БЪЛГАРСКА АКАДЕМИЯ НА НАУКИТЕ. BULGARIAN ACADEMY OF SCIENCES

ПРОБЛЕМИ НА ТЕХНИЧЕСКАТА КИБЕРНЕТИКА И РОБОТИКАТА, 53
PROBLEMS OF ENGINEERING CYBERNETICS AND ROBOTICS, 53

София . 2002 . Sofia

Robots in Austria

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Introduction

The field of robotics is one of the most innovative in the last decade. Conventional, unintelligent, industrial robots from the late 70?s are now only a tool on the production level. The producers of unintelligent, industrial robots had some marketing problems between 1991 and 1993. The num bers of robots sold out worldwide decreases dramatically in these years. In 1990 the worldwide sales of robots reached 81 000 and decreases until 1993 to approximately 54 000 units. From 1993 to 1997 there was an increasing to 85 000 units dropping down in 1998 to 71 000. Reasons were a saturation of the market by industrial robots as well as taking out robots from operation – e.g. 20 000 in Japan (Fig. 1).

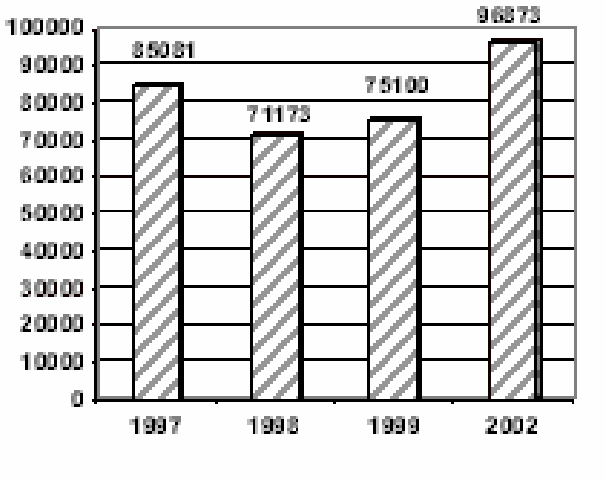

Fig. 1. Yearly installations of industrial robots [2]

Intelligent robots

Nearly at the same time one of the oldest dreams of the robotic community – intelligent, mobile and humanoid robots – starts to become reality because of the rapid development of "external" sensors. External sensors e.g. visual, auditive, force-torque, and others. offer intelligent robots the possibility to see, hear, speak, feel, and smell like humans. Compared to conventional, unintelligent, industrial robots, intelligent robots can fulfill new, innovative tasks in new application areas. The prices for external sensors and for the computer hardware decreases. It was time to develop a new robot generation: Intelligent, mobile, cooperative robots for new fields of applications.

There are three "starting" points for the development of intelligent robots (Fig. 2):

- Conventional stationary robots;
- Mobile, unintelligent platforms (robots);
- Walking machines.

Stationary industrial robots equipped with external sensors are used today e.g. for assembly and disassembly operations, fueling of cars, ..., and were the first "intelligent" robots.

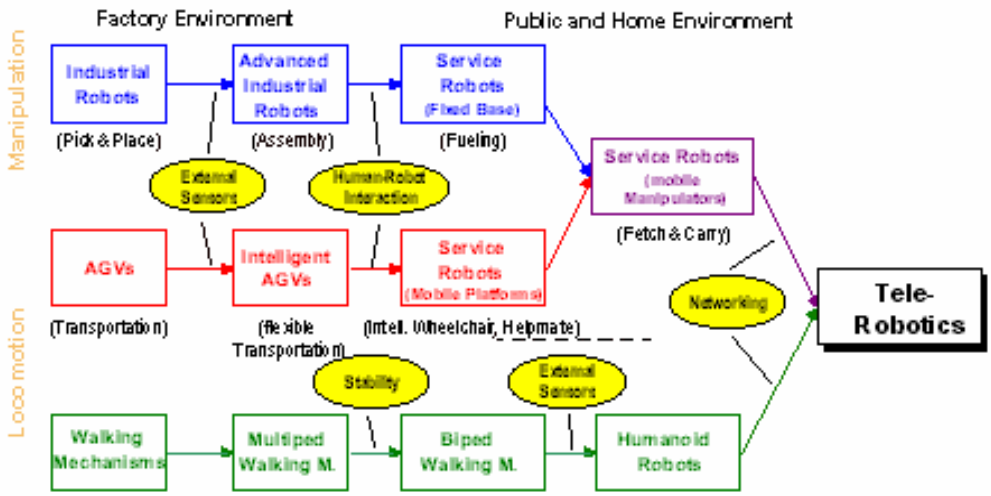

Fig. 2. From industrial to service robotics [6]

Mobile platforms with external sensors are commercially available since some years and covers a broad application field. Mobile platforms are the real roots of service robots. Application examples and further details will be given in the next chapter.

