Estimation and Categorization of Errors in Error Recovery Using Task Stratification and Error Classification

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Abstract

We have proposed an error recovery method using the concepts of task stratification and error classification in which errors are classified based on an estimated cause into several categories such as modeling errors and planning errors. When an error is classified correctly, the possibility increases that the most suitable recovery will be performed. This paper describes our procedure for the categorization of errors.

Keywords: error recovery, task stratification, error classification, manipulation, planning

1. Introduction

Error recovery is an important research theme for the manipulation tasks of plant maintenance and industrial production robots. However, systematic methods of error recovery have not yet appeared. We have proposed an error recovery method using the concepts of task stratification and error classification. A highly reliable system expression is derived by an analysis of an error and an estimate of the cause in our error recovery technique, and the task is continued based on the expressions of the corrected system.

In error recovery, judgment of an error is performed during the execution of a process by the system. In our method, classification of errors that have occurred is performed based on an estimated cause. Specifically, errors are classified into several categories such as sensing errors, modeling errors, planning errors and execution errors. When an error is classified correctly, the possibility increases that the most suitable recovery will be performed. In this paper, we describe a procedure for the categorization of errors.

A concept of error recovery is described in Section 2. A method of error classification and the recovery process

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in which the classification is used are proposed in Section 3 and 4, respectively.

2. Concept of Error Recovery

The basis of the error recovery technique we use is described in this section. The target tasks are robot applications in industrial factories and power generation facilities that mainly involve assembly and parts replacement. In recent years, as robots have been playing increasingly active roles in the daily life of humans, such tasks as cleaning, washing and cooking have also become a target of our error recovery system.

In this paper, our technique of error recovery with the concepts of both task stratification and error classification as shown in Ref. 5 is used. We proposed a new type of error recovery using both forward and backward pass in Ref. 6.

Figure 1 shows the basic concept of our error recovery method. The main part comprises tasks performed by the robot that are basically elements with sequences of sensing, modeling, planning and execution. This main part is hierarchized from the main work objective to a bottom layer in our method, but is composed of process flows of sensing, modeling, planning and execution for each hierarchy.

If a failure occurs in this main part, the process advances to the recovery part (Fig. 1). The basic flow in this recovery part is as follows: the cause of the error is estimated, the error is classified, the system is corrected, and re-execution is performed using the corrected system with improved reliability.

3. Cause of Error

We have explained that the tasks of the robot consist of the process flows of sensing, modeling, planning and execution. Therefore, the following four types of errors are considered and the Class number is assigned respectively. For simplification, the cause of the error is set to only one in this paper.

(Class 1) Execution Error

This error occurs from a problem with the machine and the task can be achieved without failing usually if the same execution is repeated many times. When a problem with a mechanism is indicated specifically, the cause of the most typical error is a backlash of a gear. The clearance is altered by abrasion. There are many causes such as changes in temperature and humidity, vibration, bending, aged deterioration, and decreased lubricant. It is desirable to identify the cause through experience and artificial intelligence.

(Class 2) Planning Error

This error occurs when the expression of the system used in the computer software does not express a real system strictly. The cause of the error is mostly a setting mistake of a threshold and a parameter in planning, and when that mistake is corrected, the task should succeed. A correct system expression is also derived by specifying the part to be corrected from an analysis of the error.

(Class 3) Modeling Error

This error occurs when the geometry model used in the computer software does not express the real object exactly. Therefore, the task may succeed if the model is corrected and the task is performed again. When the model used is a simplification of the real object, the necessary part is changed to express the model more exactly. A model appropriate for performing a more accurate task should be derived by performing it repeatedly.

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(Class 4) Sensing Error

This error occurs due to an error in sensing and insufficient calibration, and when that is corrected and the task is re-executed, the task should succeed. A camera parameter will be generally corrected. In many cases, it becomes necessary to stop the execution task and make the correction.

The correction is performed based on the cause of the error specified by the classification, and the task is performed again using the corrected system with improved reliability as shown in the flow chart (Fig. 2) depicting a task of loosening a screw using screwdriver as an example.

4. Process of Error Recovery

In this section, we will consider how to take passes based on the possibility of the error classification.

(Case 1) Estimation of the cause of the error is not possible.

The error recovery is performed by completely regarding the error cause as a virtual one. In this case, as shown in the process of the recovery in the flow chart in Fig. 3, the cause is first regarded as an execution error of (Class 1) and the task is merely repeated. When the error status continues even after repeating more than one time, the error is then regarded as a planning error of (Class 2). When numerical values for various parameters are changed, it is possible that something to improve may be found. When that is found and corrected, the task is performed and the error status is checked. When the error status is removed, it is possible to assume that a planning error was the cause. If the error recovery does not succeed, the cause is estimated as (Class 3) and (Class 4) and a similar procedure is performed successively.

(Case 2) Estimation of the cause of the error is possible to some extent.

In this case, the cause is narrowed down to some extent from experience and it can be chosen from those
tends to occur and the recovery flow chart (Fig. 3) is changed. For example, when the priority of the error cause is the following,

(i) Error 1 (Class 1)
(ii) Error 2 (Class 3)
(iii) Error 3 (Class 2)
(iv) Error 4 (Class 3)
(v) Error 5 (Class 2)
(vi) Error 6 (Class 4)

the flow chart of the recovery becomes as shown in Fig. 4. The cause is specified from the error conditions, the task when the error occurred, and the process up to that point. The system is corrected and the task is re-executed by the system with improved reliability.

5. Conclusion

We have shown a method for classifying the cause when an error occurs and how to process the recovery for the case in question. The accuracy of the estimated cause ways: with experience and without experience. In addition, we described the route that approximated the true cause in each category of the error cause. When the cause can be identified correctly, the expression of the system becomes correct. Therefore, the probability that the error will occur in the execution of a later task will decrease. Our future studies will include the applicability of our method to an actual system and a search for a method that can derive the cause more accurately even when there is little experience.

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