

EXECUTIVE SUMMARY

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- Robotics is a very active field, worldwide.
- Japan, Korea, and the European Community invest significantly larger funds in robotics research and development for the private sector than the U.S.
- There are numerous start-up companies in robotics, both in the U.S. and abroad. Venture capital appears to be available.
- The U.S. currently leads in such areas as robot navigation in outdoor environments, robot architectures (the integration of control, structure and computation), and in applications to space, defense, underwater systems and some aspects of service and personal robots.
- Japan and Korea lead in technology for robot mobility, humanoid robots, and some aspects of service and personal robots (including entertainment).
- Europe leads in mobility for structured environments, including urban transportation. Europe also has significant programs in eldercare and home service robotics.
- Australia leads in commercial applications of field robotics, particularly in such areas as cargo handling and mining, as well as in the theory and application of localization and navigation.
- In contrast with the U.S., Korea and Japan have national strategic initiatives in robotics; the European community has EC-wide programs. In the U.S., DARPA programs are highly applied and short-term oriented, while its support for basic research in robotics has been drastically reduced in the past year.
- The U.S. lost its pre-eminence in industrial robotics at the end of the 1980s, so that nearly all robots for welding, painting and assembly are imported from Japan or Europe. We are in danger of losing our leading position in other aspects of robotics as well.
- Some examples of funding disparities:
 - In Korea, robotics has been selected as one of 10 areas of technology as “engines for economic growth”; the total funding for robotics is about \$80 million per year. By contrast, NSF funding for robotics is under \$10 million per year; funding from other agencies is small. DARPA support is restricted to military robotics.
 - In Europe, a new program called “Advanced Robotics” is about to be funded at about \$100 million for three years.

A summary of the areas of major strength in various aspects of robotics in the U.S., Asia, and Europe is given in Table 1 below. The “INPUT” section refers to the kinds of resources and organizations that produce R&D, while “OUTPUT” refers to the outcomes of research, into key robotic products or applications.

Table E.1
Robotics comparison chart

AREA		DEGREE OR LEVEL OF ACTIVITY			
		U.S.	JAPAN	KOREA	EUROPE
I N P U T	Basic, university-based research (Individuals, groups, centers)	*****	***	***	***
	Applied, industry-based research (corporate, national labs)	**	*****	****	****
	National or multi-national research initiatives or programs	**	*****	*****	****
	University-industry-government partnerships; entrepreneurship	**	*****	*****	****
O U T	Robotic vehicles: military and civilian	****	**	**	**
	Space robotics	***	**	NA	***
	Humanoids	**	*****	****	**
	Industrial robotics: manufacturing	**	*****	**	****
	Service robotics: non-manufacturing	***	***	****	***
	Personal robotics: home	**	*****	****	**
	Biological and biomedical applications	****	**	**	****

NA = Not applicable

OBJECTIVES OF THE STUDY

The purpose of this study was to assess the state of robotics worldwide and to compare the R&D programs in this field between the U.S. and other countries. The comparison was to be based on the criteria of quality, scope, funding and potential for commercialization. In order to obtain a baseline for comparisons, the study was to begin with an assessment of the status of robotics in the U.S.

In order to restrict the study to the level of available funding, the survey was restricted to current efforts in Japan, South Korea, and Western Europe. Clearly, significant work is going on in many other countries, but it was not possible to include them all in this survey. Australia was included by a "virtual site visit," where selected laboratories were requested to answer a series of questions and to provide pictures of the major robotic systems they have developed. Nevertheless, the work in the countries studied provides an excellent overview of work outside of the United States.

An additional objective of the study was to encourage international cooperation in robotics research between the U.S. and other countries. Currently, exchanges of ideas occur primarily at international conferences, but there are few active research collaborations between the U.S. and other countries. By its very nature, there are significant collaborations between member states of the European community.

This report is a presentation of the findings of this study to our sponsors, other U.S. government agencies, Congress and the wider technical community from industry and academia.