Smarter Robots: Implications for the workplace of the future

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Machines that can learn could replace half of American jobs in the next decade or two: Oxford study

***Financial Post**, March 14, 2014*

http://business.financialpost.com/executive/smart-shift/machines-that-can-learn-could-replace-half-of-american-jobs-in-the-next-decade-or-two-oxford-study?__lsa=49b3-ca79

Robots are so much smarter than they used to be

***Financial Post**, April 22, 2014*

http://business.financialpost.com/2014/04/22/robots-are-so-much-smarter-than-they-used-to-be/?__lsa=f517-4a4b

…. an overview of advances in robotics, especially as it pertains to the capability of robots to adjust to changes in the workplace as well as what all of this might mean for the future.

Earlier **definitions of the robot:**

"A reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks" (*Robot Institute of America definition, 1979*),

"An automatic device that performs functions normally ascribed to humans or a machine in the form of a human." (*Webster Dictionary*).

The first definition is restricted to what a robot manipulator is doing in a mechanical sense. The second definition is more general but still limited to what robots are supposed to do.

Highlights in the History of Robotics

….

1921 *Karel Capek's play Rossum's Universal Robots introduces the term robot, derived from "robota" which means "labor".*

1930s The first **spray-painting machines with recorded paths**.

1940s *Isaac Asimov and John Campbell devise the concept of intelligent robot that follows instructions, science fiction stories.*

1944 R. Goertz introduces the **first master-slave (teleoperator) manipulator**.

1945 A Canadian Contribution [*J.J. Brown, "The inventors - great ideas in Canadian enterprise", McClelland & Stewart Ltd., 1967*]: **Eric Leaver - AMCRO (automatic machine control by recorded operation):** *"During 1945 and early 1946, Leaver …. worked out the basic design of a* ***hand-arm machine that could function as either a remotely controlled or a programmed manipulator … for making products without using the labour of men.*** *… at this company's small Toronto plant, Leaver, with the help of G.R. Mounce .... built the* ***first production tool capable of memorizing a skilled workman's operations and then playing them back to make a product****. .... Canadian, U.S. and foreign patents were granted Leaver and Mounce in 1949."*

….

1952 The first **numerically controlled machine tool** is built at MIT.

1954 George Devol designs the first **programmable robot**.

1956 Joseph Engelberger, a Columbia University physics student, buys the rights o Devol's robot and soon after starts the **Unimation Co**.

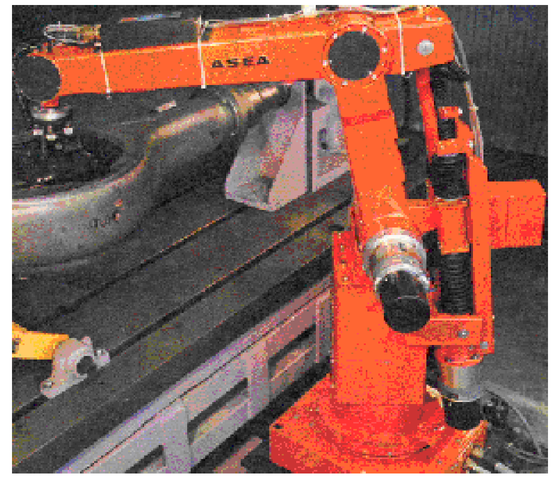
1961 The **first Unimate robot** is installed in a Trenton, NJ, plant of General Motors (to tend a die-casting machine)

