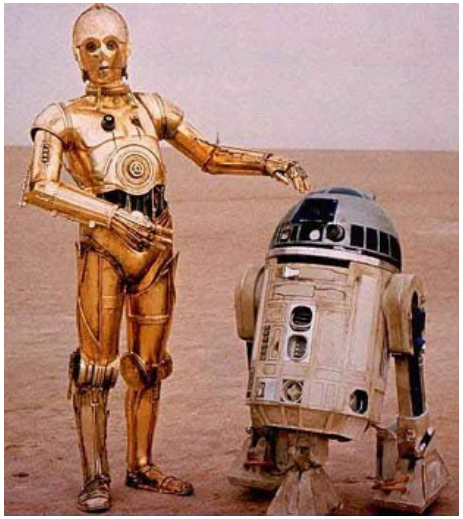
Service Robots for Special Tasks



Yvonne Löhr, Timon Giese, Lorna Slawski

Overview

1. Introduction
    (a) Definition
    (b) Some Examples for Service Robots
2. Certain Applications
    (a) Educational Robots
    (b) Surgery and Rehabilitation Robots
    (c) Guides and Office Robots
    (d) Cleaning and Housekeeping Robots

Definition Service Robots

Definition Service Robots:
A robot which operates semi or fully autonomously to perform services useful to the well being of humans and equipment, excluding manufacturing operations.

Classification:
- Servicing humans (personal safeguarding, entertainment etc.)
- Servicing equipment (maintenance, repair, cleaning etc.)
- Other performing an autonomous function (surveillance, transport, data acquisition, etc.) and/or service robots that can not be classified in the above two groups.

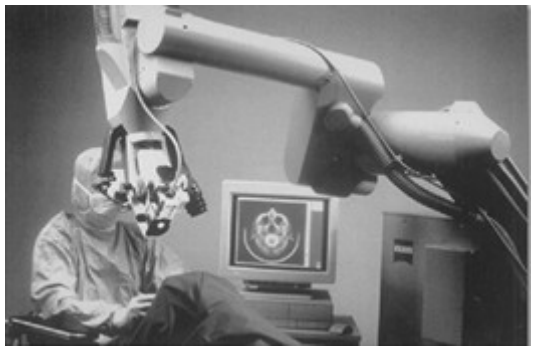
Source: http://www.ifr.org/modules.php?name=News&file=article&sid=14 (IFR)

Some Examples for Service Robots

Servicing Humans



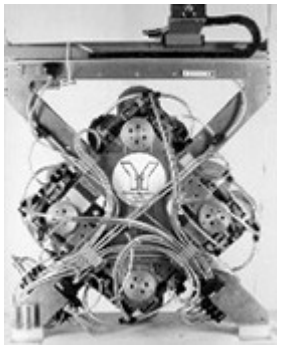




Source: http://www.ifr.org/modules.php?name=News&file=article&sid=14

Some Examples for Service Robots

Servicing Equipment



Source: http://www.ifr.org/modules.php?name=News&file=article&sid=14

Some Examples for Service Robots

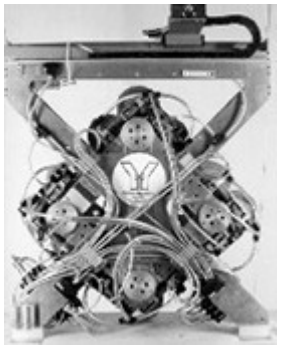
Other service robots, performing an autonomous function




Source: http://www.ifr.org/modules.php?name=News&file=article&sid=14

Some Examples for Service Robots

Servicing Equipment



Source: http://www.ifr.org/modules.php?name=News&file=article&sid=14

Educational Robots

Definition (in our service robotic context)

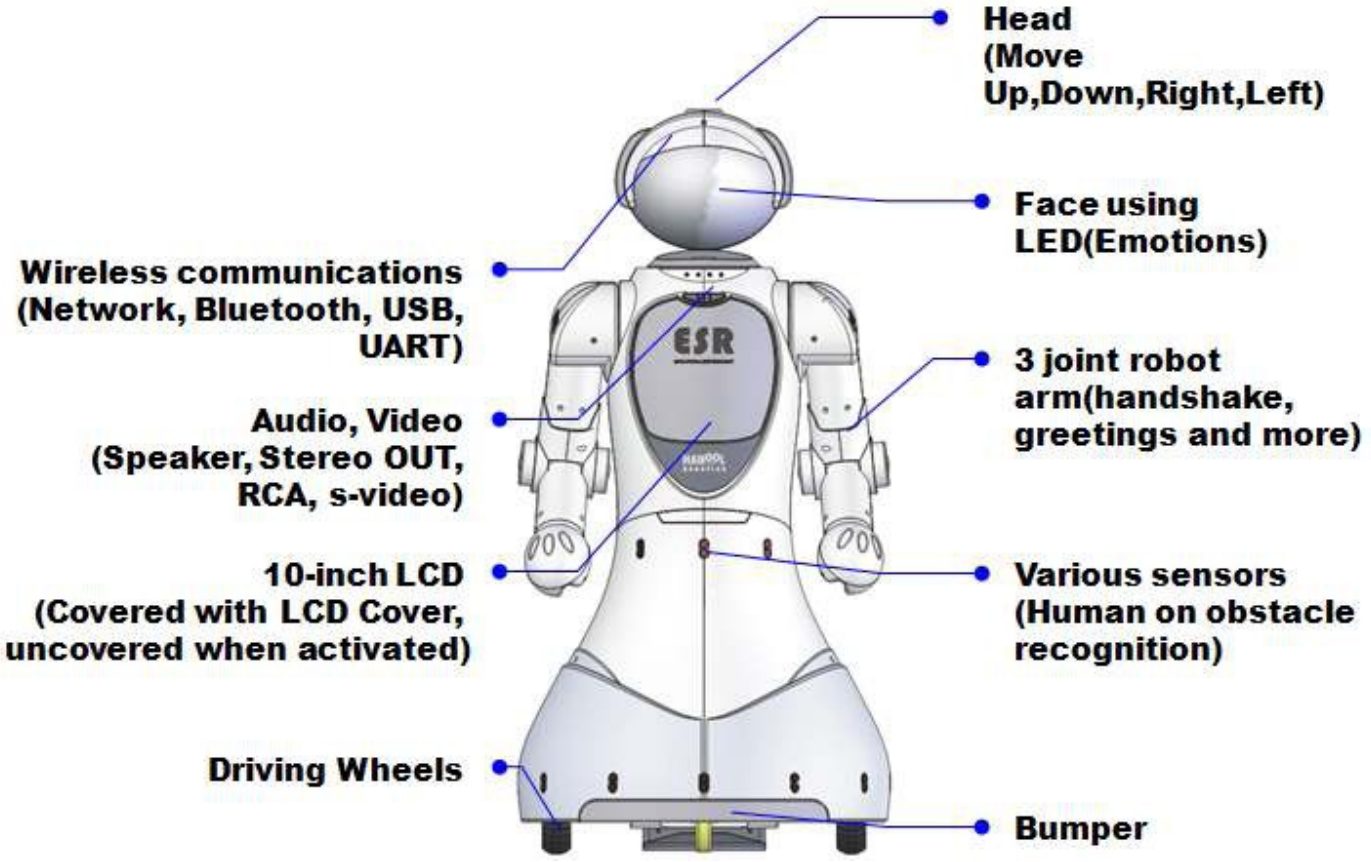
A robot with the task to teach a human being

