The Robots are Coming!

Hugh Durrant-Whyte
ARC Federation Fellow, Research Director
ARC Centre of Excellence for Autonomous Systems
The University of Sydney, Australia
hugh@cas.edu.au
What is a Robot: The Hollywood Version
What is a Robot: The Current Reality
What is a Robot?
Essential Elements

Perception → Sensing → Representation Of The World → Learning → Decision Making → Action

“Robotics is the intelligent connection of perception to action”
Perception

- Sensors and Sensing
- Representations/Data Fusion
Robot Vision

- Colour
- Shape
- Texture
- Stereo
- Vergence
- Shading
Touch Sensors

Tactile

Grasping

Force
Other Sensors

- **Passive:**
  - Infra-red
  - Multi and Hyperspectral

- **Active:**
  - Lasers, Radar
  - Sonar

- **Proprioceptive**
  - Inertial
  - Encoder/pedometer
Mixed Sensor Examples

- Vision/laser
- Laser/multi-spectral/vision
Representations: On the Ground

- Rich sensed data
- Probabilistic models
- Learning structure
Representations: Underwater
Sub-Sea Navigation
Control and Decision Making

- Platform and Environment Modelling
- Control: Search, exploration
- Control: Coordination
Models

- Platform Models
- Environment Models
Control: Search and Exploration
Sensing, Planning and Control
A Word About “Systems”

- Autonomous system design
- Essential Ideas in:
  - Formal verification
  - Middleware
  - Large-scale systems
The Big Questions

• Are Robots Ready To Do Useful Things ?
• Can We Really Build Intelligent Robots ?
• Why Don’t Real Robots Look Like The Ones In The Movies ?
• Will Robots Take Over the World ?
The Big Questions

- Are Robots Ready To Do Useful Things?
- Can We Really Build Intelligent Robots?
- Why Don’t Real Robots Look Like The Ones In The Movies?
- Will Robots Take Over the World?

“Dirty, Dull and Dangerous”
Automated Cargo Handling

- Integrates research in sensing, navigation, control, and systems design
- World's most technically advanced terminal
- Located in Brisbane, operated from Sydney
- $150m investment to create $1bn of value.
Mining Automation

- Integrates research in sensing, data fusion, control and systems
- Focus on safety and productivity
- Mining sensors, equipment automation
Aerospace and Defence

- Integrates technology in data fusion and control
- Collaboration with companies including BAE Systems and agencies including USAF, ONR, UK MOD.
- Applications in
  - Broad-area surveillance
  - Search and rescue
  - Air defence
Marine Systems

- Integrates research in perception, navigation and control
- SLAM: perception, mapping
- Autonomous habitat monitoring
- Biology models
- Defence applications
Robotics in Agriculture
Robots for Exploration
Media Art

- Integrates research in perception, systems and human interaction
- Fish-Bird: Exhibited in Australia, US, China
- Generates diverse art/science interactions
Are Robots Useful?

Yes!

But are they Intelligent?

“Whatever we don’t know how to do is called Artificial Intelligence (AI). When we know how to do it, it is called an Algorithm”, P. Winston
The Big Questions

- Are Robots Ready To Do Useful Things?
- Can We Really Build Intelligent Robots?
- Why Don’t Real Robots Look Like The Ones In The Movies?
- Will Robots Take Over the World?
Recall

Perception

Representation Of The World

Sensing

Learning

Action

Decision Making

World
Learning

• Perception and Recognition
• Control and Decision Making
• Multi-Agent Systems
Unsupervised Learning of Percepts

- Left: true nonlinear manifold,
- Centre: sampled manifold,
- Right: LLE computed low dimensional embedding
Model Inference

Use Probabilistic Ideas for Inference
Symbolic Grounding

“Tree”

“Stuff”
Application to Navigation
Application to Place Recognition
Learning in Control

- Learning Dynamics
- Learning Controllers
- Learning Behaviour
Multi-agent Learning

- Learning to cooperate
- Learning group interactions
Are Robots Intelligent?

No

But we think we understand the question now!
The Big Questions

- Are Robots Ready To Do Useful Things?
- Can We Really Build Intelligent Robots?
- Why Don’t Real Robots Look Like The Ones In The Movies?
- Will Robots Take Over the World?
Hand-Eye Coordination
A Question of Balance!
Humanoids - Sony
Humanoids – Honda Asimo
Are Robots Like in the Movies?

Yes, They Can Be!

But they are mechanisms, not intelligent machines
The Big Questions

• Are Robots Ready To Do Useful Things?
• Can We Really Build Intelligent Robots?
• Why Don’t Real Robots Look Like The Ones In The Movies?
• Will Robots Take Over the World?
Biomimetics – Evolving Robot Brains
Perception – The Grand Challenge
Will Robots Take Over The World?

Yes, But Not Yet

Robots are the logical conclusion of the machine age
And what are the consequences?

- Ethics is a major issue for robot scientists
- Immediate issues in defence and security
- Longer term issues about the world we want to live in
- Be careful about what you wish for!
Questions ?