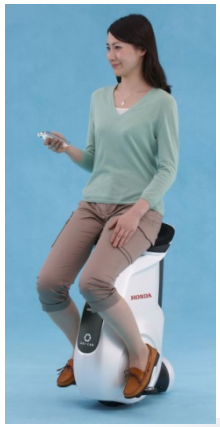
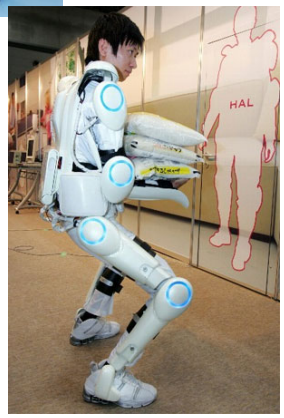
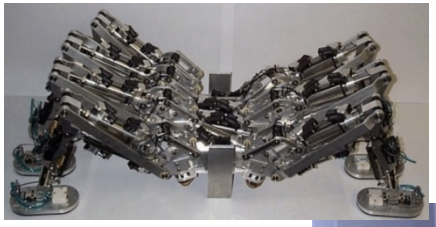
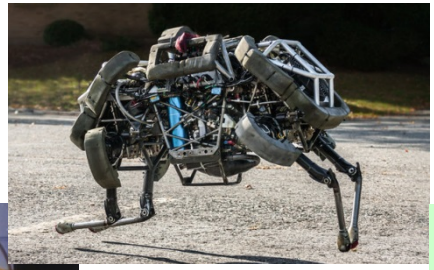
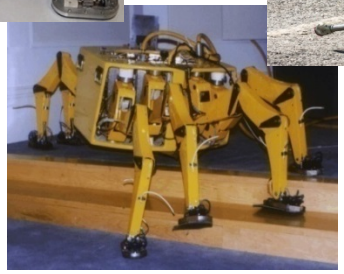
Robot design assessment and benchmarking











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Assignment: Service robot design

Perform a concept design of a service robot for one of the following applications;

1. **A mobile robot able to take a pet dog for a walk outdoors**
2. **A floor cleaning robot for a public railway station**
3. **A mobile robot able to welcome and guide visitors to their hosts in an organisation**

Define assumptions made using sound logical reasoning bearing in mind:

- **Specific aims of robot (tasks, safety, performance needed, etc)**
- **Key behaviours needed and how these may be achieved using appropriate sensors, decision making and actuators**
- **Need for a modular block diagram of key behaviours of the robot designed**

Work individually or in small groups and prepare your concept design as a short Powerpoint presentation (maximum 6 slides) by 16.00 today and send to Professor Virk (gurvinder.virk@innotecuk.com).

Powerpoint file should contain:

i. **Names, organisations, and email addresses of all group members**

ii. **Design structured as follows**

   a) **Aim of robot and assumptions made about application and operational environment**
   b) **Main behaviours needed in your robot system. Specify any constraints**
   c) **How a few behaviours can be achieved using a modular supply chain approach**
   d) **Explain decisions made and pay attention to design assessment criteria presented in lectures**
   e) **Present a sketch of your design**

General robot design process

1. **Gathering information: What must robot do?**
2. **Identifying specific details of the design which must be satisfied and operational environment**
3. **Identifying possible and alternative design concept solutions (can be assessed)**
4. **Planning and designing an appropriate structure including detailed drawings**
5. **Building and testing prototype**
6. **Test and assess final robot**

1. Design requirement process can be unclear!!

2. Deciding rankings of features can be hard to agree on!!

3. Developing concepts can be easy but deciding which to select can be difficult

4. Following project plan is easy!!

5. Tests difficult to get agreement on

Testing and assessing designs can be hard

Robotics design and assessment

- **Robotics design and assessment process is rather ad hoc and not developed to "a sufficient science" that allows for proper assessment or benchmarking of individual designs so they may be ranked in a clear and definitive manner.**
- **This is seen as having a negative impact on robot technology transfer as it is difficult to objectively assess the state-of-the-art in a given area and if the technology is ready for commercialisation**
- **Objective replication and benchmarking are needed to foster cumulative advancement of our knowledge of robotics. It has been suggested that we take inspiration from experimental practice in disciplines such as biology or medicine**

euRobotics TG Benchmarking
(F Bonsignorio fabio.bonsignorio@sssup.it)