1968 Kawasaki Heavy Industries in Japan obtains a licensing agreement from Unimation.

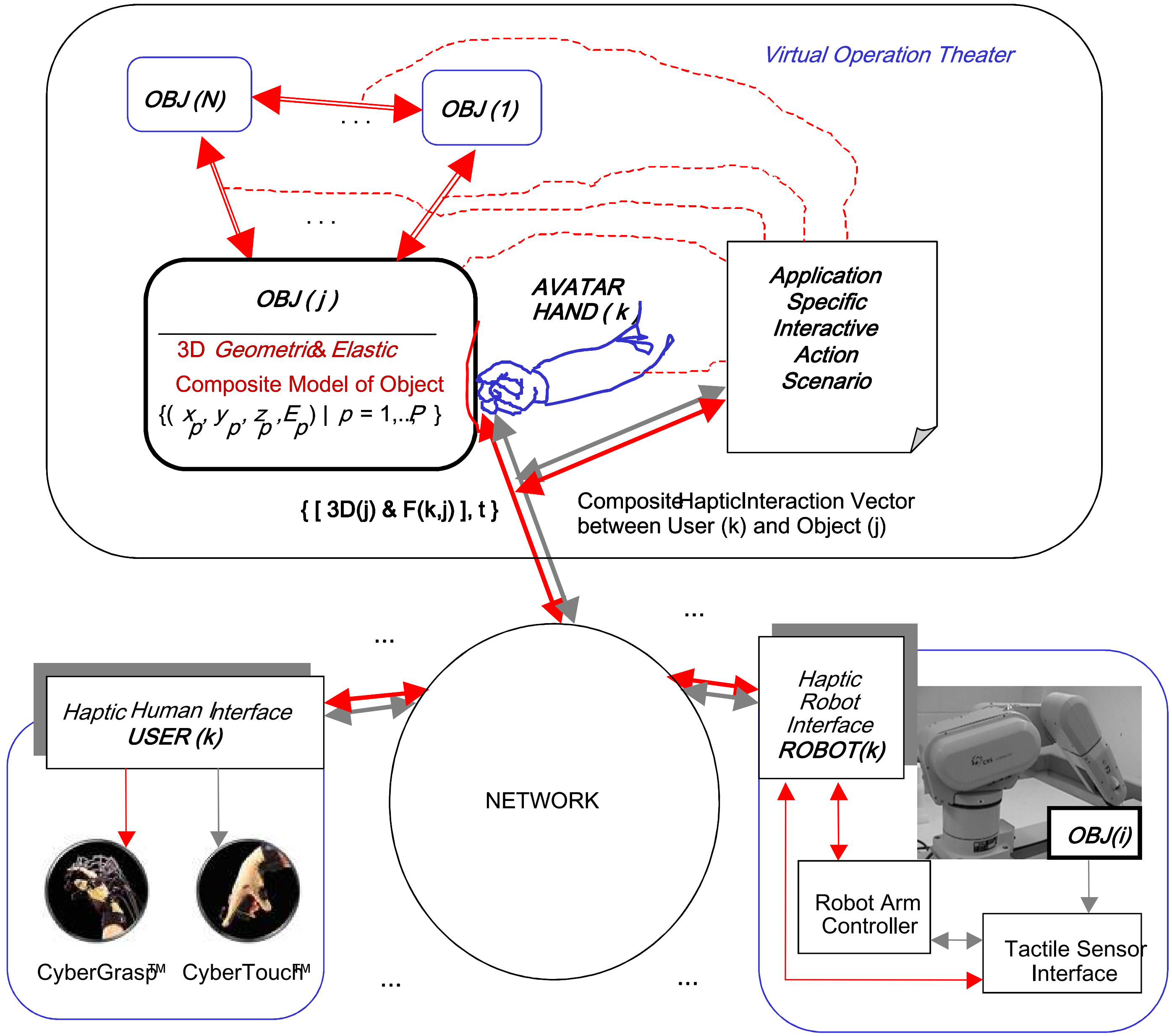
1975 **Unimation Inc. registers its first financial profit**.

1978 The first PUMA (whose design is based on Victor Sheinman's Stanford manipulator) is shipped to GM by Unimation.

1980 **Fujitsu Fanuc Co. of Japan develops the first totally automated factory**.



ASEA robot performing mechanical assembly tasks.



Interactive Model-Based Hapto-Visual Teleoperation - a human operator equipped with haptic HCI can telemanipulate physical objects with the help of a robotic equipped with haptic sensors.

Canadian Space Agency:

In 1981, Canada confirmed its position as a world leader in space technology with the development of the Remote Manipulator System, or **Canadarm**. The RMS can be used: to deploy and retrieve satellites, to hold targets, to explore samples, and to manipulate hardware for the Space Shuttle.

In 1988, Canada agreed to join the international partners to build a permanently inhabited Space Station. Canada's contribution is to design, manufacture, and operate a robotic system, the **Mobile Servicing System** (MSS), for assembly, maintenance, and servicing tasks on the Space Station.

IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, VOL. 48, NO. 4, AUGUST 1999

Vision-Based Sensing and Control for Space Robotics Applications

Michael E. Stieber, *Member, IEEE*, Michael McKay, George Vukovich, *Member, IEEE*, and Emil Petriu, *Senior Member, IEEE*

***Abstract*—The following problems arise in the precise positioning of payloads by space manipulators:**

1) **the precise measurement of the relative position and motion of objects in the workspace of the robot;**
2) **the design of a control system, which is robust and performs well in spite of the effects of structural flexibility and oscillations typically associated with space robots.**

This paper discusses the solution to the measurement problem by a vision system using photogrammatic image processing to determine the motion of objects in real time. Performance characteristics are presented. The control problem is addressed by a new technique dealing effectively with the challenge posed by the noncollocated sensor/actuator configuration on the flexible robot structure. The laboratory implementation of the measurement and control concepts is discussed. Preliminary results validate the concepts.

***Index Terms*— Artificial vision, control, measurement of motion, photogrammetry, robotics.**

I. Introduction

ROBOTIC systems will play an important role in reducing hazards and increasing productivity of humans in space. A prime example is the Mobile Servicing System (MSS) shown in Fig. 1 which is presently being developed by the Canadian Space Agency for the assembly and external maintenance of the International Space Station (ISS) [1]. As the tasks performed by space robots become more complex, the need for more human-like characteristics emerges. As with humans, the sense of sight is essential to enabling efficient interaction with the environment. More important than the sense of sight per se is the ability to process images in such a way as to enable more efficient, accurate and autonomous control of the robot.

