



AI & Robotics @ Edinburgh six decades ... and beyond

Austin Tate

Emeritus Professor of Knowledge-Based Systems

AAI, University of Edinburgh

The New Club, Edinburgh, 6th January 2022

Artificial Intelligence @ Edinburgh over the Years

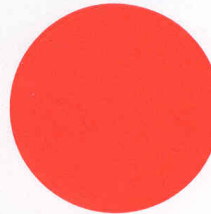
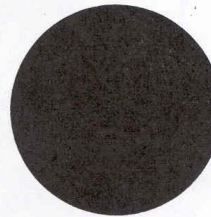
- Experimental Programming Unit (EPU), 1963-1966
- Department of Machine Intelligence and Perception (DMIP), 1966-1970
- Department of Machine Intelligence, 1970-1973
- School of Artificial Intelligence, 1973-1974
+ Machine Intelligence Research Unit (MIRU), 1973-1977
- Department of Artificial Intelligence (DAI), 1974-1998
+ Artificial Intelligence Applications Institute (AIAI), 1983-2019
- In 1998, the University joined together three departments: Artificial Intelligence, Cognitive Science and Computer Science, as well as a number of research institutes including AIAI and the Human Communication Research Centre, to form the School of Informatics.
- Institute for Representation and Reasoning (IRR), School of Informatics, 1998-2001
- Centre for Intelligent Systems and their Applications (CISA), School of Informatics, 2001-2019
- Artificial Intelligence and its Applications Institute (AIAI), School of Informatics, 2019-

A number of other departments and schools at the University of Edinburgh as well as other research institutes in the School of Informatics work on a range of topics within the field of Artificial Intelligence.

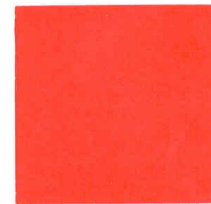


POP-2

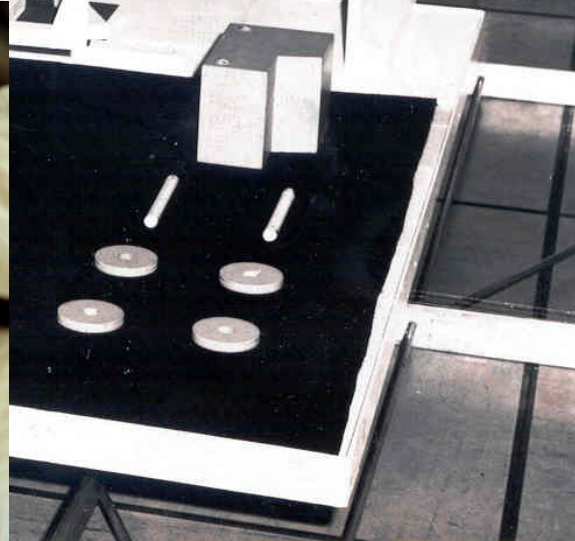
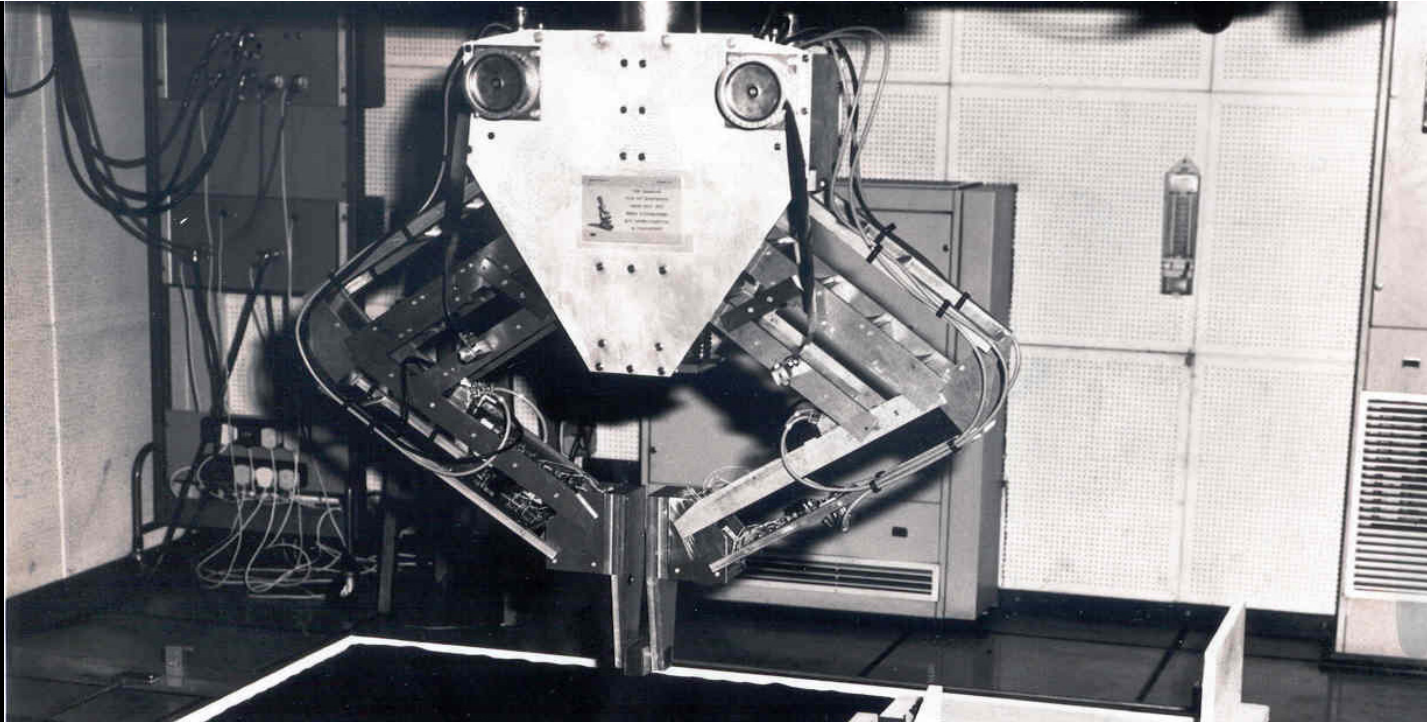
- 3 Introduction
- 3 Simplicity and ease of use
- 5 POP-2 saves money
- 6 POP-2 applications
- 7 POP-2 library and filing system
- 8 POP-2 special features
- 18 Preliminary reactions to POP-2
- 19 POP-2 implementations
- 20 Documentation



