Sheffield Hallam University | Materials and Engineering Research Institute

Robotics&Mechatronics and Social Implementations, 28.08-01.09.2018

CARR




Sharing Spaces with Robots

Lyuba Alboul

and the team: Jacques Penders, Alessandro di Nuovo, Daniela Conti, Inna Popa, Alessandro Soranzo, PhD and MSc students


Centre for Automation and Robotics Research


CARR



SHEFFIELD ROBOTICS

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

Lyuba Alboul

L.Alboul@shu.ac.uk

Mobile Machines and Vision Lab, CARR (Sheffield Robotics) & ACES/STA (Science, Technology and Arts) (Dept. of Maths and Engineering) Postgraduate Tutor MERI

Background

- **MSc in MATHS (both pure and applied)**
- **PhD in Geometry and Topology**
  Extensive training and work experience in Computer Science and AI
- **Knowledge of several engineering domains**

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

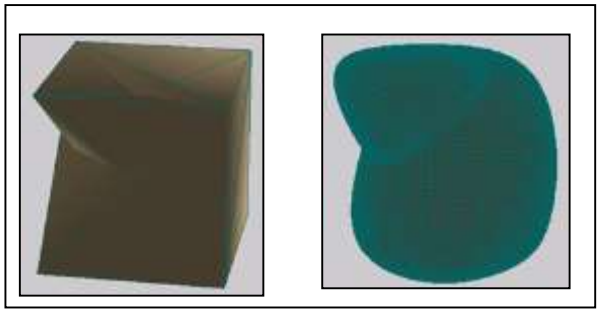
Lyuba Alboul

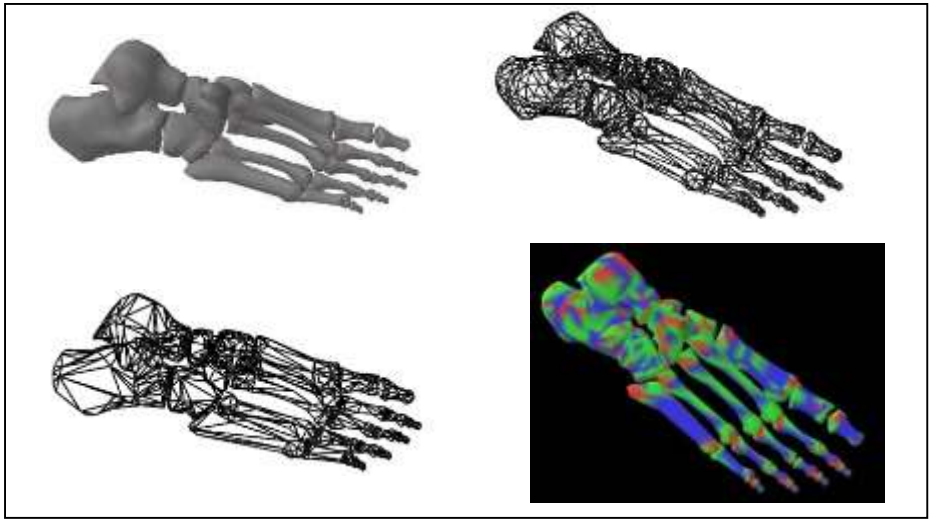
L.Alboul@shu.ac.uk

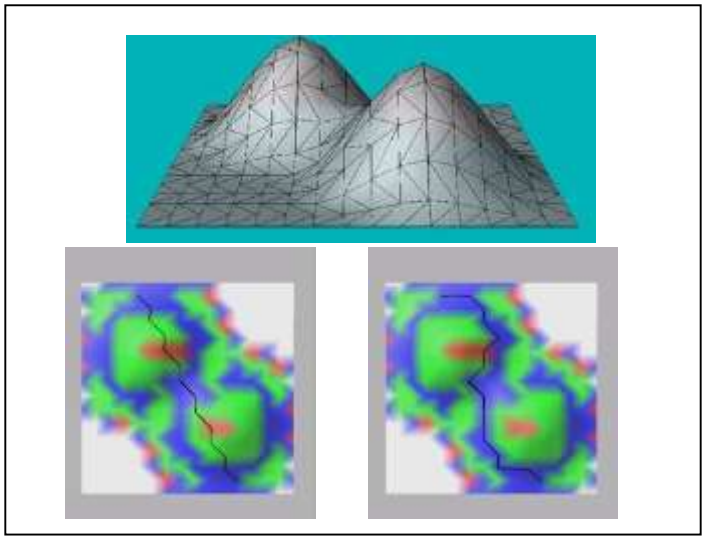
Research interests

- **Surface Modelling of 3D objects:**
  - Surface reconstruction
  - Shape modelling
  - Smoothing and simplification
  - Object comparison and recognition based on discrete curvature measures
- **Representation of the environment by sensor fusion**
  Machine Vision
- **Computational Geometry**
  Path planning
- **Team robotics**
  Modelling behaviour patterns of a group of heterogeneous agents
- **Topology and geometry of Sensor Networks**
  Map Building
  - Tactile exploration of environment
  - Grasping by robot hands
  - Robot-Human Interaction
  - Cyber-Physical-Social Experience

Surface modelling (from discrete data)







Sheffield Robotics

- Sheffield Robotics is a joint venture between two Sheffield Universities, UK: University of Sheffield and Sheffield Hallam University (inaugurated in 2011)
- Areas of research interest

  Robotics Technology

  Biomimetric and brain-based robots

  Human Robot Interaction

  Robotics and humanities

  Application of robotics in creative practice and research

  Assistive robotics

- Associated areas : Virtual Reality
  http://makinen.hallam.shu.ac.uk:9000/wifi/user/account/

