Intelligent Robotics - Solutions for Health Care Applications

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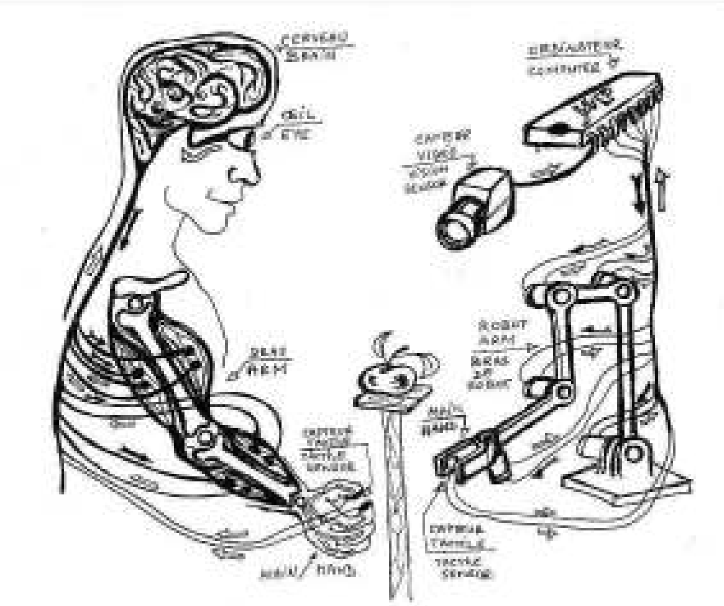


photo by Peter Thornton, *uOttawa Gazette*

Robotics

Intelligent Connection of Perception to Action

Robotics, is an emerging 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**."

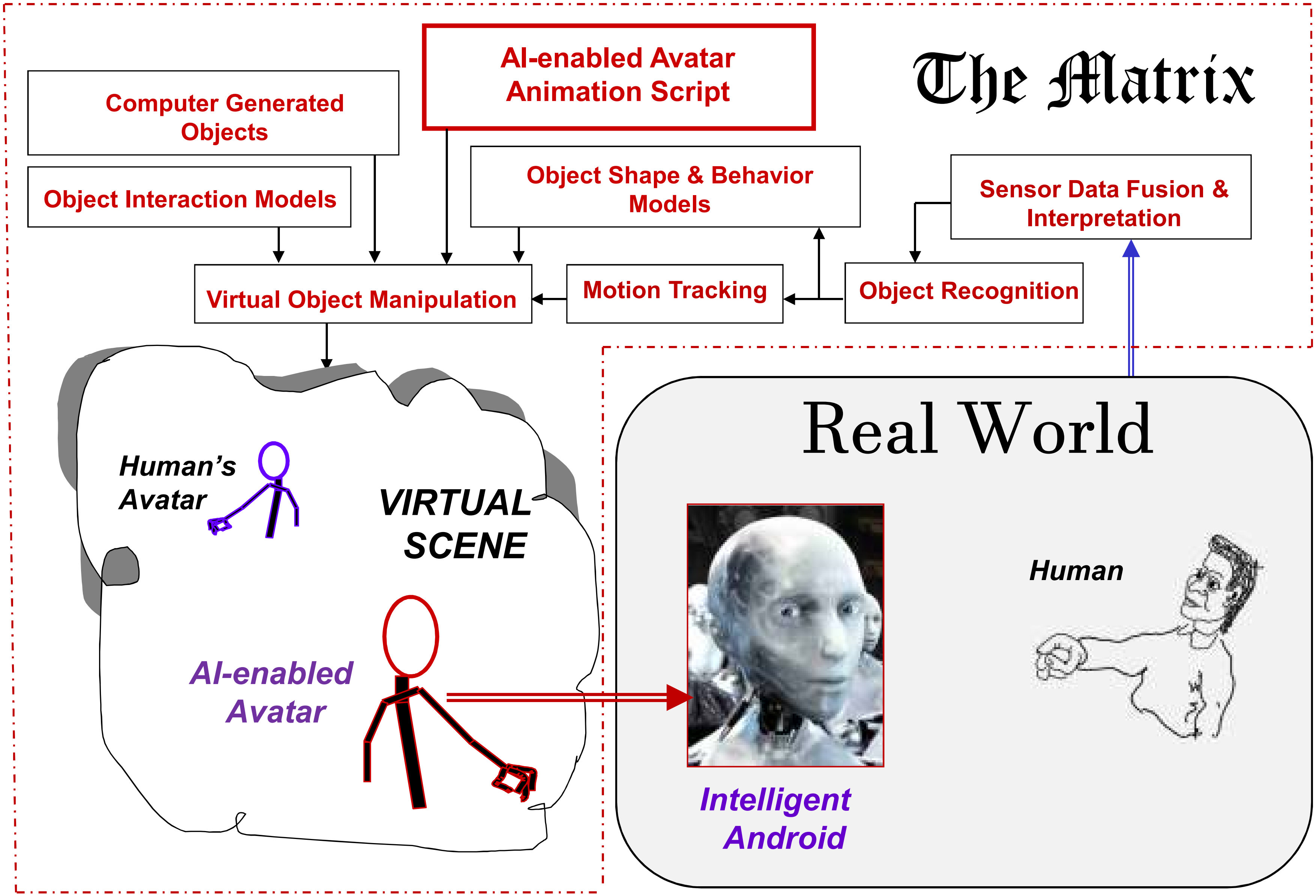
“Robots to affect up to 30% of UK jobs, says PwC”