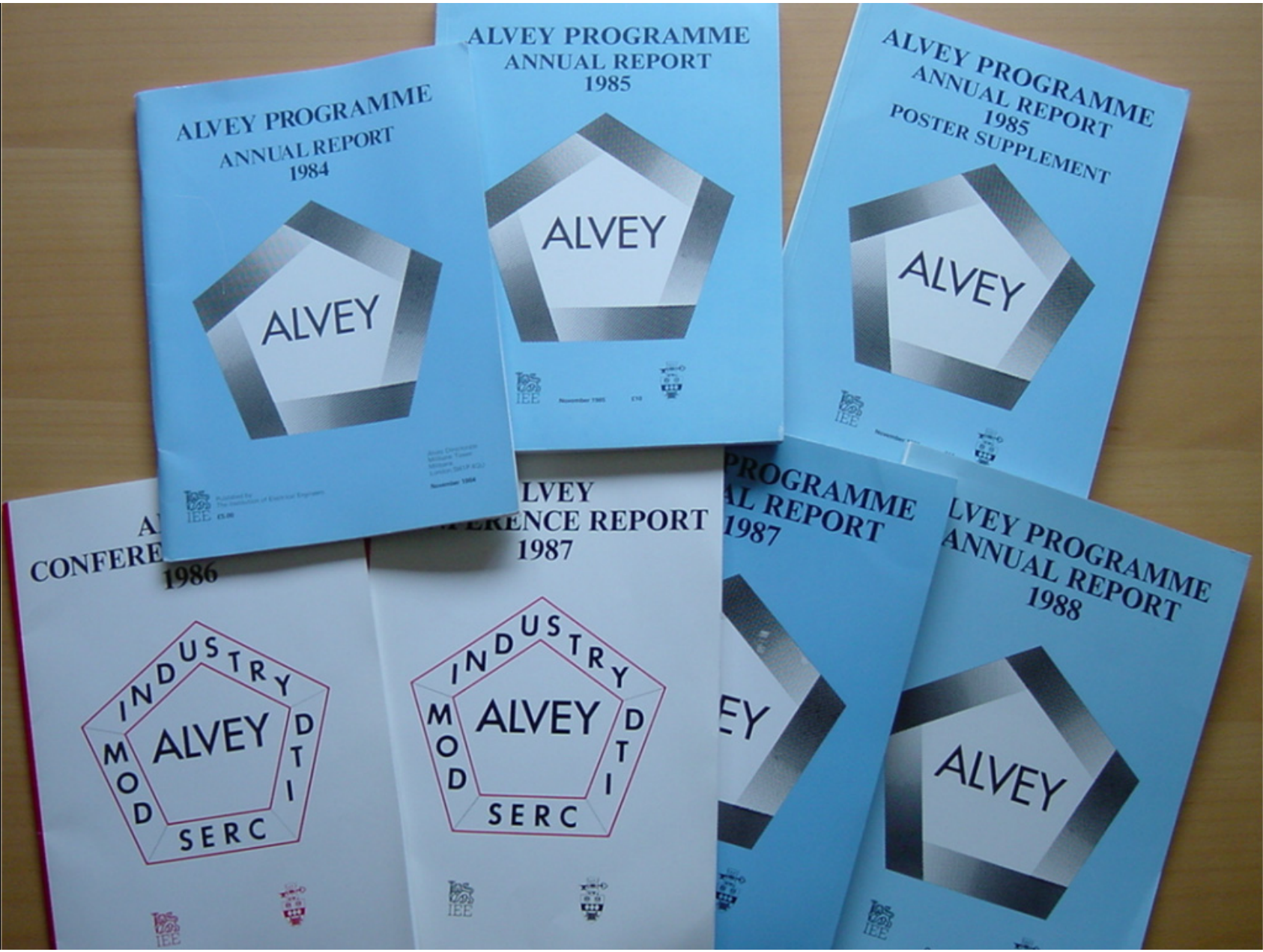
**CONVERSATIONAL
SOFTWARE
LIMITED
5 HOPE PARK SQUARE
MEADOW LANE
EDINBURGH
EH8 9NW
SCOTLAND**



First AI Company, 1969



Freddy II, 1972



ALVEY PROGRAMME
ANNUAL REPORT
1984



Published by
The Institution of Electrical Engineers
IEE
£3.00

ALVEY PROGRAMME
ANNUAL REPORT
1985



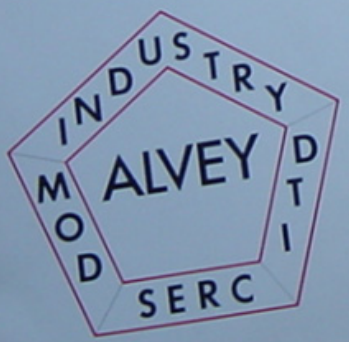
IEE
November 1985
£14

ALVEY PROGRAMME
ANNUAL REPORT
1985
POSTER SUPPLEMENT



IEE
November 1985

ALVEY PROGRAMME
CONFERENCE REPORT
1986



IEE
£10.00

ALVEY PROGRAMME
CONFERENCE REPORT
1987



IEE
£10.00

ALVEY PROGRAMME
CONFERENCE REPORT
1987



IEE
£10.00

ALVEY PROGRAMME
ANNUAL REPORT
1988



IEE
£10.00


ALVEY - IKBS DIRECTORATE
Knowledge Based Systems Club
Project Summaries
For Projects started between
October 1985 and December 1987

Proceedings of the second
**WORKSHOP ON ARCHITECTURES
FOR LARGE KNOWLEDGE BASES**
Sponsored by the Alvey Directorate

ALVEY ACHIEVEMENTS

Alan Tate

THE CATALOGUE OF ARTIFICIAL INTELLIGENCE TOOLS




Editor: Alan Bundy
Assistant Editor: Lincoln Wallen
Review Committee:

Fal Anderson	Jul Mitchell
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Max Gordon	Henry Thompson
David Haré	Frank White
John Lumley	Richard Young

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Alan Tate

GRAND MEETING OF COMMUNITY CLUBS
CBI BUILDING, CENTRE POINT
6th FEBRUARY 1987



ALVEY

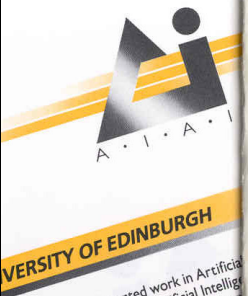
ALVEY - IKBS DIRECTORATE
Knowledge Based Systems Club

Alan Tate

SERC - DoI
IKBS Architecture Study

**Intelligent
Knowledge Based
Systems**

A Programme for Action in the UK



UNIVERSITY OF EDINBURGH

Edinburgh University started work in Artificial Intelligence as the only Department of Artificial Intelligence in the country. It now hosts the largest and most profitable result, with over 200 people researching in all aspects of Artificial Intelligence. Computer Science at Edinburgh, form one of the strongest research centres in Britain.

ARTIFICIAL INTELLIGENCE

The techniques and tools developed in Edinburgh have reached the point where they can be applied to commercial and industrial relevance. The response to this industrial interest is technology transfer or the interpretation and presentation of research results to academia.

AIAI is a technology transfer organization that interprets and presents research results to academia. AIAI is located in central Edinburgh, Department of Artificial Intelligence Technology Research.

TECHNICAL GROUPS

AIAI is organised into several specialist groups. The groups are:

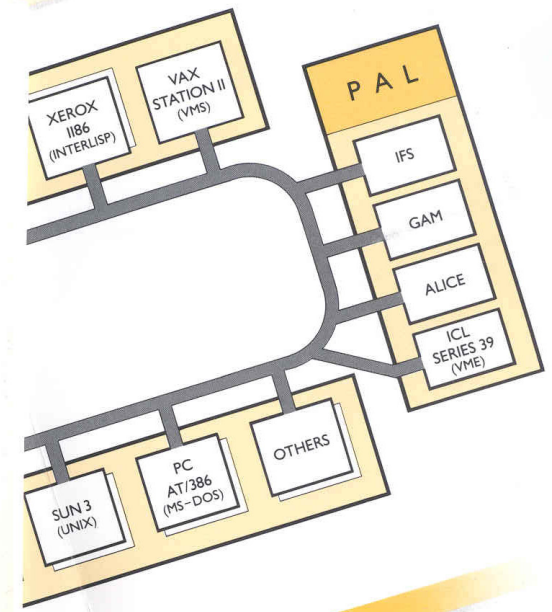
- ▲ Knowledge Engineering
- ▲ AI Programming
- ▲ AI Parallel Processing

The Establishment of an ARTIFICIAL INTELLIGENCE APPLICATIONS INSTITUTE

at the
University of Edinburgh



University of Edinburgh



PAL

AIAI hosts a national Parallel Architectures Laboratory (PAL) which aims to encourage cooperative work on novel architectures and their applications within AI. A variety of these are currently being investigated, including software systems such as Parallel Prologs and hardware systems such as the ALICE graph reduction engine and the FACT/GAM (Generic Associative Memory) and IFS (Intelligent File Store), developed under the Alvey programme.