Educational Robots

Tiro

„Tiro, the robot, makes teaching debut in South Korean classroom“
dpa German Press Agency Published: Saturday October 6, 2007 press

specifications



Educational Robots

E3

Education

Entertainment

Emotion

video1
video2
video3

Developed for:
-Education (english teaching)
-Housekeeping
-Entertainment
-Babysitting

developer page

(b) Surgery and Rehabilitation Robots

(1) Robotic Surgery

- (a) From conventional Minimally Invasive Surgery (MIS) to Robotic Surgery
- (b) Unmanned Robotic Surgery
- (c) Master-Slave Robotic Surgery

(2) Robotic Rehabilitation

- (a) Prostheses
- (b) Exoskeletons
- (c) Remote Presence
- (d) Nurse Robots

(b) Surgery and Rehabilitation Robots

Robotic Surgery

Robotic surgery is the use of robots in performing surgery.

Source: http://en.wikipedia.org/wiki/Robotic_surgery

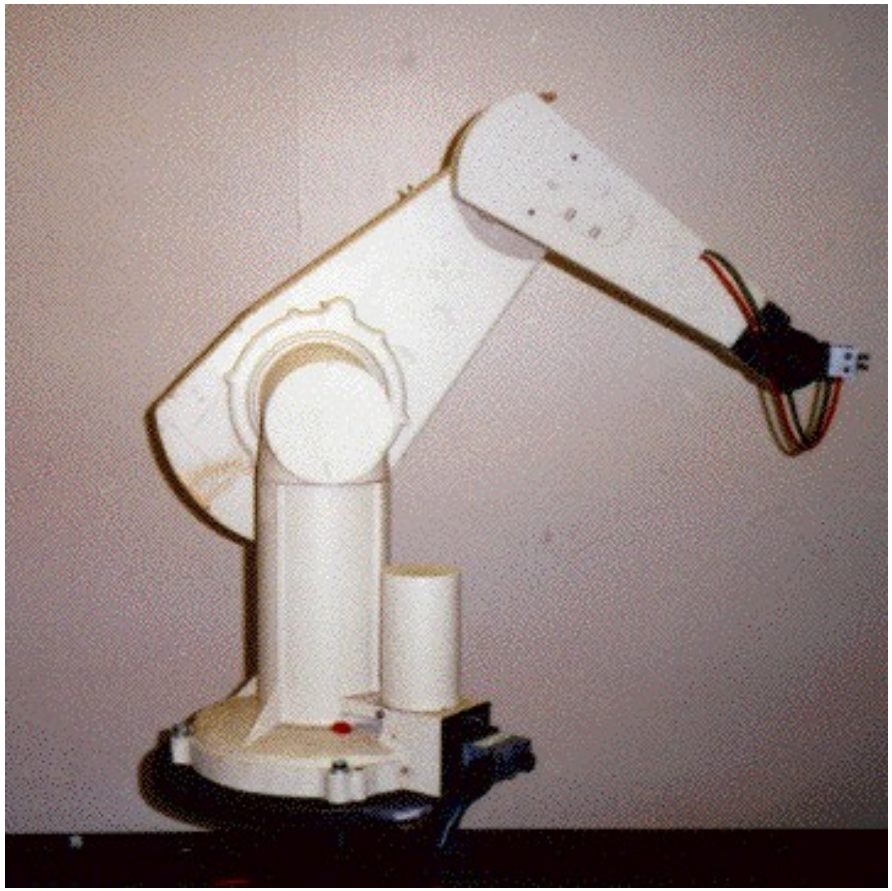
From MIS to Robotic Surgery

Minimally Invasive surgery
Advantages
• less pain
• incisions are smaller
• decreased risk of infections
• shorter hospitalization time

Disadvantages
• haptic feedback (force and tactile) is only given visually => handicapted hand-eye-coordination
• Instruments offer fewer degrees of freedom than the human hand has

Motivation for Robotic Surgery
• Robots are able to work highly precise
• Robots were commonly used in the manufacturing industry -> Available technology

Unmanned Robotic Surgery



PUMA 560 developed by Unimation

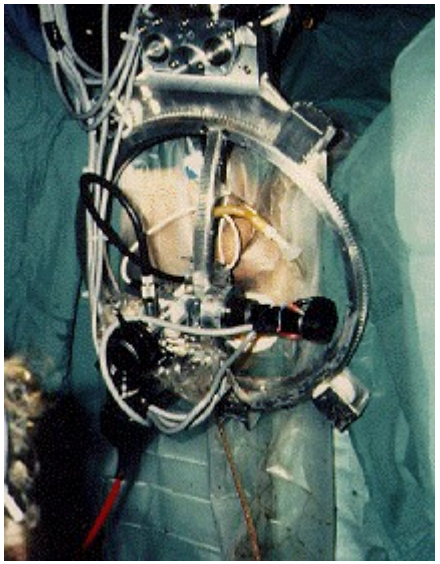
- Industrial robot manipulator
- 6 degrees of freedom
- End-effector can reach a point within its workspace from any direction

1985: San Kwoh et al make the Puma 560 place a needle for a brain biopsy using Computed Topography (CT) guidance

1987: Davies et al use the PUMA 560 for a prostate cancer removal

PUMA 560
http://www.youtube.com/watch?v=mK7N2sFxE7U&feature=related (1'19)