(BBC, 24 March 2017)

http://www.bbc.com/news/business-39377353

- Transportation and storage - 56% of jobs at high risk from automation
- Manufacturing - 46%
- Wholesale and retail trade - 44%
- Administrative and support services - 37%
- Financial and insurance - 32%
- Professional, scientific and technical - 26%
- Construction - 24%
- Arts and entertainment - 22%
- Agriculture, forestry and fishing - 19%
- **Human health and social work - 17%**
- Education - 9%

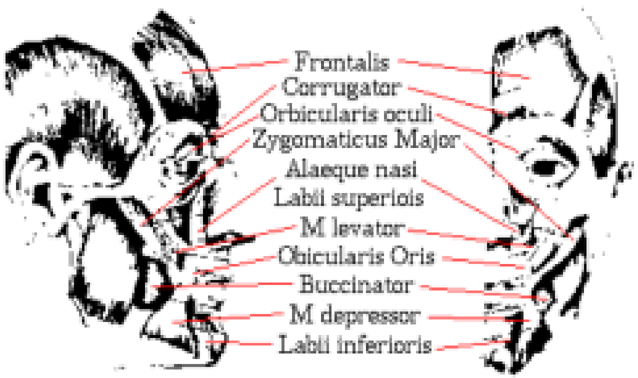
In order to naturally blend within human society, **the new-generation robots should not only look as humans, but should also behave as much as possible as humans.** They are expected to be, as initially *imagined by Čapek in his R.U.R. Rossum's Universal Robots* play, anthropomorphic artefacts, **androids,**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



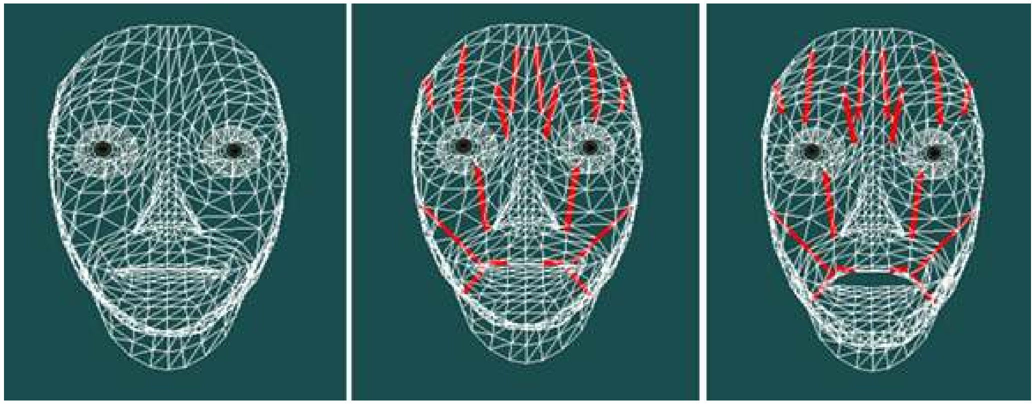
Matrix-trained, AI – enabled, avatar gets into the *Real World* as an intelligent android able to interact and collaborate with humans

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.