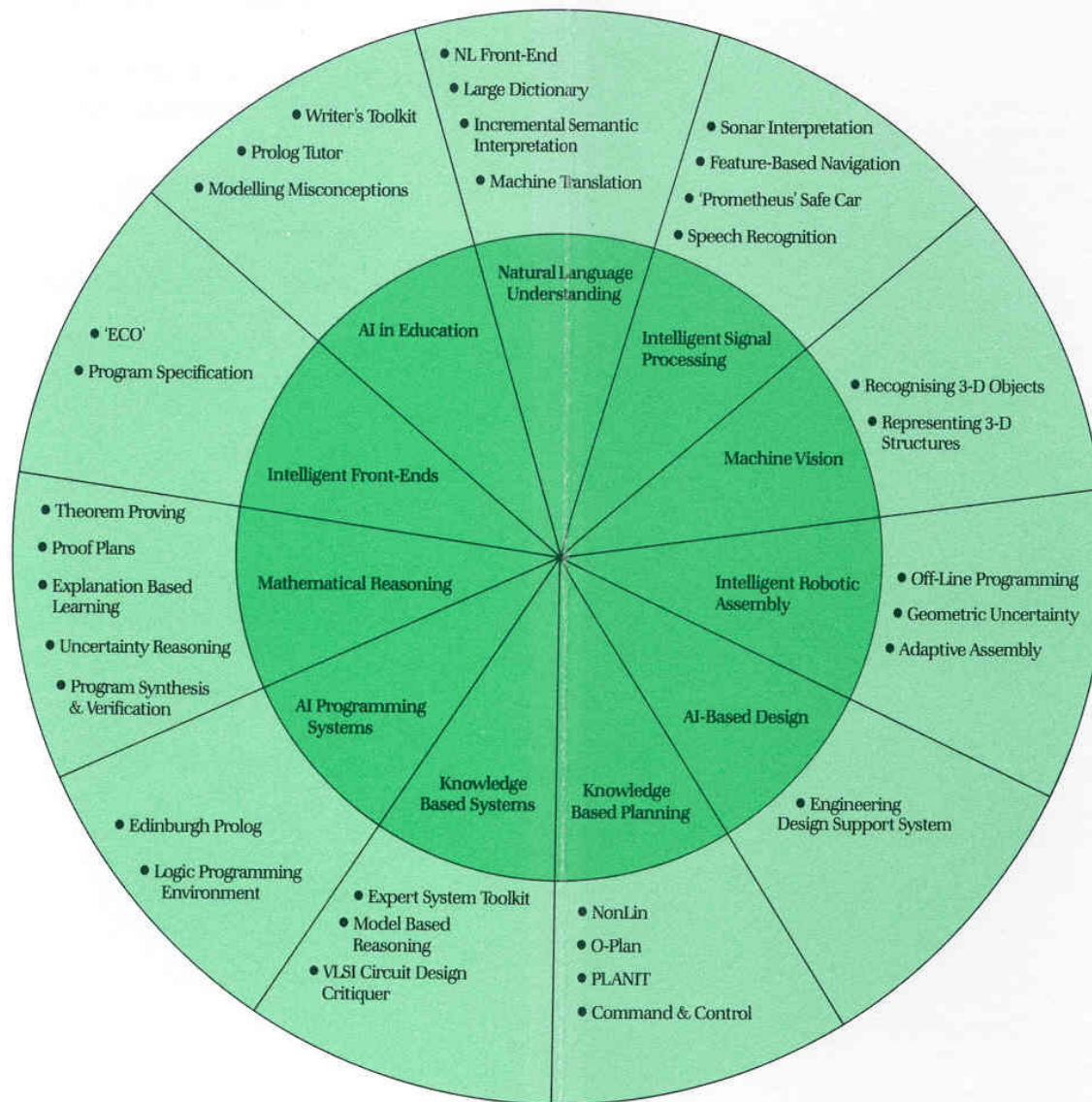
Further architectures are accessible through the University's Parallel Computing Consortium of which AIAI is a member. PAL is jointly supported by DTI, SERC and Alvey.

established hardware and software substantial and suitability software available

JPLOG

JPSS

able to assist visiting researchers in the Alvey Programme.



Application
 Research

Research Topics, 1980s

Call for participation

The scientific scope of the conference includes, but is not limited to the following topics:

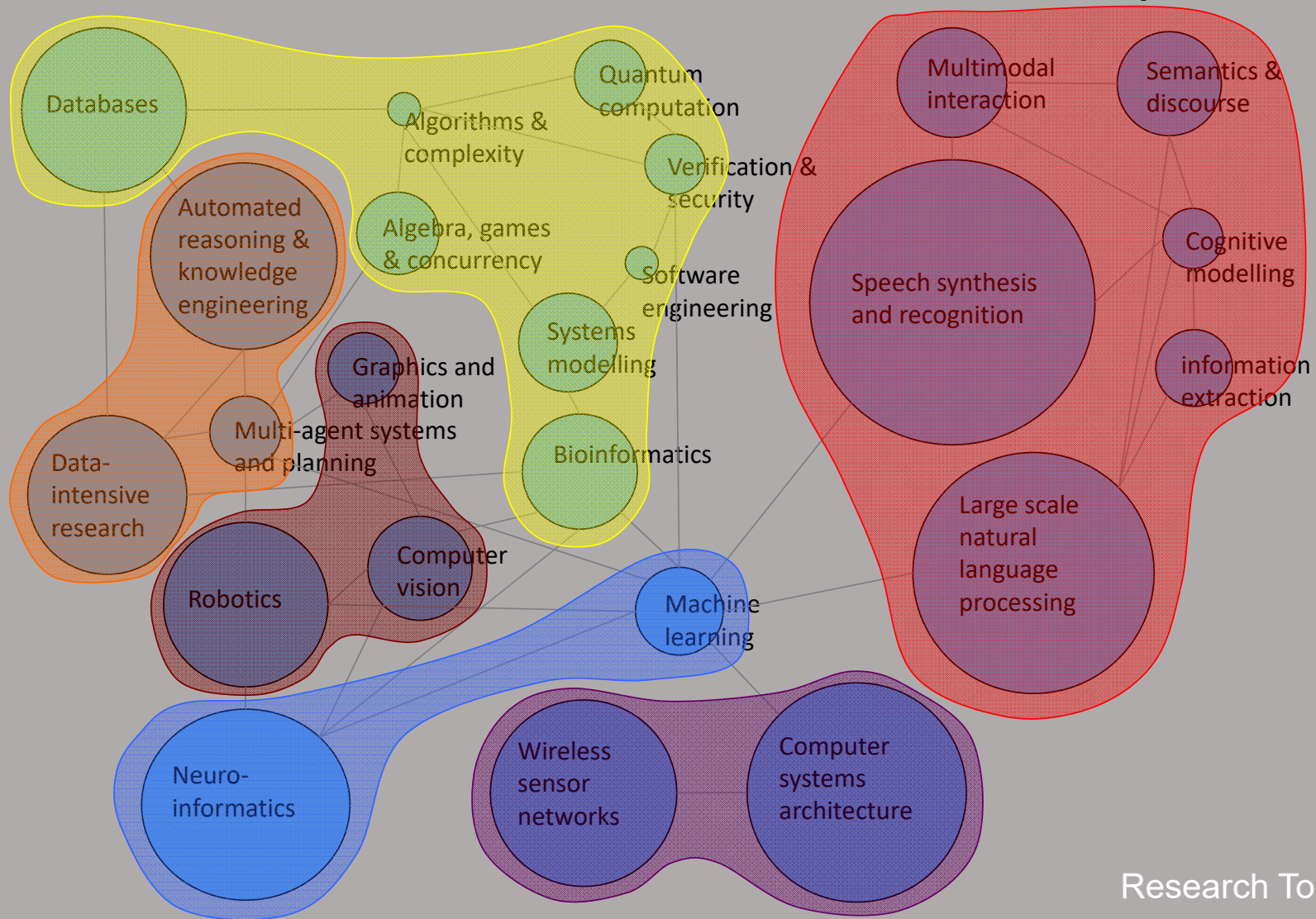
List of area keywords

abduction
adaptive systems
AI architectures
AI and data integration
AI and creativity
AI and security
AI and the Internet
applications
art and music
artificial life
automated modeling
automated reasoning
autonomous agents
belief revision and update
business intelligence
case-based reasoning
causality
cognitive modeling
cognitive robotics
common-sense reasoning
computational complexity
computer-aided education
conceptual graphs
configuration
constraint programming
constraint satisfaction
corporate knowledge
customer relationship management
data mining
decision theory
decision trees
description logics
design and configuration
dialog processing
diagnosis
discourse modeling
distributed AI
enabling technologies
expert systems
game playing
genetic algorithms
geometric reasoning
heuristics
human computer interaction
inductive logic programming
information agents
information extraction
information retrieval
intelligent databases
intelligent e-mail processing
intelligent query processing
knowledge acquisition
knowledge discovery
knowledge engineering
knowledge representation
lifelike characters
logic programming
machine learning
machine translation
market-oriented programming
mathematical foundations
model-based reasoning
multiagent systems
multimedia
natural language
negotiation
neural networks
non-classical computation models
nonmonotonic reasoning
ontologies
perception
personalization
planning
philosophical foundations
predictions
probabilistic reasoning
problem solving
qualitative reasoning
reactive control
real-time systems
reasoning about actions and change
reinforcement learning
resource-bounded reasoning
robotics
rule learning
satisfiability
scheduling
scientific discovery
search
semantic web
simulation
software agents
spatial reasoning
spatial and temporal databases
speech processing
temporal reasoning
theorem proving
uncertainty
user interfaces
user modeling
validation and verification
virtual reality
vision
web agents
web intelligence
web mining
web search