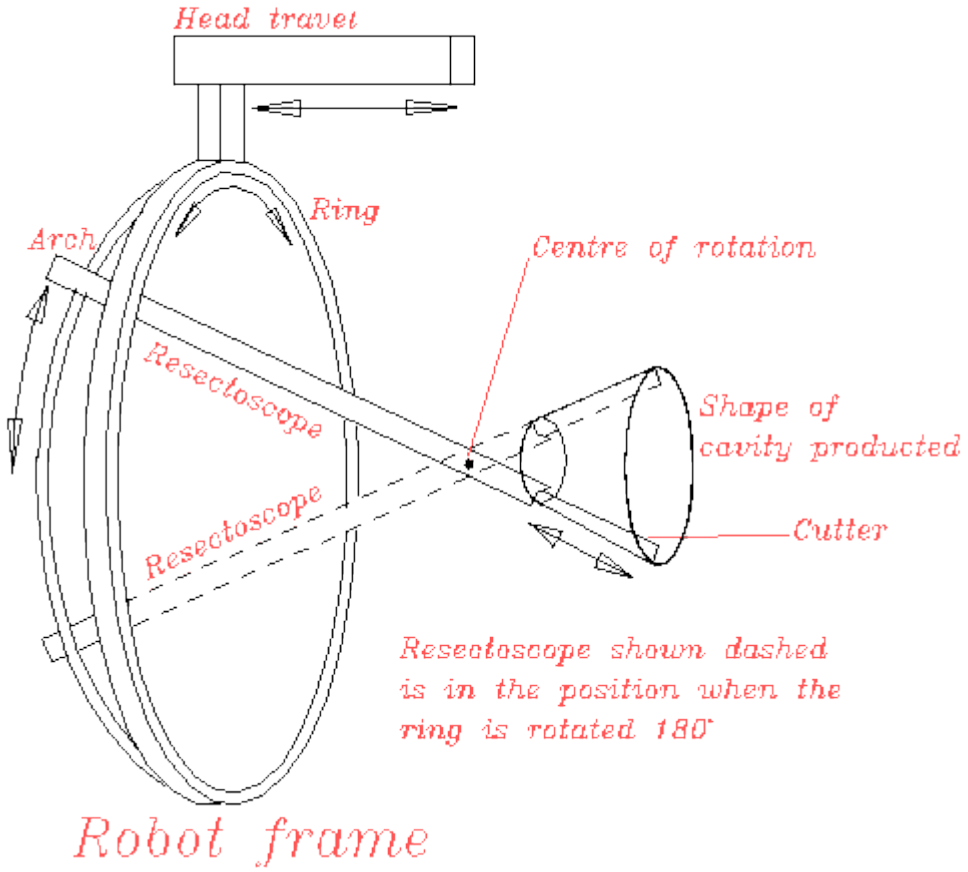
Unmanned Robotic Surgery



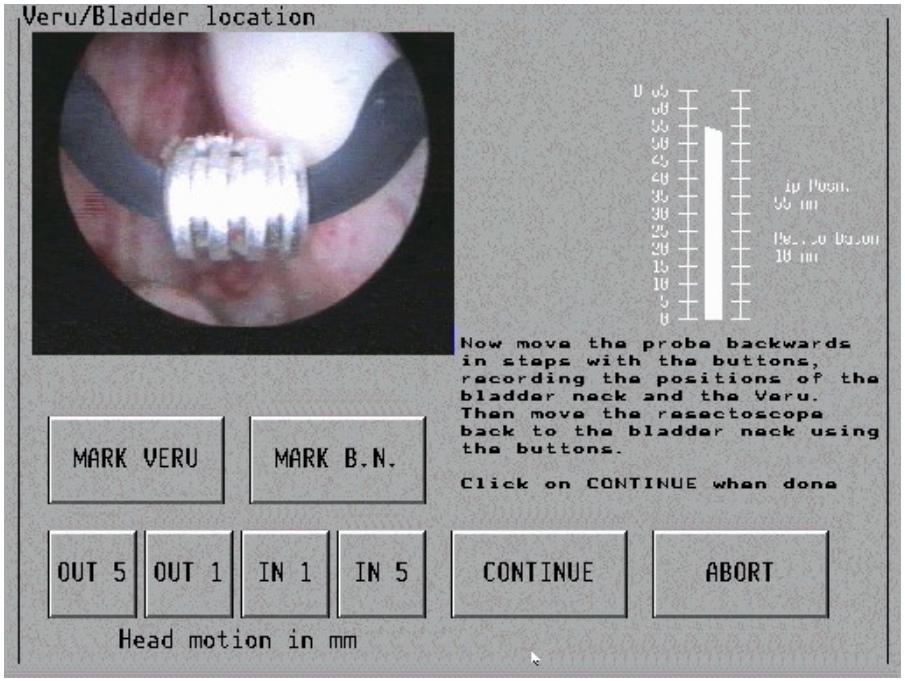
PROBOT developed by Davis and his group at Imperial College of London

- Robot for Prostate surgery
- 3 axes of movement and a fourth one to move the cutter
- controlled by a pair of programmable embedded motor control systems, which are in turn controlled by a 486-based PC.

Unmanned Robotic Surgery



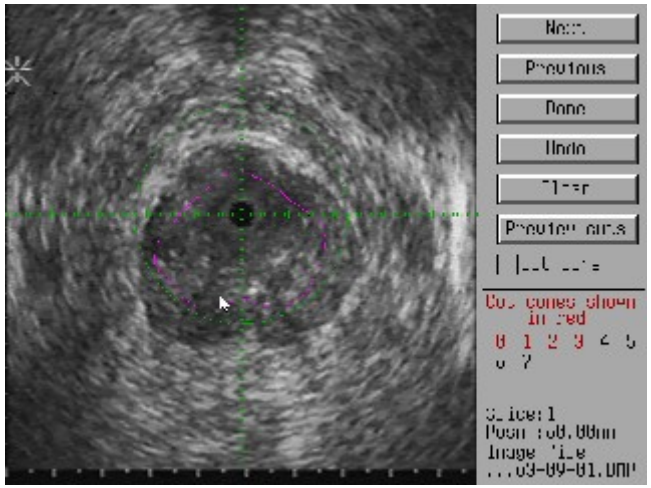
Unmanned Robotic Surgery

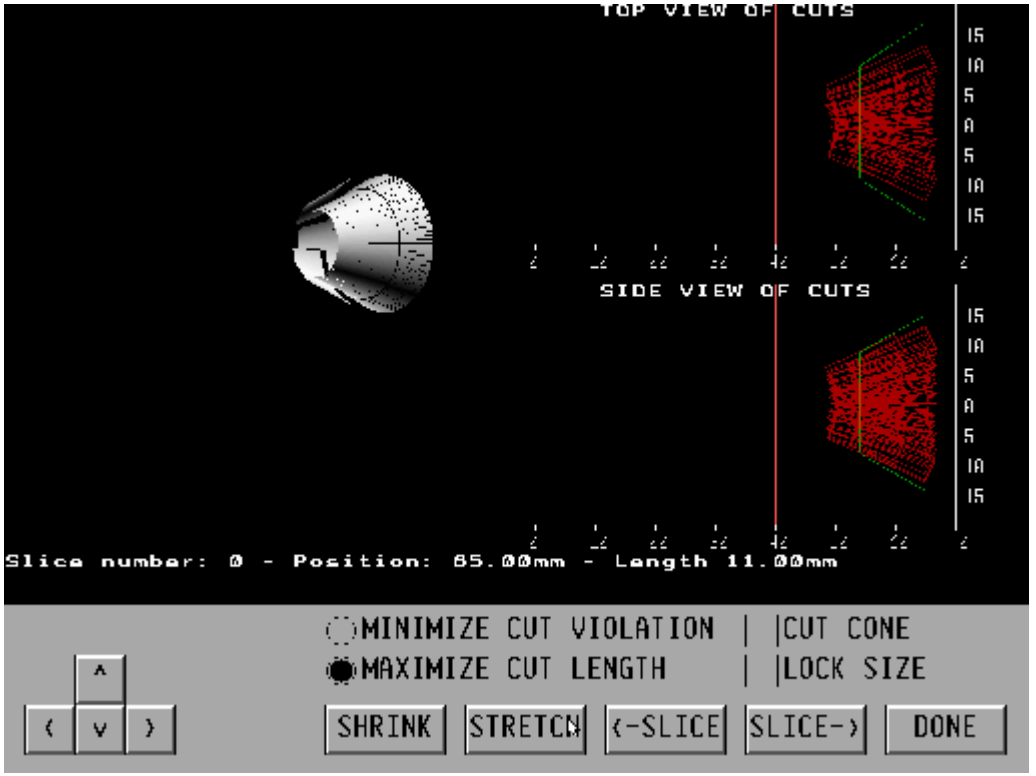


During measurement phase the surgeon moves the robot inside the patient's prostate to mark certain parts.

