How to make a mobile robot move more reliably?

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Abstract When we explore the navigation of a mobile robot, we have to consider how to get necessary data from sensors and how to make good use of those data. Based on present technology, sometimes we can not automatically extract data used for reliable navigation in any environments from those sensors with present algorithms. Even in the structured environments, because of the errors of sensors, the extracted data are not always reliable. In view of above problems, we developed the tele-control subsystem through Internet besides the general control strategy. With the tele-control, the data gotten from sensors, will be sent to the supervisor's computer directly in addition to the robot. And the supervisor can also send the control commands to the robot directly based on human's experience. By this way, the robot may be controlled even in a strange environment.

Key Words Mobile robot, Navigation, Tele-control

1. Introduction

In this paper, we mainly consider how to make a mobile robot move more freely and reliably in structured and unstructured environments. Here the structured environment is the ideal environment with fixed settings. Although the states of some objects in that environment can be changed, but those change do not influence the working state of that robot. On the contrary, it is the unstructured environments. That is, the unstructured environments are more complex. And the practical environment is one of the unstructured environments. Because the change of the environment should be considered when the robot is moving, the control of that robot should be more flexible and reliable.

Navigating freely in the specified environment is the basic and necessary function for a mobile robot. Then the robot can carry out more specified tasks. Here at least two main problems will be considered for the solutions. One is the environment may not always be ideal structured environment. Another is the self-location in the navigation. The ability to solve above problems will determine what kind of jobs the robot can do. Although they seem to be separate problems, they are the necessary components of the navigation subsystem being developed. Here the self-location is mainly explored for the long distance navigation with the errors of sensors and slip at high speed. And the unstructured environment is the structured environment that is changed by some unexpected requirements. Such environment is similar to some practical environments.

In order to solve above problems efficiently, the vision subsystem, voice subsystem, touch screen control subsystem and tele-control subsystem by Internet were developed. Those subsystems shared necessary information from sensors by TCP/IP protocol. For most cases, only one of the subsystems is used. But it will be robust when it works with all the subsystems in some complex environments. All subsystem mainly use the data extracted from the captured images by the CCD video camera to control the driven subsystem. Although the CCD video camera may provide more information than other sensors, we may not develop any corresponding algorithms for any specified applications. That means the robot can not automatically make full use of the information from the CCD video camera. On the other hand, the supervisor may not always follow the robot even if the robot is working. Thus we developed the voice subsystem when the supervisor is not far from the robot, the tele-control subsystem by Internet when the supervisor is far from the robot and the touch screen subsystem when the supervisor is near to the robot. Especially in the tele-control subsystem, the images taken by that CCD video camera will also send to the supervisor's computer at the same time. The supervisor can send the corresponding commands directly to that robot based on some practical requirements. When that robot is confused in a strange environment, with the help of the supervisor by the tele-control through Internet, that robot will complete specified tasks.

On the other hand, making use of as many sensors as possible is another solution to increase the robustness and flexibility of a robot. But it also brings new problems: 1) the cost of sensors; 2) develop algorithms to make good use of the data received from sensors; 3) how to efficiently compound those data received from different sensors etc. At the same time, we have to admit the robot will not have the similar intelligence like a human being till now. The robot can not make good use of all data from all sensors. It is not difficult for us to control a robot to work in a structured environment. But we can not make a robot work in any environments automatically and freely. That is the main purpose that we developed the tele-control through the Internet.

The robot developed in our laboratory is one with the approximate height of 1.7m. All control information is based on the data extract from the CCD video camera. The head is designed with one degree of freedom, which can rotate 360^o. The camera has two degree of freedoms, which can tilt up and down, left and right. Thus the robot can searching specified objects. Just like the common mobile robots, it can move forward and backward for specified distance, and it can rotate for specified angles. Some landmarks, such as triangle and circle, can be recognized. It can also move at a high speed along the double guideline. Moreover, it can perform simple obstacle avoidance. However, with such functions, it can only move freely at structured laboratory. If moving in the more complex environments, the robot will be helped by the voice subsystem or tele-control subsystem base on practical requirements. The corresponding experiments have been done in our laboratory.

2. The realization of the navigation system

The Alife robot prototype, as shown in Figure 1, is a custom built mobile robot which has four wheels: two independently driven wheels located along the central axis, and two auxiliary castor wheels in its front and back. There are six ultra sonic sensors-switches for obstacle detection within a preset range. The robot has two color Charge Coupled Device (CCD) cameras mounted on its head. Each camera is capable of independent pan and tilt movement. The head can be rotated left-right using a stepping motor. Speaker and a microphone are mounted in the body and on the head respectively. A mobile phone may be used instead of the speaker/microphone.

