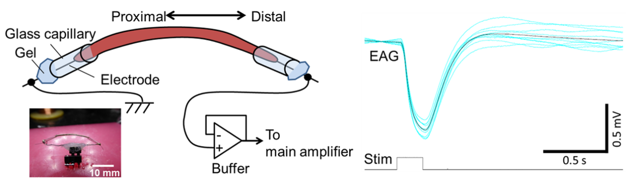

Figure 1: Antenna preparation and EAG to pheromone stimulus.

Figure 2: Drone with insect antennae (arrows).

from EAG will pass through amplifiers, which are including a pre-amplifier and an amplifier, then receive by an Arduino board (Arduino M0 Pro, Arduino, Italy). As EAG was recording signal from one electrode at the distal end, the response of it was negative. The board was used as an interface for analysing signals from EAG and then gives feedbacks back to the drone. For example, send a command to make the drone move forward and get closer to the source of odour.

3 Signal Processing

Since short latency and low power consumption for signal processing are very important for flying robots, it is necessary to find an algorithm to eliminate noise as simple as possible. Therefore, in order to catch the correct odour signal sending from EAG, we need to understand how the noise looks like. Basically, there are 4 types of signal that we will meet in the experiment:

1. Noise on the ground
2. Noise in the air
3. Odour signal with noise on the ground
4. Odour signal with noise in the air

The noise on the ground might be caused by electrode or air flow, and the one in the air includes the previous and mechanical noise such as wind oscillation. Normally,

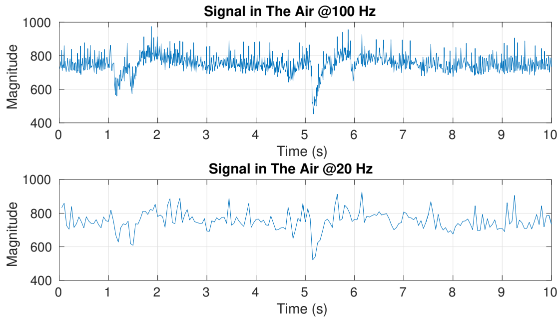

Figure 3: Comparison of different sampling frequency.

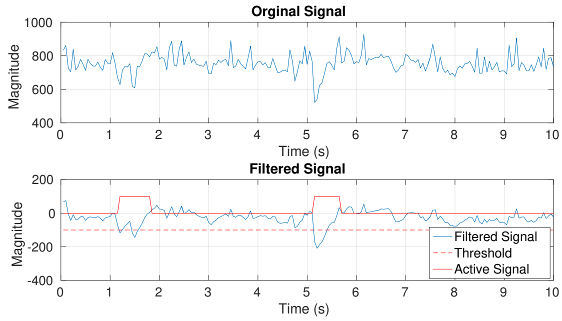

Figure 4: Filtered signal with active line.

without heavily disturbance, any signal can be seen as a combination of the four basic signals above. Also, these four are the most easiest signal that we can get from EAG. That is to say, once the algorithm can handle all the types of signal above, we can make sure there is no problem when facing full signal.

Since the noise, especially in the air, is high frequency noise, with the higher sampling rate, the more noise would be collected. It is possible to reduce the sampling frequency to do some easy noise cancellation. For testing, the experiment collected data in 100 Hz. However, after picking up the 20 Hz dataset, from Figure 3, we can see that the signal became much more simple and easy to deal with.

Considering the time delay of a low-pass-filter, it should be designed as easy as possible. That is, a high order filter is not under consideration though it gives a better result. In the experiment, an exponential moving average (EMA) filter, which is also a type of infinite impulse response (IIR) filter, was chosen. At time period n, the filtered data y can be known by original data value x through Eq. (1).

$$\begin{aligned} y[0] &= x[0] \\ y[n] &= \alpha x[n] + (1-\alpha)x[n-1], n > 0 \end{aligned} \tag{1}$$

where α is a smoothing factor, and $0 < \alpha < 1$.

Since the odour signal gives a negative response, we can make the dropping signal much stronger than the rising one. After giving an offset value to the signal, in order to make the difference stronger, the smoothing factor was assigned to two different values, 0.7 and 0.3. Once the Arduino board receives the dropping signal from EAG, then the smoothing factor is set to 0.7; otherwise, it is set to 0.3. From Figure 4, we can see that the filter made the rising signal weaker than the others. Finally, a threshold need to be set to check if the antennae catch the odour or not, then the Arduino board can give some feedback to the drone.

4 Conclusion

In the research, it proves that a prototype of flying odour tracking robot was build. Though this is just the early stage of the design, this kind of robot has a great potential, no matter it is used in civil or industry. This kind of robot, in the future, can be used for detecting special gases instead of using animals directly such as dogs. Furthermore, more functions will be added in the research and gives better algorithms to ensure it can also works normally even in a turbulent environment.

Acknowledgement

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