At next the robot builds up a three dimensional ultrasound image of the prostate.

Unmanned Robotic Surgery

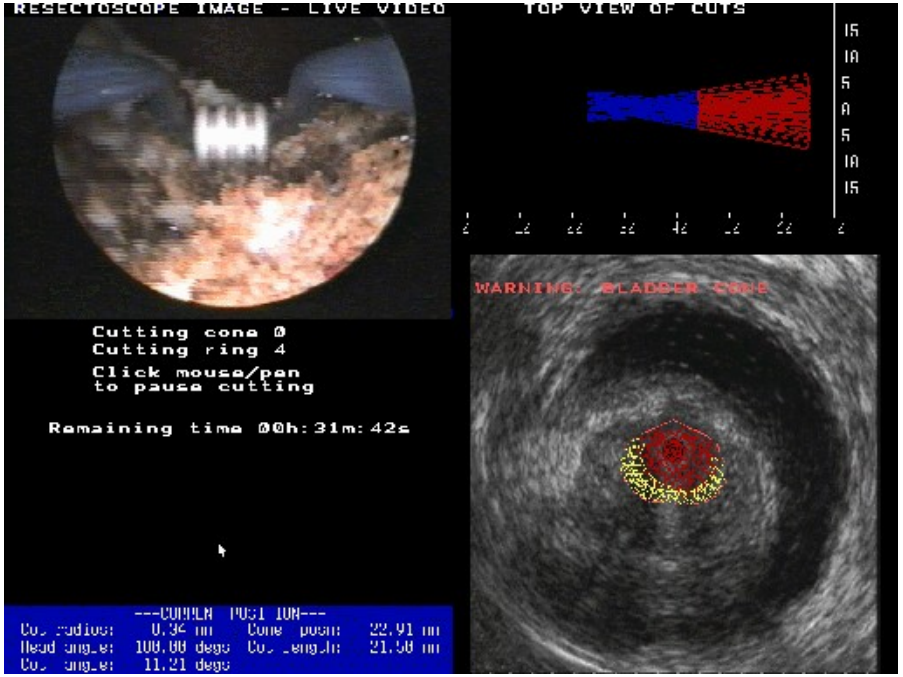




Then the surgeon outlines the cutting volume on the three-dimensional ultrasound image.
As it can be seen on the right image the surgeon can adjust the cutting cones.

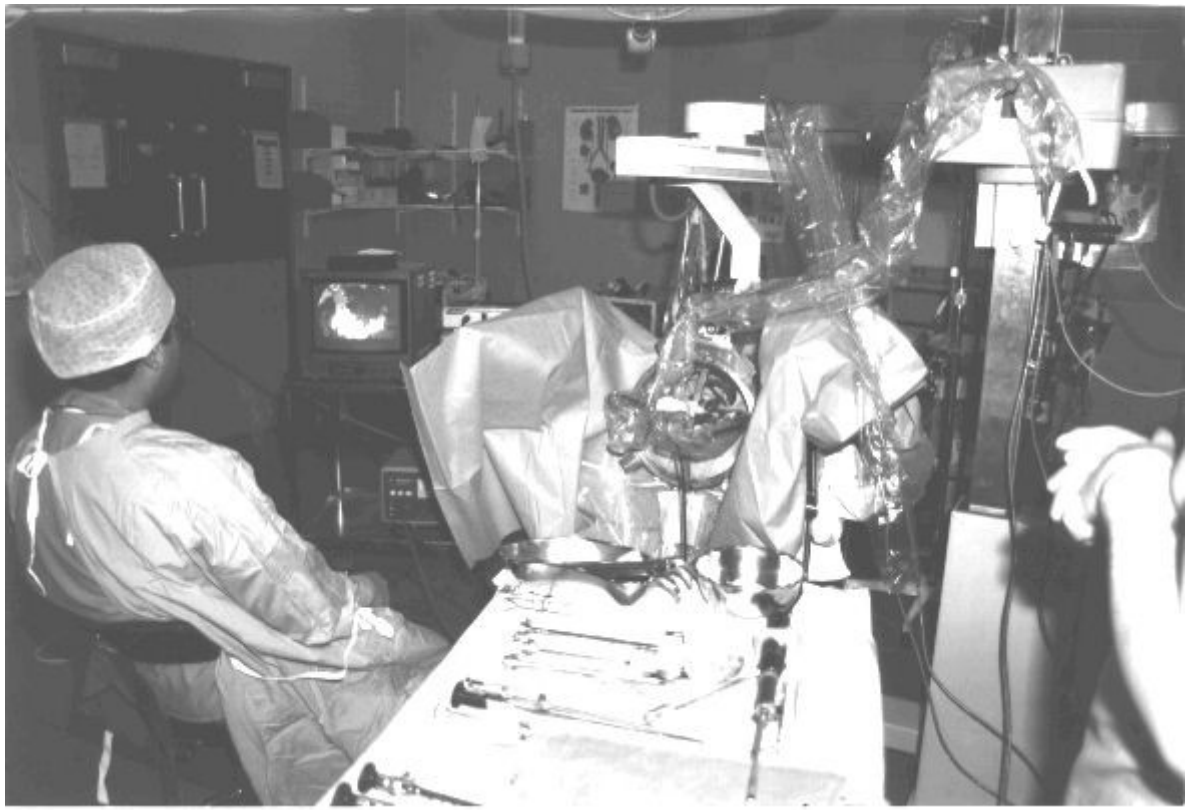
PROBOT Software

Unmanned Robotic Surgery



During cutting phase the surgeon can watch the real-time image, a schematic view of the cutting process and the ultrasound image.