To control the robot, two Personal Computers (PCs) have been built into the body. The PCs are connected to the hardware via controller cards and the serial ports. The PCs also have Ethernet cards, so that network message may be used to carry information (about items seen or heard), from one PC (which has access to the frame grabber/sound card) to another PC (responsible for controlling hardware). If necessary, those information may also be sent to the supervisor's computer.

The integration of the system is shown in figure 2. The figure 3 is the illustration of the implementation process. All of the subsystems were developed separately. It is convenient to later increase any specified based on requirements. In the vision subsystem, the image taken by the CCD video camera, will be processed to extract necessary data for recognition and some signals for navigation. Till now, the sign landmarks, such as circle and triangle etc, and the continuous landmark, the double guideline, have been developed. The voice subsystem can receive Japanese and English commands and translate them to the corresponding signals used for the robot. At the same time, any explanation text will be spoken by this system. The behavior system is responsible for all basic actions of the robot. It can receive specified signals from other subsystems to perform required actions. If necessary, the signals can also be sent to the supervisor's computer by Internet for the tele-control. Based on such system, the robot can satisfy most requirements.

3. Experiments

The experiments on the voice subsystem and image processing subsystem can be found in the reference[1,2]. Here we mainly explain the problems about the tele-control through the Internet. In order to make the tele-control reliable and robust, the communication subsystem must be reliable, and the necessary data should be sent to the supervisor in time. Because the images taken by the CCD video camera will be sent to the supervisor, the volume of the image data and the frequency of the transformation should be controlled in order to make the tele-control system work for all time. On the other hand, the commands sent through Internet should be as simple and short as possible. Most of important, the connection priority between different subsystems should be parallel, and in each system the connection is point to point. Thus the problem produced by one subsystem, will not influence the work of other subsystems. An simple introduction of our system can be seen in figure 4.

4. Conclusions

In order to realize reliable navigation, the robust system, the reliable data extracted from the signals of sensors and the reliable feedback information are necessary. In our system, we make good use of the volume of signals from the CCD video camera. Because we can not deal with all of that information with present algorithms, the tele-control subsystem was developed to realize reliable navigation in the strange environment.

Reference

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[2] J. Wang, M. Sugisaka, Study on visual-based indoor navigation for an alife mobile robot, ICSEng2002, Las Vegas, USA, 2002, August 6-8 : 390-396.