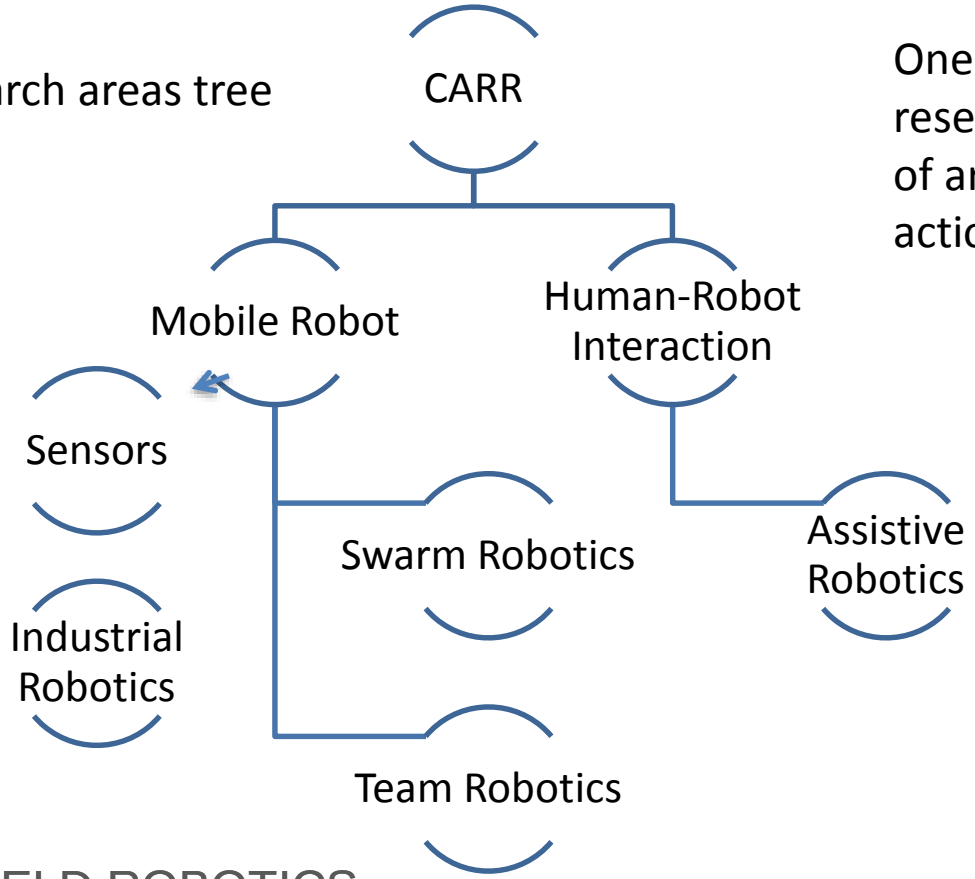
  Serious Games

  http://steelminions.com

http://www.sheffieldrobotics.ac.uk/

CARR (Centre for Automation and Robotics Research)

Research areas tree



One of the main theme of our research is on the connection of artificial perception and physical action

Starting Point: mobile robots

- A mobile robot is a robot which (its entire body) can move intelligently in the environment, e.g. navigate purposefully
- Navigation is a fundamental feature of most animals and any intelligent mechanism
- One of the most distinguished features of mobile robotics is the problem of large-scale spaces, often unstructured environments.

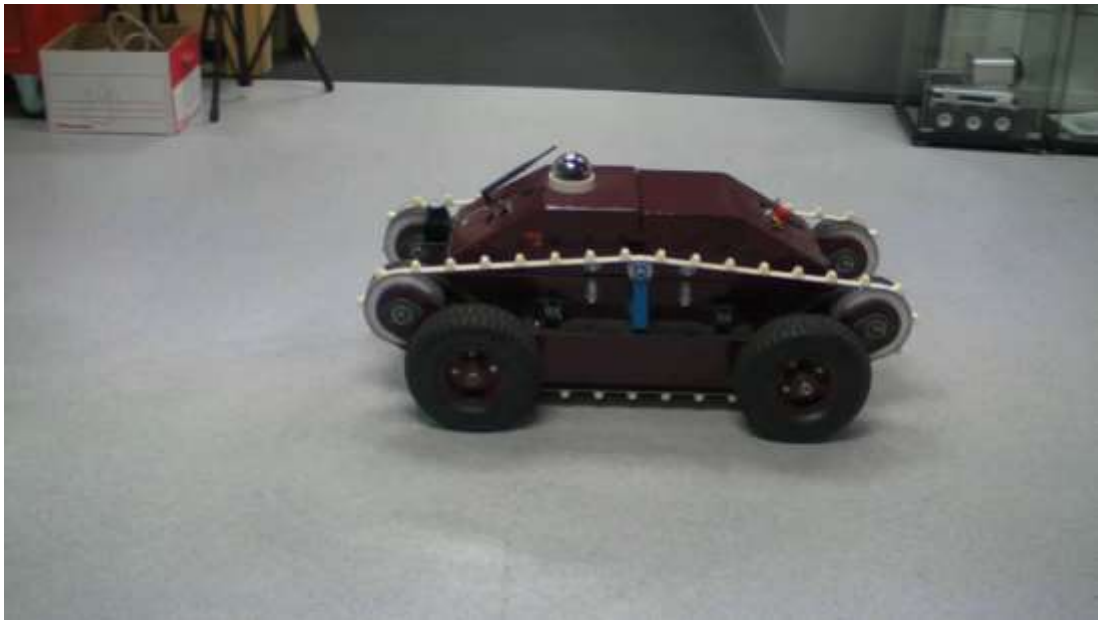
A Navigational Example

(inspired by R. Arkin and J. Penders)

1. Getting to the destination from the current location
2. Not bumping into anything
3. Not colliding with other people on the campus (negotiating the way around other people)
4. Observing cultural idiosyncrasies (habits), e.g. passing on the right (or left)
5. Coping with change in the environment (dynamic environment)

Moving from A to B may be harder than you think

A Navigational Example



Getting to the destination from the current location
Not bumping into anything
Not colliding with other people on the campus (negotiating the way around other people)
Observing cultural idiosyncrasies (habits), e.g. passing on the right (or left)
Coping with change in the environment (dynamic environment)

Moving from A to B may be harder than you think

Where a mobile robot can be used?

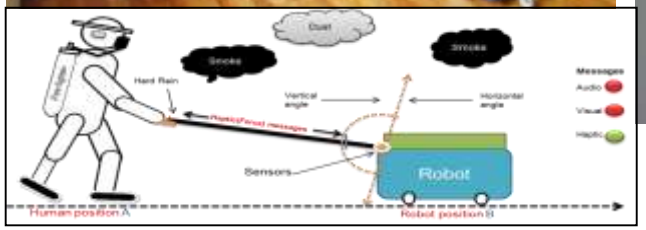
- exploration of unknown environments, mapping of unknown or partially known environments,
- surveillance,
- search and rescue,
- navigation indoor and outdoor,
- transportation of large objects,
- agriculture (farming),
- Assistive robotics (robot as a companion)

Challenges of mobile robotics

- Sensing
  - –Limited, noisy sensors, can fail in some environments such as vision
- Actuation (Locomotion)
  - –Limited capabilities of robot effectors
- Thinking
  - –Time consuming in large state spaces (polynomial, NP-problem)
- Environments
  - –Highly dynamic, impose fast reaction times, low visibility

Autonomous robots that can work for and alongside human beings

- **Combines sensor technologies (machine vision and others) and collective sensing for situational awareness**
- **Aims to understand and develop haptic human-robot interfaces (HRI)**
- **EU/EPSRC-funded projects on Search and Rescue**
- **HRI based on a physical connection; human 'feels' the robot when navigating visually-occluded environments**



Search and Rescue

EU funded projects

- View-Finder
- GUARDIANS

EPSRC

(EPSRC, Engineering and Physical Sciences Research Council)