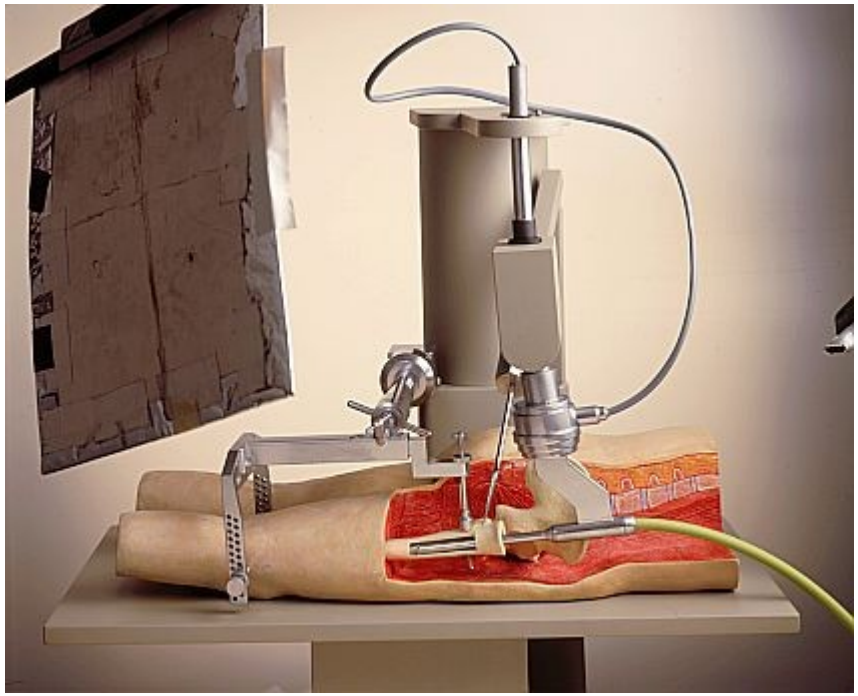
Unmanned Robotic Surgery



At any time the procedure can be aborted or interrupted to adjust parameters.

After having received the necessary information the Probot works autonomously.

Unmanned Robotic Surgery



Robodoc developed by Integrated Surgical Systems (ISS) Ltd of Sacramento (CA)

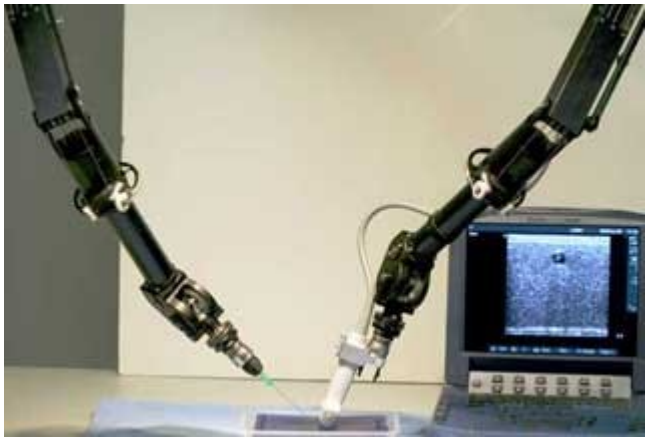
- modified industrial robot for hip surgery
- first surgical robot to be approved by the FDA (US Food and Drug Administration).
- Software Orthodoc is needed
- Cut away too much of the gluteus => lead to many lawsuits

Unmanned Robotic Surgery

Computert Assisted Surgical Planning And Robotics (**CASPAR**) was developed by ortoMaquet in Rastatt

- autonomous surgical robot for knee surgery
- successfully used for hip-surgery

Master-Slave Robotic Surgery



M7 was developed at Stanford Research Institite and tested by the US Army and the National Aeronautics and Space Administration (NASA) in parabolic flights

- 4,5 kg weight for each arm
- Robot is powered by the same system as the aircraft
- can be operated by a single surgeon, who views the procedure through a camera installed between the arms and uses a remote control to manipulate them
- compensates accidental movement

M7
http://de.youtube.com/watch?v=EsqdKUk63Js (3'06)

Master-Slave Robotic Surgery

Automated Endoscopic System for Optimal Positioning (**AESOP**) was developed in 1994 by Computer Motion Inc of Santa Barbara(USA).

- robotic arm controlled by surgeon voice commands to manipulate an endoscopic camera
- provides a motionless image

AESOP
http://de.youtube.com/watch?v=vU_4zhph93w (7'29)

Master-Slave Robotic Surgery

Zeus surgical system was developed in 1995 by Computer Motion Inc for remote surgery

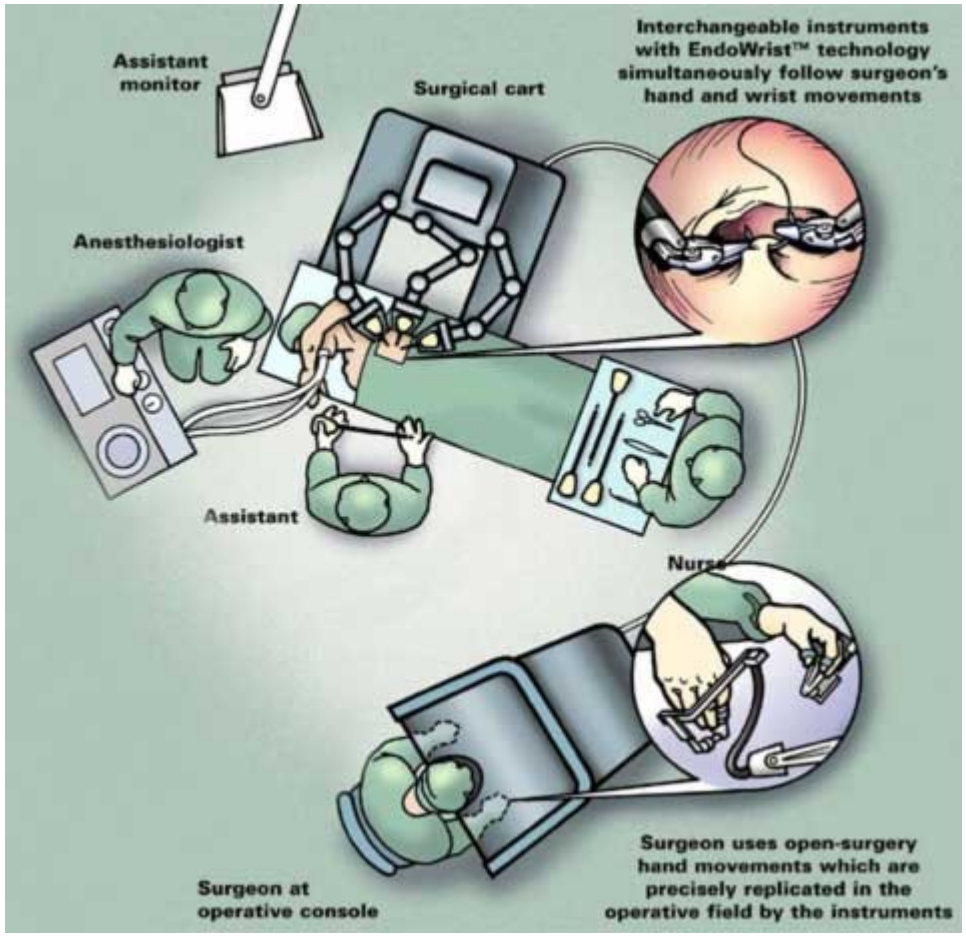
- First transatlantic remote surgery in 2001 (gall bladder removal).
- approved by the FDA in 2002 for use in general and laparoscopic surgeries with the patient and surgeon in the same room
- surgeon control console and 3 table-mounted robotic arms
- right and left robotic arms replicate the arms of the surgeon, the third arm is an AESOP endsocope
- uses instruments similar to conventional endoscopic instruments and jointed instruments with end-effectors offering 7 degrees of freedom

Master-Slave Robotic Surgery

In 2003 Intuitive Surgical Inc. merged with Computer Motions Inc. In favor of the Da Vinci surgery system the ZEUS system is no longer sold.