Typical AI Conference Topics
IJCAI 2003, Mexico



Informatics Research Landscape



Research Topics, 1998

Informatics Institutes and Relationships

medicine

engineering

mathematics

geosciences

philosophy,
psychology,
language
sciences

icsa | Institute for Computing
Systems Architecture

aiai | Artificial Intelligence
and its Applications Institute

ipab | Institute of Perception,
Action and Behaviour

informatics

anc | Institute for Adaptive
and Neural Computation

physics

lfcs | Laboratory for Foundations
of Computer Science

ilcc | Institute for Language,
Cognition and Computation

social and
political
sciences

college of
art

education

law

Edinburgh Startup Ecosystem

Palace of Holyroodhouse

- BayesCentre
- MAXWELL INSTITUTE FOR MATHEMATICAL SCIENCES
- design informatics
- informatics
- INFORMATICS™ VENTURES
- intel
- ICMS
- COGNIHEALTH
- THE DATALAB
- epcc
- THE UNIVERSITY OF EDINBURGH
- robotics
- INFORMATICS™
- WALLET SERVICES
- ABAKA
- vrec
- mungoparc
- MODULARITY GRID.
- edjo.io
- VOXSIO
- appii
- UrbanTide
- HUAWEI

Waverley Gate

- NHS SCOTLAND
- amazon Development Centre Scotland
- BRITISH COUNCIL
- Museums Galleries Scotland
- eyec
- Microsoft
- amazon
- Colony Growth
- ALBA - CHRISTMAS
- H&M
- the gym
- Balfour Beatty

Appleton Tower

- auris
- Inrobin
- Actual Analytics
- BOXERGY
- INPUT | OUTPUT
- Design Point
- Quorate
- CONTINUUM INDUSTRIES

Quatermile

- IBM
- skyscanner
- MERCER
- CIRRUS LOGIC
- Investec Wealth & Investment
- FanDuel
- MORTON FRASER
- open optimized environments
- maclay murray & spens
- scotch whisky

techcube

- Monsters & Critics
- mhn
- THE SKINNY
- medanex
- d
- INTERFERENCE PATTERN
- Spectrolytic
- PH
- texaport
- PRODUCT FORGE
- Venture English

Other Callouts:

- Usher Hall**: kin, KMsoft, KYTHERA, LIVE IT, make it social, MM, MERCUNA, Money Partners, MRM, NOVAFUT, NUMBERTELLING, Outplay, pasabi, PINGO, PITCHBOOKING, PROPER QA, relagmed, seymourpowell, .Sharein, SIGNUM AUDIO, SKYMOONS, SpecifiedBy, SYMPHONIC, thinkWhere, TOPOLYTICS, tvsquared, UltraHuman, UrbanTide, UWI TECHNOLOGY, VELOCITY, Voysis, Worktribe™, WALLLET SERVICES, Wallscope
- Waverley Gate** (Additional): AbarCloud, Administrate, airts, ALLATUS, AOULANSIGHT, bemo, bigger at target, Blockchain Technology Partners, BLUE CLIFF MEDIA, bright ascension, CORE SOURCE, CODECLAN, CogBooks™, CONFBUZZ, cludsoft, CKNOW, cloudhelix, Criton, Cultivate, CYAN FORENSICS, device lab, dialexy, dijify, ECM, EcoSurgical, EUAN'S, findr, FIX.LIVE, float, Holoxica Limited, INTO FILM, itison, KAREN MABON, World of Fun



Bayes Centre

Making Data Matter

- Innovation Centre for Data Science and AI
- Putting Data Driven Technologies to Practical Use
- Research, Education, and Innovation

Bayes and the Bayes Theorem

Bayes Theorem - describes the probability of an event, based on prior knowledge of conditions that might be related to the event.

Underlies much of the “deep learning” data driven (“big data”) systems now being studied and applied in many practical situations.

Rev. Thomas Bayes, minister, philosopher & statistician
1701-1761, University of Edinburgh (logic & theology).



E-Commerce

Navigation

Robotics

Human Resources

Healthcare

Agriculture

Gaming

Vehicles

Social Media

Marketing

The Bayes Centre

Edinburgh Parallel
Computing Centre

Edinburgh Centre
for Robotics

External R&D and
Innovation Groups

Design Informatics

Commercialisation &
Innovation Teams

The Bayes Centre

International Centre for
Mathematical Sciences

Centres for
Doctoral Training

- Up to 600 students, scientists, designers and external partners
- Working across sectors and disciplines to make data work for people

