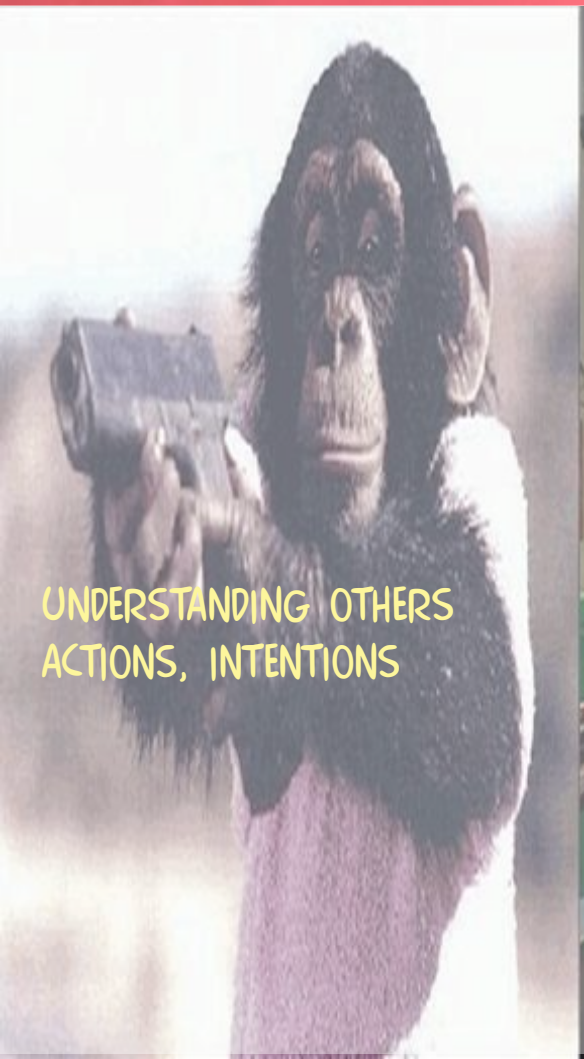
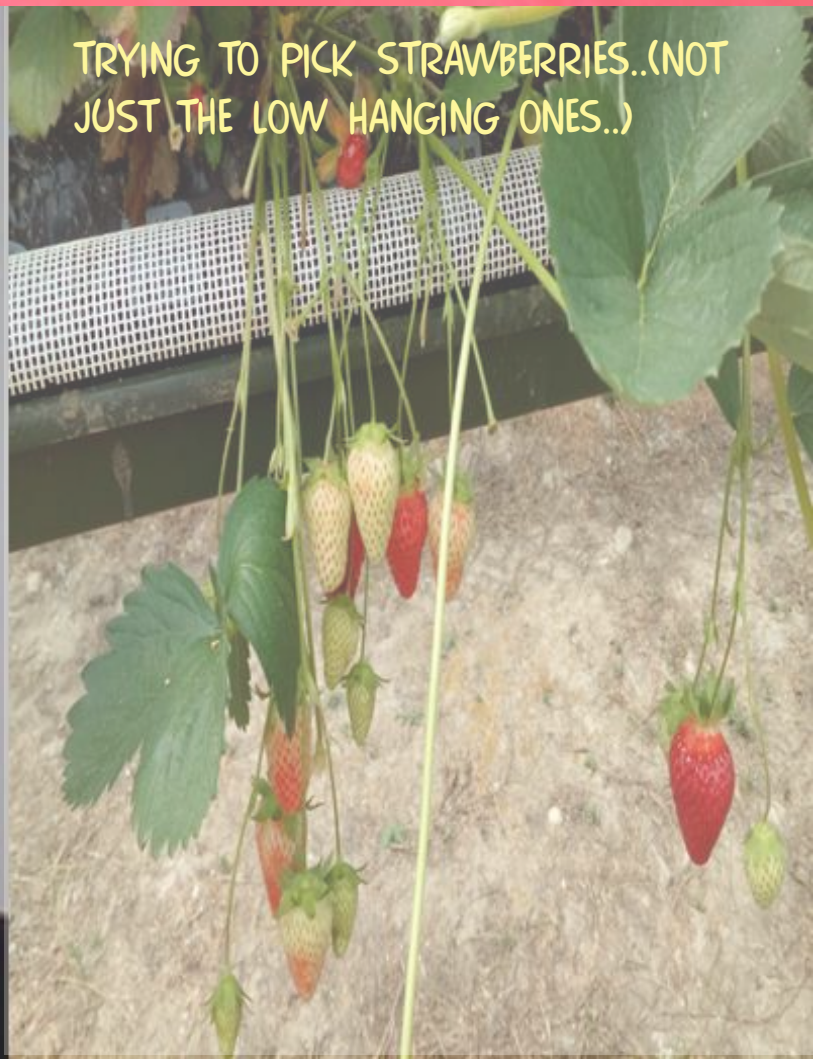
ROBOTICS AND SENSORS