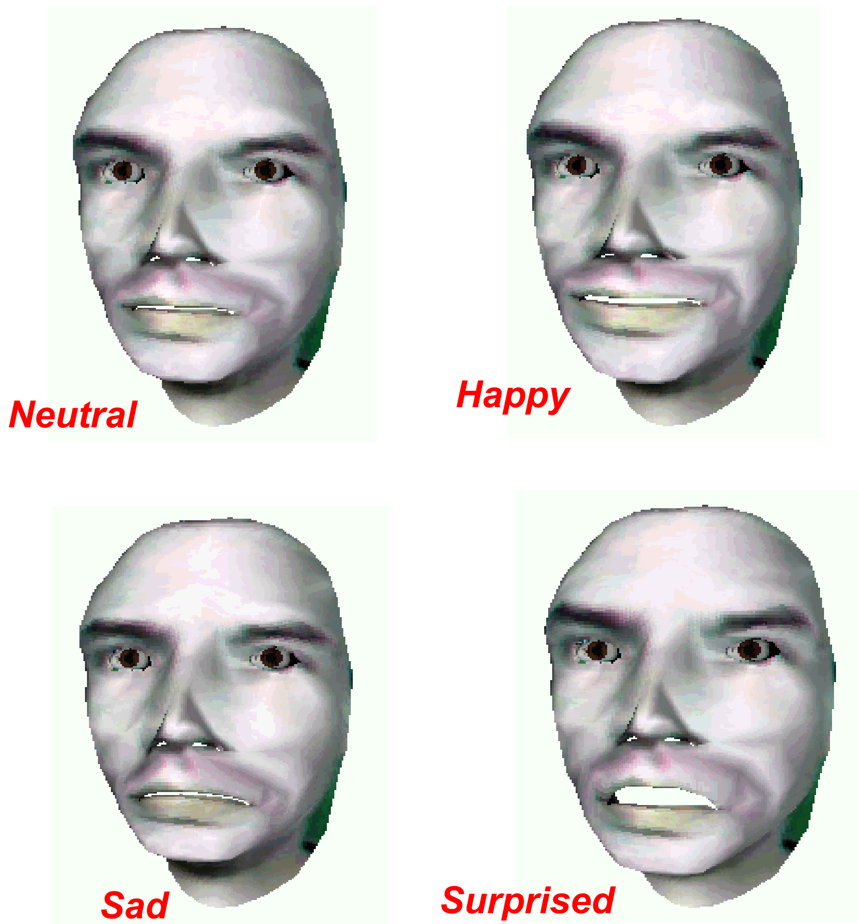


Face Expression Recognition using a 3D Anthropometric Muscle-Based Active Appearance Model



3D generic face deformed using muscle-based control

[from M.D. Cordea, E.M. Petriu, D.C. Petriu, "Three-Dimensional Head Tracking and Facial Expression Recovery Using an Anthropometric Muscle-Based Active Appearance Model," *IEEE Trans. Instrum. Meas.*, vol. 57, no. 8, pp. 1578 – 1588, 2008]

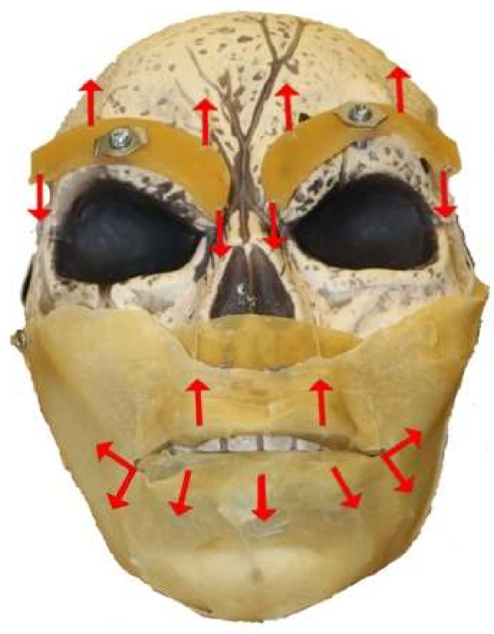


Combining muscle actions it becomes possible to obtain a variety of ***facial expressions*** of Marius' avatar:

