Application of WrightOcean Team for RoboCup SPL 2015

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1 Introduction

WrightOcean, a team which belongs to Lab of Robotics, School of Information and Electrical Engineering, Ludong University in China, was established in April, 2012. We have five H25 V3.3 NAO robots now. It is a young and passionate team, and all of the members are undergraduates keen on robotics. The team consists of the following numbers.

(1) **Instructors**: Fei Liu. Gaohuan Lv

(2) **Students**: Liming Liu, Haiming Ding, Tangqing Yuan, Zhaoxu Zhang, Hongliang Qiao, Zheng Ge, Yongjin Qu, Anzhi Wang, Xiyue Huang, Shujie Zhou, Dan Li, Yaxin Liu, Hui Li

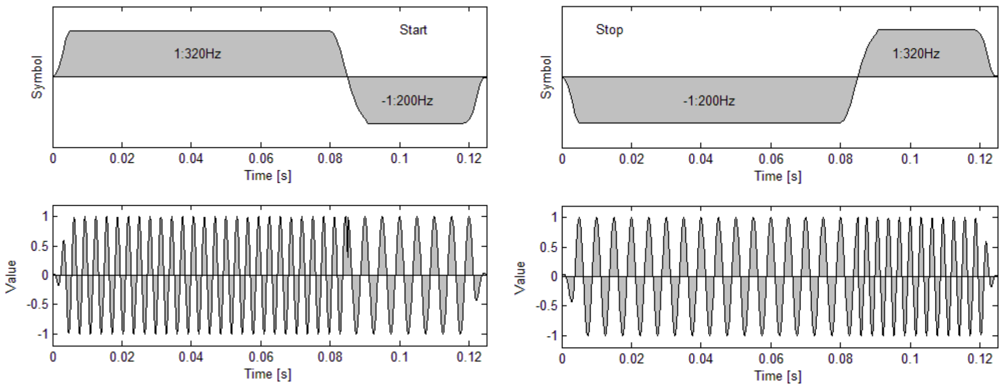
The WrightOcean team participated in the Standard Platform League of RoboCup China Open in 2013 for the first time, and we were the runner-up to the TJArk(a team from Tongji University) in a team competition. In 2014, we took part in three technical challenges and shared the third place with Dalian University of Technology. All of the team numbers hope that we can qualify in the drop-in player competition and the technical challenges of Stand Platform League in RoboCup 2015. We really look forward to take the opportunity to share ideas with other teams coming from different countries and regions. Obviously, RoboCup 2015 will greatly improve the development of robots' culture in China and will be paid more attention by the students in our university on robotics and RoboCup. In addition, we can afford the domestic travel in that RoboCup 2015 will be held in Hefei, China.

The techniques we used in RoboCup China Open 2014 will be introduced in detail as follows.

2 Sound Recognition Challenge

2.1 Question Analysis

The basic speech signal is divided into start type and stop type. In fact, these two types of signals are the same feature signal --the frequency shift keying signal. As it is shown in figure 1, we represent the symbol of "+1" by using a 320Hz signal and the symbol "-1" by using a 200Hz signal. The duration of each symbol is about 40 ms. Thus the start and stop signal can be coded as "+1, +1, -1" and "-1, -1, +1", respectively.



(a) start signal (b) stop signal

Figure 1. Two basic signals used in RoboCup.

As the chart shows, different code corresponds to different frequency. A robot will lift up its hands according to the competition rules as soon as it receives the pre-designed signals. This section will discuss the methods that how a robot processes these two kinds of signals based on the digital signal processing theory with the aid of computers.

2.2 Decoding Principle

2.2.1 Selection of Filter

The real signal frequencies are 200 Hz and 320 Hz. According to the Nyquist sampling theory, the sampling rate will be 640 Hz at least to perform the lossless demodulation. As the sampling rate in the robot is 16000Hz, it sounds reasonable to down-sample the signal at the frequency of 1600Hz. As a result, 271 sampled data will be obtained in every 170ms to recover the command codes. In order to get the complete encoding information of start or stop signal in a signal processing period, we combine two successive sampled data sequences into an array. It means that 542 sampled data will be processed to get the command information.