VISHWANATHAN MOHAN





ROBOTICS GROUP ++++

HUOSHENG HU

DONGBING GU

JOHN WOODS

ADRIAN CLARK

VISHUU MOHAN

DIMITRI OGNIBENE

- 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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DONGBING GU

JOHN WOODS

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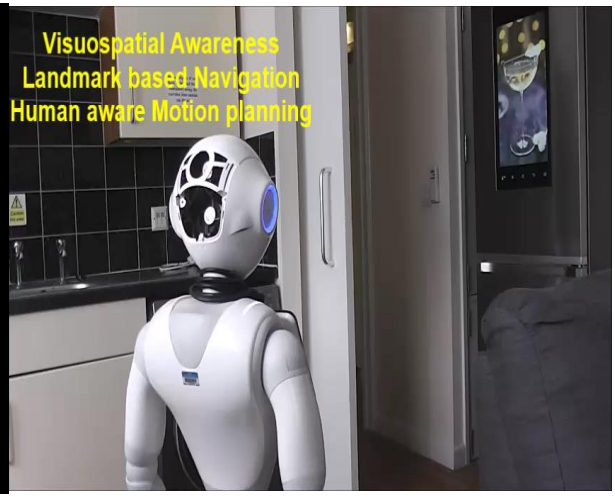
RESEARCH HORIZON- 'ABOVE, BELOW AND AROUND'



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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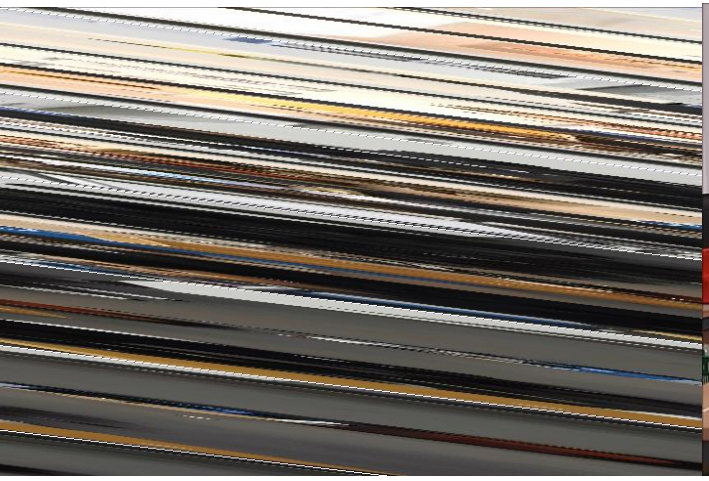
  - BENG MECHATRONIC ENGINEERING (2019-)

NOT JUST BUILDING FRUIT PICKING ROBOTS BUT ALSO-UNDERSTANDING WHAT MAKES HUMANS SO GOOD!