This paper addresses measurement and control problems associated with the precise positioning of large space robot manipulators like the Space Station Remote Manipulator System (SSRMS) shown in Fig. 1, which typically have a very high payload-to-manipulator mass ratio (e.g. 116 000 kg/1500 kg for SSRMS) and relatively low stiffness, resulting in highly time-variant dynamic behavior with significant low-frequency oscillations. A theoretical concept for the systematic design of an instrumentation architecture for such systems was presented in [2]. This paper discusses the experimental implementation and evaluation of this concept in a laboratory setting. Section II discusses the measurement of the manipulator payload motion, including the contributions due to structural flexibility, relative to other objects in the manipulator workspace using a vision system. In Section III we extend the theoretical concept of [2] to the case of partially noncollocated sensor/actuator configurations on flexible structures and discuss the design and performance of a control system for the laboratory robot.

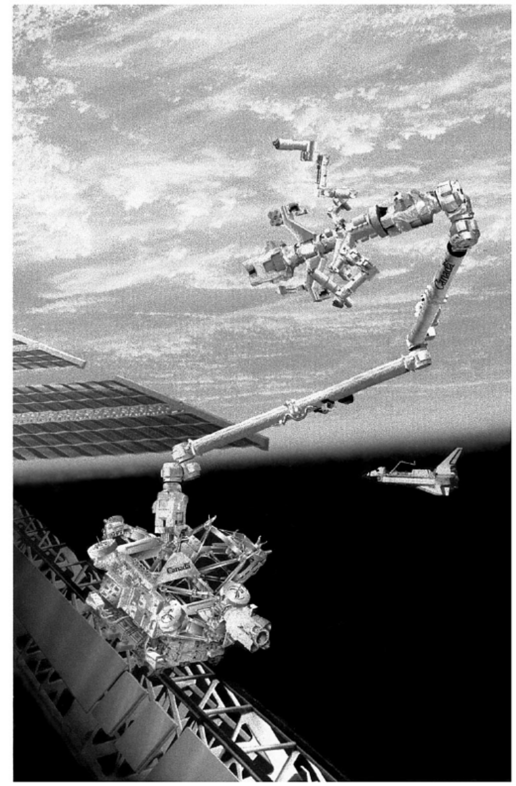


Fig. 1. Mobile Servicing System on the International Space Station.

Manuscript received May 23, 1996; revised April 12, 1999.
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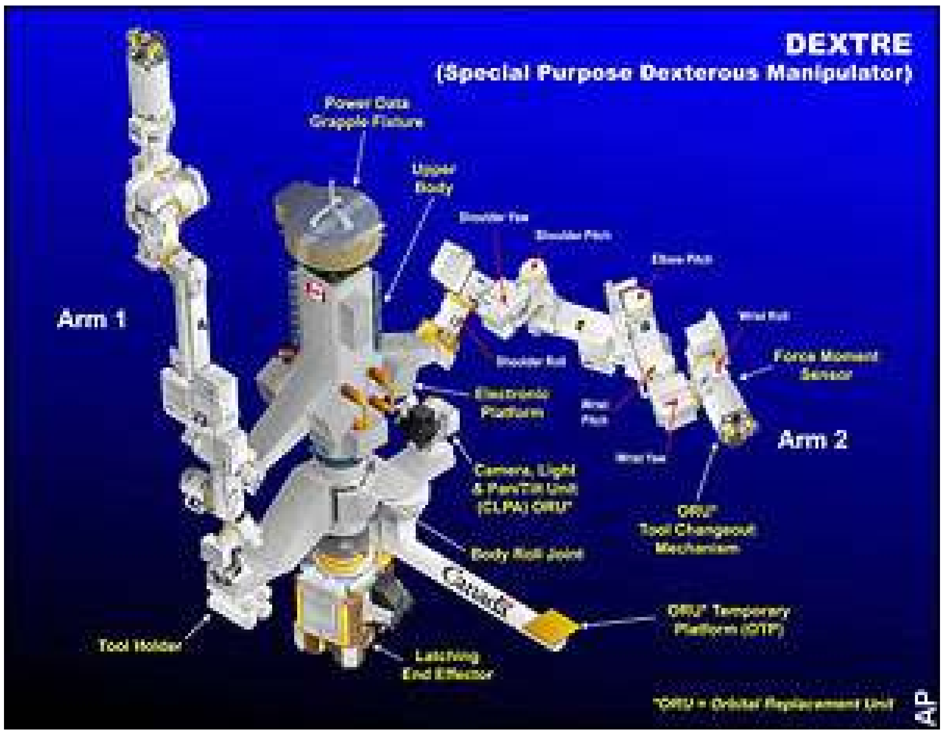
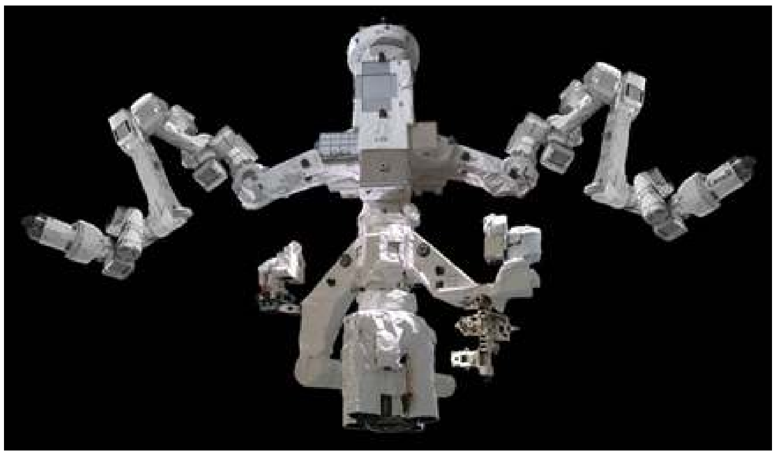
Publisher Item Identifier S 0018-9456(99)06676-0.