ZEUS, robot planned by Leonardo da Vinci

Master-Slave Robotic Surgery



Da Vinci robotic surgery system was developed by Intuitive Surgical Inc. (formerly Integrated Surgical Systems)

- first system to be approved by the FDA for general laparoscopic surgery in 2000
- used for prostate, cardiac, gynecologic, laparoscopic and thoracic surgical procedures
- surgeon has the 3-dimensional view given by the endoscope while controlling the patient-side cart's three or four robotic arms (depending on the model)
- camera always looks on top of the instruments to give a natural hand-eye-coordination

Da Vinci
http://video.google.com/videoplay?docid=4013743839854966148 (1'07)

Master-Slave Robotic Surgery

• Motion scaling and tremor reduction interpret and refine the surgeon’s hand movements
• scaling can be adjusted to the surgeon's preferences and needs
•With the foot pedals the surgeon controls the camera focus and the instrument and arm clutches
•The assistant has the surgeon's view on a separate monitor and can change the instruments when necessary.

Da Vinci
http://video.google.com/videoplay?docid=4013743839854966148 (1'07)

Master-Slave Robotic Surgery

The instruments' jointed-wrist design enables the surgeon to reach targets from any direction.
It has 6 degrees of freedom and can pick up objects.

Da Vinci
http://video.google.com/videoplay?docid=4013743839854966148 (1'07)

(b) Surgery and Rehabilitation Robots

Robotic Rehabilitation

Rehabilitation is an activity which aims to enable a disabled person to reach an optimum mental,
physical, and/or social functional level. Thus, rehabilitation robotics deals with robot technology to
provide physically and mentally disabled people with tools to improve their quality of life.

Source: http://www.certec.lth.se/doc/roboticsin/

Prostheses

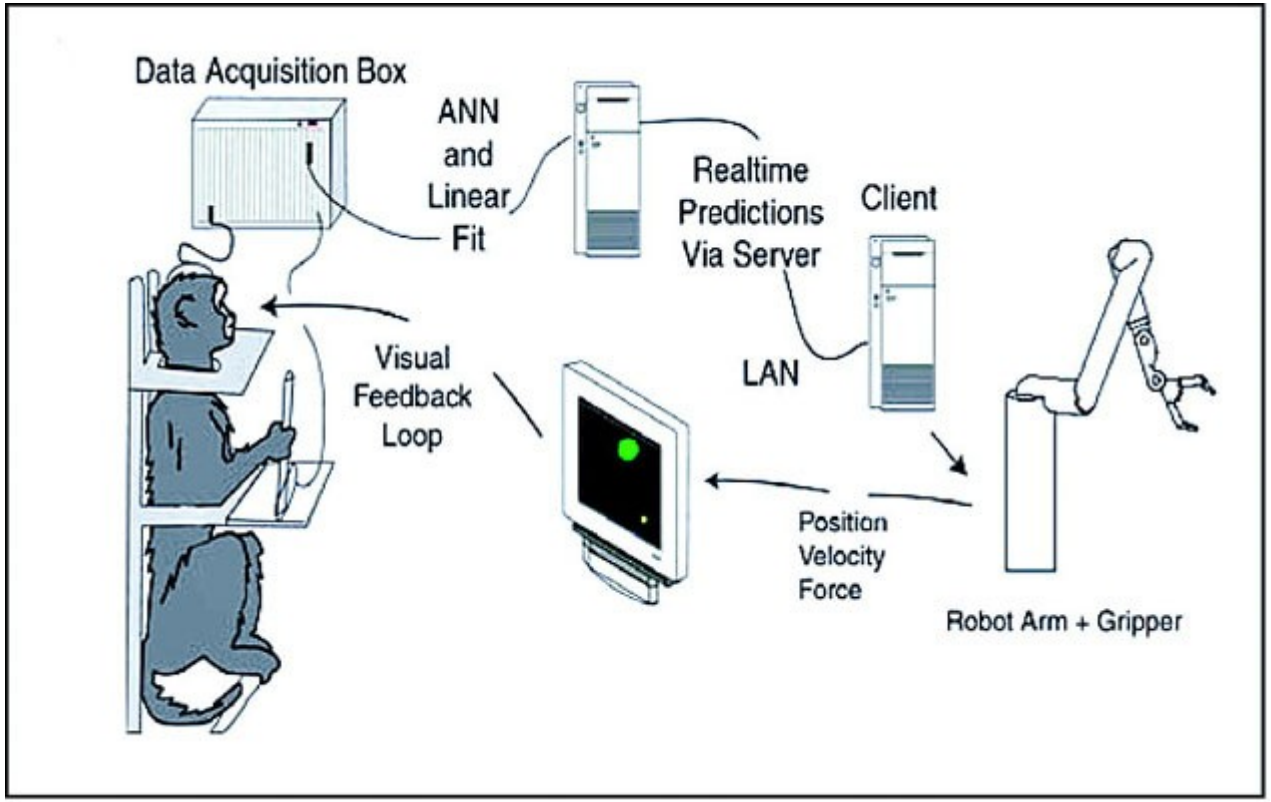
Biomechatronics is an applied interdisciplinary science that aims to integrate mechanical elements in the human body, both for therapeutic uses (e.g. artificial hearts) and for the augmentation of existing abilities.

Current approach for robotic prosthesis is to use a Brain-Computer-Interface to control the actuator.

A brain-computer interface (BCI), sometimes called a direct neural interface or a brain-machine interface, is a direct communication pathway between a brain(or brain cell culture) and an external device.
Examples include wires that detect electrical activity on the skin, needle electrodes implanted in muscle, or solid-state electrode arrays with nerves growing through them.

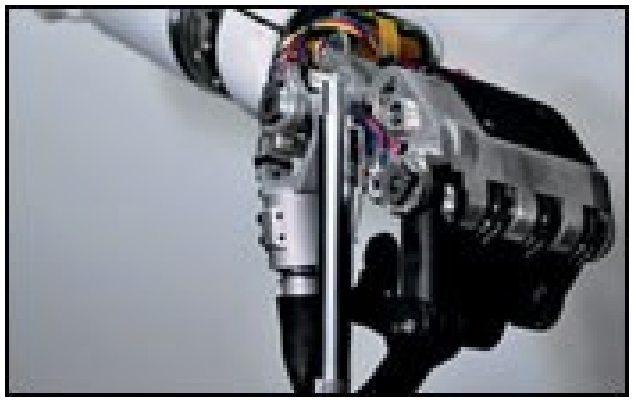
Source: http://en.wikipedia.org/wiki/Biomechatronics
http://en.wikipedia.org/wiki/Prosthesis
http://en.wikipedia.org/wiki/Brain-computer_interface

Prostheses



http://www.youtube.com/watch?v=i0jhPp3-b14 (9'15)

Prostheses



Defense Advanced Research Projects Agency (DARPA) is currently working on a **robotic prosthetic arm**.