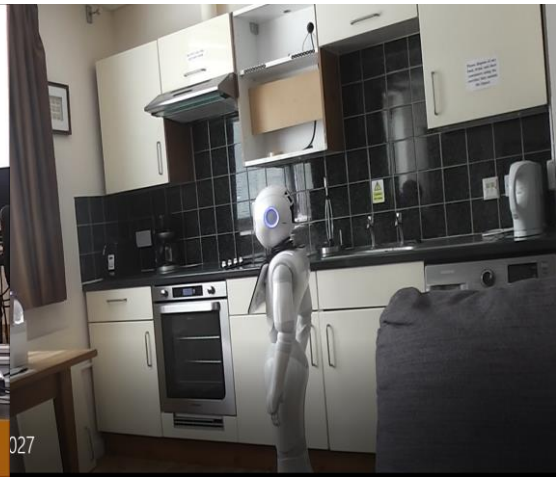
ROBOTICS RESEARCH FACILITY / EQUIPMENT

ROBOTICS ARENA

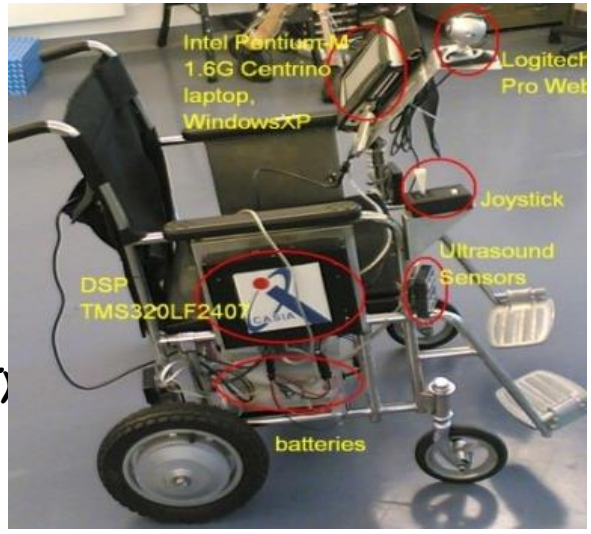


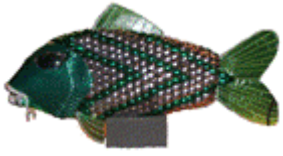
THE BEAST'S DEN

ISPACE



- FLEET OF 30 MOBILE ROBOTS
- SEVERAL DRONES (>20)
- 3 ROBOTIC FISH
- 5 HUMANOID/COMPANION ROBOTS (WITH HOSPITALS)
- ESSEX AGROBOT (MOBILE, BIMANUAL, SOFT, COLLABORATIVE ROBOT)
- 2 VICON MOTION CAPTURE SYSTEMS (8 AND 26 CAMERAS)
- 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

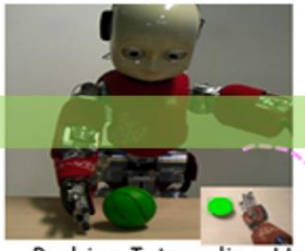
ASSORTED HUMAN SOCCER

SOFT FRUIT HARVESTING ROBOTS - WHAT'S NOVEL

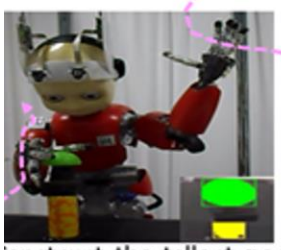
NEURAL NETWORK FOR COORDINATION OF ACTION- MULTIPLE ROBOTS

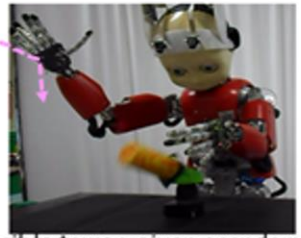
ICUB HUMANOID

Tool Use



Pushing..Internalize How objects move

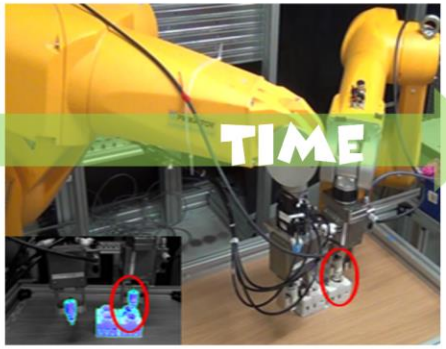




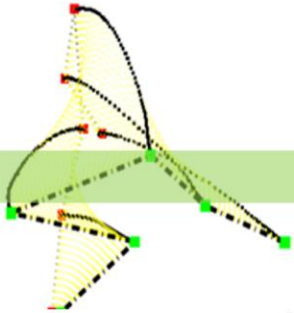
onstrust the tallest possible tower given arandom et of objects

lore complex Assembly tasks

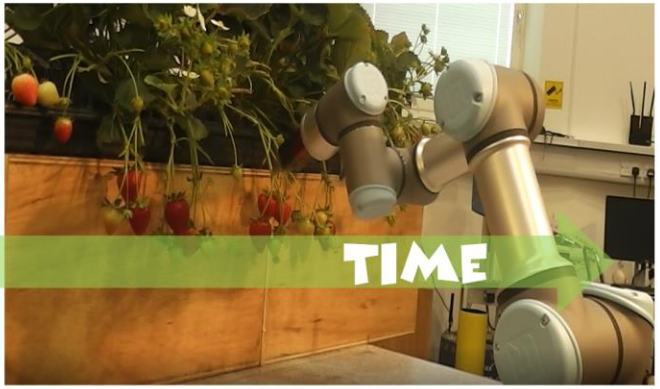
ASSEMBLY OF ELECTRONIC COMPONENTS



WHOLE BODY SYNERGIES UNDER LOADING CONDITIONS



BERRY PICKING / PACKING



1979-1985
BIZZI LAB, MIT
HOGAN LAB, MIT

Impedance Control: An Approach to Manipulation:

Part I—Theory

Neville Hogan
Associate Professor,
Department of Mechanical Engineering
and Laboratory for Manufacturing
and Productivity,
Massachusetts Institute of Technology,
Cambridge, Mass. 02139

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.