Dozens of experiments show that a fourth-order infinite impulse filter can meet the requirement under the actual operating situation. A band-pass filter centering at the frequency of 200Hz takes the form of

$$H_1(z) = \frac{0.0055 - 0.0111z^{-2} + 0.0055z^{-4}}{1 - 2.6802z^{-1} + 3.5794z^{-2} - 2.3976z^{-3} + 0.8008z^{-4}} \tag{1}$$

A band-pass filter centering at the frequency of 320Hz can be written as

$$H_2(z) = \frac{0.0055 - 0.0111z^{-2} + 0.0055z^{-4}}{1 - 1.1713z^{-1} + 2.1226z^{-2} - 1.0478z^{-3} + 0.8008z^{-4}} \tag{2}$$

The amplitude frequency response is shown in figure 2.

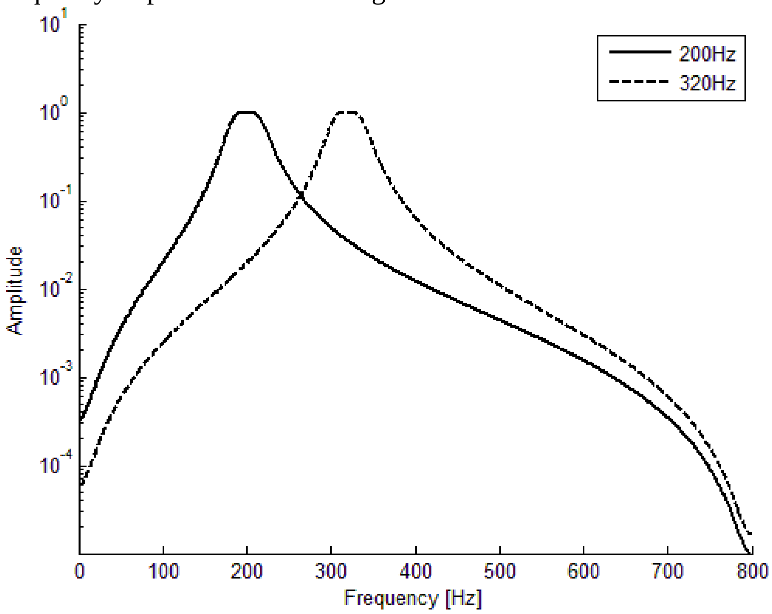
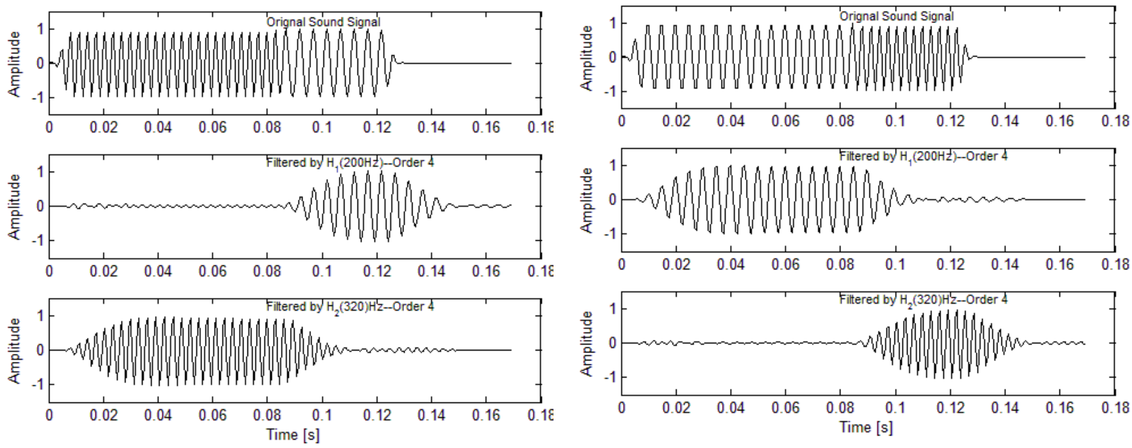


Figure 2. Frequency response of the two 4-order band-pass filters.

