Power consumption reduction method by classifying individual differences using machine learning

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Abstract：In recent years, the use of multiple robot services on disasters, restaurants and other sites is being considered. However, it is necessary to consider that robots have individual differences. This individual difference is caused by the state of service and hardware. This increases the power consumption of the entire system. At this time, it is possible to reduce power of the entire system by collectively managing and operating properly. Specifically, by allocating motions to the robot based on individual differences, power consumption is reduced. At this time, it is necessary to grasp individual differences that affect power consumption. In this research, we clarify the influence of the prediction expression of variables constructed by log data on power consumption by machine learning and classify variables with great influence. We propose a method to reduce electric power by assigning actions considering the result.

キーワード：Robot, log data, task distribution processing, power management, power saving,

1. Introduction

Recently, robotic activity places worldwide have been applied to manufacturing fields such as factories, medical fields, security, disaster sites, various scenes, becoming more familiar [1]. The service robot market is expected to expand in the future. Because it can be a support and substitute for people in various fields such as nursing care, welfare, dangerous place. Robots are generally support the human work, and in the dangerous place, automatic works are expected instead of the human. Especially these days, at the place that the requires the efficiency of the work, it is reasonable to carry out the work with multiple robots. In these work-style, we considered that following three problems should be considered. The first issue is the fault management. It is expected to manage multiple robots during operation and continued support for the individual robot's breakage [2]. The second issue is the optimal placement. This is an aid to improve work efficiency by physical optimal placement of the robot to should be managed [3]. The third issue is power management. This is support to reduce overall power while increasing work efficiency. Many studies have already been presented for the first and second issues [2, 3], while the third issue has not been fully discussed. Therefore, in this research, we propose a method to reduce the power consumption of multiple robots. Preliminary experiments showed that the two factors affect power consumption. The first factor is individual differences arising from the state of hardware due to aged deterioration and others. The second factor is individual differences arising from differences in operating conditions. Based on the above recognition, we will reduce the power consumption by utilizing the difference between the state and operation of individual hardware. We organize the research as follows. First, a prediction expression is constructed by using the difference between the power consumption of the hardware itself and the operation itself. Prediction of power consumption becomes possible by this equation. Next, the cumulative total of the values obtained by the prediction formula is obtained and the total power consumption is predicted. Based on the above two predicted values, a combination of hardware and operation that minimizes the total power consumption is derived. This combination reduces power consumption by adapting to the robot. As a result of verifying two exchanging methods with a simulator for verification, it was confirmed that the effect increases as the number of units to adapt the method increases. However, there are problems in which the effect varies depending on the adaptation factors.

As a solution to this problem, considering only elements that have a significant influence on power consumption. As a concrete method, machine learning is performed in a random forest using individual difference elements, and elements that affect power consumption are discriminated. It was thought that by allocating the operation in consideration of the result, it leads to reduction of power consumption.

2. Proposed Method

2.1 Prediction formula

In this section, we will explain variables of prediction formula. First, CPD_x^V and CPS_x^V express individual differences of hardware. Next, D_y and S_y express individual differences in operation.

$$\mathrm{MC}_x = \mathrm{CPD}_x^V \times \mathrm{D}_y + \mathrm{CPS}_x^V \times \mathrm{S}_y \cdot\cdot\cdot (1)$$

Prediction formula (1) finds the sum of two products and predicts the power consumption of individual (x). The first is the product of the power consumption per distance (CPD_x^V)[%] and the cumulative travel distance D_y[cm]. This product predicts the power consumption due to movement. The second is the product of power consumption (CPS_x^V)[%] and stop count (S_y) due to operation from the stopped state. This product predicts the

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increase in power consumption due to the operation from the stopped state. Finally, the total power consumption is estimated by obtaining the total power consumption (MC_x) of a specific individual (x).

2.2 Simulator overview

In the Figure 1, we illustrated a schematic diagram of the simulator .