2019

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Review

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

Vishwanathan Mohan [a,*], Ajaz Bhat [b], Pietro Morasso [c]

[a] *School of Computer Science and Electronic Engineering, University of Essex, Wivenhoe Park, CO34SQ, UK*
[b] *Dept. of Psychology, University of East Anglia, UK*
[c] *Robotics, Brain and Cognitive Sciences Dept., Via Enrico Melen 83, 16152 Genova, Italy*

Received 31 December 2017; received in revised form 12 April 2018; accepted 16 April 2018

Communicated by J. Fontanari

EQUILIBRIUM POINT HYPOTHESIS (BIZZI ET AL, FELDMAN ET AL)

KINEMATIC NETWORKS (SANDRO MUSSA IVALDI, MORASSO ET AL)

PASSIVE MOTION PARADIGM (MOHAN, MORASSO, ET AL)

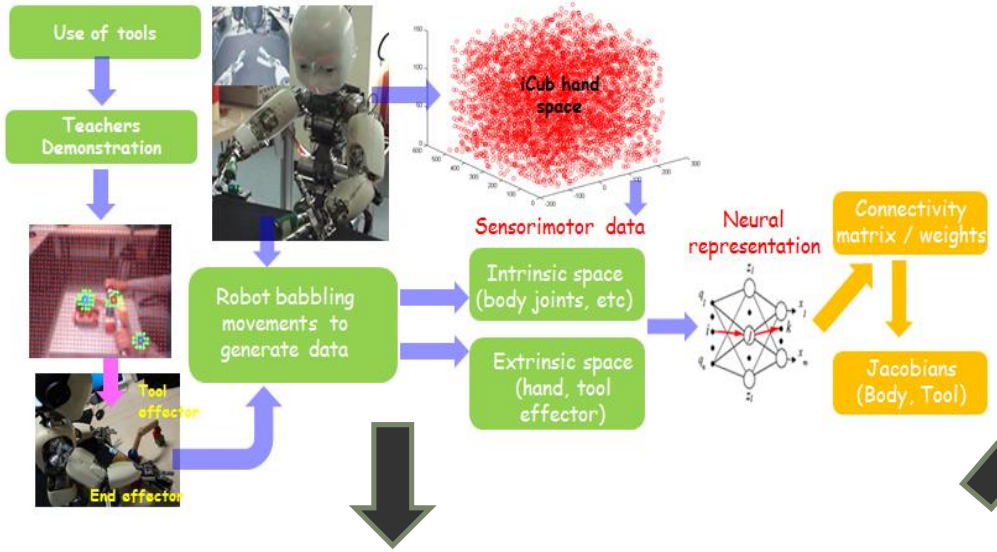
SIMULATION THEORY/ IDEOMOTOR THEORY (JEANNEROD..)

ACTIVE INFERENCE/FREE ENERGY PRINCIPLE (FRISTON ET AL.)

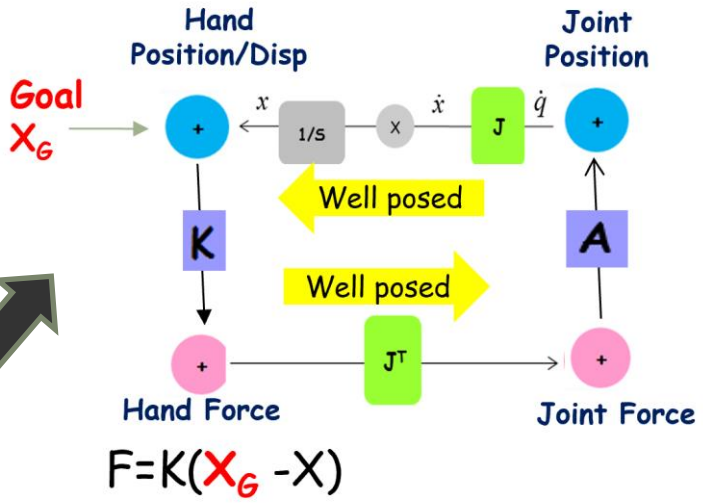
COMMENTARY FROM N HOGAN, FRISTON (2019)

