UNDERSTANDING OTHERS ACTIONS, INTENTIONS

ACTING, PERCEIVING AND LEARNING FROM MISTAKES..

TRYING TO PICK STRAWBERRIES..(NOT JUST THE LOW HANGING ONES..)
ROBOTICS GROUP ++++

- 6 Faculty members (Most of us are around today)
- AI/Machine Learning, COMMS, BCI Faculty from CSEE (Reini, Javier, Hossein, Amit, Mays)
- 18 KTP Associates or Research Officers, 36 PhD students

If you give us **problems**, we give you **solutions**.
ROBOTICS GROUP

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- AI/Machine learning Faculty (Javier, Hossein, Amit, Mays)
- 18 KTP Associates or Research Officers, 36 PhD Students

RESEARCH HORIZON - 'ABOVE, BELOW AND AROUND'

Visuospatial Awareness
Landmark based Navigation
Human aware Motion planning
RESEARCH THEME ROBOTS/COBOTS WORKING FOR AND ALONGSIDE HUMANS....

ALIGNMENT WITH ICT CORE RESEARCH THEMES (EPSRC & EU)

- COMPUTER VISION
- DEXTROUS ACTION/MANIPULATION AND SOFT ROBOTICS
- LIFELONG AND HUMANLIKE LEARNING
- COBOTICS AND SOCIAL INTELLIGENCE
- DEVELOPMENTAL ROBOTICS (GOING BACK TO THE BRAIN)

ALIGNMENT WITH KTP PROGRAM TO SUPPORT LOCAL BUSINESS/ECONOMY

- 12 ONGOING INNOVATE UK FUNDED KTP'S

CONTRIBUTE TO EDUCATION:

- TWO NEW DEGREE PROGRAMS
  - BENG ROBOTIC ENGINEERING (2018-)
  - BENG MECHATRONIC ENGINEERING (2019-)
RESEARCH THEME: ROBOTS/COBOTS WORKING FOR AND ALONGSIDE HUMANS....

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NOT JUST BUILDING FRUIT PICKING ROBOTS BUT ALSO-UNDERSTANDING WHAT MAKES HUMANS SO GOOD!
Robotics Research Facility / Equipment

Robotics Arena

- Fleet of 30 Mobile Robots
- Several Drones (>20)
- 3 Robotic Fish
- 5 Humanoid/Companion Robots (with hospitals)
- Essex Agrobot (Mobile, Bimanual, Soft, Collaborative Robot)

The Beast’s Den

- 2 VICON Motion Capture Systems (8 and 26 Cameras)
- Intelligent Wheelchairs
- Several Educational Robots, Strange Robots

I-Space

Equipment

- Intelligent Wheelchairs
- Several Educational Robots, Strange Robots
TODAYS MENU..

• COBOTS FOR **SOFT FRUIT HARVESTING** (SUPPORT OF TIPTREE- ANDREY/CHRIS)- EXPANDING TO OTHER CROPS- LETTUCE, COFFEE (ME, ADRIAN)
• WEED/BLACKGRASS DETECTION, **AERIAL SURVEYING** USING DRONES (ADRIAN, JOHN, DONGBING)
• **OYSTER** FARMING (JOHN WOODS)
• AUTONOMOUS **NAVIGATION** OF AGROBOT FLEETS (LOGISTICS, TRANSPORT, YIELD ANALYTICS) (ALL OF US)
• **SHARED CONTROL/COLLABORATIVE ROBOTICS** (ME, DIMITRI)
• **RESPONSIBLE AI, ETHICAL DESIGN** (JAVIER, ME)
SOFT FRUIT HARVESTING ROBOTS CHALLENGE - ACHIEVING 'HUMANLIKE' DEXTERITY

