Total Power Reduction Method Based on Features of Mobile Multiple Robots

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Abstract : In recent years, the use of multiple robots at the site of disaster, food and drink industry, etc. However, discussion about power saving has not been done sufficiently. Even when the robot is of the same type, there is a difference in power consumption. It is due to differences in behavior and hardware. We consider that it is possible to reduce electric power by devising allocation of operation. In this research, we proposed a power saving method for multiple robots. Based on the idea, we created a simulator and confirmed the effect with an evaluation, and it's index was the total reduction amount. We found that the evaluation indicator is limited for confirming the overall power reduction effect, then we added the reduction rate to the evaluation index and evaluated. As a result, it was confirmed that the reduction rate also increases as the number of robots increases.

Keywords: 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 [1-4]. 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, it requires the fault management. It is expected to manage multiple robots during operation and continued support for the individual robot's breakage [5]. The second, it requires the efficient relocation. This is an aid to improve work efficiency by physical optimal placement of the robot to should be managed [6]. The third, it 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 [5, 6], while the third issue has not been fully discussed.

To solve the problem, we propose a power management method aimed to reduce total power of the multiple robots. Based on the proposed method, we realize power reduction by considering the utilization of the difference between hardware and operations of individual robot. The implementation method reduces the total power by deciding the operation according to the performance of the each robot. We organize the research as follows. First, a prediction model is constructed based on the differences in the hardware power consumption and it's operation. It will make possible to predict the individual power consumption correctly. Then, based on the prediction model, the total power consumption of multiple robots is defined as the total predicted power consumption. Based on the above two predictions, we obtain a combination of robot and motion that minimizes the total power consumption. This combination is applied for reducing the total power consumption of the multiple robots. In the evaluation, we implemented a simulation method from the prediction to the change of the combination, and verified the proposed method. As a result, it was confirmed that the total power was reduced [7]. However, there was a problem that the processing time increased in the simulator as the number of robots increased. In this research, we describe the results of improvement and evaluation for solving the problem.

2. Proposed Method

2.1 Prediction formula

First, we constructed a prediction formula for one robot. At this time, the power consumption ($\mathrm{MC_x}$) [%] of a certain robot can be expressed by the following prediction equation.

$$\mathrm{MC_x} = \mathrm{CPD_x^V} \times \mathrm{D_y} + \mathrm{CPS_x^V} \times \mathrm{S_y} \cdot\cdot\cdot (1)$$

Prediction formula (1) is one time for each product (x), the product of the power consumption ($\mathrm{CPD_x^V}$) [%] per distance of a certain speed (V) and the cumulative moving distance ($\mathrm{D_y}$) [cm] The power consumption of the operation is predicted by adding the product of the power consumption ($\mathrm{CPS_x^V}$) [%] due to operation from hit / hit and the number of stops ($\mathrm{S_y}$) in a certain operation. Next, the total power ($\mathrm{MC_{all}}$) predicts the power consumption by using the prediction expression (2).

$$\mathrm{MC_{all}} = \sum_{i}^{x} \mathrm{MC_i} \cdot\cdot\cdot (2)$$

Prediction formula (2) predicts total power by calculating the

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total amount of power consumption (MC_i) of a certain individual (i).

2.2 Simulator overview

In the Figure 1, we illustrated a schematic diagram of the simulator [7].

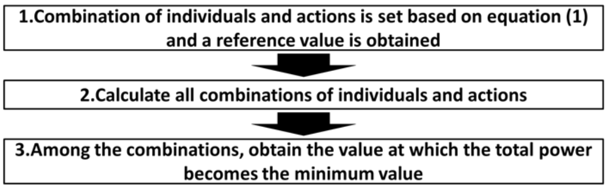

Figure 1 Simulator overview

In order to confirm the effectiveness, we reviewed the following two values that has been presented in [7].

1. The difference (reduction amount) and the reduction rate between the maximum value and the minimum value of total power
2. Reduction rate of the difference (reduction amount) between the total power (reference value) and the minimum value before the adaptation

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 [7].

3. Evaluation results

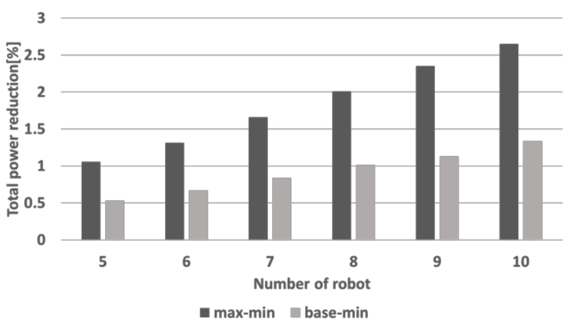

Figure 2 Simulator result: Displayed in reduction amount

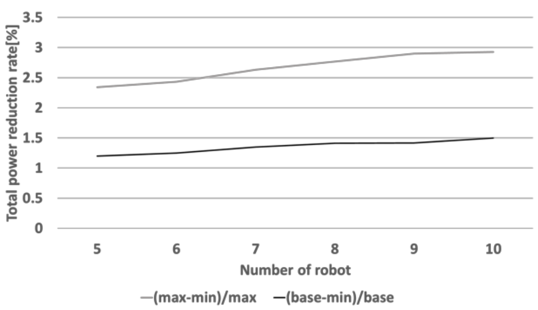

Figure 3 Result of simulator: displayed in reduction rate

3.1 Results

In Figure 2, the vertical axis shows the amount of decrease. Next, the horizontal axis shows the number of robots. Power consumption is calculated from the remaining battery capacity of the robot. Therefore, the unit of the vertical axis is [%]."Max-min" in the legend is the difference between the maximum value and the minimum value of total power. This is a comparison between the worst value and the minimum value when the proposed method is not applied. Next, the "base-min" in the legend shows the difference between the reference value and the minimum value of the total power before the proposed method adaptation. As mentioned in the previous study [7], we confirmed that the reduction amount increases as the number of robots increases.

In Figure 3, the vertical axis indicates the reduction rate. Next, the horizontal axis shows the number of robots. The reduction rate is calculated by dividing the reduction amount by the total power before reduction. As the number of robots increases, it can be confirmed that the reduction rate is gradually increasing.

4. Conclusion

In Section 2.3, it was confirmed that the reduction amount increased with increasing number of robots in the proposed method. This result still yields similar results [8]. Similarly, the reduction rate which is a new evaluation index increases as the number of robots increases. From this, it was concluded that the reduction was also increased by the increase of the reduction rate.

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