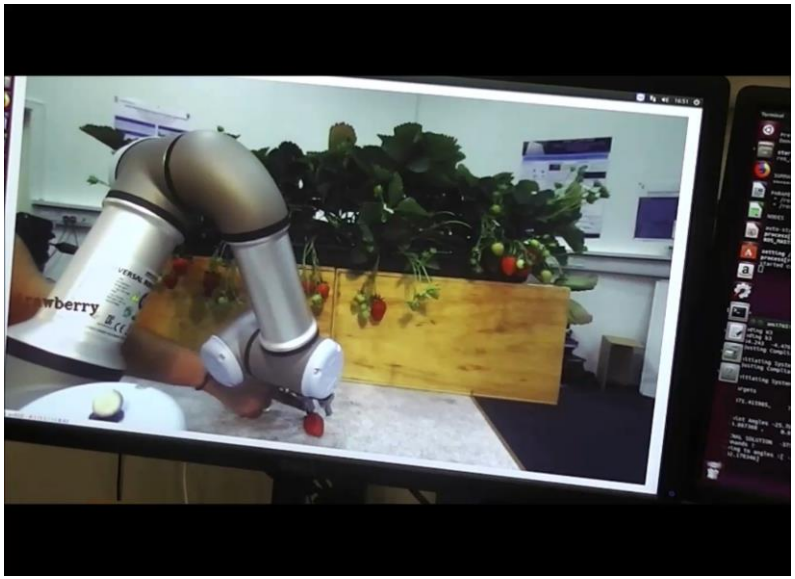
SOFT FRUIT HARVESTING ROBOTS - WHAT'S NOVEL

NEURAL NETWORK FOR COORDINATION OF ACTION (INTERNAL BODY MODEL)



GOAL = DISTURBANCE





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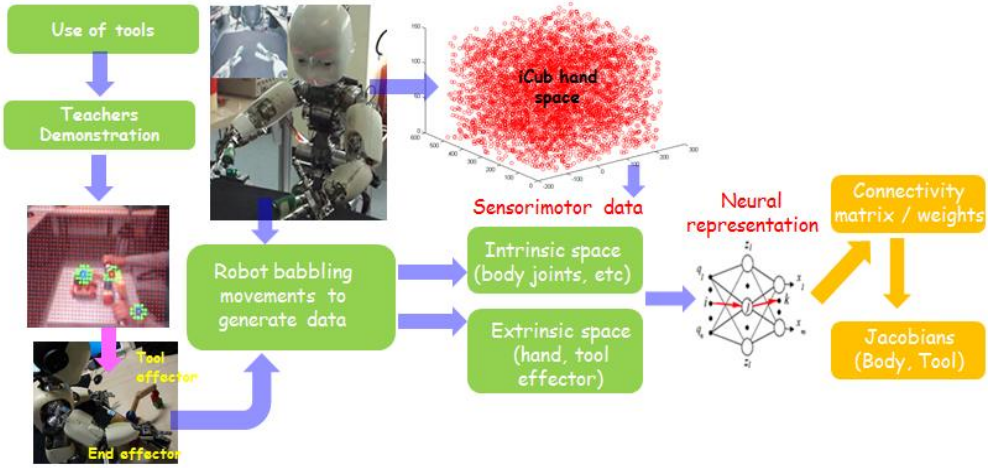
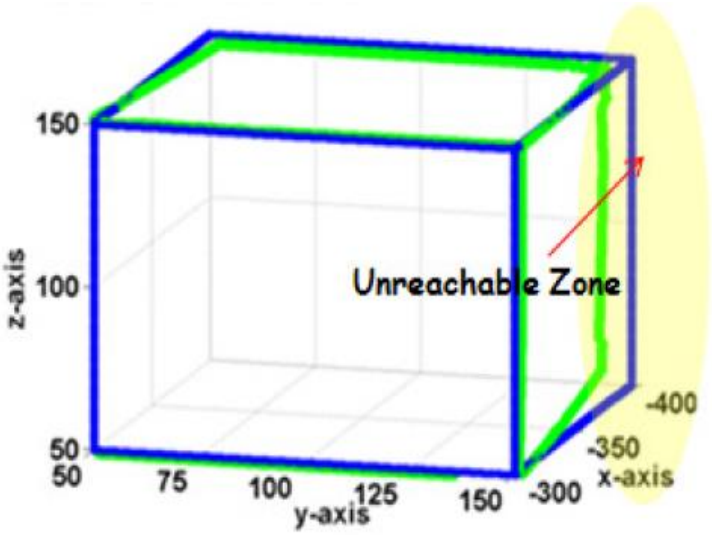
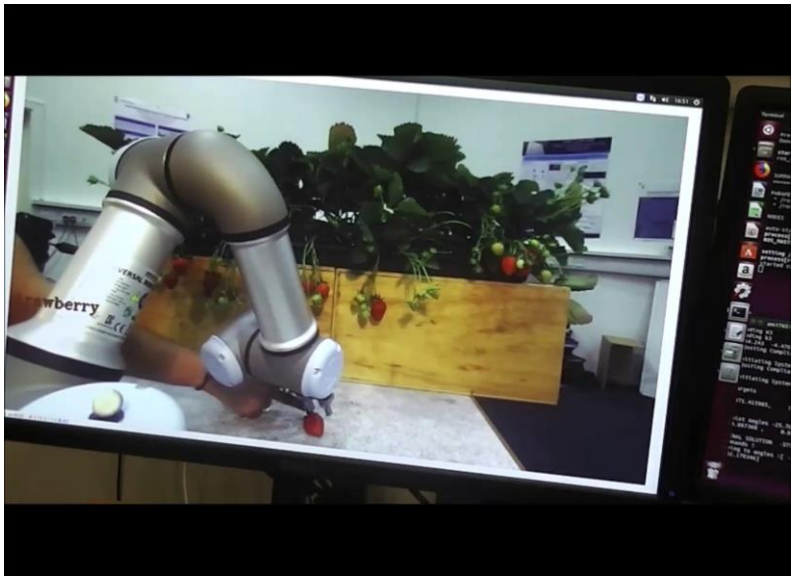
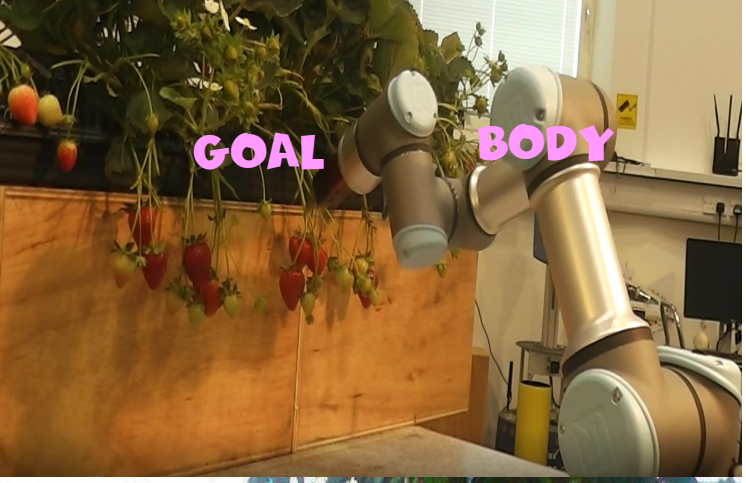