Walking machines or mechanisms are well known since some decades. Usually they have 4 to 6 legs (multiped) and only in some cases 2 legs (biped) – walking on two legs is from the view point of control engineering a very complex (nonlinear) stability problem. Biped walking machines equipped with external sensors are the basis for "humanoid" robots. Some prototypes of such robots are available today.

In addition these intelligent robots – especially mobile platforms and humanoid robots – are able to work together on a common task and form a so called "Multi Agent

System – MAS". A MAS consists of a distinct number of robots (agents), equipped with different arms, lifts, tools, gripping devices, etc. and a host computer. A MAS get a whole task e.g. assemble a car. The host computer in cooperation with his agents divide this whole task in a number of different subtasks (e.g. assembling of wheels, gear, windows, brakes, etc.) as long as all this subtasks can be carried out at least by one agent. The agents will fulfill their distinct subtasks in a cooperative way until the whole task is solved – e.g. the car is assembled.

Servicerobots

First applications of such robots were in the service field – robots in hospitals, museums, the household, hotels and gastronomy, department stores, agriculture, food processing, underwater, space etc.

One of the main problems of producers of such robots is currently the market, but cleaning robots for various tasks, battery and solar-powered lawn moving robots, robots for disabled persons, the robotised waiter, the robot as a watchdog as well as a guide in museums, the robot for transportation tasks and as a surgery assistant in hospitals, fire and bomb fighting robots, robots for handling nuclear material and others are reality and commercially available today.

Worldwide approximately 5000 service robots were only in use at the end of 1998 – compared with nearly 720 000 industrial robots a small number.

For a broad introduction in the market it was to early and the robots were too expensive to reach reasonable lot sizes in production. The development costs for such robots were very high and the first robots were usually single purpose robots, that means special robots only for one task. Examples are robots for maintenance of water channels, for cleaning of jumbo jets, petrol filling robots for cars, and others. Such robots were developed and produced usually by small, new companies and not by the classical robot companies.

The number of industrial robots increases only slow – estimations for 2002 are approximately 800 000 (Fig. 3). The number of service robots is dramatically increasing – estimations for 2002 are approximately 30 000 plus 450 000 vacuum cleaning robots.

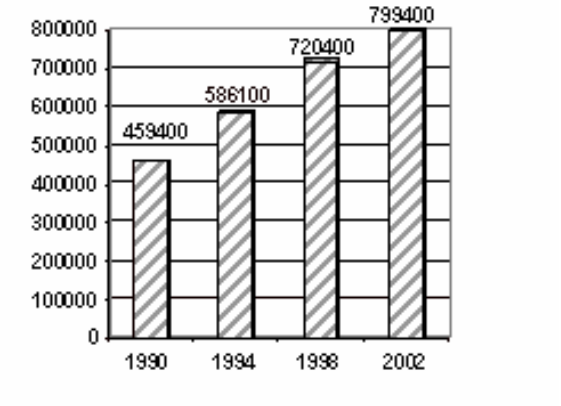

Fig. 3. Operational stock of Industrial robots [2]

Robots in entertainment, leisure and hobby

One of the newest application area of servicerobots is the field of entertainment, leisure and hobby because people have more free time, modern information technologies yield to loneliness of the humans (teleworking, telebanking, teleshopping, ...). We need robots to assist, support and join humans. The field “robots in entertainment, leisure and hobby” was born. The roots of such robots goes back more than 20 years ago. First examples were “Maildog” a guiding robot for blind people, robots or teleoperators in movies e.g. Jurassic park, or “Ralphie” one of the first toy robots.

Entertainment robots are expected to be one of the real frontiers of the next decade. According to the last estimations we will have millions of such robots in use in the next years. Today we have available a guitar playing robot, the robot band “MUBOT” and several robot theater companies.

Humanfriendly robots

Newest developments are “friendly” robots for humans. For example, elderly people need listening and talking to friends. We have now dogs, cats, humanlike robots for reasonable prices available but not really humanoid robots walking on two legs.

A well known example is the robot dog AIBO (***A***rtificial ***I***ntelligence ro***BO***t). He is the first entertainment robot that can think, feel and act by himself. He can walk and play, sit and stretch like dogs and cats. AIBO`s brain contains an emotion model – to handle feelings – and an instinct model – to handle drives. The emotion model covers six feelings: happiness, sadness, anger, surprise, fear and dislike. The instinct model has four components: love, search, movement and hunger.

Another company designed a prototype of a personal robot to be a partner for people in their homes with its ability to recognize people, understand voice commands and talk with users. This robot provides a much more natural, button-less interface for people to a variety of electronic appliances while supporting communication between people. Its seen by the producers as the future of computing at home.

Therefore servicerobots will become a real “partner” of humans in the nearest future. One dream of the scientists is the “personal” robot. In 5, 10 or 15 years everybody should have at least one of such a robot. Because the term personal robot is derived from personal computer the prices should be equal. Some new ideas in automation especially in robotics are realized very fast while others disappears.

