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# Study of a self-diagnosis system for an autonomous mobile robot

SHINNOSUKE OKINA [1,*], KUNIAKI KAWABATA [2], TERUO FUJII [3], YASUHARU KUNII [1], HAJIME ASAMA [4] and ISAO ENDO [2]

[1] *Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan*
[2] *Biochemical Systems Laboratory, The Institute of Physical and Chemical Research (RIKEN), 2-1 Hirosawa, Wako-shi, Saitama 351-0198, Japan*
[3] *Institute of Industrial Science, University of Tokyo, 7-22-1 Roppongi, Minato-ku, Tokyo 106-8558, Japan*
[4] *Advanced Engineering Center, The Institute of Physical and Chemical Research (RIKEN), 2-1 Hirosawa, Wako-shi, Saitama 351-0198, Japan*

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Most research related to intelligent robots are discussed in case when the system works ideally and does not consider how to cope with the fault situations. However, it is an important topic for robots working in real environments. Therefore, we are developing a self-diagnosis system for an autonomous robot. In this report, we build a self-diagnosis system of an omni-directional mobile robot (ZEN) which was developed in RIKEN. Figure 1 shows the configuration of the self-diagnosis system on ZEN. The diagnosis system needs to observe the detailed status of the system to maintain reliability. We consider that the system consists of plural modules and equip new sensors to the mobile robot system for detailed inspection. When the difference between a realizable and required function is over its allowable limit, the system falls into fault. Here, realizable function means the ability that the system can work and required function means the ability that the system should work. For detecting detailed fault parts, the system must know what kind of influence each module's fault gives to the whole system. Here, we compose a status table which indicates the robot's condition corresponding to each module's fault (Fig. 2). For example, when it occurs that the motor or the wheel does not rotate, although the battery and the motor driver work normally, the system can identify which part has

*E-mail: okina@cel.riken.go.jp

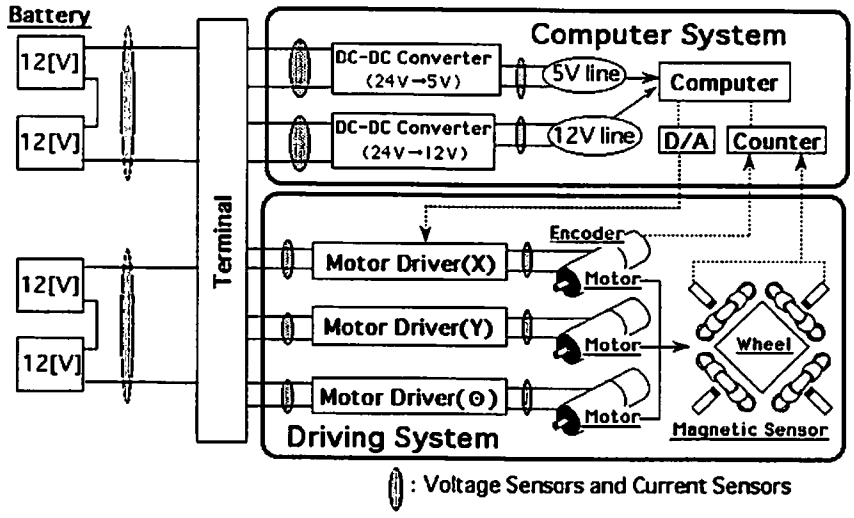


**Figure 1.** Overview of system.

| | | Condition (A Faulty Point) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | System Fault | | | | | | Sensor Fault | | | | |
| | | Normal | Slip of Wheel | Gear, Axle Fault | Motor Fault | Motor Driver Fault | Power Line Fault | Low of Battery Level | Encoder Fault (on Motor) | Encoder Fault (on Wheel) | Current Sensor Fault (on Motor Driver) | Current, Voltage Sensor Fault (on Power Line) | Current, Voltage Sensor Fault (on Battery) |
| Sensor Output | Gyro Sensor | ○ | × | × | × | × | × | × | ○ | ○ | ○ | ○ | ○ |
| | Encoder(on Wheel) | ○ | ○ | × | × | × | × | × | × | ○ | ○ | ○ | ○ |
| | Encoder(on Motor) | ○ | ○ | ○ | × | × | × | × | ○ | × | ○ | ○ | ○ |
| | Current Sensor (on Motor Driver) | ○ | ○ | ○ | ○ | × | × | × | ○ | ○ | × | ○ | ○ |
| | Current, Voltage Sensor (on Power Line) | ○ | ○ | ○ | ○ | ○ | × | × | ○ | ○ | ○ | × | ○ |
| | Current, Voltage Sensor (on Battery) | ○ | ○ | ○ | ○ | ○ | ○ | × | ○ | ○ | ○ | ○ | × |