Figure 3 (a) and (b) present the filtering effects on the given “start” and “stop” signals, respectively. It can be seen that the two filters work well.



(a) The effect on "start" signal (b) The effect on "stop" signal

Figure 3. The Filtering effect of the proposed two filters.

2.2.2 Decoding Algorithm

This project detects the expected target signal by using the average power method. The response of the filter can be written as

$$y_i(n) = h_i(n) * x(n), i = 1, 2, n = 0, 1, 2, ..., N-1 \quad (3)$$

where x(n) is the collected data, $h_i(n)$ is the impulse response of the band pass filter H_i, In our method, M samples are used to compute the average power of $y_i(n)$, i.e.,

$$P_{i,k} = \frac{1}{M}\sum_{m=0}^{M-1} | y_i(kM+m)|^2 \quad k = 0, 1, 2..., K-1, 1 < M \le N, i = 1, 2 \quad (4)$$

The threshold power can be expressed by

$$P_T = \alpha P_N \quad (5)$$

where α is the threshold coefficient, and P_N is mean power of the environment noise. In the laboratory case, α can be set to 1000, which is higher than the noise power by 30dB.

The decoding process is as follows:

If $P_{1,k} > P_{2,k}$ and $P_{1,k} > P_T$, the code is "-1". else:

If $P_{1,k} < P_{2,k}$ and $P_{2,k} > P_T$, the code is "+1". else:

Null

2.3 Experimental Results

A NAO robot was used to verify our method. During the experiment, we found that the robot was not sensitive to the signal with frequency of 200 Hz, and the corresponding data were very small. It will lead to deviation in the actual amplitude comparison. To circumvent the dilemma, we only adopt the second step of the decoding process. By computing the length of the "+1" code in the second step, the "start" or "stop" signal can be identified and the robot can take corresponding actions according to the demodulated codes.

Figure 4 shows the effect of decoding algorithm based on the field start signal. Figure 4(a) shows the actual sampling signal, Figure 4(b) shows the filtering result of filter H_1, Figure 4(c) shows the filtering result of filter H_2, and Figure 4(d) shows the decoding result. It is can be shown that the proposed algorithm can be used to get correct start codes.

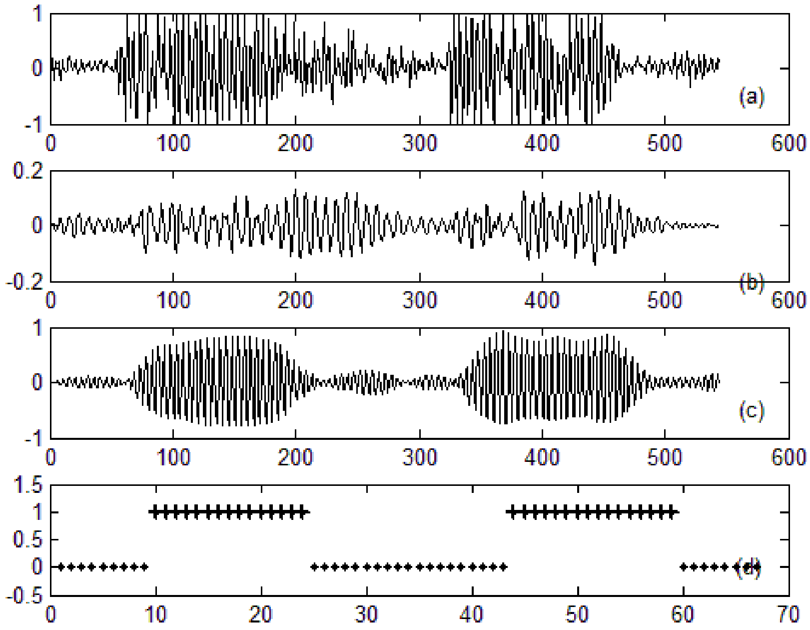


Figure 4. Filtering effects on the real “start” signal.