The Data Lab

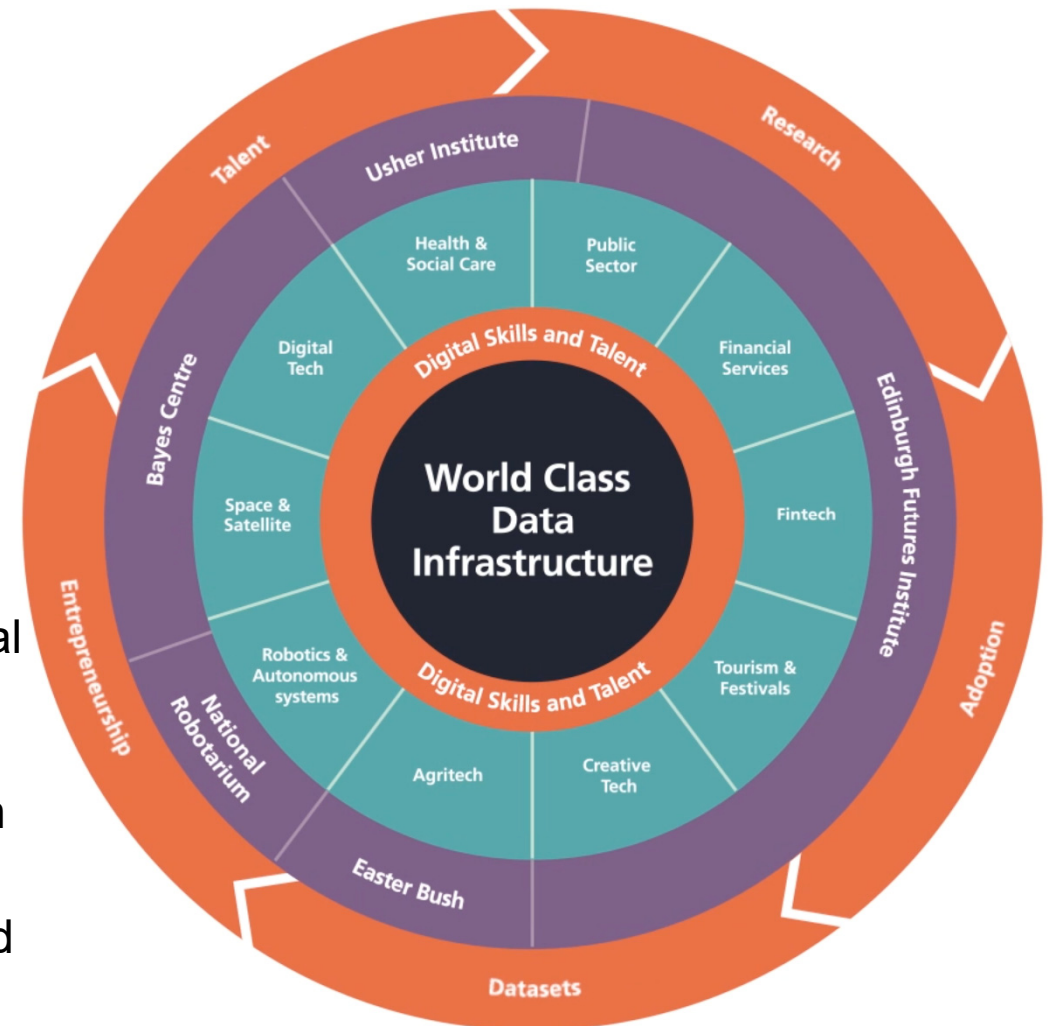
Link to The Alan
Turing Institute

AI & Blockchain
Accelerator

City Deal - Five Hubs – Ten Sectors



- **2018** – £1.3bn City Region Deal for Edinburgh & SE Scotland
- Includes: housing, transport, skills, culture – and **innovation**
- Data-Driven Innovation component is worth **£660m** and will run for 15 years



Data Science \neq AI

- Remember the very wide range of areas of AI described earlier. Data driven technologies and probabilistic reasoning are just one part of this range of technologies and applications.

Going Forward – Hybrid AI

Unfortunately there is a history in the subject of the “latest” AI technology predominating and lack of awareness or use of earlier mixed approaches as well as the “hyping” of the latest whiz-bang.

- But for useful “Explainable Systems” ...
- Human-machine cooperation & mixed-initiative systems
- Cognitive “human understandable” level
- Sub-cognitive data driven, extensive search space exploration, constraint management level which is explained via a “behavioural envelope” at the cognitive level.
- A good example where a mix of technologies is required to make progress is for...

ROBOTS

ROBOTS

≠

≠

Autonomous

≠

Intelligent

Robots ≠ AI

Lower level "reactive" behaviours – becoming very effective due to rapid advances in machine learning and large scale data technologies.

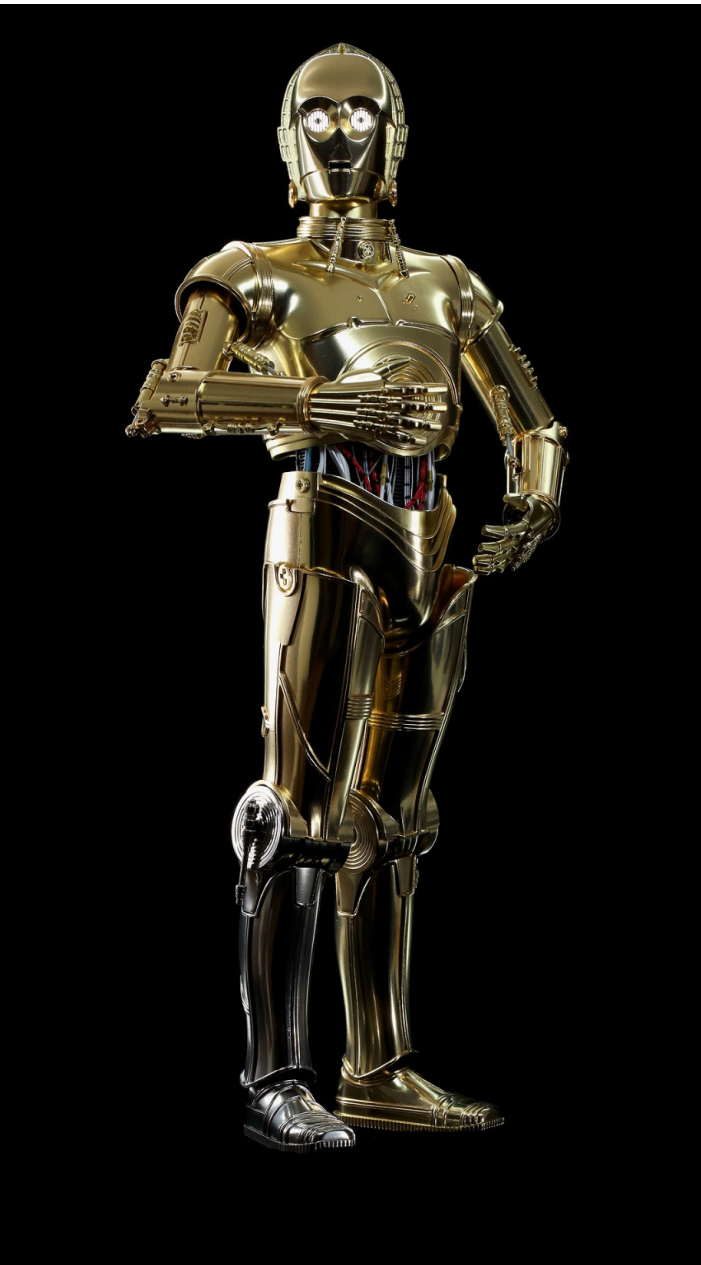
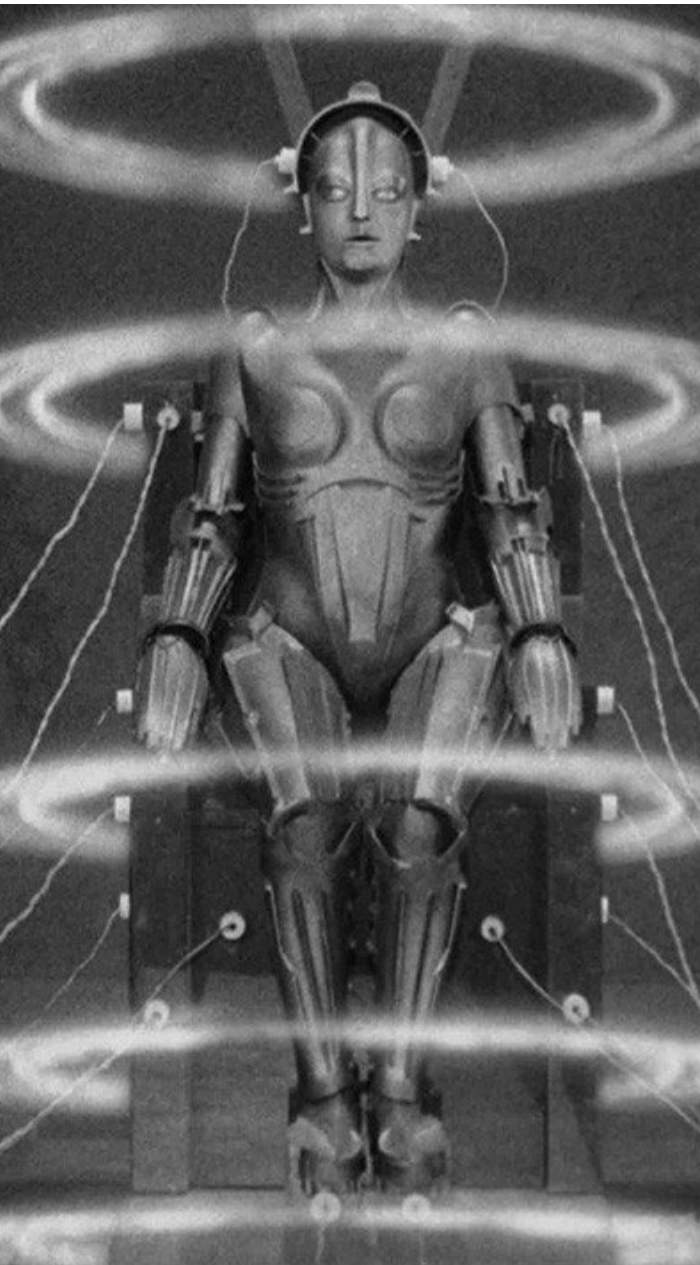
Higher level cognitive capabilities – such as sense making, planning and decision making... often in cooperative situations with humans.