2018 ROBOT SOCCER

ASSORTED HUMAN SOCCER
SOFT FRUIT HARVESTING ROBOTS - WHAT'S NOVEL

NEURAL NETWORK FOR COORDINATION OF ACTION- MULTIPLE ROBOTS

ICUB HUMANOID

Tool Use

Pushing-Internalize How objects move

Construct the tallest possible tower given arandom set of objects

More complex Assembly tasks

ASSEMBLY OF ELECTRONIC COMPONENTS

WHOLE BODY SYNERGIES
UNDER LOADING CONDITIONS

BERRY PICKING / PACKING

TIME

TIME
Impedance Control: An Approach to Manipulation:

Part I—Theory

Manipulation fundamentally requires the manipulator to be mechanically coupled to the object being manipulated; the manipulator may not be treated as an isolated system. This three-part paper presents an approach to the control of dynamic interaction between a manipulator and its environment. In Part I this approach is developed by considering the mechanics of interaction between physical systems. Control of position or force alone is inadequate; control of dynamic behavior is also required. It is shown that as manipulation is a fundamentally nonlinear problem, the distinction between impedance and admittance is essential, and given the environment contains inertial objects, the manipulator must be an impedance. A generalization of a Norton equivalent network is defined for a broad class of nonlinear manipulators which separates the control of motion from the control of impedance while preserving the superposition properties of the Norton network. It is shown that components of the manipulator impedance may be combined by superposition even when they are nonlinear.

Available online at www.sciencedirect.com

ScienceDirect

Physics of Life Reviews

Review

Muscleless motor synergies and actions without movements: From motor neuroscience to cognitive robotics

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SOFT FRUIT HARVESTING ROBOTS – WHAT’S NOVEL

NEURAL NETWORK FOR COORDINATION OF ACTION (INTERNAL BODY MODEL)

Use of tools
Teachers Demonstration
Robot babbling movements to generate data

Cub hand space
Sensorimotor data
Neural representation
Connectivity matrix / weights

Goal = Disturbance

Goal $X_G$

Hand Position/Disp
Joint Position

$F = K(X_G - X)$

Well posed

Hand Force
Joint Force

Goal = DISTURBANCE
SOFT FRUIT HARVESTING ROBOTS – WHAT'S NOVEL

NEURAL NETWORK FOR COORDINATION OF ACTION (INTERNAL BODY MODEL)

Use of tools

Teachers Demonstration

Robot babbling movements to generate data

End effector

Sensorimotor data

Intrinsic space (body joints, etc)

Extrinsic space (hand, tool effector)

Cub hand space

Neural representation

Connectivity matrix / weights

Jacobian (Body, Tool)

REACHING ACCURACY (5MM)
Central Features

- Coordinate Complex Networks of 'Body-Tools-Other Bodies' (Electrical Circuits)
- Synthesized at Runtime Based on the Goal
- Any Number of Degrees of Freedom
- Multiple Task Specific Constraints
- Multireferential
- No Inverse Kinematics, Predefined Cost Functions
- Force/Position Control
- Synchronization Through Terminal Attractors
- Internal Body Model and Extension to Tools is Learnt
- Generate Action / Simulate Actions
SOFT FRUIT HARVESTING ROBOTS – WHAT’S NOVEL

CLOSING PERCEPTION-ACTION LOOP

STEREO VISION, POINT CLOUD ANALYSIS – “WHAT/WHERE”

GEOMETRICAL PROPERTIES, POINT OF CONTACT

DETECTING/LOCALIZING THE STEM

EDGE DETECTION, POLYGON SIMULATION
SOFT FRUIT HARVESTING ROBOTS - WHAT'S NOVEL

CLOSING PERCEPTION-ACTION LOOP

STEREO VISION, POINT CLOUD ANALYSIS - 'WHAT/WHERE'

GEOMETRICAL PROPERTIES, POINT OF CONTACT

PREDICTING THE WEIGHT THROUGH VISION USING ANN (LOT OF HELP FROM TIPTREE !!!)
WHAT DO WE DO WITH THE STEM.....