○ : Normal Output × : Abnormal Output

**Figure 2.** Table of fault detection.

an error by referring to this table. We also examine a self-diagnosis algorithm with this status table (Fig. 3). The system the compares input and output value of the section, which consists of the modules. If the system finds the section is faulty after this inspection, the system inspects each module in this section in detail. Using this algorithm, the system classifies the fault into 'sensor fault', 'system fault' and 'combined fault'. Also, the diagnosis system can detect error parts in the system to repeat the inspections automatically. To confirm the validity of our proposed method, we have performed a fault detection experiment with a real mobile robot. The objective of this experimentation is to detect the motor's fault (system fault) and the inside-encoder's fault (sensor fault). Figure 4 shows the experimental result. In

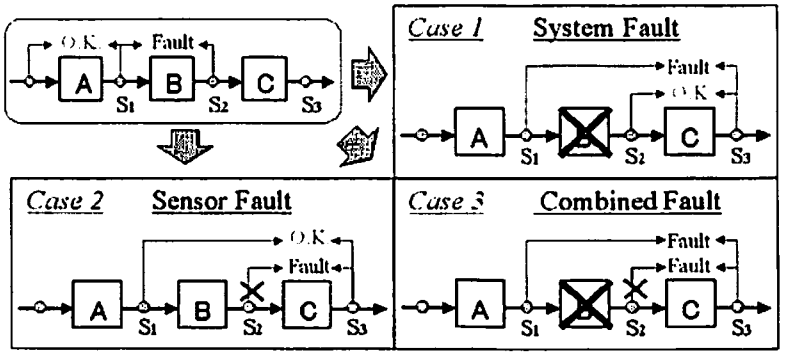


**Figure 3.** Algorithm of fault detection.

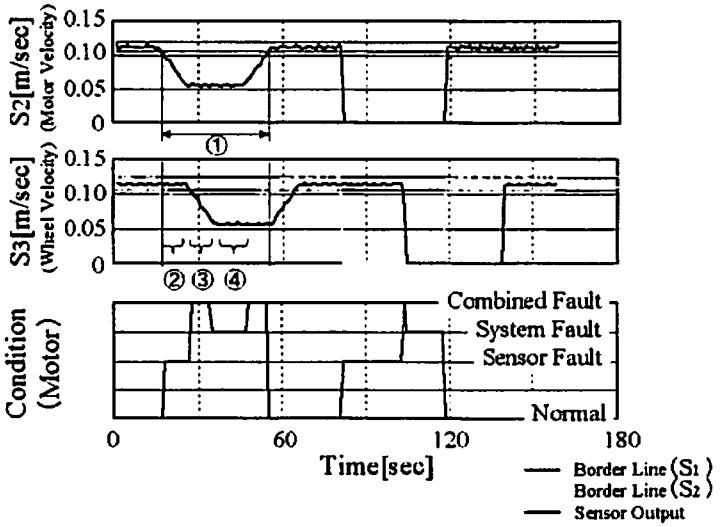


**Figure 4.** Experimental result.

this experiment we produce the troubles artificially while the robot goes straight ahead. Using an output value of the outside-encoder (magnetic sensor), which directly measures the wheel rotation, the diagnosis system divides the fault into the inside-encoder's fault, motor's fault and combined fault. As the result, our proposed method detects the fault parts in the system (Fig. 4). In our future work, we will try to examine an adaptive behavior generation method when the faults occur.