Unimate Robot, 1961

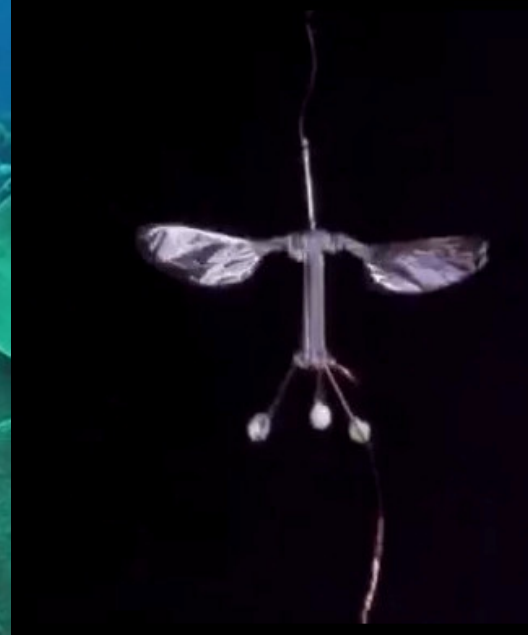
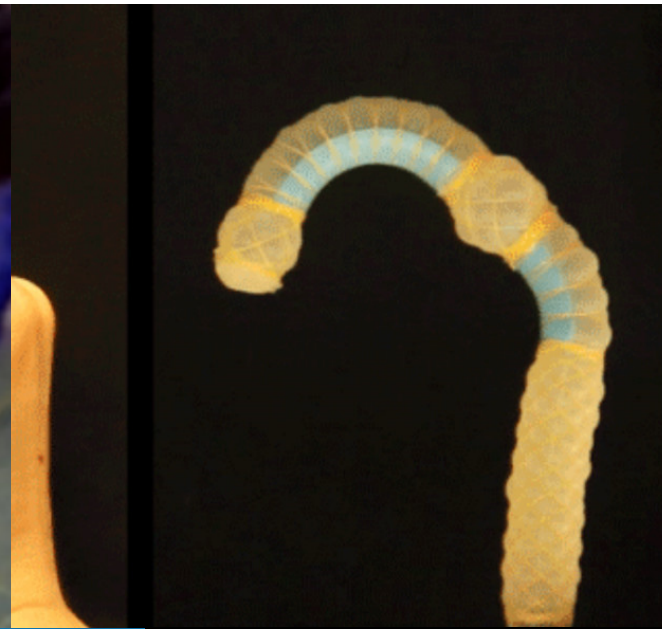
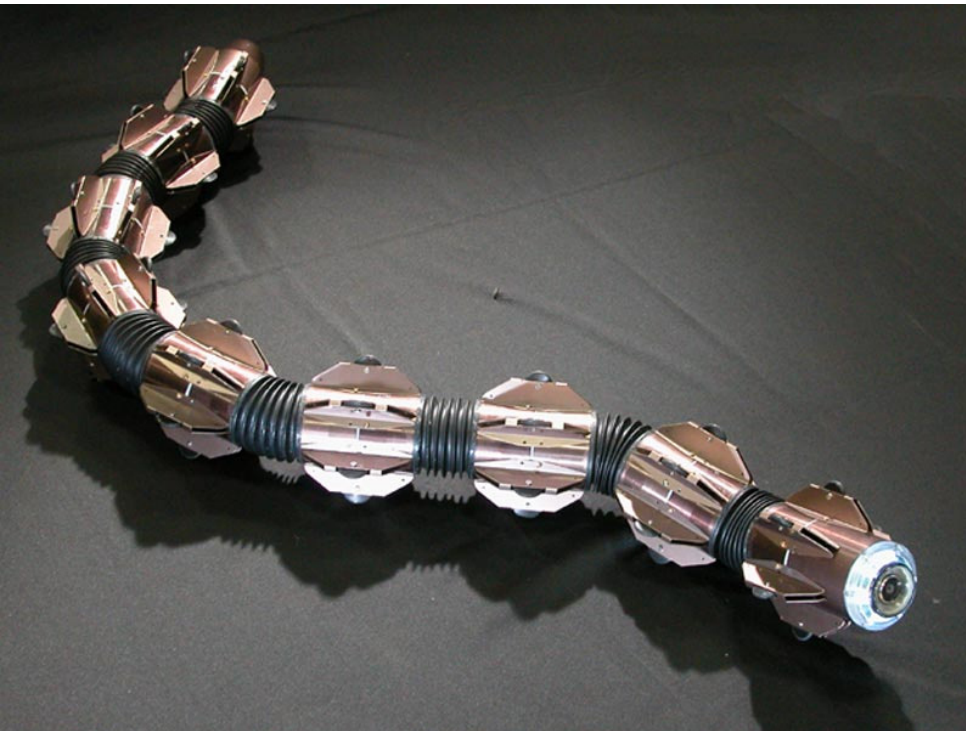


