Future Shock: Robots in the Next Millennium

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Year 2005: A joint U.S.-Russian space mission has landed on the surface of Mars. The exploration of the planet is being carried out by an autonomous planetary rover, which moves over a large area of the planet, gathering information, transmitting it to earth and carrying out various scientific experiments. This vehicle, unlike its counterparts in the 20th century, is almost completely autonomous, using advanced sensors, learning systems and precise yet robust mechanical components and does not require any instructions from the mission control on earth.

This scenario may not be as outlandish today as in the days of the Apollo mission. Tremendous advances in robotics, have made possible many applications which were previously only conceived of by sci-fi writers. Autonomous driverless vehicles and smart industrial robots are just some of these. Starting from fairly primitive "pick and place" material transfer industrial robots in the 60's, the field of robotics has developed enormously. In fact, the 80's has seen a virtual flooding of competent industrial robots which are increasingly being incorporated in the automated shop floor environment. That there are roughly 500,00 robots in Japan alone gives us an idea of their proliferation.

In some senses robotics is a field which integrates several other computer related fields. Any robot has to integrate perception, comprehension and finally manipulation to carry out the required task. Perception of the environment means development of sensors and transducers (devices which convert non-electrical signals like light into electrical signals). Thus advances in the field of computer vision play an essential role in todays robots.

Comprehension involves computing and some "understanding" of the task which invariably entails a process of learning. Once again, with the phenomenal increase in the computing power available now (as compared to even a decade ago) the capacity of contemporary robotic systems to handle data is mind boggling. This, coupled with the advent of learning systems like neural networks has opened up new vistas in the field which were previously unimaginable. Be it welding an automobile door or moving on Mars, ultimately a robotic system has to perform a mechanical task which involves control systems and locomotion. Here again, with improved electronics and micromechanical engineering, today’s robots are far more advanced than their ancestors.

With increasing sophistication, robots are finding a host of applications in todays research and industrial environments. One area where they have contributed significantly is the area of rapid manufacturing. With increased globalization of the markets, it is imperative for manufacturers to respond rapidly to changing market needs. Thus a speeding up of all the processes in manufacturing, from design to prototyping to mass production is necessary.

One such technology which can contribute significantly to the goal of rapid manufacturing is shape deposition. Here the idea is to build up the desired object by incremental deposition of materials. The design is taken from a CAD(Computer Aided Design) system and a predetermined material is deposited in the required configuration. Robots are already playing a major role in this process. Working with a variety of materials, from metals to ceramics, robotic thermal spraying systems are capable of a many tasks like fabricating injection mouldings and industrial dies. Enhanced speed, greater versatility in the kinds of materials which can be handled, and the ease of operation are only some of the advantages offered by robotic systems in this area. Nevertheless, many more years of intensive research would be required before a completely automated manufacturing facility, with CAD systems, robotic deposition stations, automated inspection systems and robotic transport systems to move the material, becomes a reality.

Taking the robots from the "protected" environment of the factory to a more rugged and hostile outdoor environment is another challenging area where considerable work has been going on in the last few years. Several groups in the United States, Europe and Japan have developed systems which perform a variety of tasks in natural surroundings. The applications of intelligent outdoor systems are mind boggling --- from hazardous toxic dump cleaning to autonomous, driverless vehicles as part of an intelligent highway system.

The complexity and unpredictability of natural surroundings make it a daunting task for the designer to foresee all eventualities. Here the recent advances in learning systems and computer vision have proved to be a boon to the researchers. NAVLAB, an autonomous driverless vehicle developed by the Carnegie-Mellon University is an example of such an application which incorporates these systems. The input taken from a video camera is fed into a neural network. The images of the road are processed by the on board computer system as the vehicle is driven by a driver. The neural network is thus trained to not only determine the parameters for the correct vehicle heading but also several other eventualities which might arise due to malfunctioning.
@Robots are also finding use in environments too inhospitable for humans. They have been used for radioactive cleanups, mining and even exploring the Antarctica. However, their capabilities at the moment are limited and they invariably rely on human intervention crucial decision making in their operation. This may not be too limiting for terrestrial use but is absolutely disastrous in planetary exploration which is another area of interest. The time delay in receiving and transmitting instructions to the mission control on earth from Mars can be catastrophic. Thus what are needed are completely autonomous systems which can take decisions when faced with unforeseen conditions. This will entail major developments in computer vision, high speed computing, data storage and robust learning systems. Although these are yet to be developed, the rapid advances in the field make the designers confident that it is feasible in the next decade.

From military surveillance vehicles to micromechanical devices, from completely automated manufacturing to decommissioning of nuclear reactors , robots are rapidly becoming indispensable in many areas. The sci-fi image of robots with almost human

capabilities, which have the potential of destroying their creators still remains far fetched. Nevertheless, the next few years promise many developments in the field of robotics which could spurn myriads of applications. These applications hold the promise of revolutionizing life in the next century.