- Defining experiments to facilitate replication and standardisation of robot platforms
- Competitions (euRathlon, RoCKIn, Robocup)
- Challenges (Darpa, Argos, etc)
- Use of international standards

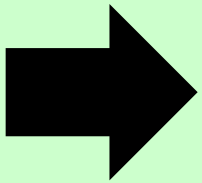
Robot competitions and challenges

- **Competitions and challenges are a catalyst for smarter, more dependable robots by focussing on key technologies via defined scenarios. Examples:**
  - **Micromouse, from 1970s, small robot to solve maze problem, (https://en.wikipedia.org/wiki/Micromouse)**
  - **Robocup 1997 robots playing football to promote robotics and AI by publically appealing but formidable challenges. Different leagues set up, http://www.robocup.org/**
  - **DARPA (2004 onwards), US military: Robots perform "everyday" tasks (eg drive car, open door and enter, climb ladder, etc (https://en.wikipedia.org/wiki/DARPA_Grand_Challenge)**
  - **euRathlon 2013 onwards, http://www.eurathlon.eu/: emergency scenario robots inspired by 2011 Fukushima accident. Now continuing via https://eu-robotics.net/robotics_league**
  - **ARGOS (Autonomous robot for gas and oil sites), June 2015-March 2017, Total, http://www.argos-challenge.com/en**
  - **ETC**

Towards objective assessment of robot designs

It is possible to do the following individually:

- **Assess specific aspects of a design and rank it in terms of other functions in the robot system's architecture**
- **Cluster sub-systems (eg. behaviours implemented in the robot system) to identify common themes in the overall design that are needed from the following views:**
  - **Sensing: requirements and how well satisfied**
  - **Locomotion / actuation: requirements and how well satisfied**
  - **Decision making: requirements and how well satisfied, etc**
- **Determine the criteria set that should be used to assess the design, etc.**



Ask many individuals (experts) to do the same assessment and average the results!! This is the Delphi approach

Get more information by Googling "benchmarking robot designs"

Issues important in assessment

- Cost
- Power
- Speed
- Safety
- Size/ weight/ volume
- Robustness
- Software optimality
- Collaboration
- Information fusion
- Environment
- Materials

- Technical
- Recovery
- Legal
- Appearance
- Interaction/ useability
- Compliance with Standards
- Should satisfy the equation:
- Cost < Price < Value
- ETC

Clustering of performance metrics

- **Goal achievement metrics**
  - Cost, safety, power, robustness, technical
- **Constraint satisfaction metrics**
  - Size/ weight/volume, environment, speed,
  - Legal, compliance with standards
- **Usability metrics**
  - Autonomous, semi-autonomous and tele-operated systems metrics (may be different)
  - Difference and complexity of requirements
  - Performance subjective to operator's skill
- **Overall acceptability**
  - Value for money
  - Reliability and robustness to level required
  - Will it be usable and acceptable by the users?
- **Others?**

Assessment questionnaire: 5 point scale

1. Design considers cost to be important for measuring success
2. Technical criteria is likely to be achieved by design
3. Design is inherently safe and presents no issues of concern
4. Design is acceptable from all legal and regulatory aspects
5. Design has a good user interface
6. Design is sound from reliability and maintenance aspects
7. Design has good appearance making it acceptable to users
8. Autonomy level is acceptable
9. Overall design is good value for money
10. Power requirements and operating time is acceptable
11. Communication aspects are good
12. Design has good potential to be usable in practical situations
13. Design offers good potential for robot component modularity

Assess your robot designs

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	2	3	4	5

Summary

- Overview of robot design process
- Key robot components described and design process based on modularity introduced
- Assignment on robot concept design assessed via Delphi approach

Thanks are expressed to all the colleagues (too many to mention individually) across the world who have helped with the formulation of this lecture on Robot design and assessment from material placed on the www