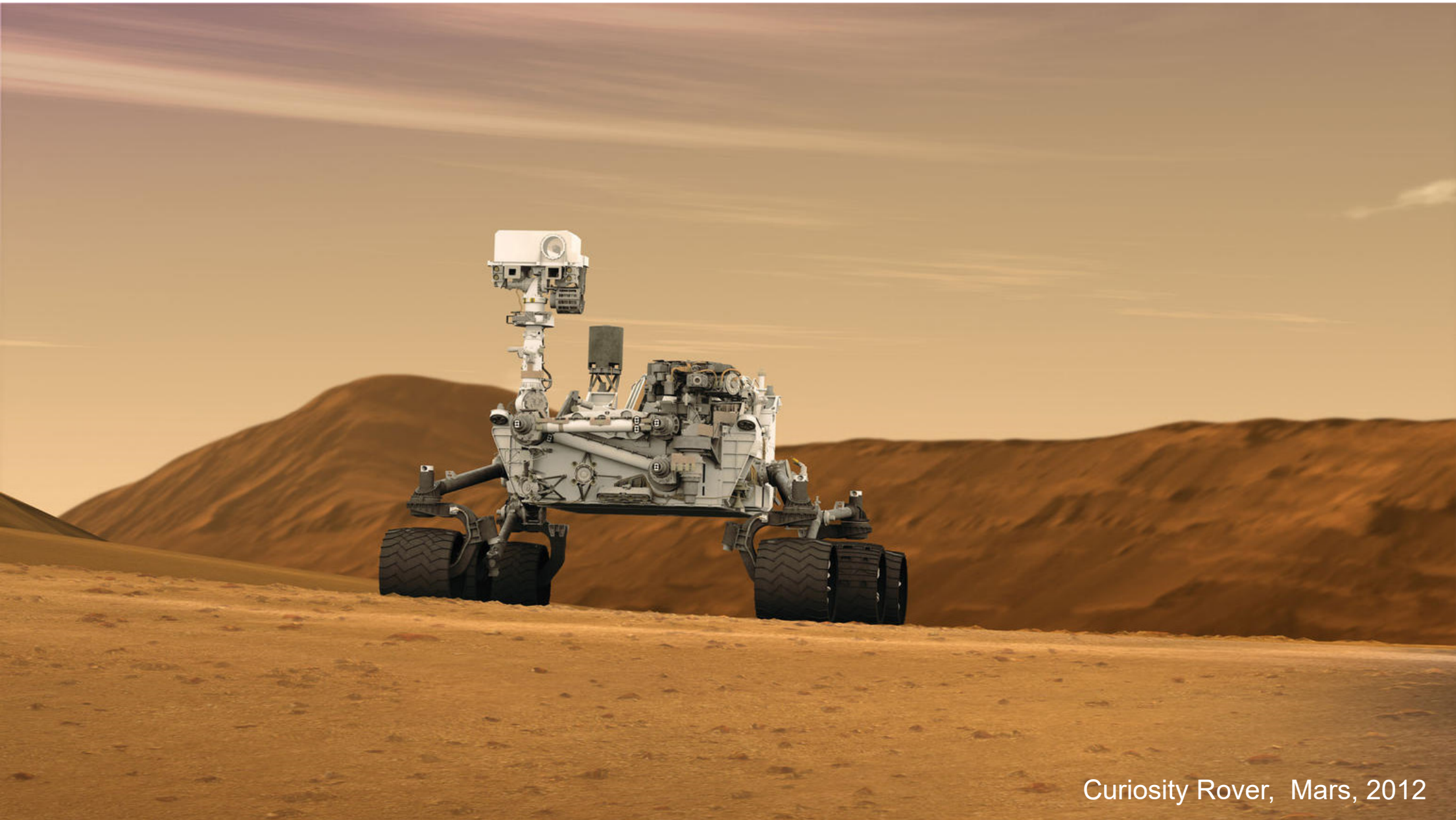
Roomba, iRobot, from 2002



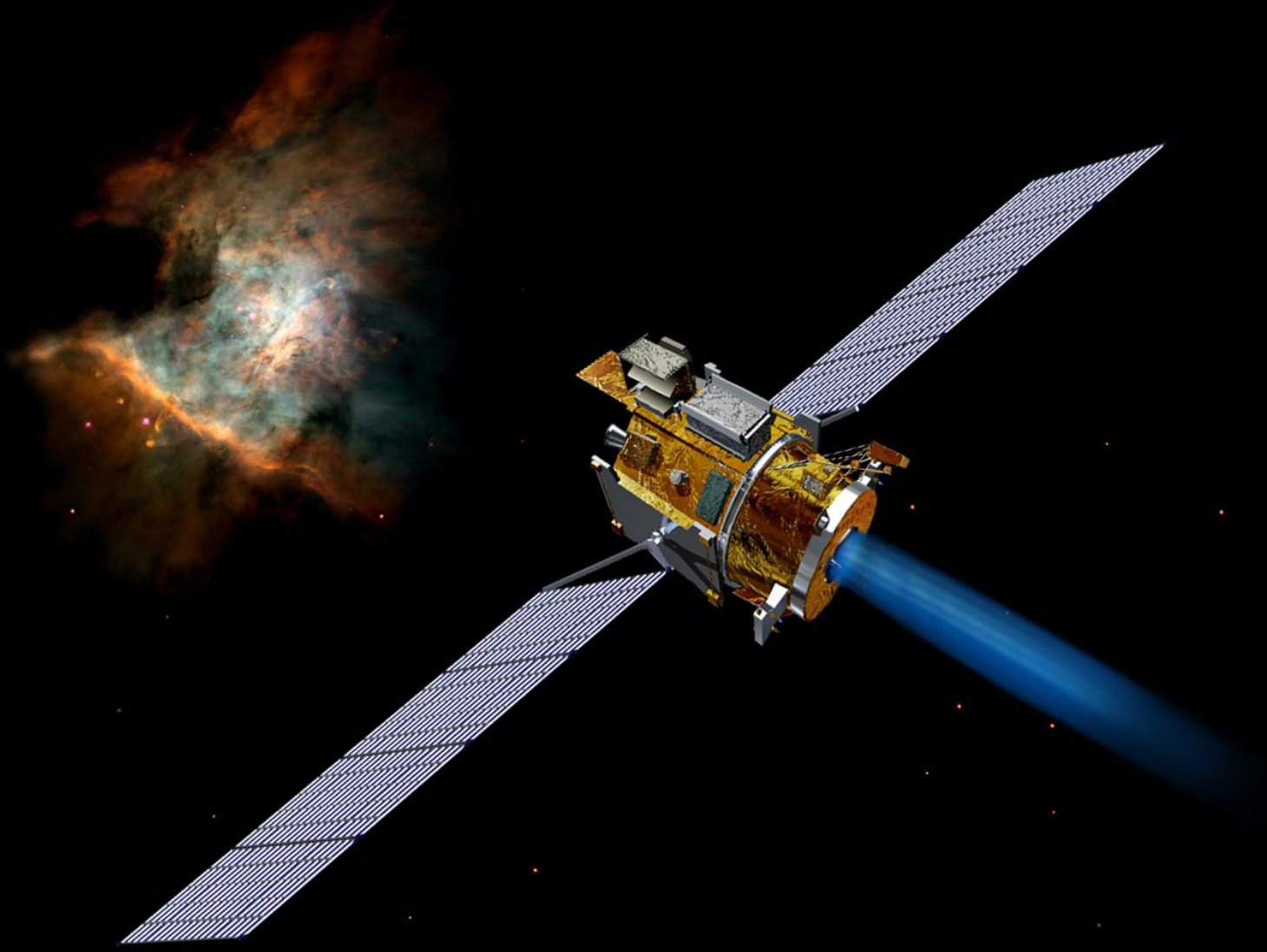


ASIMO
<http://www.honda.co.jp/ASIMO/>
ASIMO is a registered trademark of Honda Motor Co., Ltd.





Curiosity Rover, Mars, 2012



Deep Space One, 1998

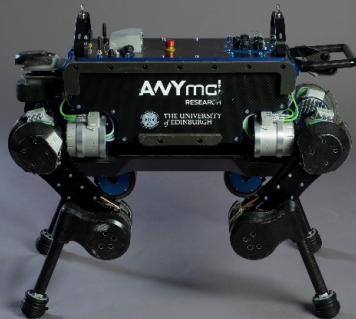


da Vinci Surgical Robot, 2000

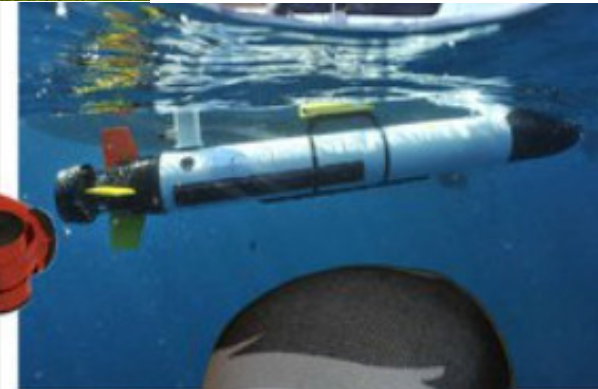
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EDINBURGH CENTRE FOR
ROBOTICS



robotstadium_nao_vs_nao.wbt - Webots PRO 6.4.4

File Edit View Simulation Build Robot Tools Wizard Help

Scene tree C:\Program Files (x86)\Webots\projects\contests\yobotstadium\worlds\yobotstadium_nao_vs_nao.wbt

C:\Program Files (x86)\Webots\projects\contests\yobotstadium\controllers\ nao_team_1\FieldPlayer.java

FieldPlayer.cpp FieldPlayer.java

```

1 // File:      FieldPlayer.java (to be used in a Webots java co
2 // Date:     April 30, 2008
3 // Description: Field player "2", "3" or "4" for "red" or "blue"
4 // Project:   Robotstadium, the online robot soccer competitio
5 // Author:    Yvan Bourquin - www.cyberbotics.com
6 // Changes:   November 4, 2008: Adapted to Webots6
7
8
9
10 import com.cyberbotics.webots.controller.*;
11
12 public class FieldPlayer extends Player {
13
14     private Motion backwardsMotion, forwardsMotion, forwards50Motion;
15     private Motion turnRight60Motion, turnLeft60Motion, turnLeft180M
16
17     private double goalDir = 0.0; // interpolated goal direction (wi
18
19     public FieldPlayer(int playerID, int teamID) {
20         super(playerID, teamID);
21         backwardsMotion = new Motion("../motions/Backwards.moti
22         forwardsMotion = new Motion("../motions/Forwards.moti
23         forwards50Motion = new Motion("../motions/Forwards50.mot
24         turnRight40Motion = new Motion("../motions/TurnRight40.m
25         turnLeft40Motion = new Motion("../motions/TurnLeft40.mot
26         turnRight60Motion = new Motion("../motions/TurnRight60.m
27         turnLeft60Motion = new Motion("../motions/TurnLeft60.mot
28         turnLeft180Motion = new Motion("../motions/TurnLeft180.m
29         sideStepRightMotion = new Motion("../motions/SideStepRight
30