Competition robots

A special group are robots for competitions. Classical examples are:

Robot outdoor tournaments,
Robot soccer,
Ping Pong playing robots
Robot wrestling,
Sumo wrestling robots
Billiard robots.

This list will be much longer in the nearest future. As an example robot soccer will described in more details.

Robot soccer

Robot soccer was created 5 years ago in Korea and Japan. From the scientific point of view, robot soccer is one of the first application of a MAS. The players – robots or agents – have to solve the common task – win the game.

A soccer robot is an excellent example of mechatronics. Its main parts are wheels, drives, a power source, a microprocessor and a communication module – all these parts have to be included in a very small volume (e.g. a cube 7.5 x 7.5 x 7.5 cm or 4.0 x 4.0 x 5.0 cm). The soccer robots of a team (between 1 and 5 players) are controlled by the team computer.

The Robot itself has a drive mechanism, power supply, electronic part for control the robot behavior as well as the communication. Mostly the digital PID-controller is used. The problem is the setting of the controller parameters. Therefore Fuzzy control and neural networks [5]are applied to adapt the parameters.

Fig. 4. Overall view of robot soccer

Main problems are the power sources of such robots. Usually batteries are approximately 50% of the weight of the robot and have only a “life” time between 3 and 10 minutes. The recharging time for such batteries is between 2 and 12 hrs.

Worldwide there are already more than 100 teams competing and the next World Championship will take place in Rockhampton (Australia) in September 2000.

As pointed out earlier a soccer robot is a excellent example for interdisciplinarity. For construction and manufacturing of the body knowledge of mechanical and because of the small dimensions precision engineering is required. Electrical as well as control engineering is necessary for the drives and the power source. The control and communication board of the robot is more or less applied electronics. As an internal controller serves a microprocessor. It is also responsible for the wireless communication with the host computer. For these task and for the software of the host computer fundamental knowledge in computer science is necessary. The software of the host computer include on line image processing, game strategies, control of the own players, communication with these and together, user interface.

Development of a robot soccer team is therefore a teamwork of specialists from various disciplines – having different thinking and a different language. The project leader

have to harmonize such a team and must have at least basic knowledge of all these necessary subjects.

One possibility to go into a broader market is to replace conventional games in amusement parks and restaurants. Therefore, as a first step into this direction, the software had to be adopted to also use a joystick to control each robot player. This offers the following possibilities for playing:

– Humans against humans (both teams controlled by joysticks)

– Humans against computer (only one team controlled by joysticks)

– Computer against computer (state of the art)

In contrast to the soccer video games this new technology offers a “real life” feeling similar as in the soccer stadium.

Until now the robots are completely unintelligent they have no sensors and are controlled by the host computer. In the future robots will be more and more intelligent and will be equipped with different sensors (ultrasonic, infrared, laser, etc.). This offers the possibility for the robots to adapt the commands of the host computer.

Next developments will be towards humanoid soccer players. As a first step some producers are offering robots with 4 or 6 legs to a high price. Probably in some years we will have players with two legs available – then we can start with the first soccer games humans against robots.

New control tasks

New robot generations create new tasks for robot control. Position control of classical industrial robots is an established research field since the early 70-ties. A lot of new control algorithms were developed and known control algorithms were applied for robot control. The main task of a robot controller was and is the position control.

Most of the service robots are mobile. Mobility requires also position control but not only for the robot links the main task is the position control of the whole robot. This requires the use of a lot of information from external sensors in the controller. Additional tasks for control of mobile robots are path planning, collision avoidance and others. Mobile robots have to work in an unknown environment with static as well as dynamic obstacles. The position of static obstacles like walls, doors, furniture, machine tools could be usually learned by the robot. After a distinct time of operation the robot has a map of its working environment stored.

Moving obstacles in the service sector are humans, animals and other robots. For such a “dynamic” environment modern control strategies are necessary for path planning as well as collision avoidance.

For example the working environment of a soccer robot – as an agent in a MAS – consists of static obstacles – the walls of the playground – and of moving dynamic obstacles 5 other robots and a ball. The main task of the soccer robot is:

– to recognize the usually fast moving ball,

– to estimate the future position of the ball,

– to determine his position relatively to the opponent goal,

– to find the optimal path to bring the ball near or in the goal,

– to realize the task under disturbance of other players - agents.

All the calculations have to carried out “on line” – the speed of the robots are up to 2.5 m/s, the speed of the ball approximately 4 m/s – new tasks for the robot controller and an application area for “advanced” control algorithms and strategies.

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Роботы в Австрии

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(Р е з ю м е)

На рынке сегодня можно найти мобильные и интеллигентные роботы. Число роботов, которые в применении, драматически увеличивается в последных годах. Одна из основных областей применения – "Забавления, отдых и хоби".

Это создает новые задачи управления. Первые шаги в этом направлении уже сделаны, но мы предлагаем возможность применения новых стратегий управления.

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