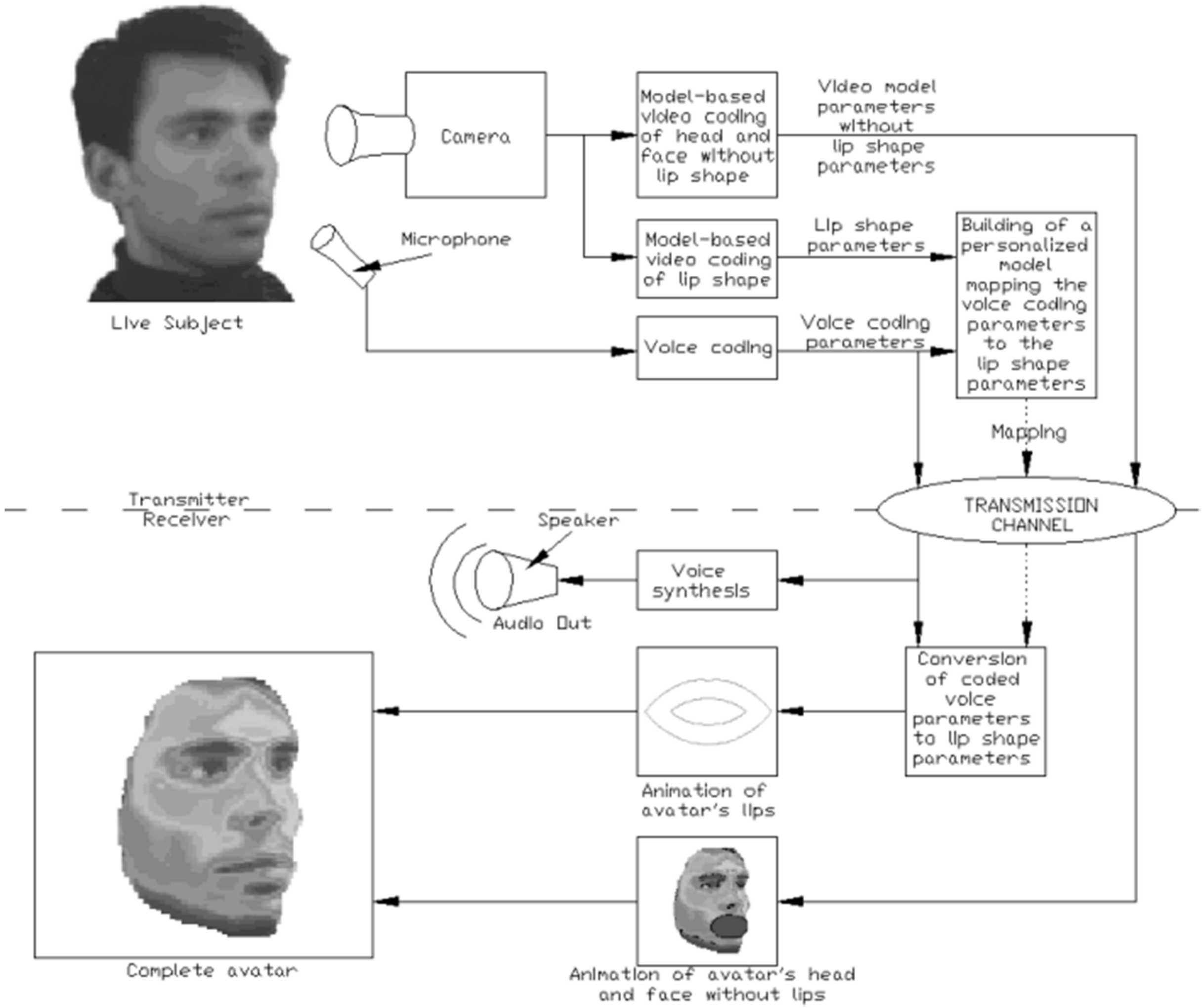
Expressive Android Face

https://www.youtube.com/watch?v=za-WWPVRSEw

by Erbene de Castro Maia Jr. and Lidia Brigido Santiago Melo .