Canadian space robot 'Dextre' a high-tech marvel

Updated Mon. Mar. 10 2008 8:35 AM ET CTV.ca News Staff

When finished, Dextre the robot will be the latest Canadian-built addition to the International Space Station. "Dextre is the second arm for the station built by Canada," astronaut Steve Swanson told Canada AM on Monday from Cape Canaveral. "And its task is to do jobs that are more of a fine, finesse manipulator-type activity. Usually we would do spacewalks to change out components that have broken on the station. But now with Dextre, we can do that from inside and use Dextre's arms to do things that a human could do."





http://www.ctv.ca/mar/static/dextre/

Da Vinci Surgical System is a robotic surgical system made by the American company Intuitive Surgical. Approved by the Food and Drug Administration (FDA) in 2000, it is designed to facilitate complex surgery using a minimally invasive approach, and is controlled by a surgeon from a console.

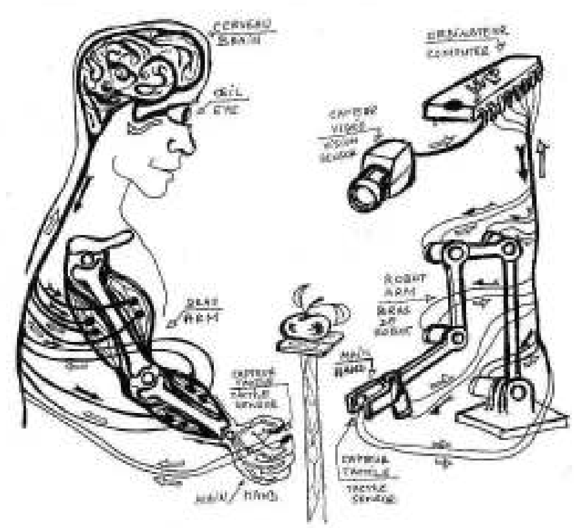
Da Vinci System allows the surgeon's hand movements to be translated into smaller, precise movements of tiny instruments inside the patient's body.

As of June 30, 2014, there were installed 3,102 units worldwide. …. an estimated 200,000 surgeries conducted in 2012

Robotics : Intelligent Connection of the Perception to Action

M. Bradley's modern definition, **"Robotics is the intelligent connection of the perception to action"** considers robotics from a system integration perspective, indicating how robots are doing things. Programmable robots (manipulators, vehicles) provide the *action* function. A variety of sensors provide the *perception* capability. Computers provide the framework for *integration/connection* as well as the *intelligence* needed to coordinate in a meaningful way the perception and action capabilities.

Bradle'y definition recognizes a new step in the evolution of robotics. Today robots are more and more seen from an **anthropomorphic perspective** as representing arms, legs and wheels that, together with sensors, allow computer-based intelligent agents to interact with the physical reality.



Robotics, an emerging digital technology of major strategic importance to Canada, as recognized in *MetaScan 3: Emerging Technologies*, by Policy Horizons Canada, Government of Canada, Sept. 2013 which states that "**Robots help with or take the place of humans in dangerous environments or manufacturing processes, and/or resemble humans in appearance, behaviour or cognition. Increasingly, robots are designed to act in roles complementary to humans**."