REACHING ACCURACY (5MM)







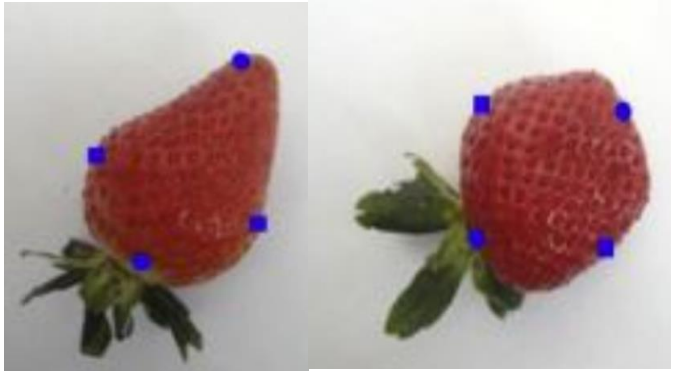
CENTRAL FEATURES

- 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

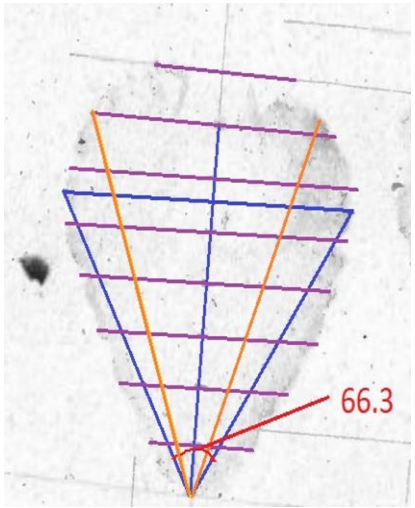
SOFT FRUIT HARVESTING ROBOTS - WHAT'S NOVEL