```

Team-0 - 0

0 - Team-1

READY

WorldInfo

Viewpoint

Background

DirectionalLight

SoccerField

Walls

DEF YELLOW_GOAL Goal

DEF BLUE_GOAL Goal

DEF BALL Ball

Supervisor

DEF GOAL_KEEPER_0 Nao_H21_V40

DEF PLAYER_1_0 Nao_H21_V40

DEF PLAYER_2_0 Nao_H21_V40

DEF PLAYER_3_0 Nao_H21_V40

DEF GOAL_KEEPER_1 Nao_H21_V40

DEF PLAYER_1_1 Nao_H21_V40

DEF PLAYER_2_1 Nao_H21_V40

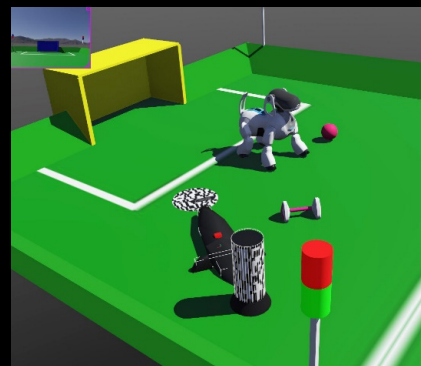
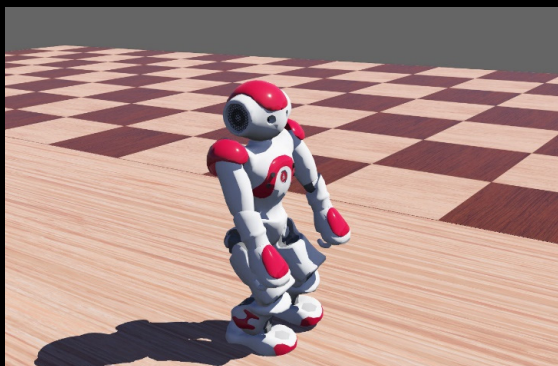
DEF PLAYER_3_1 Nao_H21_V40

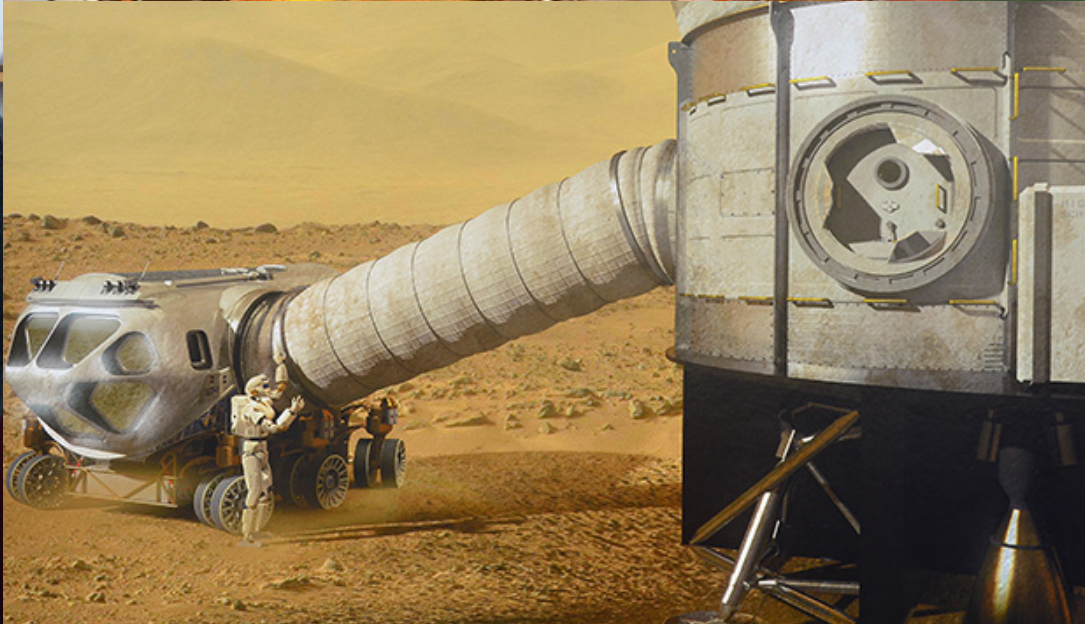
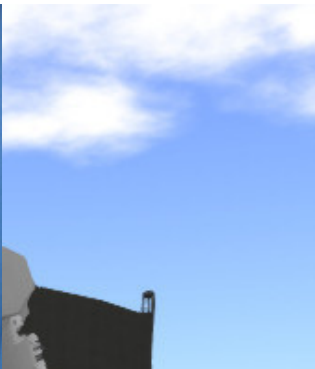
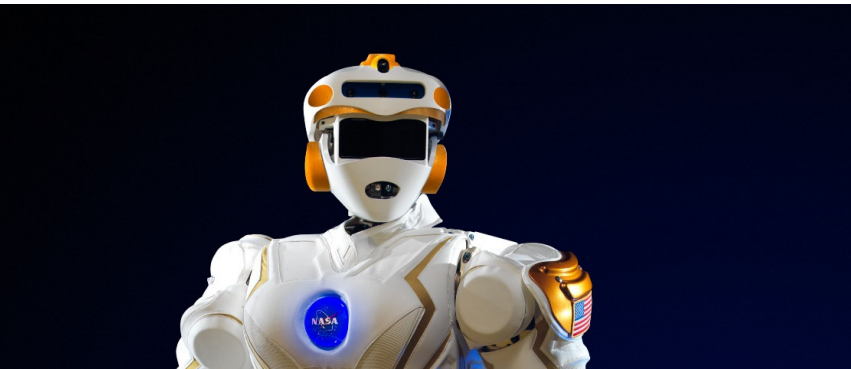
SoccerField (Solid)

DEF

camera: pixel(37,13)=#78671B

0:00:08:000 0.967x





Ethical and Societal Issues

- Privacy issues
- Personal data (mis-)use
- Ease of reversing pseudo-anonymization
- Cultural, racial and gender issues in training data sets
- Autonomous vehicle deployments
- Autonomous weapons deployments - who is responsible?
- Job displacement and work practices
- Wealth sharing and fair distribution



Ethics and safety in AI

A remarkable time of human promise has been ushered in by the convergence of the ever-expanding availability of big data, the soaring speed and stretch of cloud computing platforms, and the advancement of increasingly sophisticated machine learning algorithms.

Innovations in AI are already leaving a mark on government, by improving the provision of essential social goods and services from healthcare, education, and transportation to food supply, energy, and environmental management. These bounties are likely just the start.

The prospect that progress in AI will help government to confront some of its most urgent challenges is exciting, but legitimate worries abound. As with any new and rapidly evolving technology, a steep

learning curve means that mistakes and miscalculations will be made and that both unanticipated and harmful impacts will occur.

In order to manage these impacts responsibly and to direct the development of AI systems toward optimal public benefit, The Alan Turing Institute's public policy programme partnered with the Office for Artificial Intelligence and the Government Digital Service to produce guidance on the responsible design and implementation of AI systems in the public sector.

The guide, *Understanding Artificial Intelligence Ethics and Safety*, is the most comprehensive guidance on the topic of AI ethics and safety in the public sector to date. It identifies the potential harms caused by AI systems and proposes concrete,

operationalisable measures to counteract them. The guide stresses that public sector organisations can anticipate and prevent these potential harms by stewarding a culture of responsible innovation and by putting in place governance processes that support the design and implementation of ethical, fair, and safe AI systems.

The guidance is relevant to everyone involved in the design, production, and deployment of a public sector AI project: from data scientists and data engineers to domain experts, delivery managers and departmental leads. Our aim -- and hope -- in writing the guide is to encourage civil servants interested in conducting AI projects to make considerations of AI ethics and safety a first priority.



David Leslie
Ethics Theme Lead, and Ethics Fellow,
The Alan Turing Institute



Read the *Understanding artificial intelligence ethics and safety* guide at turing.ac.uk



<http://www.aiai.ed.ac.uk/~ai/resources/>