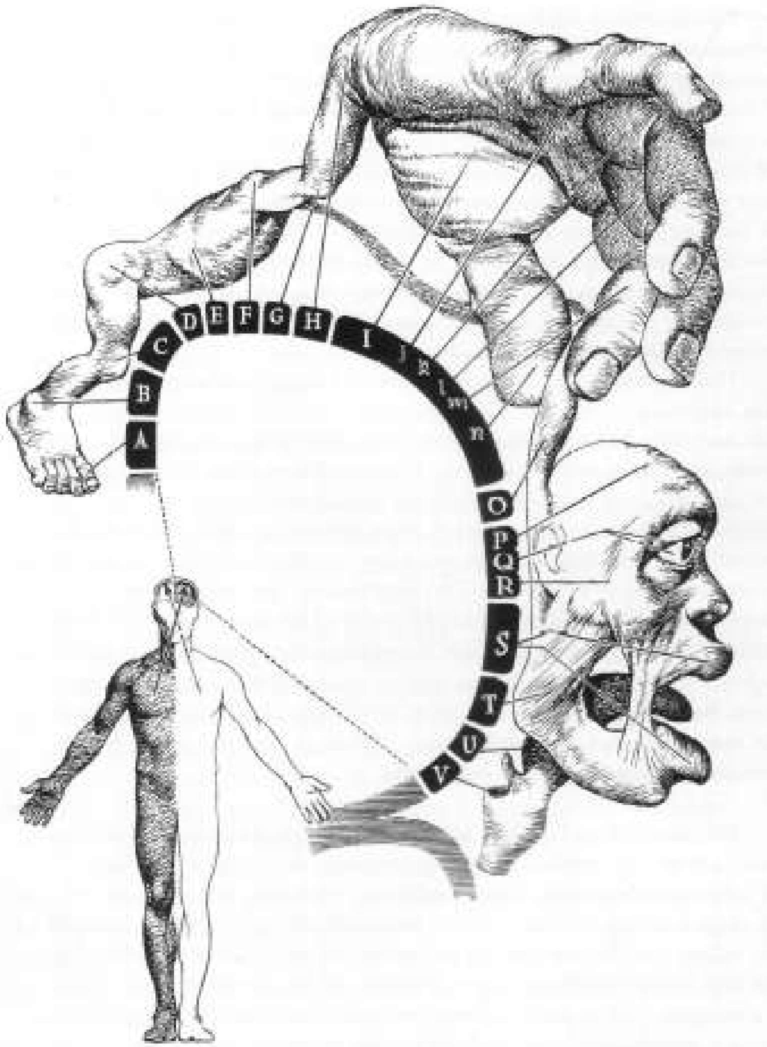
A new generation of intelligent robots with advanced, human-like, tactile perception capabilities, enabling them to perform complex in-hand telemanipulation operations under poor or nonexistent visibility conditions, such as underwater, in space, in hazardous or high-risk security operational environments like nuclear power stations, highly infectious hospital rooms, war zones, robotic surgery, or elder care robots, where touch feeling is of a paramount importance.

In order to naturally blend within human society, **the new-generation robots should not only look as humans, but should also behave as much as possible as humans.** They are expected to be, as initially *imagined by Čapek in his R.U.R. Rossum's Universal Robots* play, anthropomorphic artefacts, **androids,** enabled to think on their own and *governed by Asimov's laws of robotics hardwired into every robot's positronic brain.*

While for a long time, engineers have built upon mathematics, physics and chemistry in order to develop an ever growing variety of industrial artefacts and machines, this approach cannot anymore rise to the challenge of designing these androids.

The time has now arrived to add biology and more specifically, human anatomy, physiology and psychology to the scientific sources of knowledge to develop a new, bio-inspired, generation of intelligent androids.

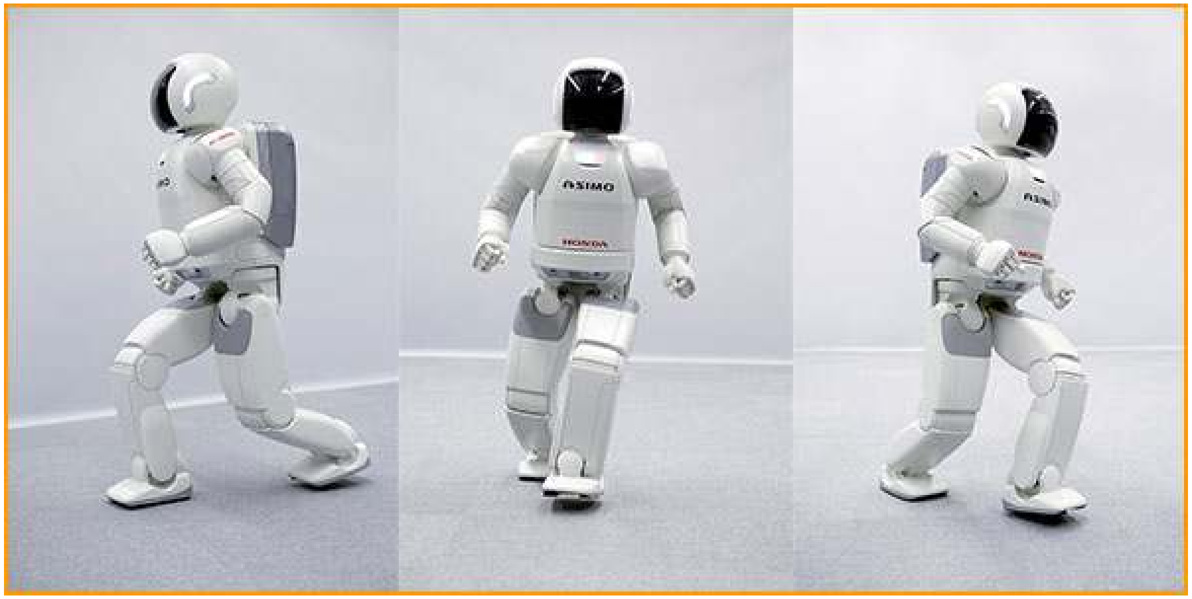
Bio-inspired Haptic Sensing



The sensory cortex: an oblique strip, on the side of each hemisphere, receives sensations from parts on the opposite side of the body and head: foot (A), leg (B, C, hip (D), trunk (E), shoulder (F), arm (G, H), **hand (I, J, K, L, M, N),** neck (O), cranium (P), eye (Q), temple (R), lips (S), cheek (T), tongue (U), and larynx (V). Highly sensitive parts of the body, such as the hand, lips, and tongue have proportionally large mapping areas, the foot, leg, hip, shoulder, arm, eye, cheek, and larynx have intermediate sized mapping areas, while the trunk, neck, cranium, and temple have smaller mapping areas.