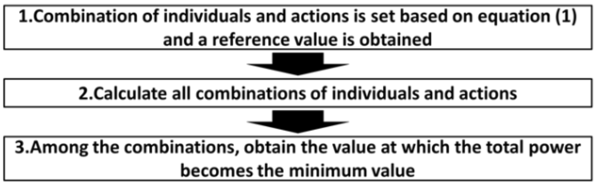

Figure 1 Simulator overview

We verified with two kinds of algorithm methods A and B.

A) In advance, sorting either the $CPD_x^V \cdot CPS_x^V$ in descending order, the corresponding variables in ascending order, and combining in order to determine the combination

B) Those that calculate a combination whose total power is the minimum value by obtaining a combination of all robots and actions

3. Evaluation

The two methods were compared with the following values. In order to verify the total power that can be reduced by the proposed method, verification was performed using PRR_{max} ((Maximum value - minimum value) / (Maximum value) * 100) since it is necessary to verify even when the combination of individual and action becomes worst.

In this research, we added the reduction rate to the evaluation index, and evaluated it again with the metrics, since the previous trial count was as small as 100 times. This time, evaluation is carried out with 500 trials. Experimental parameters are the same as before except for the number of trials.

Figure 2 shows the Evaluation results.

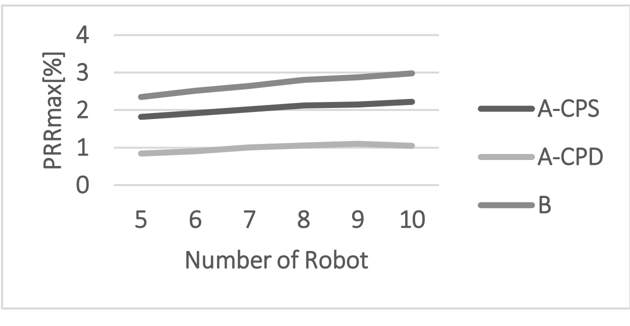

Figure 2 Result of simulator: displayed in reduction rate

In Figure 2, the vertical axis shows how much the minimum value is reduced relative to the maximum value, and the horizontal axis is the number set in the simulation. The legend attached with A is the value obtained when combining is obtained by method A. A-CPS shows the value obtained by applying CPS_x^V of the variable of the formula (1) with the method A. This also applies to A-CPD. When comparing them, method B has the highest reduction rate, and reduction rate when method A is applied by A-CPD is the smallest. In addition, it can be confirmed that values of A-CPS and A-CPD obtained by method A are different from each other. The possible cause is considered to be due to the magnitude of the influence of the variables to be sorted. In this simulator, random numbers are set using data obtained by an experiment using an actual robot. Because of this, the value of CPS_x^V is set to fluctuate more than CPD_x^V. Therefore, even if CPD_x^V is sorted, it is thought that the influence of the value of CPS_x^V and the corresponding action S_y indicating the corresponding operation is not greatly reduced successfully. Conversely, when CPS_x^V is sorted, the reduction rate is considered to have increased from the magnitude of the influence.

4. Future Method

We summarized the outline of the power consumption reduction method using deterministic arrival learning which we devised below (Figure 3).

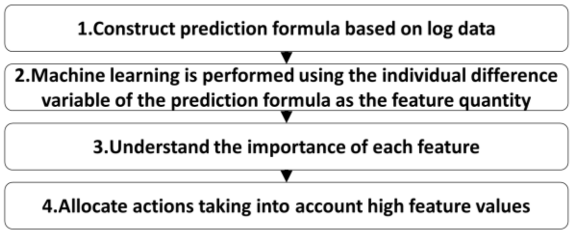

Figure 3 Outline of reduction procedure

As a method, the following procedure is performed.

1. Construct prediction expressions based on log data and grasp individual differences in hardware
2. Machine learning is performed in a random forest using two variables of a prediction expression which is an element showing hardware individual differences and power consumption
3. Understand the importance of each variable
4. Allocate actions taking into account highly important variables

5. Conclusion

In this issue, we devised a method to cope with the rise in the number of variables of the prediction formula. This method is thought to lead to finding effective variables when using method A. From now on, I would like to confirm the reduction effect by verifying it after increasing the variable of the prediction formula.

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