The goal is an artificial limb with the same size, weight, and dexterity as a real arm.

Sensors are placed into the flesh to look for bioelectrical activity in a muscle contraction and are used to control the robotic prosthetic arm.

DARPA Robotic prosthetic arm

Prostheses

Isella is a bionic arm being developed at the Fraunhofer Institute .

- controlled by two motors to verify a higher rate of safety against uncontrolled movements
- was inspired by elephant trunks
- has over 40. 000 artificial muscles

Exoskeletons

The Hardiman

Exoskeletons are worn by the human operator as an orthopedic device. Its joints and links correspond to those of the human body. They can be used for automatic physiotherapy and as amplifiers for the human force and movement.

The Hardiman was the first exoskeleton to be developed by General Electric in the 1960s.

Exoskeletons

Berkeley Lower Extremity Exoskeleton (**BLEEX**)

- mechanical metal legs
- power unit
- Backpack to carry a large load
- pilot controls BLEEX by moving his body
- no special training needed
- System reduces shock forces on the user's body
- Control algorithms constantly calculate how to move the exoskeleton so that it moves in concert with the human

BLEEX
http://de.youtube.com/watch?v=EdK2y3lphmE (4'31)

Exoskeletons

Wearable Energetically Autonomous Robots (**WEAR**) developed by Raytheon Sarcos Research Corporation

- designed with legs, torso and arms
- combination of sensors, actuators and controllers
- amplifies human force and speed

WEAR
http://de.youtube.com/watch?v=Nhj3Z9o6t0g (1'13)

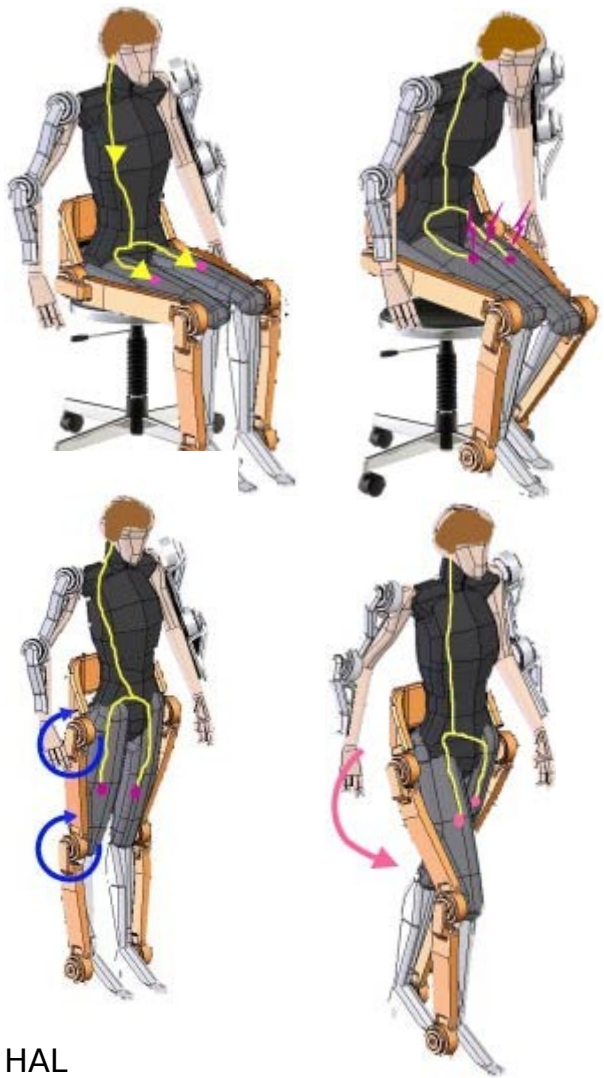
Exoskeletons

Hybrid Assistive Limb (**HAL**) was developed by Cyberdyne and currently released

- designed to expand and improve physical capability
- Height: 160 cm
- Weight: 15 kg (lower body part) and 23 kg (full skeleton)
- Operating time: 2h 40min

HAL
http://de.youtube.com/watch?v=sE9MLbLgC7M (2'32)

Exoskeletons



HAL
http://de.youtube.com/watch?v=sE9MLbLgC7M (2'32)

Hybrid control system:

- 'voluntary control system': biosignals are detected on the pilot's skin, the wearer's intention is interpreted movement is provided
- 'autonomous control system': the humans' movements are collected in a database and a complex motion is recognized on an initial aggregate of movements
- autonomous robotic control system' is used if there are very weak or no biosignals

HAL's movement is explained on the manufacturer's homepage:
http://www.cyberdyne.jp/english/robotsuithal/m

Exoskeletons

Walking Assist Device (**WAD**) developed by Honda in 2008

- aims to enable physically weak persons to walk
- Designed using experience on human walking made with ASIMO
- saddle, leg-like frames and shoes
- Reduction of load on users' legs while walking or climbing and descending stairs by supporting body weight
- Weight: 6,5 kg

WAD
http://www.youtube.com/watch?v=pp4XUvgqkbU (2'02)

Remote Presence

Remote Presence is the ability to project yourself to another location (without leaving your current location) and to move, see, hear and talk as though you were actually there.

Source: http://www.intouchhealth.com/products.html

Remote Presence

Sister Mary invented at Imperial College of London and is tested out at St.Mary's hospital in London.
It's height is about 162 cm and it weighs 98 kg.
The robot is controlled remotely via Wireless Network by a doctor, whose face appears on the monitor.
It runs on Windows XP.

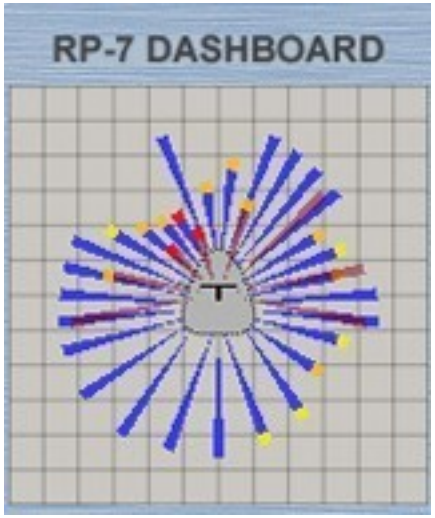
Remote Presence

The mobile robotic platform **RP-7** developed by Intouch Health

• controlled by the person sitting at the control station
• control station: software, camera, microphone, speaker and joystick
• Controller maneuvers the robot
• two-way-communication.

RP-7
http://www.youtube.com/watch?v=33Mu7mpSzH8 (5'50)

Remote Presence



- Infrared Sensors to avoid collisions
- The RP-7 can be extended with printers e.g.