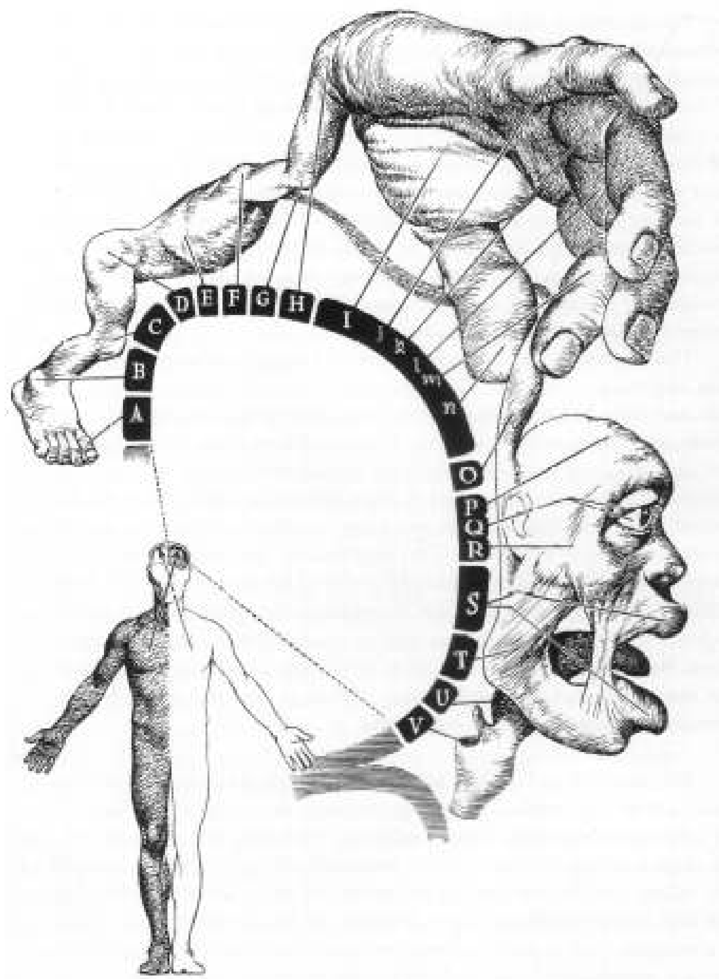
Face and Lip Animation Using Model-based Audio and Video Coding



M. D. Bondy, E. M. Petriu, M. D. Cordea, N. D. Georganas, D. C. Petriu, T. E. Whalen, "Model-based Face and Lip Animation for Interactive Virtual Reality Applications", *Proc. ACM Multimedia 2001*, pp. 559-563, Ottawa, ON, Sept. 2001

The **new generation of intelligent robots** shall have 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.

Bio-Inspired Sensing & Perception



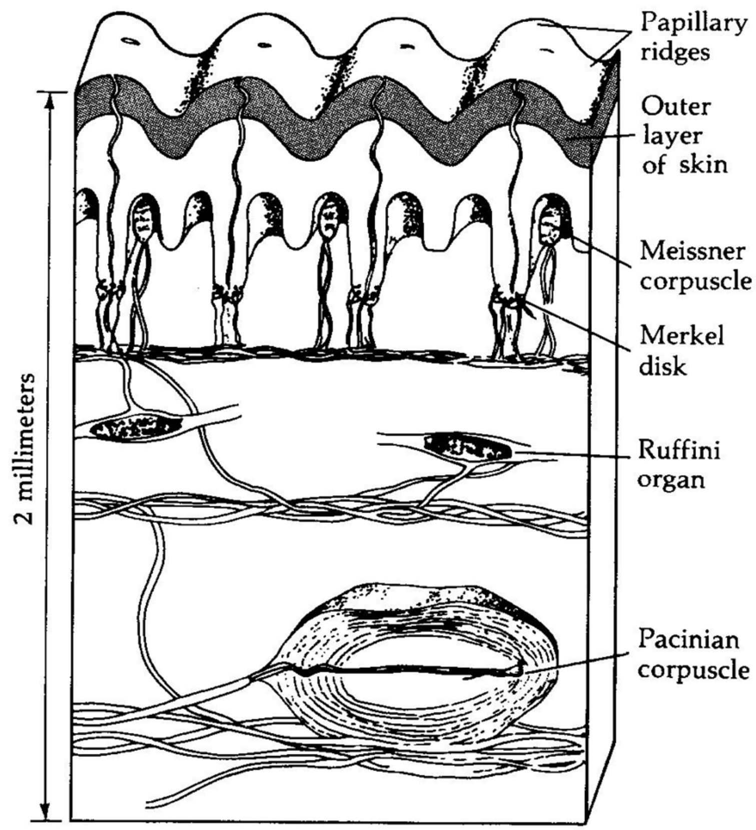
The sensory cortex: an oblique strip, on the side of each hemisphere, receives sensations from parts on the opposite side of the body and head: foot (A), leg (B, C, hip (D), trunk (E), shoulder (F), arm (G, H), **hand (I, J, K, L, M, N),** neck (O), cranium (P), eye (Q), temple (R), lips (S), cheek (T), 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.