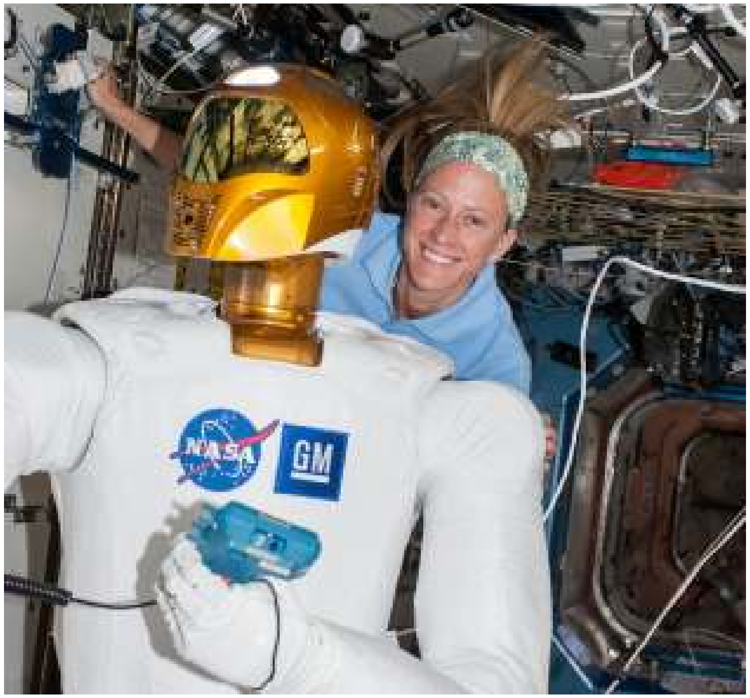
(from [H. Chandler Elliott, *The Shape of Intelligence - The Evolution of the Human Brain*, Drawings by A. Ravielli, Charles Scribner's Sons, NY, 1969])


ASIMO
The Honda Humanoid Robot ASIMO
"While we were sleeping"
1986
1991
1993
2000
History
Robot Development Process


ASIMO
HONDA

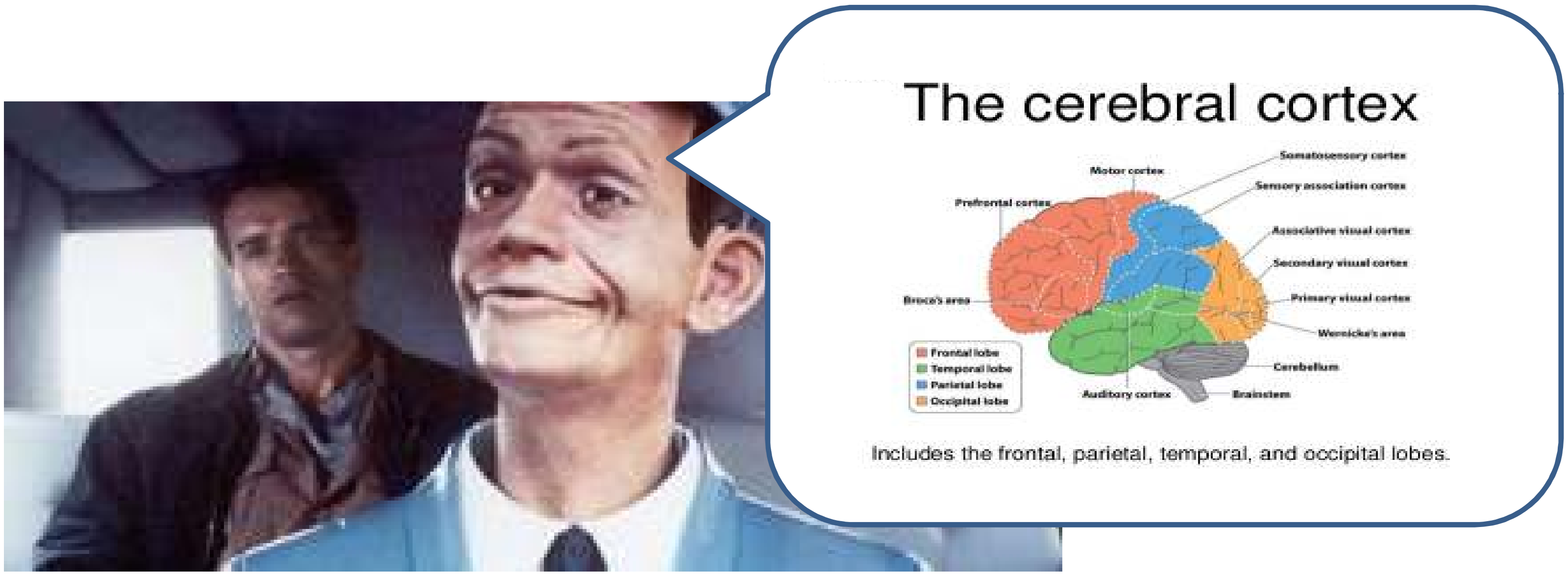
Dexterous humanoid robot ***Robonaut 2*** **developed at NASA Johnson Space Center to help humans work on board the International Space Station**

https://robonaut.jsc.nasa.gov/R2/



Autonomous Robotics Cars

In Isaac Asimov's science-fiction short story, "Sally" (1953), **autonomous cars have "positronic brains"** and communicate via honking horns and slamming doors, and save their human caretaker.