CLOSING PERCEPTION-ACTION LOOP

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

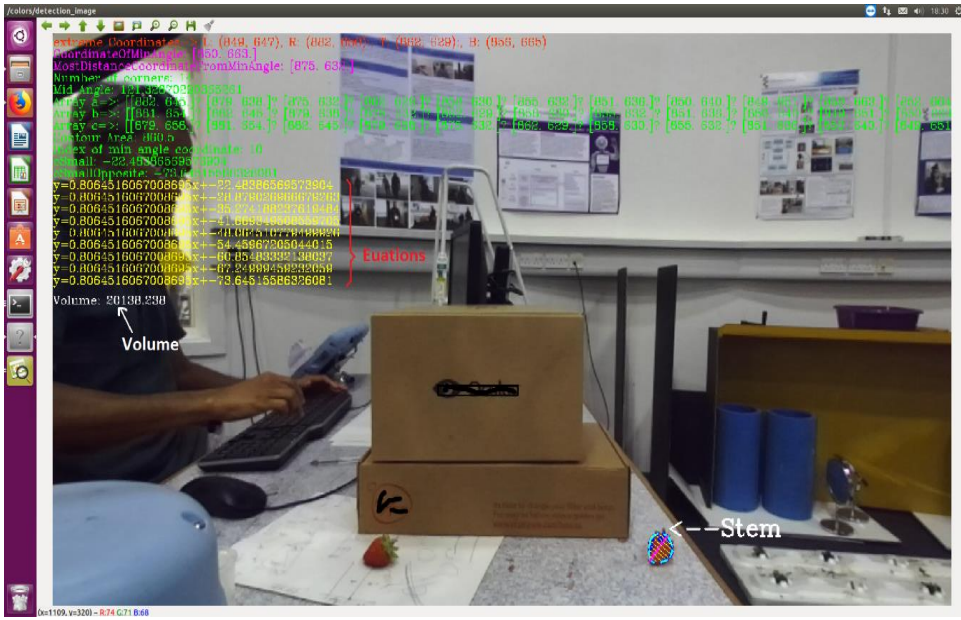


GEOMETRICAL PROPERTIES, POINT OF CONTACT



EDGE DETECTION, POLYGON SIMULATION

DETECTING/LOCALIZING THE STEM



SOFT FRUIT HARVESTING ROBOTS - WHAT'S NOVEL

CLOSING PERCEPTION-ACTION LOOP

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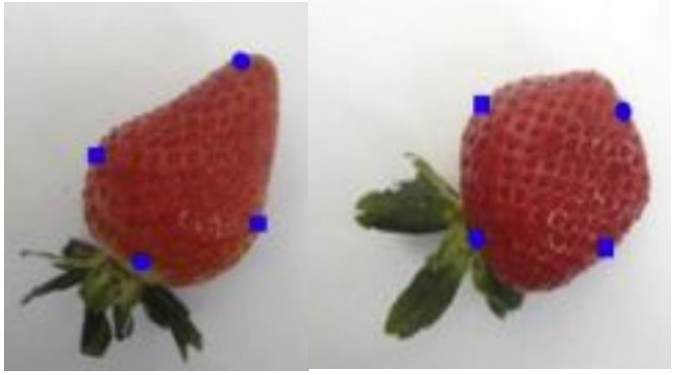
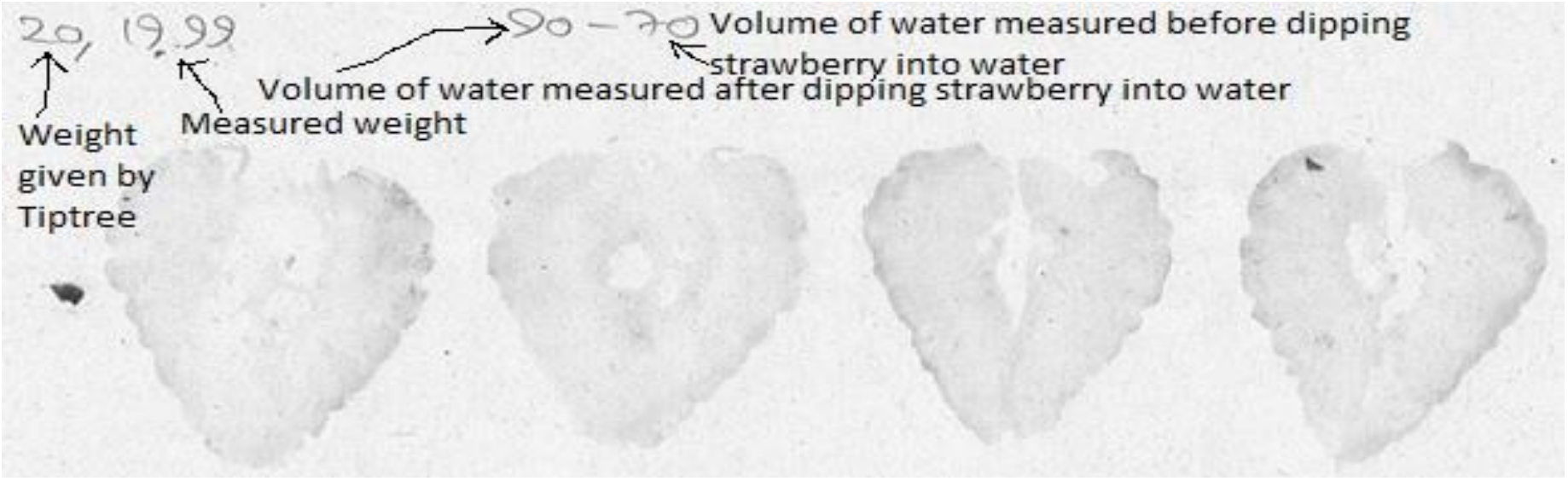
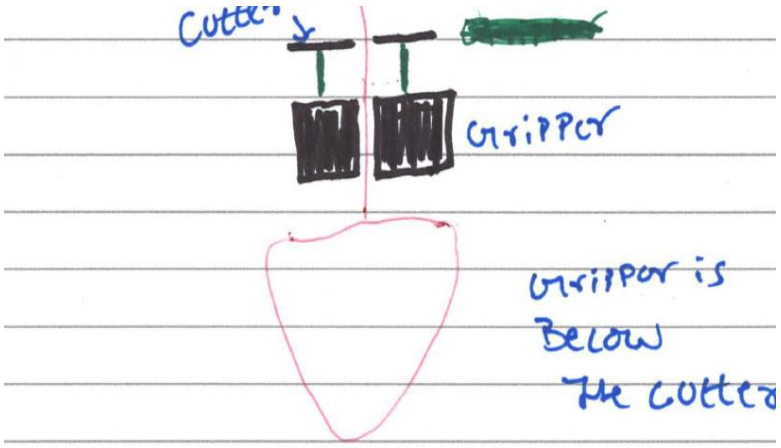