Figure 5 shows the effect of the proposed algorithm based on the real “stop” signal. Figure 5(a) shows the field data, Figure 5(b) shows the filtering effect of filter H_1, Figure 5(c) shows the filtering effect of filter H_2, and Figure 5(d) shows the decoding result. It shows that the proposed algorithm can be used to get correct stop codes.

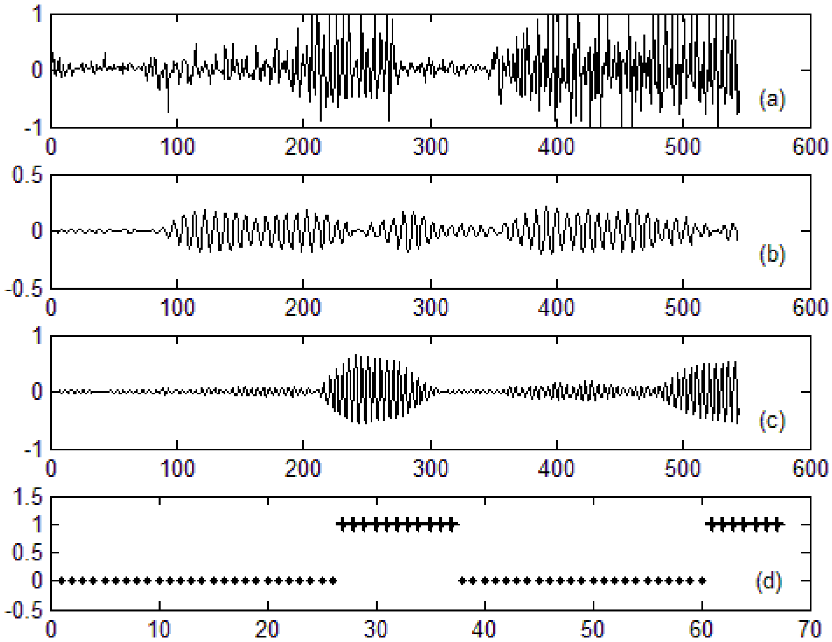


Figure 5. Filtering effects on the real “stop” signal.

2.4 Implementation

In this project, we designed the functions of getting sound by using ALAudio module from NAOqi SDK with C++ language.

3 Open Challenge

3.1 Project Description

The project introduced in this section establishes a Robot Localization Model and Target Information Obtaining Model according to color recognition and information acquisition. NAO robot understands the speech command and researches specified surroundings and counts all the balls with different colors. The aim is to form a Memory Model and then NAO finds out the closest ball to itself as required color via interactive voice orders. In addition, NAO reaches the closest ball quickly and adjusts its orientation and localization by updating the Memory Model. And more details are shown in Figure 6.

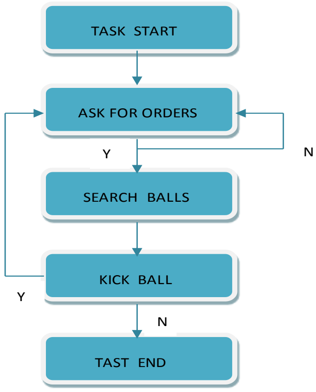


Figure 6. Flow diagram of Open Challenge

3.2 Implementation

We have developed the Speech Recognition Model with NAOqi SDK 1.14.5. At the same time, the Image Processing Module in this project is established by using OpenCV2.4.

4 Team Competition

We have developed different team strategies and soccer roles (striker, defender and keeper) based on B-Human Code release in 2011. We want to thank B-Human team here.

5 Conclusion

The paper presents the techniques we used in RoboCup China Open 2014. In 2015, we are going to design a new algorithm optimizing the localization when robot players are kidnapped in competition and the other task is to design a coach player applied to the competition.

Acknowledgement

We sincerely thank open source movement of B-Human, Nao Devils, Austin Villa, Northern Bites, Kouretes and all other SPL teams. Because of your contribution, we can go ahead and contribute our strength for the development of SPL.

Appendix

Here is the link of video on Youku website:

http://v.youku.com/v_show/id_XODY0MDI1Mzky.html

Here is the link of video at YouTube website:

http://youtu.be/-67Y71mC8MU

Team logo is as Figure 7.

Figure 7. Team logo.