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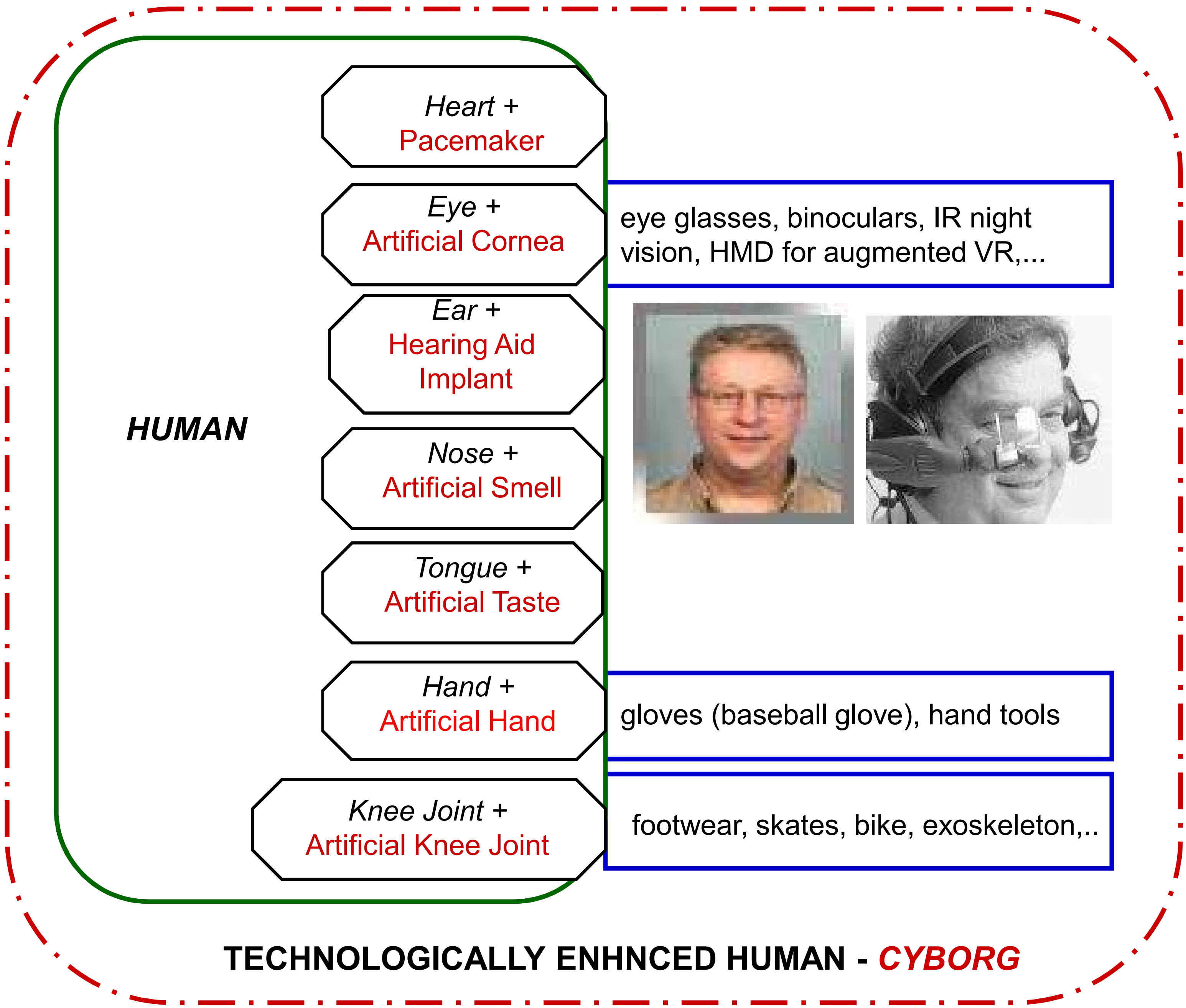
* Tesla's Autopilot can be classified as somewhere between NHTSA levels 2 and 3. At this level, the car can act autonomously but requires the full attention of the driver, who must be prepared to take control at a moment's notice

Human & Android & Cyborg Hyper-Society


HUMAN
Heart +
Pacemaker
Eye +
Artificial Cornea
eye glasses, binoculars, IR night vision, HMD for augmented VR,...
Ear +
Hearing Aid Implant
Nose +
Artificial Smell
Tongue +
Artificial Taste
Hand +
Artificial Hand
gloves (baseball glove), hand tools
Knee Joint +
Artificial Knee Joint
footwear, skates, bike, exoskeleton,..
TECHNOLOGICALLY ENHNCED HUMAN - CYBORG