RP-7
http://www.youtube.com/watch?v=33Mu7mpSzH8 (5'50)

Nurse Robots

Pearl was developed at Carnegie Mellon University in Pennsylvania and at the University of Michigan in 2002

- used in a home for elderly people in Oakmont, Pennsylvania for entertainment
- ultrasound and laser for orientation
- speaks and displays messages on a touch-sensitive screen in very big type
- has evolved several discussions about man-machine-interaction

Pearl can tell jokes, one is: "*Why did the jellybean go to school*?" - "*Because she wanted to become a Smartie*. "

Nurse Robots

Help Mate was developed by Joe Engelberger (Unimation) and Pixys in 1997. Now it is distributed by Cardinal Health Inc.

- Height: 121 cm, weight: 272 kg
- Light Improved Direction And Range (LIDAR) scanner (18 sensors) for autonomous navigation in quasi-structured environments not needing an external guidance system
- Central robot management through a monitoring system to determine location, status, and project destination arrival times
- Robots can communicate via WLAN with each other (=> Robot Convoy DARPA MARS)

Helpmate
http://www.youtube.com/watch?v=jwYNXS3S8kw (1'22)

Nurse Robots

Alicebot is a modified Samsung Cleaning Robot

- Hospital courier service, nurse assistance and patient communication
- First versions has been recognized as too small for certain tasks
- Software implemented by Robot-Hosting
- Nurse knowledge base is being developed at Auckland University (New Zealand)
- Alice AI is used in the natural language processing unit
- Speaks 8 languages
- Shall be controlled by several server clusters

Nurse Robots

This Nursebot was developed in Spain to help the elderly in their homes.

The Intelligent Robot Swarm for Attendance, Recognition, Cleaning and Delivery (**IWARD**) project which was funded by the European Comission uses it to make robots work in swarms.

- Each robot carries sensors and equipment for different jobs
- Via direct communication robots assign themselves or each other for relevant tasks

Nursebot used by the IWARD project

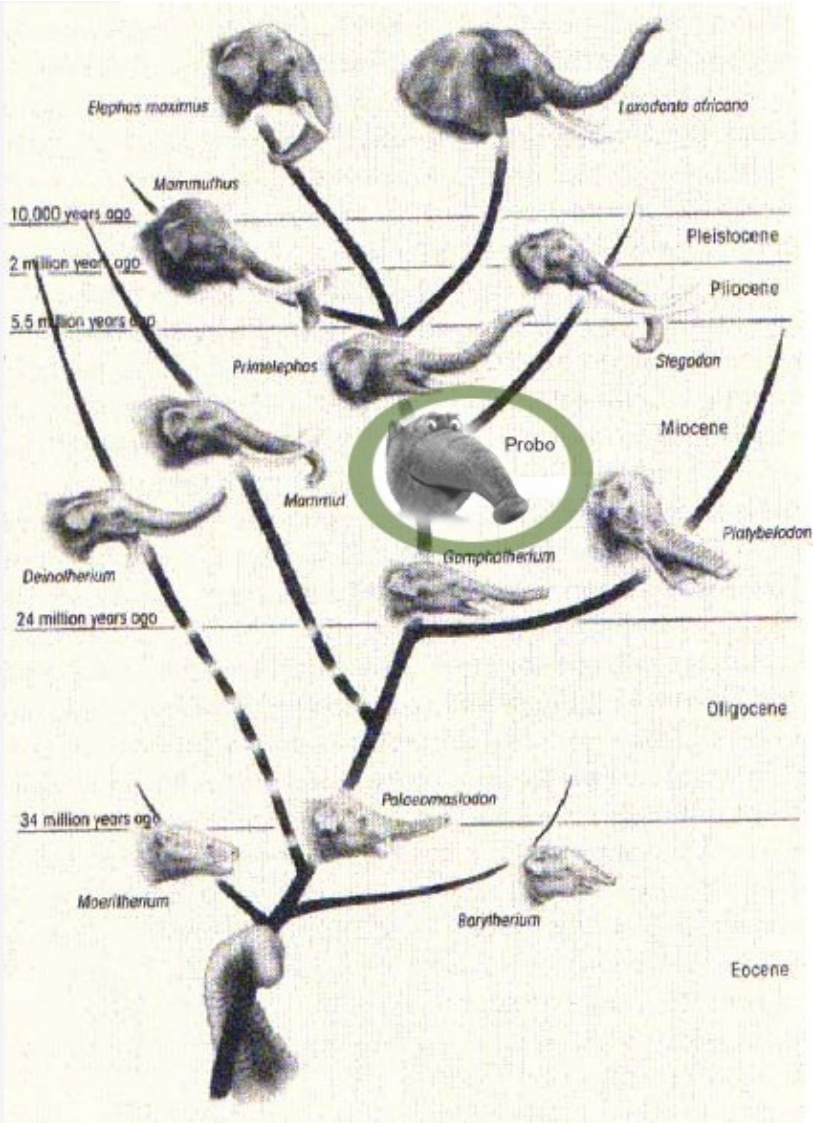
Nurse Robots

Probo was designed by the ANTY project at the Vrije Universiteit in Brussel

- sensors for vision, audio and touch for interaction
- enlighten the children's stay in the hospital.
- exploration of child-robot-interaction in Robot Assisted Therapy

Probo
http://www.youtube.com/watch?v=jLbK9P2CeUk (0'23)

Nurse Robots



Probo
http://www.youtube.com/watch?v=jLbK9P2CeUk (0'23)

Nurse Robots

Paro was invented by Takanori Shibata (Japan) for the same reason as Probo

- light and temperature sensors, microphone
- Touch sensors are placed all over the surface
- Artificial Intelligence imitating a baby seal

Paro

Guide & Office Robots

Stationary Guide & Office Robots

- Give Information
- Often have a human like design
- Use gestics and mimics to underline the spoken sentences

video-example

video-example

video-example

Guide & Office Robots

Mobile Guide & Office Robots

- guide people to special places
- explain objects to them
- sometimes can carry things or even persons
- can be used for surveiliance (detection of fire, unauthorized persons etc.)

Guide & Office Robots

Toyota Tour Guide Robot (TPR-Robina)

Outline of Toyota Tour Guide Robot

Type	Wheeled model
Main areas of application	Guiding visitors and providing explanations of exhibits
Features	- Autonomous motion, allowing the robot to move toward a destination while avoiding obstacles - Jointed fingers, allowing the robot to sign autographs - Verbal communication, allowing the robot to interact with visitors - Image recognition, allowing the robot to recognize visitors' nametags and direct its explanations to them directly
Height	1,200mm
Weight	60kg
Tour guide hours at Toyota Kaikan Exhibition Hall	Weekdays (Mon – Fri), starting from 2 p.m. Time required: approx. 30 minutes

video(300k) video(56k)

source

Guide & Office Robots

Fujitsu Service Robot (enon)

Main Tasks

1. Information and Assistance
2. Transport
3. Patrolling and Surveillance

specifications (page-end)

source source2

Guide & Office Robots

MINERVA

- guide robot for a heavily crowded museum in the USA (1998)

- could be advised via internet

- german – american development team

interesting video

http://www.cs.cmu.edu/~minerva/ring-index.html