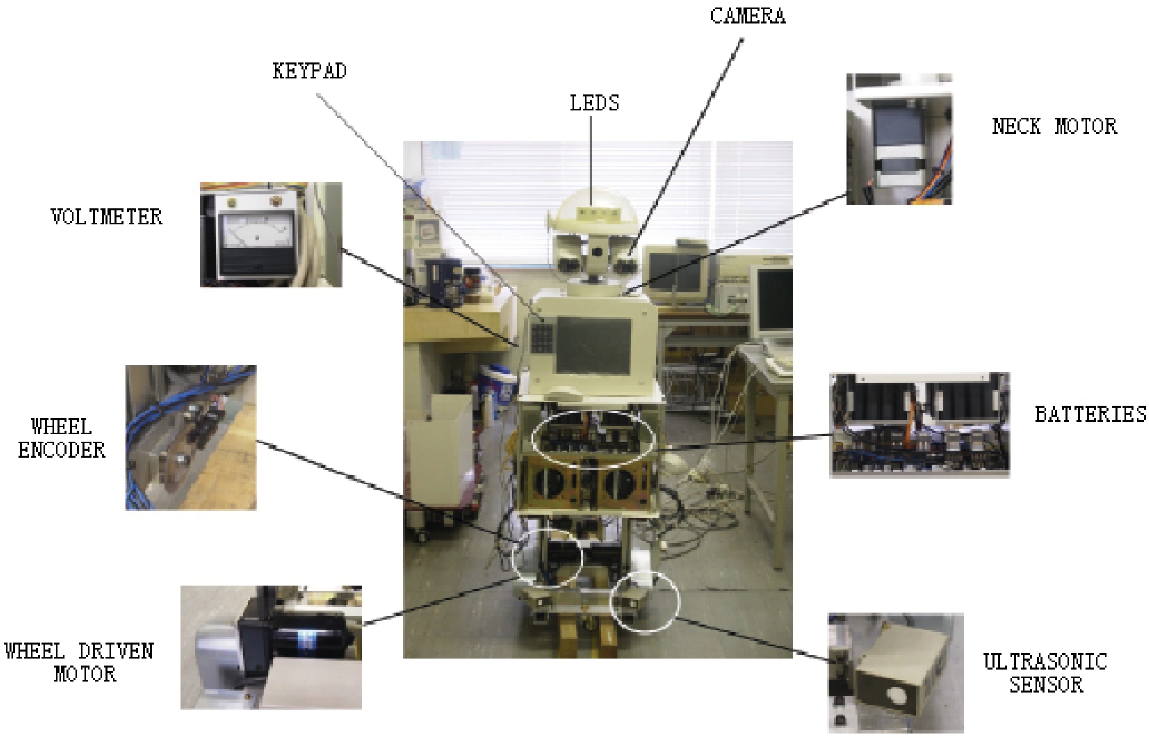

Figure 1. The structure illustration of our mobile robot

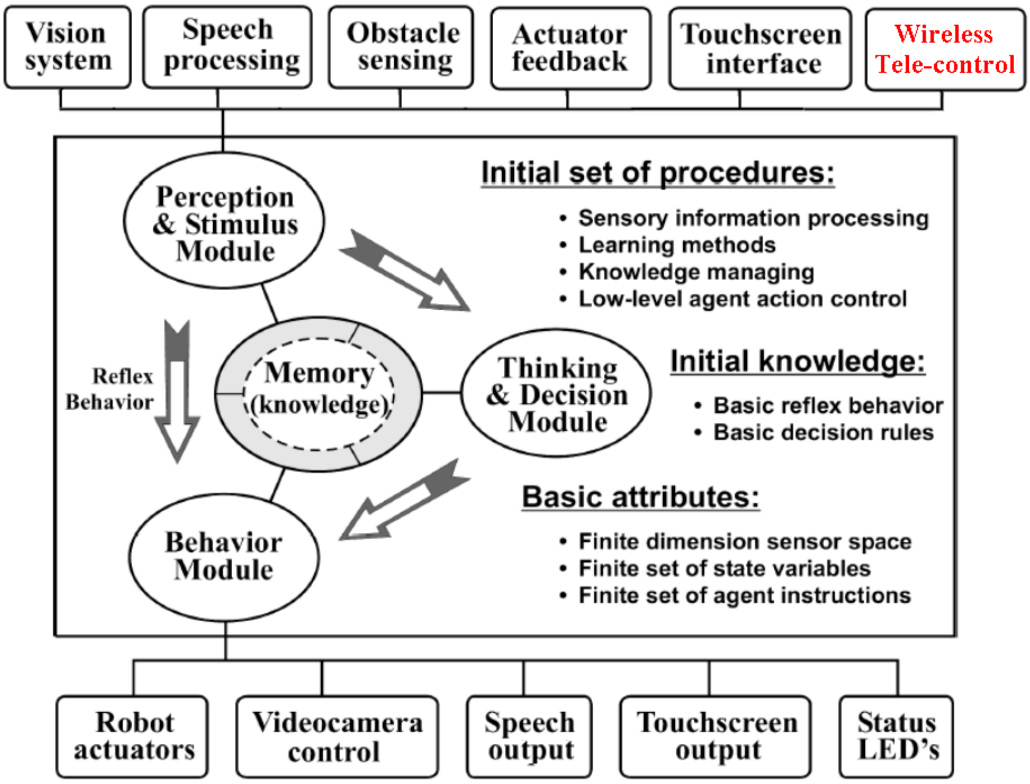

Figure 2 Illustration of the processing of input and output data