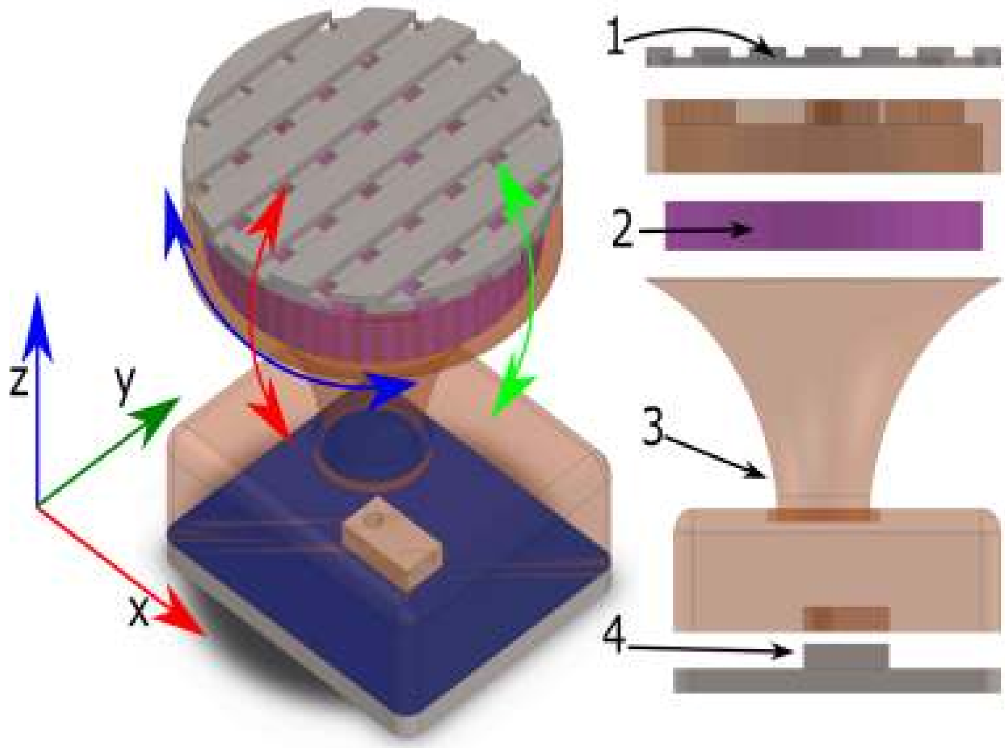
[from H. Chandler Elliott, *The Shape of Intelligence - The Evolution of the Human Brain*, Drawings by A. Ravielli, Charles Scribner's Sons, NY, 1969]

Human Tactile Sensing

The skin of a human finger contains four types of **cutaneous sensing elements** distributed within the skin: *Meissner's corpuscles* for slippage; low frequency vibration; local skin deformation; *Merkel's disks* for sensing sustained pressure and shapes; *Pacinian corpuscles* for sensing pressure changes and vibrations of about 250 Hz; and *Ruffini corpuscles* for sensing skin stretch and slip.

[from R. Sekuler and R. Balke, Perception, McGraw-Hill, 1990]