Gripper could be an attachment to the cutter - so they can control jointly

Gripper should have opener

Thickness -> so it moves more

Gripper will hold the berry stem while cutter cuts from the top
WHAT DO WE DO WITH THE STEM.....

Cutter

Gripper

Gripper is below the cutter

Gripper could be an attachment to the cutter - so they can coordinate jointly

Gripper should have opener

Thickness - so it moves more

Gripper will hold the berry stem while cutter cuts from the top
BACK TO THE ACTION SYSTEM - BERRY PICKING IS A BIMANUAL TASK

AFTER SEVERAL ITERATIONS (WITH TIPTREE)
BACK TO THE ACTION SYSTEM - BERRY PICKING IS A BIMANUAL TASK

BIMANUAL COORDINATION, SPATIAL PLANNING, PERIPERSONAL SPACE REPRESENTATION (ONGOING)

EU DARWIN PROJECT (DEXTROUS ASSEMBLER ROBOTS WORKING WITH EMBODIED INTELLIGENCE)
BACK TO THE ACTION SYSTEM- BERRY PICKING IS A BIMANUAL TASK

ACTIVE PERCEPTION AND SOFT ROBOTICS

ACTION DRIVES PERCEPTION (BERRY SEEKING VS. BERRY PICKING)

HUMAN ACTION PERCEPTION, COLLABORATION

BEING ADAPTED TO LETTUCE....(WITH HELP FROM ANGLIA SALADS)
BACK TO THE ACTION SYSTEM- BERRY PICKING IS A BIMANUAL TASK

ACTIVE PERCEPTION AND SOFT ROBOTICS

ACTION DRIVES PERCEPTION (BERRY SEEKING VS. BERRY PICKING)

HUMAN ACTION PERCEPTION, COLLABORATION

- DOMAIN AGNOSTIC (AGRI SURGEON)
- PLANT AGNOSTIC...
- BIOMIMETIC...(GOING BACK TO HUMAN)
- LOW COST...(3D PRINTING)
- MODULAR..
- HUMAN IN LOOP...
AUTONOMOUS NAVIGATION (MONITORING, TRANSPORTING, PREDICTIVE YIELD ANALYTICS)

DEEP LEARNING SLAM (PROF DONGBING GU)

MULTIMODAL GROWING NEURAL GAS (INSPIRED FROM ANIMAL FORAGING, RAT NAVIGATION)

PHYSICAL LOCATION, VISION, SOUND ACTIVATE THE NEURONS
BLACK GRASS DETECTION USING MACHINE LEARNING (ADRIAN)

VISIBLE AND NIR WAVEBANDS AND THE BLACK GRASS IDENTIFIED USING MACHINE LEARNING
NOSY - NON-INVASIVE OYSTER SENSOR (JOHN WOODS)

A sensor

B sensor data

C gaping

Innovate UK KTP ON Laser cutting (2019-21)
THE END- Necessity is the mother of invention: The Story of Betty

Alex Kacelnik's Lab, Oxford
NECESSITY IS THE MOTHER OF INVENTION: THE STORY OF BETTY
WHAT IF - BETTY WAS A ROBOT INSTEAD ??

Dinner
Wire
Betty

Alex Kacelnik’s Lab, Oxford
IF BETTY WAS A ROBOT INSTEAD??

- **Perception** (Beyond labelling..... Understanding the scene)
- **Inference** (The goal is not achievable by predicting)
- **Memory** (Recall of a specific past learnt experience: playing with wires, twigs)
- **Fine Manipulation** (Creating a hook tool and using it as an extension of its body)
- **Knowledge of Cause-Effect Relations** (Pulling the basket with a hook tool)
- **Integration**: The magic glue

**Connecting the Dots**
UNSTRUCTURED WORLD... IS FULL OF SUCH PROBLEMS..

LOW TRL/HIGH TRL...
Agricultural robotics is a great stress test covering the whole perception-action-interaction and learning loop !!!!!