Description and inference to the topological relation between objects for situation awareness

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Recently, the application domain of the robot has been rapidly expanded to the whole field from the industry. For example, ASIMO is an acronym for advanced step in innovative mobility, developed and built by Honda, Sony's AIBO is a robotic dog designed to do a variety of tricks for entertainment, iRobot's Roomba is a robotic vacuum cleaner known as the most successful domestic robot, and the BigDog is a military robot for transporting munitions. Like this, now the robot is expected to do a crucial role in the household chores, welfare for aged people, extreme works, and military field. It is implied that the robot is being made popular, and began to penetrate into every department of human being's life. But, unfortunately, it also means that the robot is required to fulfill a given task in unknown, complicated environment unlike the well-settled environment. Consequently, the robot would face problems of how to recognize something in the unknown environment, how to make a decision to plan appropriate behaviors from the existing state of things and how to act exactly to achieve a goal. It is very difficult for the robot to adapt intelligently to the dynamically-changing environment and situation without any a priori information. Although many researchers have studied about the problems employing various approaches, many issues remain unsolved.

So, in this research, I pay attention to the question of how the robot defines and acquires needful information from the unknown environment for appropriate decision making; situation awareness.

Situation awareness can be defined as follows: "the perception of the elements in the environment within a volume of time and space, and the comprehension of their meaning and the projection of their status in the near future". Namely, there are three phases to make a decision. First, it is needed to perceive what is happened by detecting the symptom from the environment. Next, it is reguired to grasp the kind of state of a specific object. And future prediction should be made to affect the state.

Under the definition, many researches have been tried in a variety of fields such as cognitive robotics, automobile, and uninhabited airborne vehicle that adequately recognizes the situation of emergency. Particularly, there have been many attempts that recognize effectively the environment and its situation and inferring relation between objects. Yanai *et al.* proposed a method to recognize objects in indoor images employing the supporting relation between objects. By qualitatively inferring the supporting relations between objects, the method enables recognition of an object occluded by other objects. Torralba *et al.* proposed a scheme for indoor place identification based on the recognition of global scene views. Scene views are encoded using a holistic representation that provides low-resolution spatial and spectral information. Yoshimura *et al.* constructed a robot that memorizes the position of an object while the robot walks around in an office environment. They proposed a recognition model for the posture using color or shape of an object.

As mentioned above, it is important to represent the environment and the situation systematically for acquiring necessary information, and making a decision appropriately in continuously-changing environments. Therefore, in this work, I represent the relations between objects under the laws of qualitative physics of real world. To describe exactly the relation between two objects in space, without any global coordinates, three elements have to be defined at least; distance relation, direction relation and tangency relation. I defined topological relations between objects on the basis of a common descrption of the three elements. The topological relation has some advantages: First, it is defined uniquely. Secondly, it expresses simply

the relative position between objects. Thirdly, it can be inferred easily from other relations between objects.

In this paper, I proposed a novel system to describes and estimates topological relations between objects in a dynamic environment using the co-occurrence matrix. The system estimates the topological relation between objects drawing out specified features of the matrix from disparity images captured by the stereo vision system. Furthermore, to verify the underlying relation between objects, the habituation concept was employed in the system, and it enables to infer the intrinsic relation between objects estimating habituation value at events triggered by motion vector. The obtained relations would be accumulated in the knowledge base. This system is expected to enable the robot to gather needful information autonomously for making a decision in the unknown environment.