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Abstract

Recently, various robots have been used in the human life. Therefore, it is necessary that robots learn desirable behavior in order to establish a life of the cooperation between robots and human. In this paper, we propose methods using interactive genetic algorithms so that robots acquire the behavior that users like. These are a non-contact interaction method using a personal computer connected wireless LAN and a contact interaction method using the touch sensor. Also, We apply these methods to behavior acquisitions of the AIBO.

1. Introduction

Recently, various robots have been used in the human life [1][2]. In the future, it is likely to become closer the relation between man and robots. Therefore, it is necessary that robots learn desirable behavior in order to establish a life of the cooperation between robots and human. On the other hand, interactive genetic algorithms (IGAs) [3] are methods using interaction between systems and human. The IGA is a GA method that optimizes systems based on subjective human evaluation, and is an effective technique to

Figure 1. AIBO ERS-210A

problems on the individual variation and human *kansei* [4][5]. In this paper, we propose methods using IGAs so that robots acquire the behavior that users like. These are a non-contact interaction method using a personal computer connected wireless LAN and a contact interaction method using the touch sensor. Also, We apply these methods to behavior acquisitions of the AIBO.

2. Interaction between Human and Robot using IGA

In this study, AIBO ERS-210A (see Figure 1) is used. Figure 2 shows concept of interaction between human and robots using IGA in this study. The IGA is a GA method that optimizes systems based on subjective human evaluation.

Users who are looking at the behavior of AIBO subjectively evaluate it by actions. These actions to robots are messages by character, speaking, touching to robots, and so on. The AIBO receives these actions from interfaces such as wireless LAN, touch sensors and microphones. Signals received from interfaces are sent to the Behavior Evaluation System, and evaluation values are calculated based on criteria having the robot. These are fitness values. And some behavior patterns of the next generation are generated by GAs. Generated behavior patterns are actually executed by AIBO. Therefore, these behaviors are presented to the user by operating each module such as each joint and LED.

These interaction between user and AIBO are iterated, and the robot learns the behavior that user likes. In this paper, behaviors of AIBO are actions of its front legs described in section 3.

Figure 2. Interaction between Human and Robots using IGA

Figure 3. Generation of Behavior by Poses

3. Behavior Acquisition of Robots Using IGA

3.1. Behavior of Robots

Behavior of robots in this study is defined by repeat the shift from a pose to another pose. Figure 3 shows behavior of the AIBO in this study. In this figure, four poses are defined. The robot sequentially moves the body from pose1 to pose4, and these actions are iterated. In this behavior, each joint angle is moved from the current pose to next pose between the decided numbers of frames. Therefore, behavior acquisition is to define some poses of the AIBO and to generate a time-series pattern of poses. In this paper, basic pose of AIBO is “sleep”, and only two front legs are moved, because of simplification of problem.

Pose and behavior are defined as follows. One pose is composed of six joint angles because there are three

Figure 4. Coding of Genes

joints on one front leg. Therefore, pose p_k is expressed by Eq.(1).

$$\mathbf{p}_k = [p_{k1} \ p_{k2} \ \cdots \ p_{k6}]^T, k = 1, 2, \dots, K \quad (1)$$

$p_{k1} - p_{k6}$ are angles of each joint. K is the number of poses. These K poses are determined in advance.

Behavior $\mathbf{B}_j$ is defined by Eq.(2).

$$\mathbf{B}_j = [b_1 \ b_2 \ \cdots \ b_n \ \cdots]^T, \\ j = 1, 2, \dots, J, n = 1, 2, \dots, N \quad (2)$$

$$b_n = p_k \quad (3)$$

b_n is the pose which is executed in the behavior $\mathbf{B}_j$, and is defined from one pose of determined K poses in advance. Also the same pose may be included two times or more in the behavior $\mathbf{B}_j$.

3.2. Coding

In this method, genetic information is the time-series pattern of poses in behavior $\mathbf{B}_j$. Therefore, the pose number executed by b_n is genetic information, and the list of some pose numbers is directly coded as a gene. Figure 4 shows a example of coding and encoded poses on behavior. J is population size, and such J individuals are generated. Also, N which is the number of poses in behavior is gene length.

3.3. Interactive Genetic Algorithms

In this study, the robot acquires behaviors that users like using the interactive genetic algorithm. Figure 5 shows flow of IGA in this study.

Step 1: An initial population is produced randomly.

Step 2: Each candidate of behaviors is executed by the AIBO. User observes each behavior of AIBO, and evaluates of each based on subjective human evaluation. Evaluation methods are a non-contact interaction method using wireless LAN and a contact interaction method using a touch sensor. These are described in Section 4. These estimated values are fitness values in GA.

Figure 5. Flow of IGA

Step 3: If a prespecified stopping condition is not satisfied, proceed to Step4. If this condition is satisfied, this process is ended. The stopping condition in this method is maximum generation number.

Step 4: Create a new population using following genetic operations, and return to Step 2.

Selection: Individuals which are left to next generation are selected. One of these is the individual having highest evaluation value based on the elite method. This is left for the next generation as it is. The others are selected based on the roulette wheel model.

Crossover: A single point crossover method is conducted to form a new offspring.