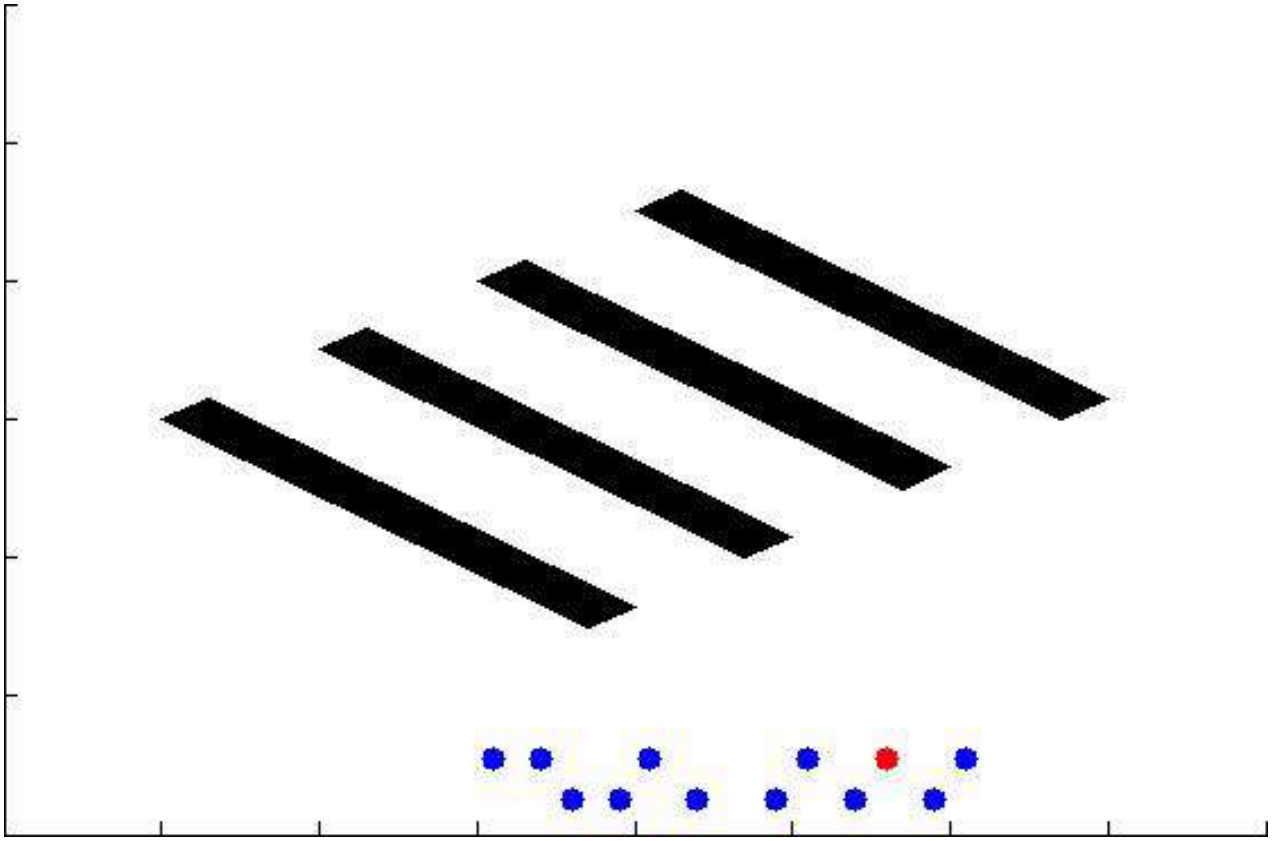
- REINS (Search and Rescue and Human-Robot Interaction)

Guardians (EU project)

- A swarm of autonomous robots applied to navigate and search an urban ground.
  - The project's central example is an industrial warehouse in smoke, as proposed by the Fire and Rescue Service (SyFire).

Guideline search procedure

Warehouse Search



Interaction
Robot Swarm ↔ Human

- Firefighters are under considerable mental and physical stress.
  - The robots should not complicate the navigation task of the human, not physical, not cognitive
- Signals from Human to Robots
- Signals from Robots to Human

Human to Robots

- Robots just assume the human is one of them.

Robots to Human

Visor design with
Minimal Cognitive Load

Robot Swarm to Human

Other developments

- How robots recognise each other?
- QR codes

Loai Sayed and Lyuba Alboul, Vision System for Robot's Speed and Position Control, 13th International Conference on Control Automation Robotics & Vision (ICARCV 2014)

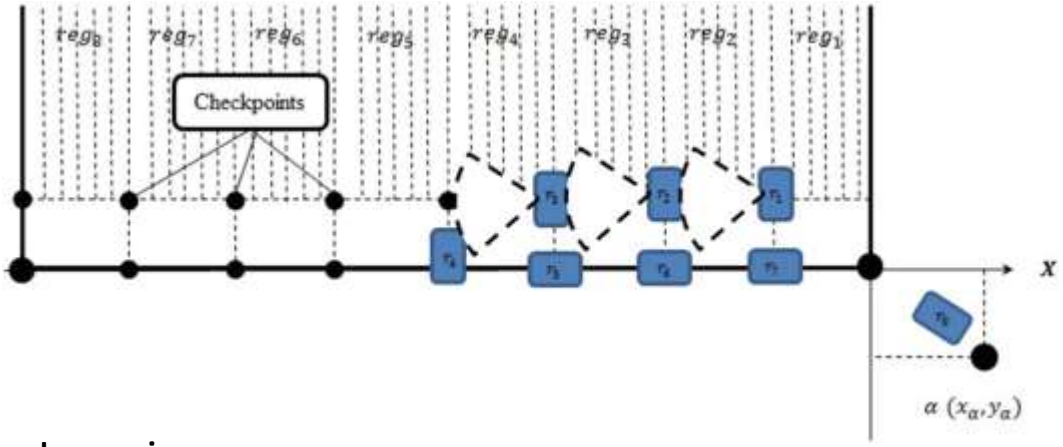
Sheffield Hallam University | Materials and Engineering Research Institute

