Implementation of Acoustic Communication in RoboCup SPL.

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Abstract

This paper discusses how sound may be used to find out the relative position of one Aldebaran Nao robot to another. This functionality can be extended to also transfer data directly from robot to robot by acoustic transmission.

1. Introduction

In a robot soccer game, we can see our robots as a team of agents. How these agents cooperate with each other is a big issue because soccer is a cooperative and interactive game. How well the robots cooperate will give a significant advantage in winning the game. Here, we want to use acoustic communication to improve the accuracy of self-localization, exchange the exact relative positions of team mates and some important messages. According to the 2013 RoboCup soccer rule, the robots can use any type communication. The most common type of communication is to use the wireless network. During competition, the wireless network is blocked because the networks of various participants interfere with each other. So we try to use acoustic communication instead. So in this work we discuss probability of transmission data acoustically and at the same time measure the reality angle letter sender and review.

Fig1.Robot Setting

2.1.Cross-Correlation Function

In digital signal processing, cross-correlation is a measure of similarity of two waveforms as a function of a time-lag applied to one of them. It is commonly used for searching a long signal for a shorter, known feature. It has applications in pattern recognition, single particle analysis, electron tomography, averaging, cryptanalysis, and neurophysiology.[1] For continuous functions f and g, the cross-correlation is defined as:

$$(f \star g)(T) = \int_{-\infty}^{+\infty} f^*(t) g(t+T)\, dt \quad (2.1)$$

where f^*denotes the complex conjugate of f and T is the time lag.
Similarly, for discrete functions, the cross-correlation is defined as:

$$(f \star g)[n] = \sum_{m=-\infty}^{\infty} f^*[m]\, g[m+n] \quad (2.2)$$

Cross-correlations are useful for determining the time delay between two signals. In the