Mutation: With a mutation rate, mutate new offspring at each locus (position in chromosome).

4. Behavior Acquisition Experiments

We experiment on behavior acquisition using the IGA method described in Section 3. Here, two human interaction methods are introduced in the IGA method in order to give subjective human evaluation. One is a non-contact interaction method using a personal computer connected the AIBO with wireless LAN. Another

is a contact interaction method using a touch sensor of AIBO's head.

4.1. Non-contact Interaction

Evaluation values based on subjective human evaluation are input to the personal computer connected with wireless LAN by user. These values are sent to AIBO by the personal computer through wireless LAN. In the robot, behaviors are evolutionary generated using these values.

In this experiment, parameters and settings were as follows. The number of generation I was 10. Population size J was 4. The number of defined poses K was 16. The number of poses for each behavior N (length of genes) was 4. The mutation rate was set 10%.

Figure 6 shows examples of AIBO's pose using this experiment. Such 16 poses were defined beforehand. The number of time frames that the robot moves a pose to next pose was 6 (about 0.75 seconds). Also, one behavior pattern (four poses) repeated two times continuously. After running on of an actual robot is seen, the user gives the subjective evaluation of ten stages. The criterion of this evaluation was "pretty".

4.2. Contact Interaction

In this method, the touch sensor on the head of AIBO is used. The user evaluates it by "hitting" or "patting" the head directly. Therefore, this is method with contact interaction. Criteria of these evaluation are that the head is patted when it is good, and is hit when it is bad.

In this method, parameters and settings were same as the non-contact interaction method. One behavior was repeated until the user touched the AIBO's head without deciding the iteration number.

Values of evaluation are calculated by the number of frames that touches continuously in touch sensor T_c and the maximum value of touch sensor T_m . This evaluation function is shows by Eq.(4).

$$fitness_j = \begin{cases} 0 & T_c \leq 5 \text{ and } T_m > 1000000 \\ 1 & T_c \leq 5 \text{ and } T_m > 900000 \\ 2 & T_c \leq 5 \text{ and } T_m > 800000 \\ 3 & T_c \leq 5 \text{ and } T_m > 700000 \\ 4 & (T_c \leq 5 \text{ and } T_m > 800000) \\ & \text{or } (5 < T_c < 10) \\ 5 & 10 \leq T_c < 30 \\ 6 & 30 \leq T_c < 50 \\ 7 & 50 \leq T_c < 70 \\ 8 & 70 \leq T_c < 90 \\ 9 & T_c \geq 90 \end{cases} \quad (4)$$

Figure 6. Examples of AIBO's pose

4.3. Results of Experiments

In two methods, subjects were five university students. Also, in the non-contact interaction method, a experiment that decreased pose number to eight in order to compare it by differences of the number of poses.

In the non-contacted method, for a lot of subjects, behaviors that user likes are obtained in later generation than initial generation. It is thought that the effectiveness of IGA can be shown. Also, experiments of 16 poses number are obtained better result than eight poses, and it is easy to evaluate behavior using many poses than few poses as subject's opinion.

In the contacted method, behaviors that user likes are obtained in later generation than initial generation, too. Furthermore, the evaluation for which subjects used both methods was that it was easy for the contact interaction method to evaluate than non-contact interaction method. This is shown that when a subjective evaluation is given, a direct interaction is better. However, there were cases to give a wrong evaluation because of difference of how to touch of each user.

5. Conclusion

In this paper, we proposed behavior acquisition methods using interactive genetic algorithms with two interaction methods. Also, we applied these methods to behavior acquisition of the AIBO. In results, it was easy for the interaction with contact to evaluate.

In the future work, it is necessary to change the genetic parameters. In this paper, population size was four, and the pose number in one behavior was four. It is necessary to increase these parameters. Also, it is considered to use LED as one of the interactions from the robot

References

- [1] K. Wada, T. Shibata, T. Saitom and Kazuo Tanie, "Relationship between Familiarity with Mental Commit Robot and Psychological Effects to Elderly People by Robot Assisted Activity", *Proceedings 2003 IEEE International Symposium on Computational Intelligence in Robotics and Automation*, pp.113–118, 2003.
- [2] T. Saitom, T. Shibata, K. Wada and Kazuo Tanie, "Relationship between Interaction with the Mental Commit Robot and Change of Stress Reaction of the Elderly", *Proceedings 2003 IEEE International Symposium on Computational Intelligence in Robotics and Automation*, pp.119–124, 2003.
- [3] H. Takagi, "Interactive Evolutionary Computation: Fusion of the Capabilities of EC Optimization and Human Evaluation", *Proceedings of the IEEE*, vol.89 no.9, pp.1275–1296, 2001.
- [4] M. Ohsaki, H. Takagi and K. Ohya, "An Input Method using Discrete Fitness Value for Interactive GA", *Journal of Intelligent and Fuzzy Systems*, vol.6, no.1, pp.131–145, 1998.
- [5] H. Nishino, H. Takagi, S. Saga and K. Utsumiya, "A Virtual Modeling System for Intuitive 3D Shape Conceptualization", *Proceedings of 2002 IEEE International Conference on Systems, Man, and Cybernetics (CD-ROM)*, Paper Number TP1D3, 2002.