CARR

SHEFFIELD ROBOTICS

Potential applications

*www.**harper-adams**.ac.uk*



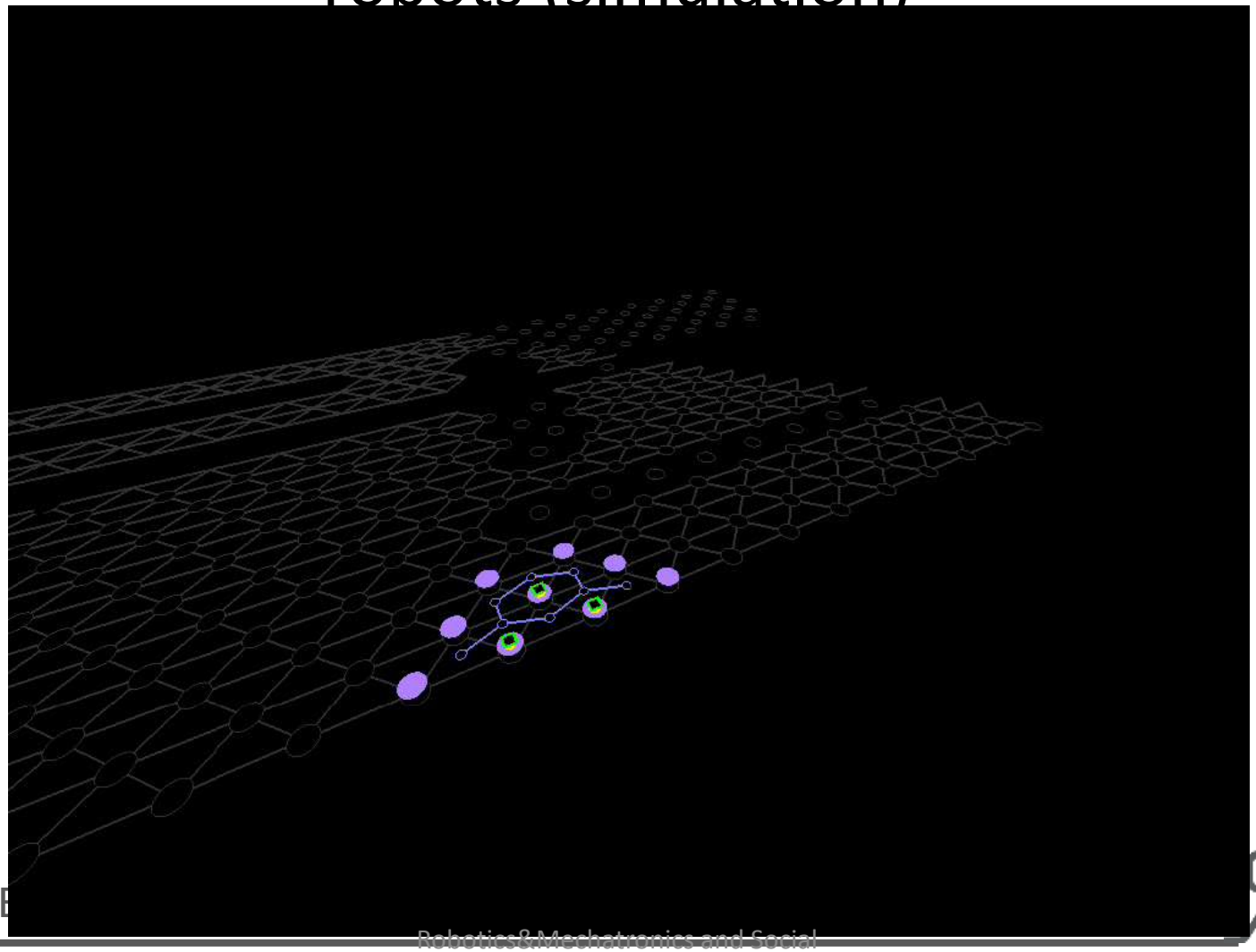
Agricultural Robotics: Alireza Janani

Janani, A., Alboul, L. and Penders, J., **2016**, May, Multi-Agent Cooperative Area Coverage: Case Study Ploughing. In: AAMAS *2016 (International Conference on Autonomous Agents & Multiagent Systems)*

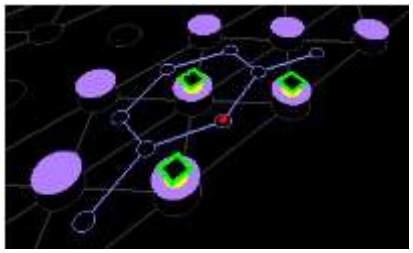
Alireza Janani, Lyuba Alboul, and Jacques Penders, *Multi-Agent Cooperative Area Coverage: Case Study Spraying*, TAROS 2016, LNAI 9716, **2016**

UAV: Patrick Saleh, Safat Khan

Movement Graph:building a map by a team of 3 robots (simulation)



Robot building the map



Reins Project (EPSRC)

- Application: a human-robot (search) team
  - for **no-visibility** conditions
- Aim:
  - Exploring the communicational landscape for (haptic) human-robot interaction