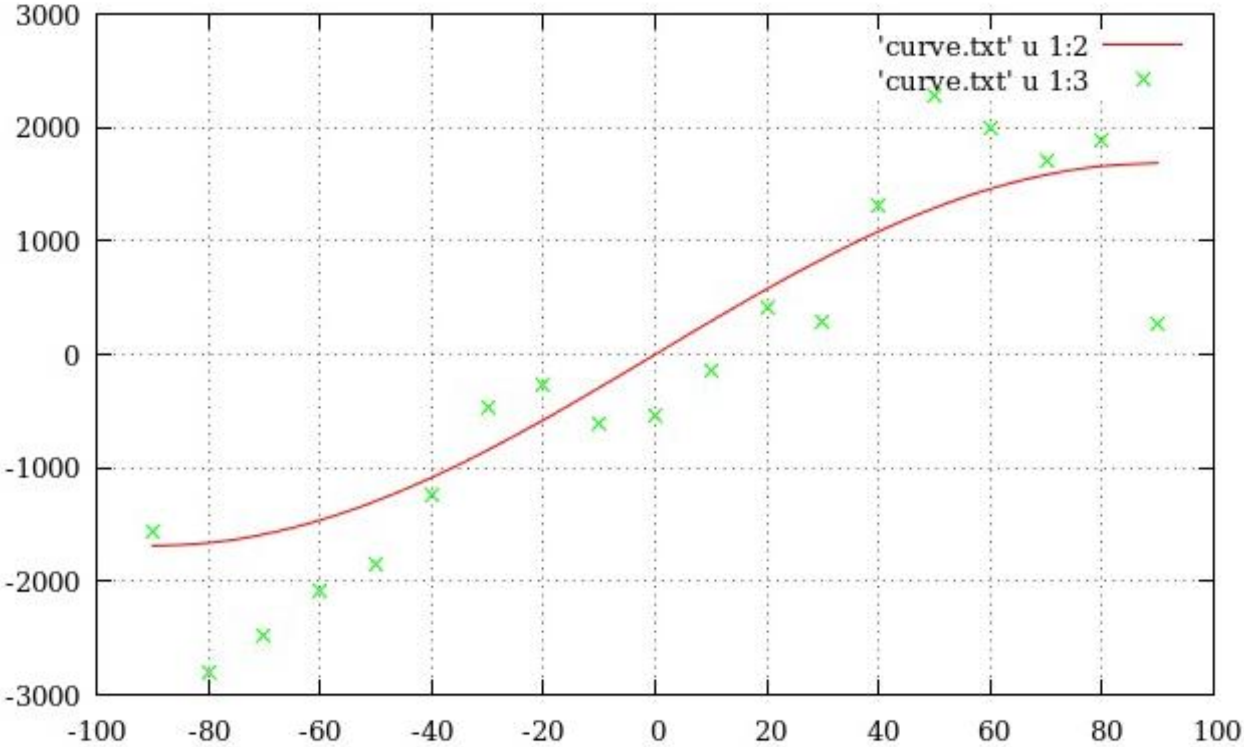

Fig. 2 visuals the result by using picture. The red curve means the theoretical lags for every angle, and the green points stand for the measurement lags.

following the process of detecting a signal using cross correlation is described: A specific signal pattern is assigned to each sender, and all receivers know these patterns. After a sender "A" has sent his signal pattern, a receiver "B" calculates the cross correlation function of his input signal and A's specific signal pattern by equation(2.2). B now assumes, that A's signal arrived at time:

$$T = \arg\max\left(\left(f * g\right)(t)\right) \quad (2.3)$$

2.2.Goertzel algorithm

The Goertzel algorithm is a Digital Signal Processing technique that provides a mean for efficient evaluation of the Discrete Fourier Transform (DFT). The algorithm was first described by Gerald Goertzel in 1958 [2].

Like the DFT, the Goertzel algorithm component from a discrete signal[3][4][5]. Unlike direct DFT calculations, the Goertzel algorithm applies a single real-valued coefficient at each iteration, using real-valued arithmetic for real-valued input sequences. For covering a full spectrum, the Goertzel algorithm has a higher order of complexity than Fast Fourier Transform (FFT) algorithms; but for computing a small number of selected frequency components, it is more numerically efficient.

3.Result

All the results are recorded in Fig.2. The theoretical lags mean the theoretical time difference of sound arrived to the left and right ear of the robot, and its absolute is maximum equals to 1686 frames, which is equals to 0.03498 second. If the measured lags exceed this value, then it can not be converted into angle. We can see that when the sound source direction is bigger than ± 40 degree, our measured lags will exceed the limitation and can't convert into angles. It may caused by the refraction and diffraction of the sound, since when the source is bigger than ± 40 degree, the sound wave may be hindered by other part of the head and can not directly hit the microphone at the further side. However, when the sound source direction is below ± 40 degree, the sound source angle can be correctly detected with an error about ± 12.7 degree.

4.Conclusion

Since the robot can distinguish what his team mate is talking correctly and knows the direction roughly, we can develop more strategies for soccer games. In the future, we should implement more messages in different combinations of the AFSK sequences, for example: the ball is here, this is the wrong goal, and kick fast, use the SSL to fast the process of some vision strategies. Also, this is a plan B to concur the situation of network communication jamming. Furthermore, the ball searching strategy can be improved with this approach since originally the robot needs 7 seconds to turn his body around to find the ball if he does not know where is it. The robot can find the ball more quickly if he heard his team mate telling him where is the ball. In this case, our NAO robot can play the soccer game more efficiently and smartly.

5.References

[1] The introduction of Cross-Correlation. *http:// mathworld.wolfram.com/ Cross-Correlation.html/*.

[2] G. Goertzel. An Algorithm for the Evaluation of Finite Trigonometric Series. *The American Mathematical Monthly*, 65(1):34–35, 1958.

[3] Chiouguey J. Chen. Modified Goertzel Algorithm in DTMF Detection Using the TMS320C80. 1996.

[4] Gunter Schmer. DTMF Tone Generation and Detection : An Implementation Using the TMS320C54x. (May):1–19, 2000.

[5] Semiconductor Systems Engineering, Digital Signal, and Processing Solutions. Add DTMF Generation and Decoding to DSP- μ P Designs. 1989.