Estimation method of the moving sound source position by the microphone array using GA and correlation function

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Abstract

In order to perform voice recording of those who move, and pursuing of a move thing, the method of pursuing the moving sound source is needed.

In this paper, we describe the microphone array method to search fast the sound source position moved using GA (Generic Algorithm). Since a GA has the characteristics to found solutions evolutionally, it can be adapted for dynamic change of sound environment.

In this study, it considers that an each individual of GA is an assumed sound source, and the position of the assumed sound source is expressed as a gene. The fitness function of GA was calculated as follows; 1) the propagation time according to the distance of assumed sound source and a sensor is rectified, 2) the correlation functions of the compensation signals of each sensor are calculated, 3) the lag time between zero and peak of the correlation function is summed up, 4) the reciprocal of the sum total lag time is defined as the fitness function.

1. Introduction

Recently, the techniques of using a microphone array and Generic Algorithm (GA) are examined for estimation of a sound source position [1], [2]. Especially, it is desired to develop the high-speed position estimation technique of sound source moving with the few number of sensors. It is also necessary to pursue the move sound source, for adaptation of human voice, robots, cars, and so on.

In this paper, the high-speed pursuing technique of sound source position using GA will be mentioned. Furthermore, since GA has the characteristics to evolve always from the present environment, the position of move sound source can be pursued.

2. Pursuit method

This chapter describes the pursuing method of the move sound source by using GA to processing of the output signal from a microphone array.
between the lag 0 and the lag time having the peak of a correlation function to fitness function. When $l$th lag time is represented as $\tau_l$, the error function $K$ is defined as follows,

$$K = \sum_{l=1}^{L} \tau_l$$

where $L = M C_2$.

$K$ becomes large as the distance between real sound source and assumed sound source becomes long. For this reason, fitness function $F$ was defined as follows,

$$F = \frac{1}{K + \varepsilon}$$

where, $\varepsilon$ is a very small number for diverging emission.

### 2.2. Generic Algorithm

In this study, we apply Generic Algorithm to find best fitness $F$. Figure 1 show the flowchart of GA. 3-dimensional coordinates of the individuals (Assumed Sound Sources) were coded as 22bit gene which is consist of 8bit x-coordinates, 8bit y-coordinates, and 6bit z-coordinates.

Primary population is generated randomly. The selection is operated based on Roulette wheel selection and the Elitist selection to avoid the degradation of the fitness is used. The uniform crossover is used, and mutation ratio is set constant.

3. Simulation of pursuing the sound source

3.1. Simulation of searching fixed sound source

The simulation was performed in order to verify this method. Arrangement of sound source and sensors is shown as figure2. A sound source and four microphones set at the coordinates (0.2, -0.5, 0.1) and (-1,-1,1) (-1,1,0) (1,-1,0) (1,1,1). We carried out the simulation of following condition, i.e., sampling frequency was 8000 [Hz], the number of cross correlation points was 256, and sound velocity was 340 [m/s].

The parameter for GA set 30 individuals, 50% of rates of crossover, and 4% of rates of mutation. Pursuing space (2[m] ×2[m] ×1[m]) is divided into 4,194,304 points (22bits).

The result of a simulation is shown figure3. The solid line in figure3 shows the distance between real sound source and assumed sound source (error of distance). According to the generation progressed, the distance was decreased, and became 4 [cm] in 30 generations. Although initial individuals position is random, fast pursuing of the large space can be achieved.

**Figure 1: Flowchart of Generic Algorithm**

**Figure 2: The arrangement of a real sound source and microphones**

**Figure 3: The simulation result**
3.2. Simulation of pursuing move sound source

In order to verify this method for move sound source, simulations were performed with move sound source.

First, initial coordinates of real sound source set to (0.2, -0.5, 0), then, 0.01 [m] per generation was added to coordinate y. The move sound source coordinates would become set to (0.2, 0, 0) in the 51st generation. The locus of a motion is shown in figure 4.

The parameters for GA was used as follow, 30 individuals, 50% of crossover rates, and 4% of mutation rates. Figure 5 shows the result of pursuit a sound source moved along y-axis. The solid and broken lines in figure 5 shown the y-coordinate of real sound source and the estimated y-coordinate which was equivalent to coordinate of elite individual.

It was found that pursuit of move sound source can be achieved well, and the convergence of pursuing could be completed by 2 or 3 generations, after once it converges, because the individuals for GA will concentrate near a sound source.

Pursuit of fixed sound source, 0.005 [m/gene], 0.01 [m/gene], and 0.02 [m/gene] move sound source were simulated. Figure 6 shows distance between real sound source and assumed sound source (estimation error) when the sound source moved on y-axis. Since GA was the randomize algorithm, we averaged the results of 10 times simulations in order to reduce an accidental error. When the move velocity was 0.02 [m/gene], the distance between real sound source and assumed sound source was increasing around 26 generations. This reason is considered as follows, when generations became a 26 generations i.e., y-coordinate became zero, the all bits of gene are reversed. Therefore we will examine the code of gene by Grey Code [3].

Figure 5 shows the distance between real sound source and estimated sound source when the sound source moved on z-axis. The simulation was carried out with same acoustic parameter, GA parameter, and averaging.
3.3. Examination of Generic Algorithm Parameter

Since it was found that convergent ability changes greatly with mutation rate when sound source moves, we carried out the simulation for examination of Generic Algorithm Parameter. The move sound source set to initial coordinates (0.2, -0.5, 0), the simulation in various rates of mutation was carried out with same parameter of above-mentioned simulation except the rate of mutation. The mutation rate of the simulation was set 0, 1, 3, 5, 10, and 20%. Figure 8 shows results of distance between real sound source and assumed sound source when sound source was fixed and moved on y-axis with 0.005, 0.01 [m], and 0.02 [m/gene].

In the case of a move sound source, most sufficient results were obtained with 10% mutant rate, the convergent ability was decreased with 20% mutant rate, i.e., it was found that the mutant rate has a proper value about 10%.

4. Conclusions

In this paper, a method to pursue sound source by using generic algorithm is proposed. As a result of performing a computer simulation, pursuit of move sound source at the speed of 0.02 [m/gene] could be achieved.

5. References