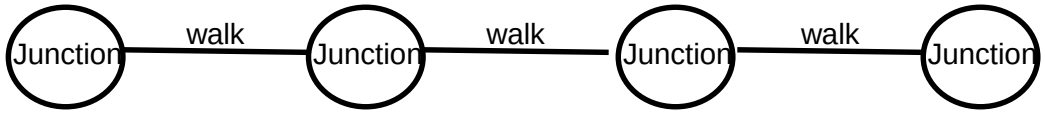
Following the robot, Final Aim

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

REINS

Guide dog Guidance



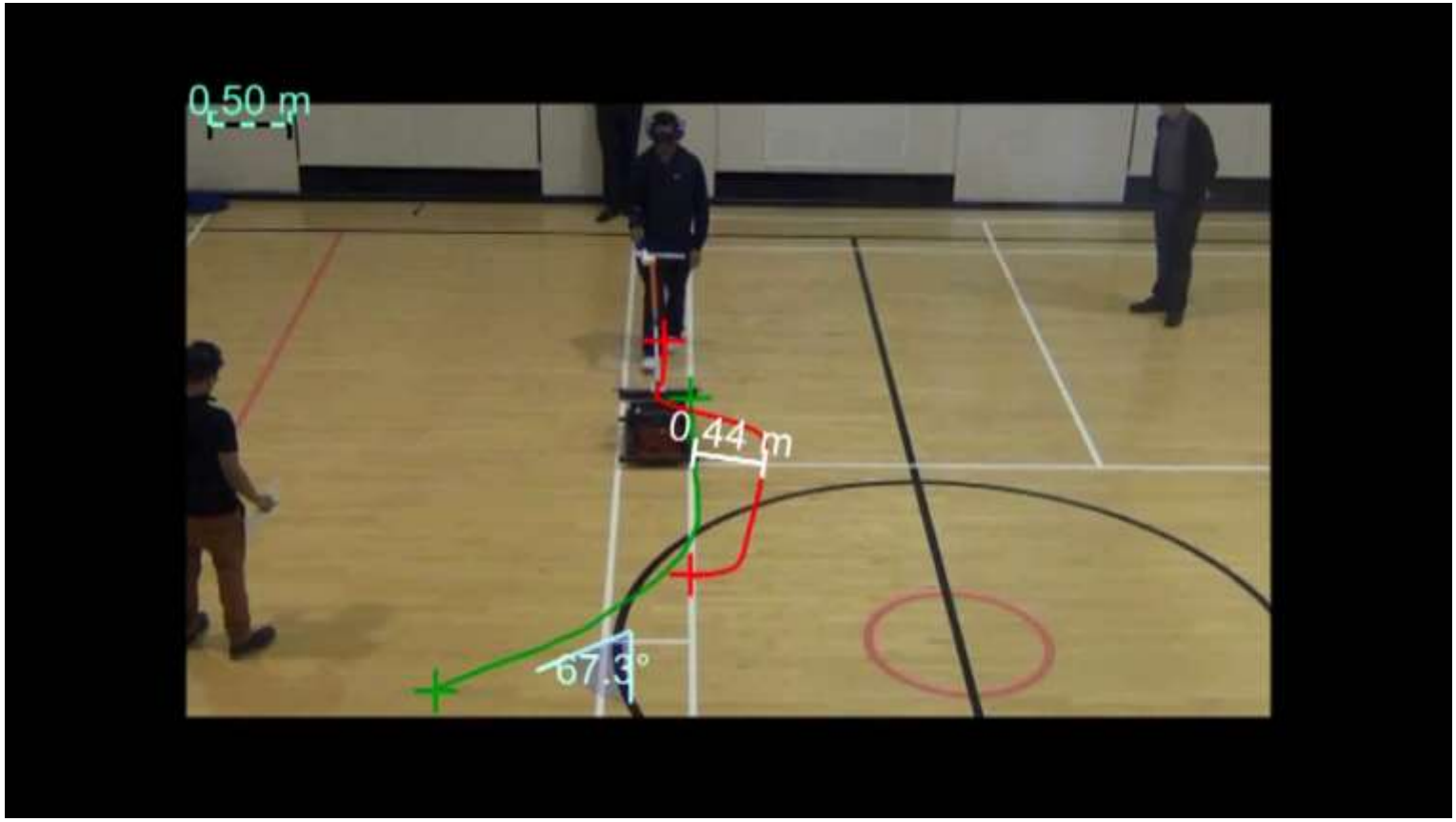
Team

Dog locomotion guidance locomotion guidance locomotion guidance

Handler navigation decision navigation decision navigation decision navigation decision