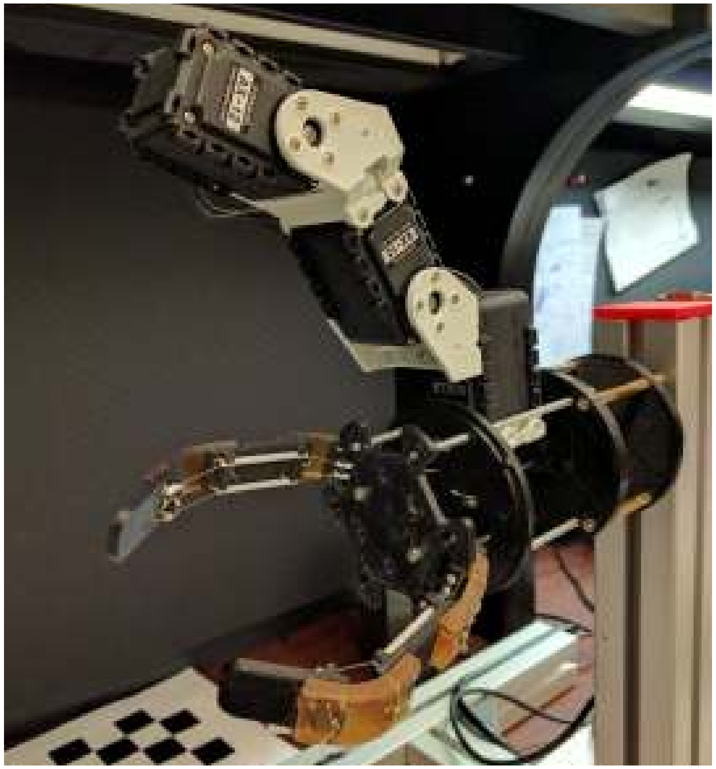


Bio-Inspired Tactile Sensing Module: (1) Merkel disk- and Meissner corpuscle–like shape, pressure, local skin deformation, and slippage sensitive tactile array - 32 taxels; (2) Rufinni corpuscle–like vibration and stretch sensitive MARG sensor; (3) compliant structure; (4) Pacinian corpuscule-like deep pressure sensor;

[from T.E. Alves de Oliveira, A.-M. Cretu, E.M. Petriu, "Multimodal Bio-Inspired Tactile Sensing Module," *IEEE Sensors Journal*, Vol. 17, Issue 11, pp. 3231 – 3243, 2017]

Multi-Finger Dexterous Robot Hand

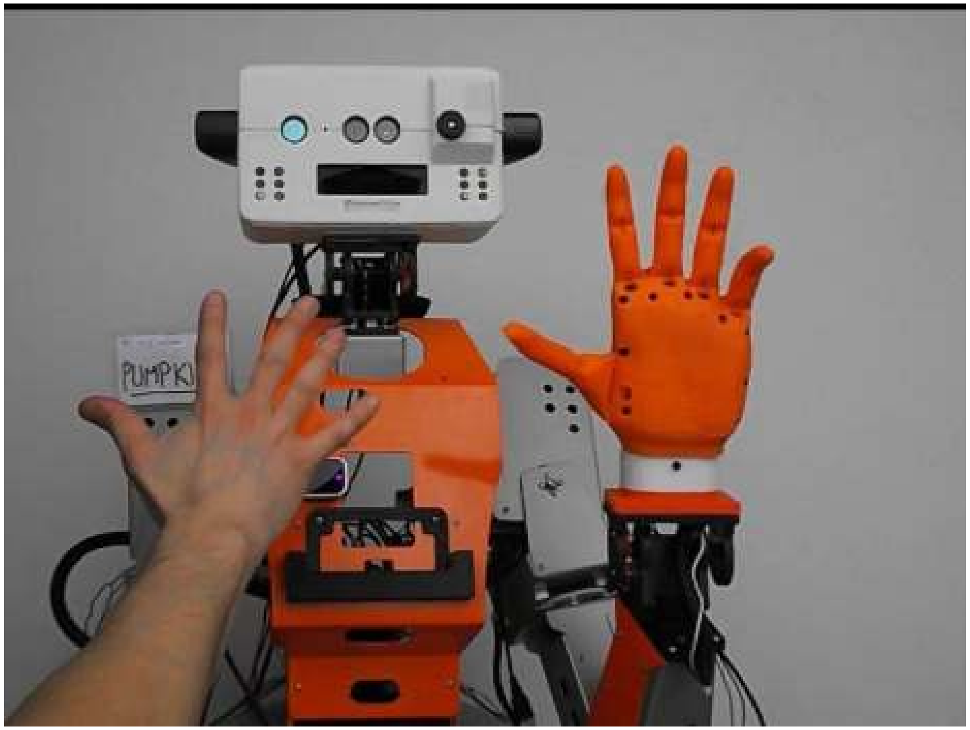
Vision, tactile, and flex joint sensors allow tracking finger phalanges' position, provide information of the object's unknown orientation for in-hand manipulation by **the two -finger underactuated hand with a fully-actuated intelligent thumb** capable of trajectory planning. A **fuzzy logic controller** allows to obtain a stable grasp After grasp, the manipulate object can be reoriented by the thumb taking advantage of the compliance of the flex joint fingers



