A Framework with Behavior-Based Identification and PnP Supporting Architecture for Task Cooperation of Networked Mobile Robots

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Abstract. In this paper, we describe a framework to integrate behavior-based identification for localization of new robots with an architecture for task cooperation of networked mobile robots in a well configured environment. In the framework, behavior-based identification for networked mobile robots is to establish relation between their identities and their positions, which are estimated from their trajectories related to each of the paths generated as designated signs. And the characteristics of the PnP supporting architecture are dynamically to connect, execute and disconnect networked mobile robots and service components related to the robot. Through the framework, networked mobile robots are able to determine their poses, and carry out and cooperate their tasks by using networked resources.

Keywords: behavior-based robot identification, networked mobile robot, PnP supporting robot architecture.

1 Introduction

With the growth of technology for networked mobile robots in an indoor environment, many researchers have investigated how to make a well-configured environment with distributed sensors for the robots that are able to fulfill the same functions [1-3]. The robots are able to know their poses with the help of the environment and carry out their tasks by using external sensors. Furthermore, the environment is able to analyze various situations and make a decision by information received from the robots. The most important characteristic is to provide resources for intelligent cooperation of networked mobile robots. Thus, a well configured environment such as the Intelligent Space can be a good platform for networked robots [4].

To realize the intelligent cooperation of the robots, we should solve two problems: robot localization for carrying out given tasks, and a design of architecture for the task cooperation of the robots. Firstly, in previous works, the environment should localize the mobile robots under a precondition that the prior knowledge of the robots is given

[5]. Thus, when new robots (i.e., an unidentified robot) comes from outside of the environment, the environment is not able to determine the current pose of the networked mobile robots; the system operator has to collect the prior knowledge of the robot in an offline step. Secondly, an architecture to control the networked mobile robots and to manage network connection for them is essential and important, since the architecture has been considered one of important issues in the research area of networked robot system.

In this paper, we describe a framework to integrate behavior-based identification for localization of new robots with an architecture for task cooperation of networked mobile robots in a well configured environment. In previous works, we proposed a method to localize new robots using its trajectory related to a given path [6], and a PnP supporting middleware framework for network based humanoid [7].

2 Behavior-Based Identification of Networked Mobile Robots

Fig. 1 illustrates the concept underlying the behavior-based robot identification. A well-configured environment identifies new robots when they come from the outside. Under the precondition that they communicate with the environment, they are able to receive paths generated by the environment. After moving according to the generated paths, the environment establishes a relation between the identity and position of the robots. Finally, the robots are able to determine their poses from the environment.

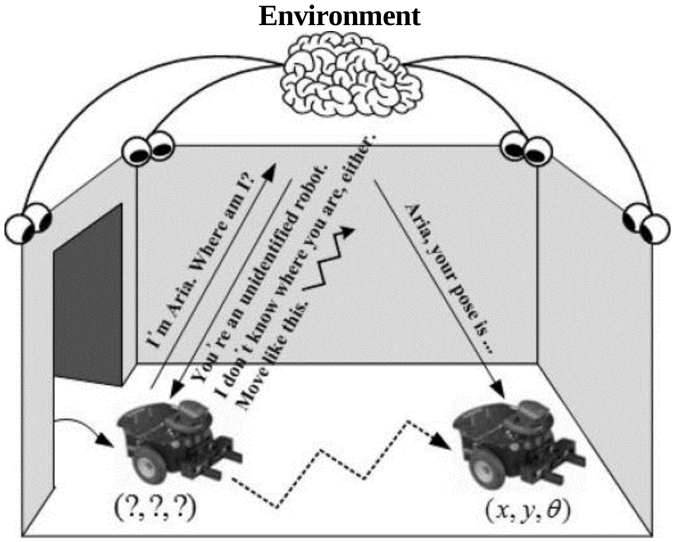

Fig. 1. Concept underlying the proposed system for identifying robots.

2.1 Approach for Behavior-Based Identification

Feature extraction step. The environment sends spin motion to unidentified robots simultaneously. This process has the following two objectives: To set the region of interest (ROI), where the motion of each robot is seen in sequential frames for a period, and To acquire the features of the unidentified robots from the ROIs.

Trajectory estimation step. In this step, the environment sends generated paths to networked mobile robots in order to ascertain their trajectories from their movements. The robots are detected and tracked using color-based particle filters. To track each robot, our behavior-based identification system utilizes the position and size of ROIs obtained in the feature extraction step.

Similarity analysis step. Finally, the environment establishes the relation between the identities and positions of the robots, using the similarity between the robots' trajectories and their paths for identification.

3 Design of PnP Supporting Architecture

3.1 Configuration of the Architecture

The architecture consists of a main manager, resource managers in a resource group, more than one service group with a networked mobile robot and service components, and monitoring service as shown in Fig. 2. All data obtained from sensors of networked mobile robots are transmitted to service components of the architecture through a wireless network. However, all of the components are not able to receive data, since the bandwidth of a wireless network is narrow. Thus, a service component should be operated as a executable software existing in a server on network. For this, we define a basic concept of a virtual robot and a service group as shown in Fig. 2.