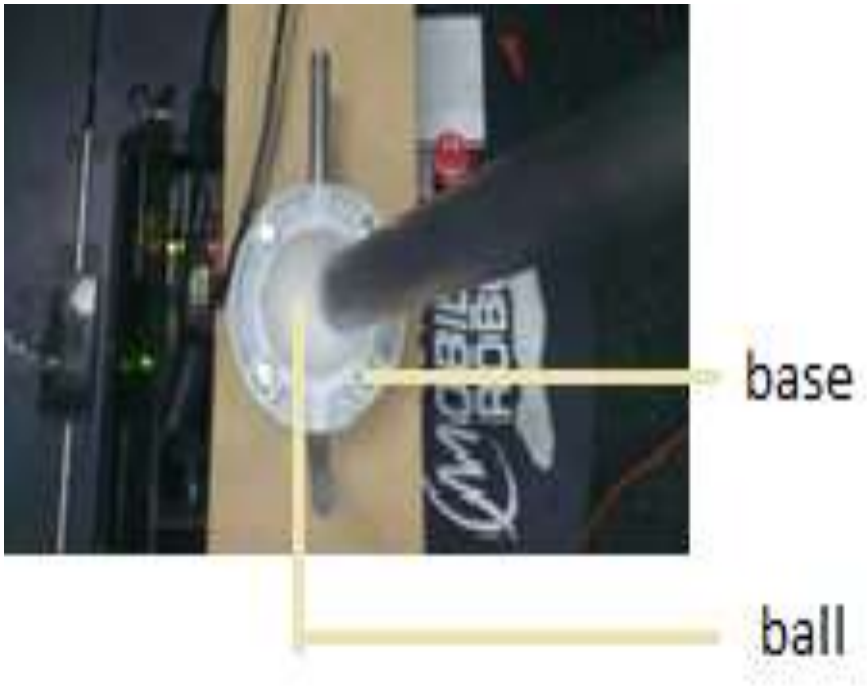
REINS: Focus on Locomotion Guidance

Following the robot



Safe path

- Connection
  - Ball free mechanism

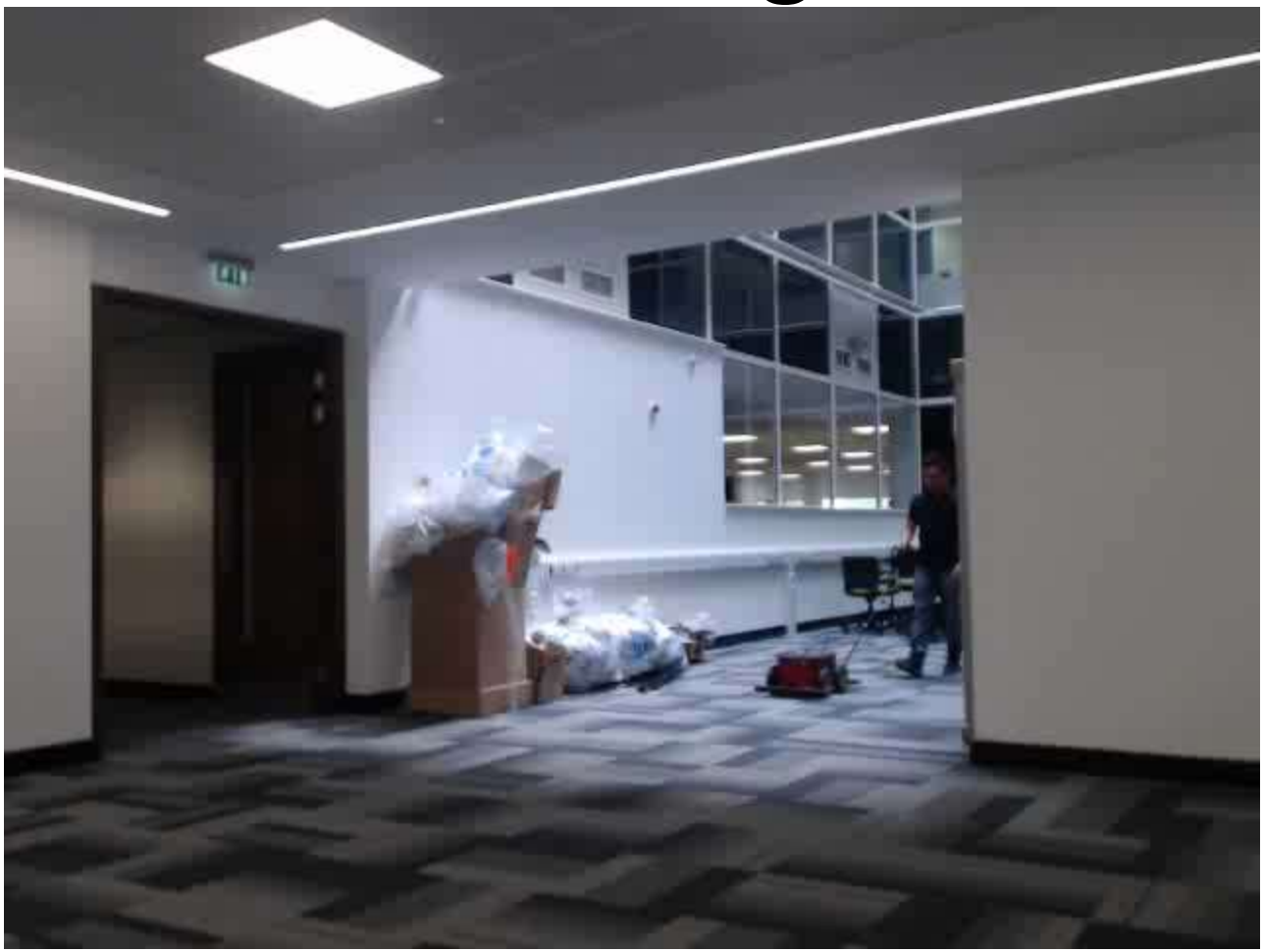


Unsafe

New Idea

- Use the robot as a walking assistant and possibly guide

Robot as a guide



Robot and Dementia

(Pilot Study and in development)

- Use the robot as a walking assistant and possibly guide (people suffering from dementia)
- Points to look at and feedback from focus group
  - Design of the robot,
  - 'Design' of the robot behaviours (walking a robot), robot leads, human leads, walk together, distracted robot

All 3 versions of the robots displayed. All of the pictures have hyperlink to 3d model .
Focus group of people diagnosed with dementia, unanimously chose design 2

Version 01

Version 02

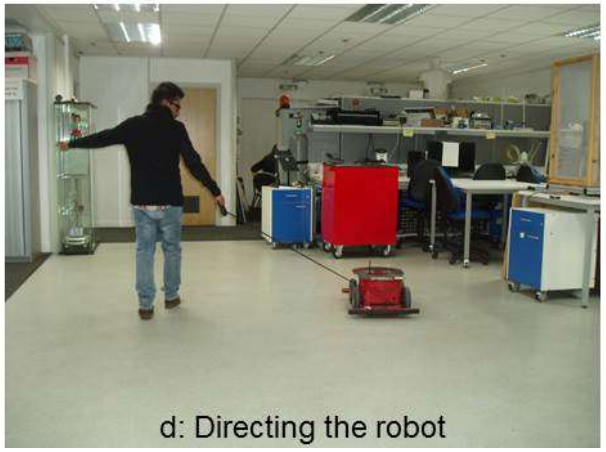
Version 03

Accompanying behaviour


a: Following the robot


b: Going together


c: The robot is distracted


d: Directing the robot

Internal state of the robot

DELPER ROBOT VERSION 01
Comparison of two scenarios of colour changing.

DELPER ROBOT VERSION 02

Calm happy robot changes colour of light very smoothly.

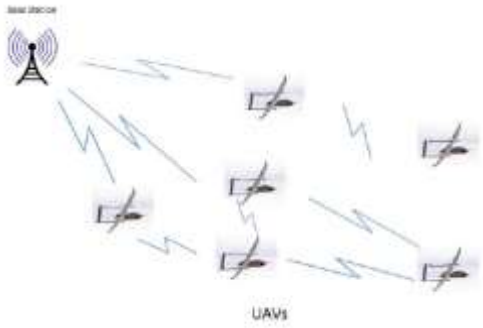
Autism, barriers to social engagement and interventions

- **2010 -2014** Engineering for Life (interdisciplinary project, EPSRC) , developing technological means

Remote shopping, visiting places

Connecting Virtual and Real Worlds

- **2012** Using Agents in Virtual Environments to Assist Controllers to Manage Multiple Assets, AAMAS 2012, CAVE 2012
- Developing a GIS-based planning and simulation system for rapid response
- Fusion of simulated (virtual) environment with aerial information from UAV's – bird's eye images
- Challenge: localisation and positioning of real UAV's and their counterparts in the simulated environment



Cognitive Assessement through Human-Robot Interaction (CATHI)

The research project aims to:

- Investigate the automatization of Psychological Cognitive Assessment and Screening
- Develop a prototype of a novel test performed by a Social Humanoid Robot.
- Test and scientifically validate the prototype in experiments with human participants.
- Create a friendly interface, tailored for clinicians, for retrieving and managing the data.

@Alessandro di Nuovo

Cognitive Assessement through Human-Robot Interaction (CATHI)

- Cognitive Level Assessment can detect early signs of dementia for prompt intervention, including non-pharmacological treatment
- Recent research (Hammer et al., 2017) points out that the older population prefer to be evaluated by a social robot rather than with a human or a computer.
- Furthermore, the interaction with robots is a novel and motivating experience that encourages people to take the test.

Hammer, S., Andre, E. & Lugrin, B. (2017), *Touch or talk? Comparing social robots and tablet PCs for an elderly assistant recommender system*, *HRI 2017*.

Robots as Cognitive Assessors

- Advantages of using a robotic assessor would be multiple:
  - widely available tools,
  - standardization of the scoring
  - the avoidance of assessor bias, scoring objectivity
  - quick and easy updates,
  - having a recording of the administration

Controlled Autonomous Robot for Early diagnosis and Rehabilitation of Autism and Intellectual Disability (CARER-AID)

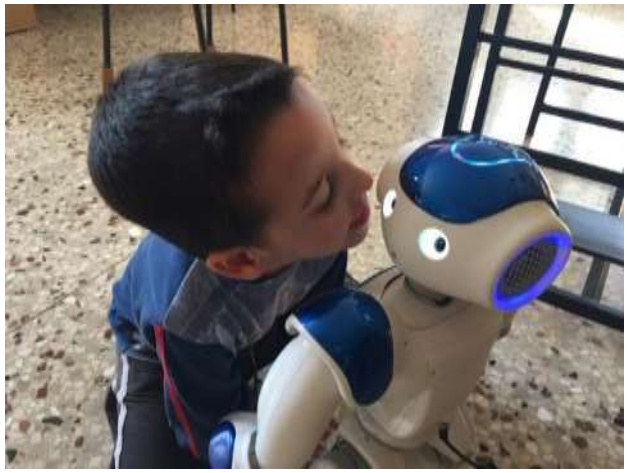
- This project envisions a humanoid robot as a supervised autonomous assistant that will support caregivers in early diagnosis and to improve the treatment of individuals with Autism Spectrum Disorder (ASD) associated with Intellectual Disability (ID).
- The robot can be part of the diagnostic team during the administration of the psycho-diagnostic tests in order to enrich the data that the psychologist can use to refine the diagnosis.

https://www.researchgate.net/project/CARER-AID-Controlled-Autonomous-Robot-for-Early-diagnosis-and-Rehabilitation-of-Autism-and-Intellectual-Disability

@Alessandro di Nuovo

Clinical experiments

- Robot has been embedded in the therapy (TEACCH approach) for four weeks
- 6 hospitalised children with ASD and ID.

imitation

emotions

Long-Term Trial

We introduce a long-term study of robots in a social shared-space and Sheffield Robotics' investigation into the dynamics of the public's interest and habituation towards the robots.

