Humanoid Robots

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ECE Seminar,
Friday January 26, 2001
Why people build Humanoid Robots?

- Challenge - it is difficult
- Money - Hollywood, Brooks
- Fame - ?? Everybody?
- “To build future gods” - De Garis
- Forthcoming technology; to survive - Honda
- To protect human life - military, police, firefighting
- Explorers - NASA Robonaut
- Have fun
Motivation (apart from fun)

- Brain-building is best tried with a body
- All aspects of Artificial intelligence, Machine Learning, Adaptive Methods, Control, Mechatronics, surface in a real-world humanoid robot
- Industrial and commercial aspects usually under estimated
What are the Humanoid Robots good for?

- Helping elderly
- Helping disabled children
- Servants
- Hazardous conditions; cosmic research - NASA
- Military and police
- Sports (soccer, football, ping-pong, sumo, fencing, weight-lifting)
- Entertainment (dance, singing, theatre)
- Studying human body and emotions
First determine solution space, next how to operate in it

• Make the robot **as unconstrained as possible**, so it can work in a world designed for humans.

• "People are the standard for almost all interactions in our world -- tools and machines are adapted to the abilities, motion capabilities and geometry of humans."
Toward a Humanoid Robot: Artificial Intelligence and the Confluence of Technologies

- Although many problems currently confront roboticists and researchers of artificial intelligence, humanoid robots capable of manipulation, locomotion, and intelligence will likely become a reality.

- Their realization will require the confluence of a number of sensing, actuation, and control technologies, but key to intelligent humanoid robots may be cognizance.
A cognizant robot will learn through interaction with its environment.

Yet even with the most favorable research outcomes, humanoid robots will see commercialization only if they can serve in practical applications and if they can find consumer acceptance.

In the next 25 to 30 years, humanoid robots could perform roles as diverse as fire fighting, nuclear-reactor maintenance, security patrol, and domestic service.

General-purpose robots for personal assistance and housework will follow perhaps 10 or 15 years later.

When the humanoid-robotics market reaches maturity, it will likely compare in size with the automobile industry.
Humanoids 2000

First IEEE-RAS International Conference on Humanoid Robots

Co-Sponsored by the Robotics Society of Japan
September 7-8, 2000
The Massachusetts Institute of Technology
The most famous robot in the world

- Honda Humanoid robot

- The most famous robot in the world
Kismet

Regulating Interaction Intensity:
Face stimulus (human)

Cynthia Breazeal (Ferrell)
Brian Scassellati

MIT Artificial Intelligence Lab
Rodney Brooks

*Social Interaction

* Tracking own hands

*Kismet: face tracking, color, motion modules
and what about us?
High School Students at PSU
Spider with a camera
Main Stages of Practical Robot Design

1. Build the body of the robot (statics, kinematics, dynamics)
2. Select the robot architecture (evolutionary, classical, situated automata, inductive)
3. Choose the realization way for software-hardware system (microcontrollers, FPGAs, laptop, parallel PC)
4. Implement sub-systems (motor control, navigation, manipulation, vision, voice recognition, text-to-speech)
5. Integrate
An Evolutionary Architecture for a Humanoid robot

or

a Sex in the mind of a robot -
or

Can we use sexual breeding of thoughts?
Neural Darwinism

• The idea is not new: William James thought the same a few years after Darwin...
Evolutionary Approaches

- EAs and Genetic Programming
- Three Layers
  - Reactive
  - Model building
  - Reasoning
Evolutionary Algorithms...

- Breeding structures, selection, variation reproduction
- Genetic programming breeds programs
- Automatic Programming
- Koza
Basic ingredients

Population

Selection

Genetic Operators
Crossover

- Crossover implemented in hardware (FPGA) or software
Example of Crossover Operation on Trees
GP-representation

- Linear structures
- Trees
- Graphs
Wide application field...

- Data Mining
- Prediction
- Information filtering
- Control
- Process modeling
- Natural Language Processing
- Signal processing
- Speech recognition
- Image processing
- Code optimization
- Data compression
- Quality modeling
Main idea: not precise + adaptive
Control Architecture

- Reactive Control
- Model Building
- Reasoning

A pyramidal humanoid architecture
Reactive control

GP SYSTEM

Genetic Operators

Selection

Population

robot
Model building

• Learning Goodness mapping
• Searches this model for best action
• Two versions
  • model complete goodness
  • model only pleasure in goodness
Genetic Reasoning

- Evolving statements, rules and the truth
- Evolution as inference engine
- Less Heuristics
- Complete search and replace inference
Evolution on two levels

- Low level *evolution of instincts* mostly offline
- High level *evolution of plans and facts*
or so to learn to stand and walk on two legs, but a Swedish robot called Elvis might do it in a matter of weeks.

If Elvis, a 40-centimetre-tall humanoid, manages to stand at all, it will be a remarkable feat.

Designing robots that can balance well has proved to be extremely difficult.

So rather than trying to do it themselves, Elvis's creators plan to let "evolutionary" software do all the hard work.

The researchers, at Gothenborg University in Sweden, plan to use algorithms that mimic genetic mutation to "breed" the robot's control systems by natural selection.

They hope this will let Elvis not only stand but also walk, navigate and perceive the world--all without anyone knowing exactly how it does it.
All Shook Up?

How evolutionary software will keep Elvis on his feet

1. Design basic control system: create first 'digital chromosome'
2. Mutate chromosome 100 times
3. Breed to create better chromosome
4. Test each mutant on Elvis
5. Does Elvis balance?
   - Yes: Breed to create better chromosome
   - No: Mutate chromosome 100 times
6. Extinct
Contribution

• Uniform approach
• Learning all control
• Light geometrically consistent platform
• Very fast machine code on low level, very powerful reasoning on high level