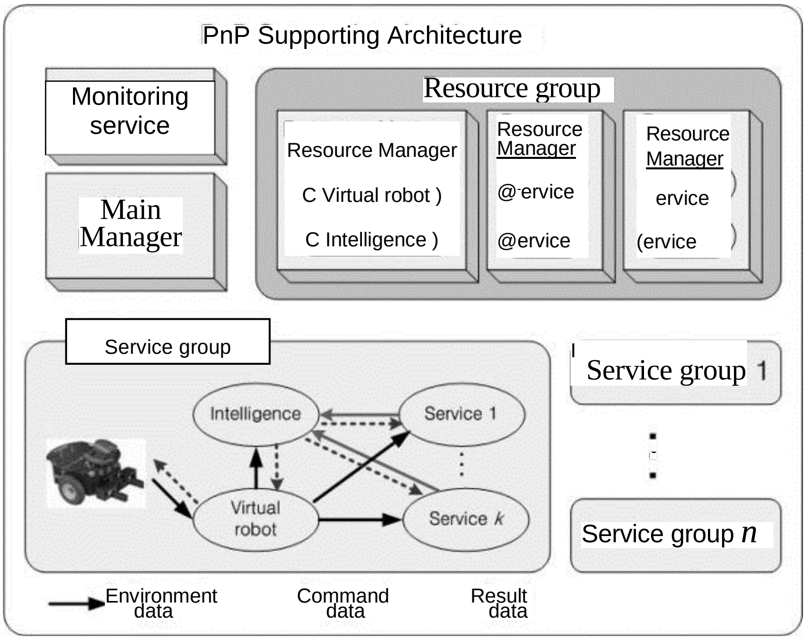

Fig. 1. The configuration of PnP architecture.

3.2 Virtual Robot

It receives all data obtained from sensors of a networked mobile robot related to the virtual robot, which broadcasts the received data to other service components. In addition, the virtual robot is able to simulate a real networked mobile robot on the architecture. Thus, if a service component sends a command to a virtual robot, then it relays the command to the real networked mobile robot. The virtual robot receives instructions only from the intelligence service component, and manages all the service components in a group. The intelligence service component has the role of the intelligence of the service group, and receives all results data from other service components.

3.3 Service Group

The service group provides the default behaviors (e.g., face, voice, and object recognition) for a networked mobile robot as an independent group on the architecture, and the service group receives its own management service from the virtual robot. Fig. 3 shows a process of a networked mobile robot join and an creation of service group to the architecture. A networked mobile robot notifies the main manager of its own connection when the robot tries to join the architecture. The main manager that received the notification gives permission to the networked mobile robot to connect to the architecture. Then the networked mobile robot transmits to the main manager the service list that the networked mobile robot needs.

3.4 Main Manager

A main manager communicates with a networked mobile robot and more than one resource managers, and receives service lists that the robot needs. And then, the main manager allocates the services of networked mobile robots to servers after obtaining service lists that each of resource managers has. If the requested service does not exist in the architecture, the main manager looks for a replacement service. If the main manager cannot find a replacement service, it rejects the networked mobile robot. If the requested service exists, the main manager organizes a new service group and lists it in XML format. Then the list is sent to the resource managers that are on the resources.

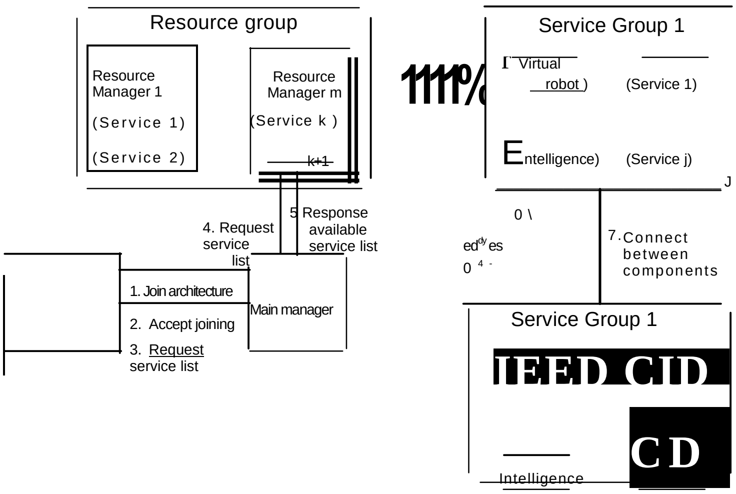

Fig. 2. The joining a networked mobile robot on the PnP supporting architecture.

4 Conclusions

In this paper, we described a framework to integrate behavior-based identification for localization of new robots with an architecture for task cooperation of networked mobile robots in a well configured environment. In this paper, we described concept and approach underlying the behavior-based identification for networked mobile robots, and configuration of the PnP supporting architecture to connect, execute and disconnect networked mobile robots and service components related to the robot. Through the framework, networked mobile robots are able to determine their poses with the help of a well-configured environment with distributed sensors. In addition, the robots joining the PnP supporting architecture are able to carry out and cooperate various tasks without physical limitations by using distributed networked resources.

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