The study has two key aims:

1) Explore factors affecting habituation towards robots in long-term interactions, particularly people's use of the shared-space around the robot

2) Develop effective and reliable non-invasive measures of public interest towards robots.

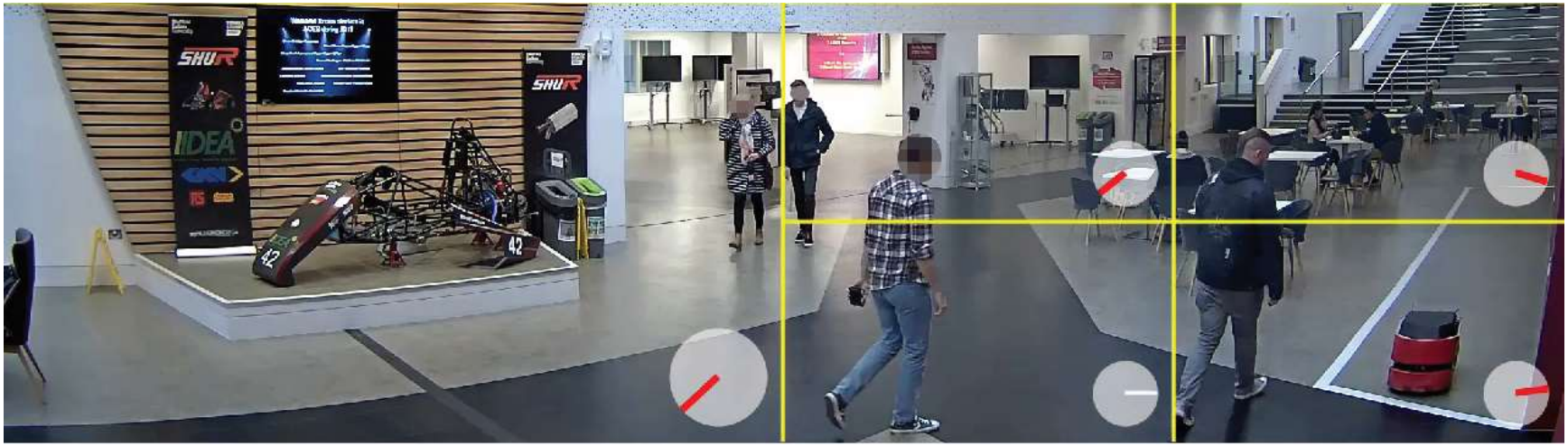
Long-term trial

Robots used: Pioneer LX, Fetch, Pepper

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

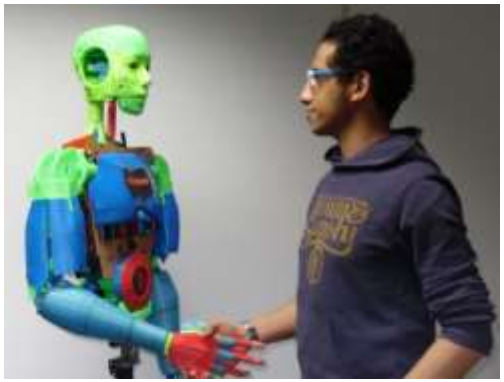
Long-term trial: analysing human interests and acceptance



STEM atrium. Sheffield Hallam University

Sheffield Hallam University | Materials and Engineering Research Institute

CARR



Festival Being Human
17th-25th November 2016

In a future where intelligent androids are fully integrated with everyday life, how do we distinguish ourselves as human?

Organisers:

Overall Lead: Dr Lyuba Alboul

Interactive Display:

Dr Martin Beer, Dr Alessandro di Nuovo, Dr Louis Nisiotis, Alexandr Lucas, Enohor Igbeyi, Matthew Haire, Muhammad Sayed, Alireza Janani

Scriptwriting: Sue Bodnar

Filming: Oliver Newman, Roagan Hall

Overall Support: Ekaterina Nikolova and Ekaterina Netchitailova

Contributors:

Professor Jacques Penders, Professor Marcos Rodrigues, Alessandra Moschetti, Inna Popa, Rinella Cere, Ayan Ghosh, Robot Pepper, Robot Betty, Robot Green/Kermit

With **special thanks** to Professor Wayne Cranton

https://www.shu.ac.uk/research/specialisms/materials-and-engineering-research-institute/news/being-human-festival-2016-fictional-human-and-real-robot

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

New applications, Robotics in Cultural Heritage

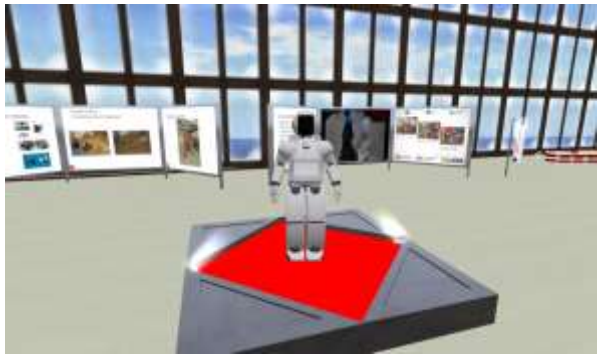
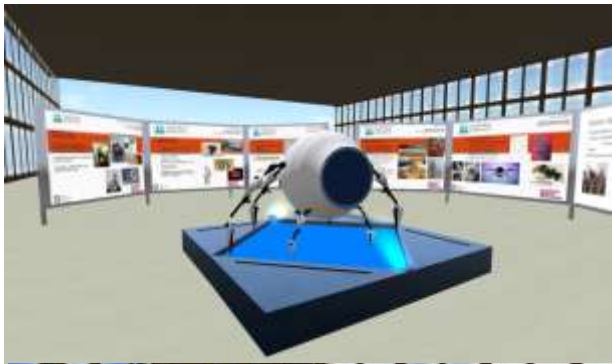
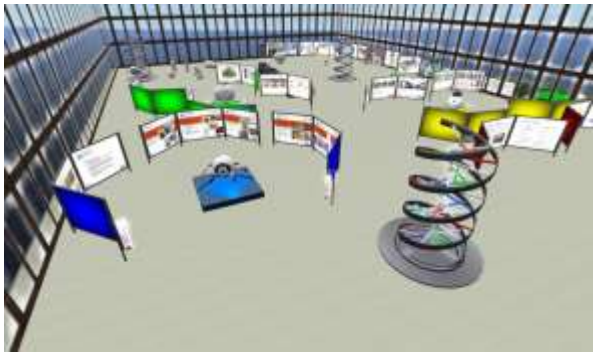
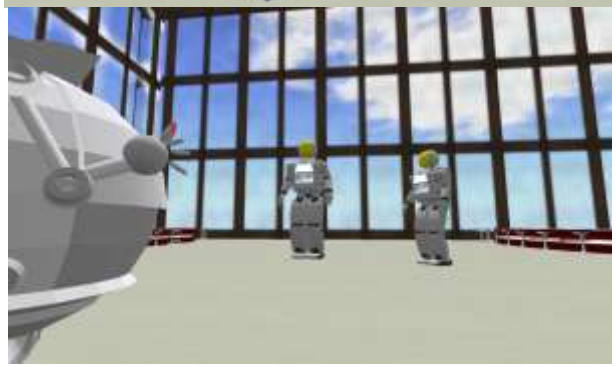
Martin Beer, Louis Nisiotis, Enohor Egbeyi

