The concept of PEIS Ecology: Integrating Robots into smart environments

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Autonomous robotic devices are vital to the peformance of space mission. These range from smart servo-controlled devices (e.g., an antenna or a camera) to autonomous mobile robots (e.g., planetary rovers) to future interactive astronaut assistants. Each robotic device operates in its specific environment, which is usually not fully predictable and not fully observable, and which may include humans. In the classical view of autonomous robotics, the robot and its environment are seen as two distinct entities. This view is often assimilated to a two-player antagonistic game, in which the robot has to find a strategy to achieve its goals in spite of the actions performed by the environment.

The "PEIS Ecology" approach to autonomous robotics takes an ecological view of the robot-environment relationship, in which the robot and the environment are seen as parts of the same system, engaged in a symbiotic relationship toward the achievement of a common goal, or equilibrium status. We assume that robotic devices (or PEIS, for "Physically Embedded Intelligent Systems") are pervasively distributed throughout the working space in the form of sensors, actuators, smart appliances, RFID-tagged objects, or more traditional mobile robots; and that these PEIS can communicate and collaborate with each-other by providing information and by performing actions. Humans can also be included in this approach as another species of PEIS inside the same ecosystem.

As an example of the PEIS Ecology approach, consider a robot with the task of grasping a milk bottle from the fridge. In a classical approach, the robot would use its sensors to acquire the relevant information from the environmnet -- e.g., the parameters of the fridge handle and of the milk bottle. It would then use its actuators to manipulate the environment -- e.g., to open the fridge door and to grasp the milk bottle. In a PEIS Ecology approch, the robot would instead ask (some of) the needed information from the environment -- e.g., it would get the shape, weight, and grasping points of the milk bottle from the bottle itself, equipped with a mote or an RFID tag. It would also ask the environment to perform (some of) the needed actions -- e.g., it would ask the fridge to open its door.

The PEIS Ecology approach was developed in the context of a collaborative project between Sweden and Korea between 2004 and 2008. The target application of this approach was everyday domestic assistance, especially (but not only) to elderly people. However, this approach can in principle be applied to other domains, both indoor and outdoor, including space exploration. In this talk, I will outline the concept of PEIS Ecology, discuss the major scientific and technological challenges entailed by its realization, and show the results achieved in the course of our development with respect to these challenges. I will also illustrate the practical benefits of a PEIS Ecology approach to realize domestic assistive robotics, and the current extensions of this approach to include the interaction with humans seen as part of the ecology. Finally, I will suggest a few starting points to discuss the applicability and benefits of this approach in the context of space exploration.

For more details, technical papers, source code, and videos please visit the PEIS Ecology Home Page.