Brain Prosthesis

"Immortality by 2045 or bust: Russian tycoon wants to transfer minds to machines
Russian billionaire Dmitry Itskov speaks to the Global Future 2045 Congress, Saturday, June 15, 2013 at Lincoln Center in New York. Some of humanity's best brains are gathering in New York to discuss how our minds can outlive our bodies." [Ottawa Citizen, June 15, 2013, http://www.ottawacitizen.com/business/Immortality+2045+bust+Russian+tycoon+wants+transfer+minds/8531949/story.html]

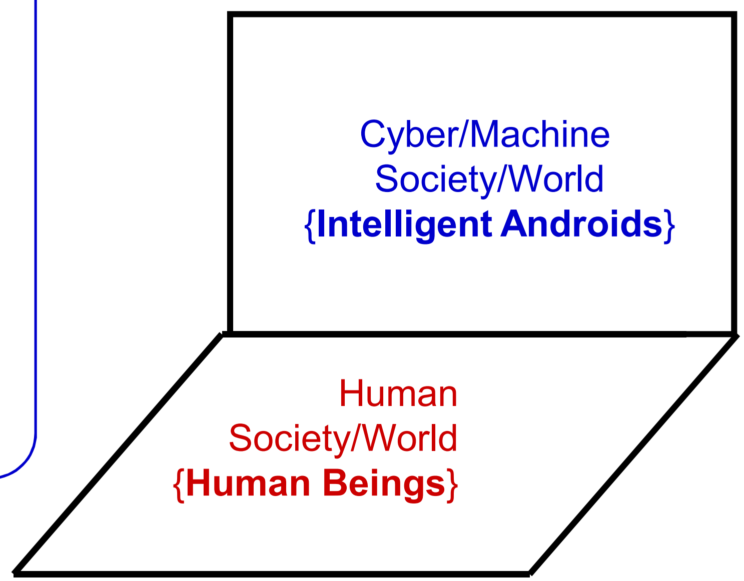
Brain Prosthesis which learns/models with an ever increasing fidelity the behaviour of the natural brain so it can be used as *behavioural-memory prosthesis* (**BMP**) to make up for the loss in the natural brain's functions due to dementia, Alzheimer disease, etc. It is quite conceivable that such a BMP could arrive in extremis to complete replace the functions of the natural brain.

***Asimov's laws of the robotics*:**

1st law: "A robot must not harm a human being or, through inaction allow one to come to harm".

2nd law: "A robot must always obey human beings unless that is in conflict with the 1st law".

3rd law: "A robot must protect itself from harm unless that is in conflict with the 1st and 2nd law".



***Asimov's laws of the robotics*:**

0th law: "A robot may not injure humanity or, through inaction, allow humanity to come to harm."

1st law- updated: "A robot must not harm a human being or, through inaction allow one to come to harm, unless this would violate the 0th law."

2nd law: "A robot must always obey human beings unless that is in conflict with the 1st law".

3rd law: "A robot must protect itself from harm unless that is in conflict with the 1st and 2nd law".

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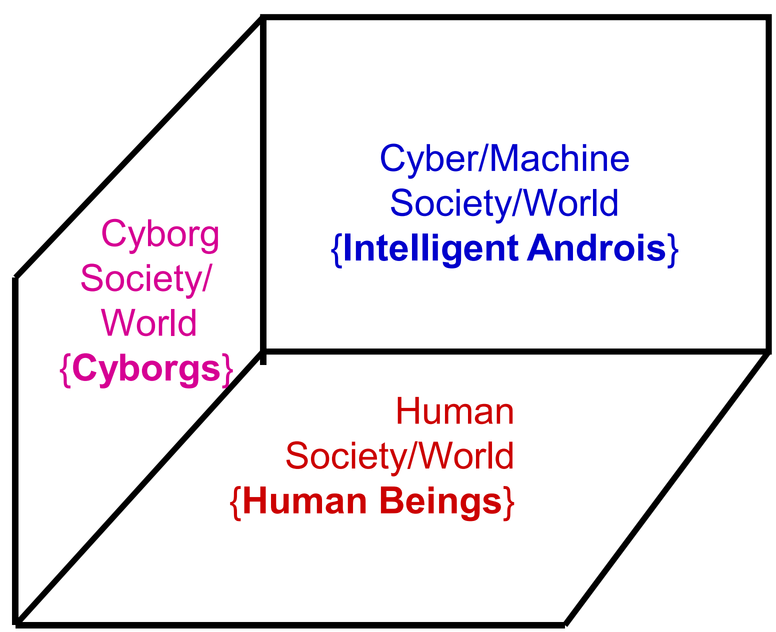
[*] I. Asimov, Robots and Empire, Doubleday & Co., NY 1985, p.291

Moral, Ethical, Theological, Legal, Biological, Psychological Social, Economic Challenges



Special Report: Trusting Robots - Robots will soon have the power of life and death over human beings. Are they ready? Are we?

IEEE Spectrum, May 2016

http://spectrum.ieee.org/robotics/artificial-intelligence/can-we-trust-robots

photo by Peter Thornton, *uOttawa Gazette*

Thank You !