Example: Virtual Museum

Special exhibition to museum visitors through the exploration of both the physical and a virtual world. This will allow visitors to be:

- Guided by a virtual curator who can respond to their particular interests, knowledge and needs.
- Explore parts of exhibits that are normally inaccessible, for example the backs of paintings, x-ray and other images, close up detail, interiors of sculptures and other artefacts etc.
- Similar works that are displayed elsewhere, or have been removed for conservation or on loan, or indeed have been lost through fire, conflict etc.
- Interact with other visitors either through real time communication, or by leaving messages on a virtual "wall"
- Improve accessibility for those unable either to travel or gain access in the conventional way
- Provide a more comfortable means of studying extremely popular exhibits without being crowded out by large numbers of visitors, tour parties etc. as can happen in a conventional museum etc.

Virtual Reality Robotics Museum

http://makinen.hallam.shu.ac.uk:9000/wifi/user/account/

Instructions how to create a login can be given by request

Cyber-Physical-Social System

- This research project proposal focusses at creating a new type of conceptually led environment that fuses real (physical) and virtual worlds interactively with cyber social spaces providing a unique experience of exploring both worlds simultaneously.
- We want to go beyond current augmented reality environment experience, and provides new modalities, for example, by merging two physical realities via a virtual link and integrating social input such as discussions between visitors in the various domains with mutual interests.

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

Projects on Collaborative robots and human working alongside

Both Sheffield Universities and several companies are involved

SHEFFIELD ROBOTICS

Sheffield Hallam University | Materials and Engineering Research Institute

CARR

Benefits

- Faster realisation of safe and ergonomic production cell design
- Increased worker job satisfaction
- More efficient production through reduced stoppage time
- Increased H&S compliance
- Greater acceptance of a cobot in the workplace
- The implementation of co-bots in the workplace will secure manufacturing in the UK
- Transferable skills and knowledge for all UK companies
- A new area of study.
- The participants reputations as world leaders on collaborative robots will be further enhanced
- Backed by experienced staff from 2 Universities and Industry

Further reading

1. Swarm Robotics

PENDERS, Jacques and ALBOUL, Lyuba (2012). Emerging robot swarm traffic. *International Journal of Intelligent Computing and Cybernetics*, **5** (3), 312-339. http://shura.shu.ac.uk/4189/

2. Robot Swarms in Search and Rescue

PENDERS, Jacques, ALBOUL, Lyuba, WITKOWSKI, Ulf, NAGHSH, Amir, SAEZ-PONS, Joan, HERBRECHTSMEIER, Stefan and HABBAL, Mohamed El (2011). A robot swarm assisting a human fire-fighter. *Advanced Robotics*, **25** (1-2), 93-117. http://shura.shu.ac.uk/3600/

3. Human Robot Interaction (no-visibility)

GHOSH, Ayan, PENDERS, Jacques, JONES, Peter, REED, Heath and SORRANZO, A (2014). Exploring haptic feedback for robot to human communication. In: SHARKEY, Paul, PARETO, Lena, BROEREN, Jurgen and RYDMARK, Martin, (eds.) *The 10th International Conference on Disability, Virtual Reality and Associated Technologies, Proceedings.* Reading, University of Reading, 309-312.

GHOSH, Ayan, PENDERS, Jacques, JONES, Peter and REED, Heath (2014). Experience of using a haptic interface to follow a robot without visual feedback. In: *Proceedings of the 23rd IEEE International Symposium on Robot and Human Interactive Communication. Edinburgh, 25-29 August.* IEEE, 329-334.

Further References

- HAYNES, Paul, ALBOUL, Lyuba and PENDERS, Jacques (2012). Dynamic graph-based search in unknown environments. *Journal of Discrete Algorithms*, **12**, 2-13.

- Loai Sayed and Lyuba Alboul, Vision System for Robot's Speed and Position Control, 13th International Conference on Control Automation Robotics & Vision (ICARCV 2014)

- EHIMWENMA, Kennedy E., CROWTHER, Paul, ALBOUL, Lyuba, BEER, Martin and OFFOR, Kennedy J. (2018). An agent based approach for improvised explosive device detection, public alertness and safety. In: *2018 IEEE Workshop on Environmental, Energy, and Structural Monitoring Systems (EESMS).* Salerno, Italy, IEEE, 89-94.

- PENDERS, Jacques, WANG, Jing, BHOWMIK, Deepayan, DI NUOVO, Alessandro, SORANZO, Alessandro, ROLPH, Joe, POPA, Inna, VARRASI, Simone, LUCAS, Alexandr, CONTI, Daniela, YOUNG, Jay and ALBOUL, Lyuba (2018). Robots claiming space: gauging public reaction using computer vision techniques. In: *TAROS 2018 proceedings.* Lecture Notes in Artificial Intelligence . Springer.

References, Assistive Robotics

- Conti, D., Di Nuovo, S., Buono, S., Trubia, G., & Di Nuovo, A. (2015). **Use of robotics to stimulate imitation in children with Autism Spectrum Disorder: A pilot study in a clinical setting.** In *Robot and Human Interactive Communication (RO-MAN), 2015 24th IEEE International Symposium on* (pp. 1-6). IEEE.
- Conti, D., Di Nuovo, A., Cirasa, C., & Di Nuovo, S. (2017). **A comparison of kindergarten storytelling by human and humanoid robot with different social behavior**. In *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 97-98). ACM.
- Conti D, Di Nuovo A, Trubia G, Buono S, Di Nuovo S. ***Adapting Robot-Assisted Therapy of Children with Autism and Different Levels of Intellectual Disability: A Preliminary Study***. In: Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction. ACM; 2018. page 91–2.
- Conti D, Trubia G, Buono S, Di Nuovo S, Di Nuovo A. ***Evaluation of a Robot-Assisted Therapy for Children with Autism and Intellectual Disability***. In: Towards Autonomous Robotic Systems. TAROS 2018. 2018. page 1–11, in press.
- Di Nuovo A., Conti D., Trubia G., Buono S., Di Nuovo S. (2018). ***Deep Learning Systems for Estimating Visual Attention in Robot-Assisted Therapy of Children with Autism and Intellectual Disability.*** ROBOTICS, 7(2), 25.