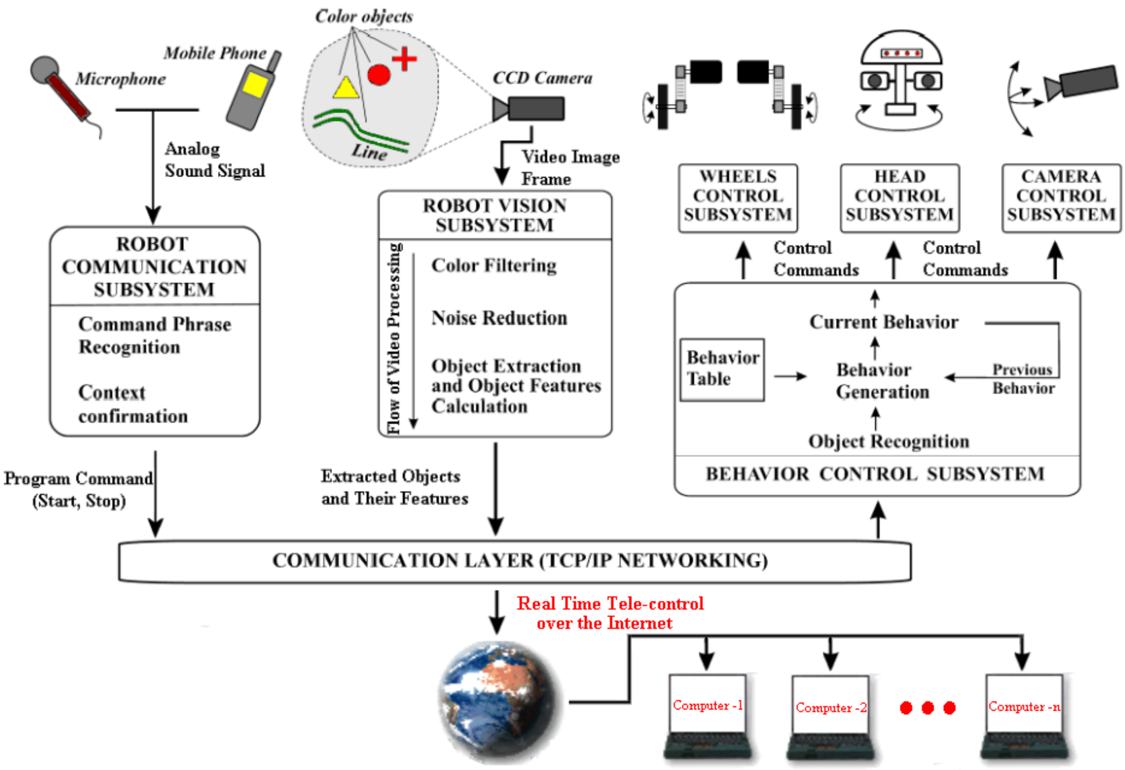

Figure 3 Illustration of the implementation of all subsystems

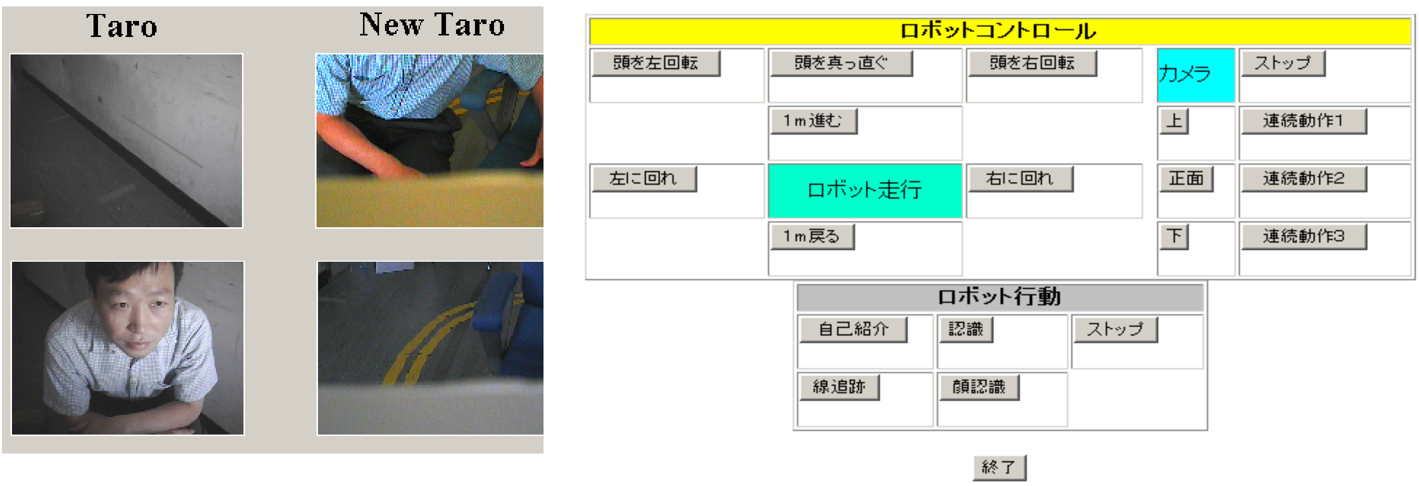

Figure 4 Illustration of the tele-control through Internet