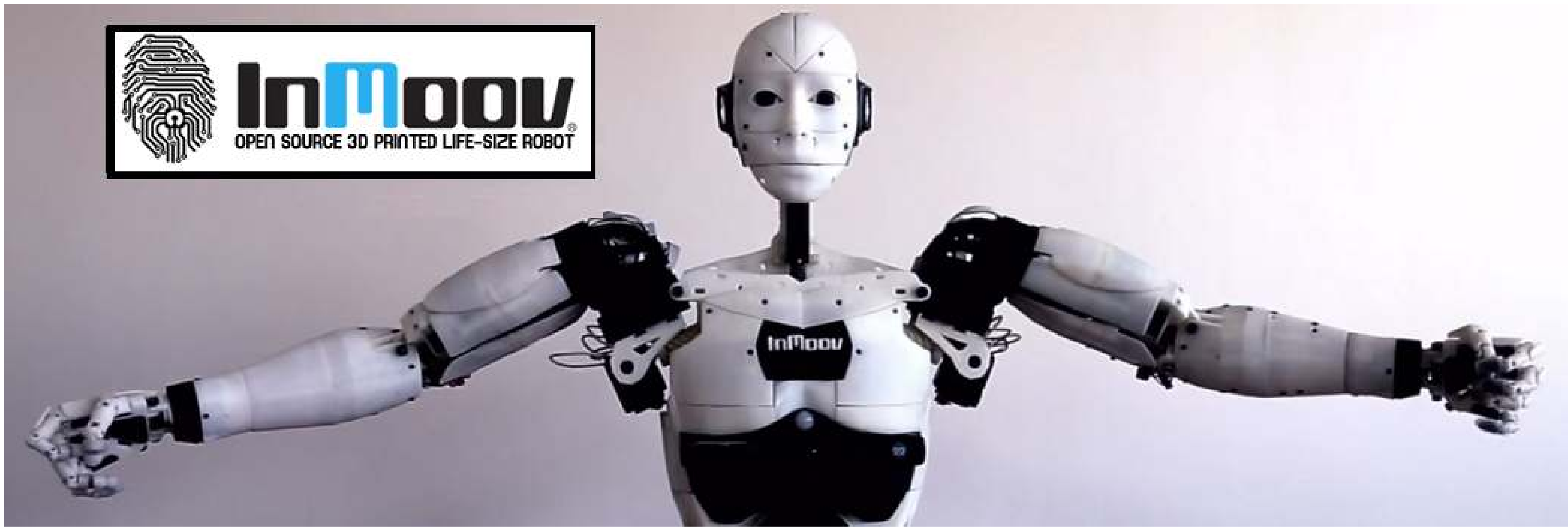
[from V. Prado da Fonseca, D.J. Kucherhan, T. E. Alves de Oliveira, D. Zhi, E.M. Petriu "Fuzzy Controlled Object Manipulation using a Three-Fingered Robotic Hand," 10th *Annual IEEE Int. Systems Conference - SysCon 2017*, pp. 346 - 351, Montreal, Que, April 2017].

Vision- and *Cyberglove-Based* Control of Five-Finger Robot Hand

https://www.youtube.com/watch?v=Q89jhZHZ_hw



by Vinicius Prado,
Thiago Eustaquio,
Jayme Boarin,
Bruno Monteiro,
and Paulo Lui.



"**InMoov",** the first Open Source life size humanoid robot you can 3D print and animate, *Gael Langevin's project, Jan. 2012,* http://www.inmoov.fr/project/

"*Gael Langevin* is a French model maker and sculptor. He works for the biggest brands since more than 25 years. *InMoov* is his personal project, it was initiated in January 2012 *InMoov* is the first Open Source 3D printed life-size robot. Replicable on any home 3D printer with a 12x12x12cm area, it is conceived as a development platform for Universities, Laboratories, Hobbyist, but first of all for Makers."

https://www.youtube.com/watch?v=JKtHCFToYPY

Thank you!