GEOMETRICAL PROPERTIES, POINT OF CONTACT

PREDICTING THE WEIGHT THROUGH VISION USING ANN (LOT OF HELP FROM TIPTREE !!!)



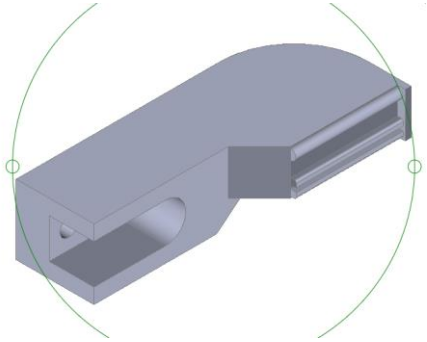
WHAT DO WE DO WITH THE STEM.....

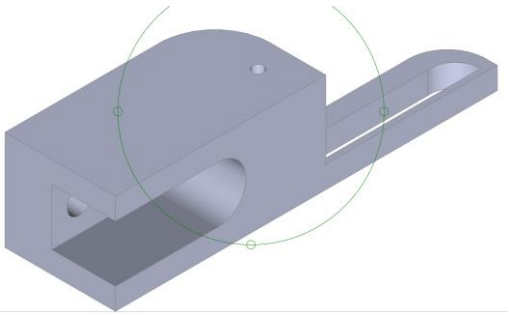


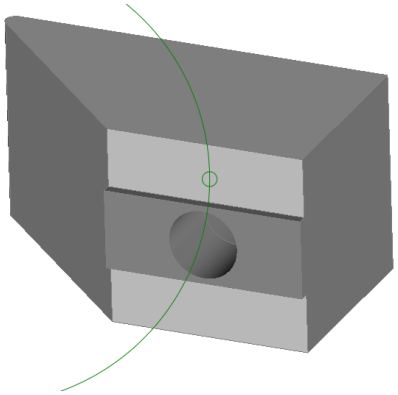
Gripper could be an ATTACHMENT to The Cutter → so they are controlled JOINTLY → ~~AS WELL~~

Gripper SHOULD HAVE DIFFERENT THICKNESS → so it moves more

Gripper will HOLD the Berry STEM while cutter CUTS from the Top







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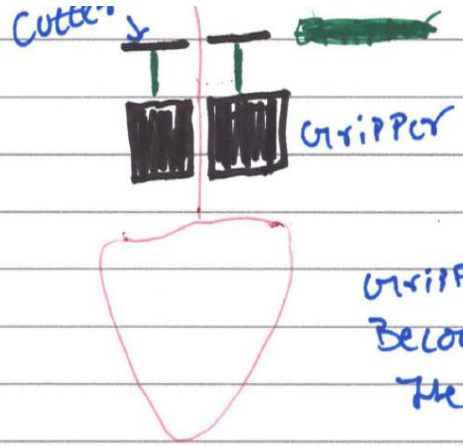


Gripper is Below The cutter

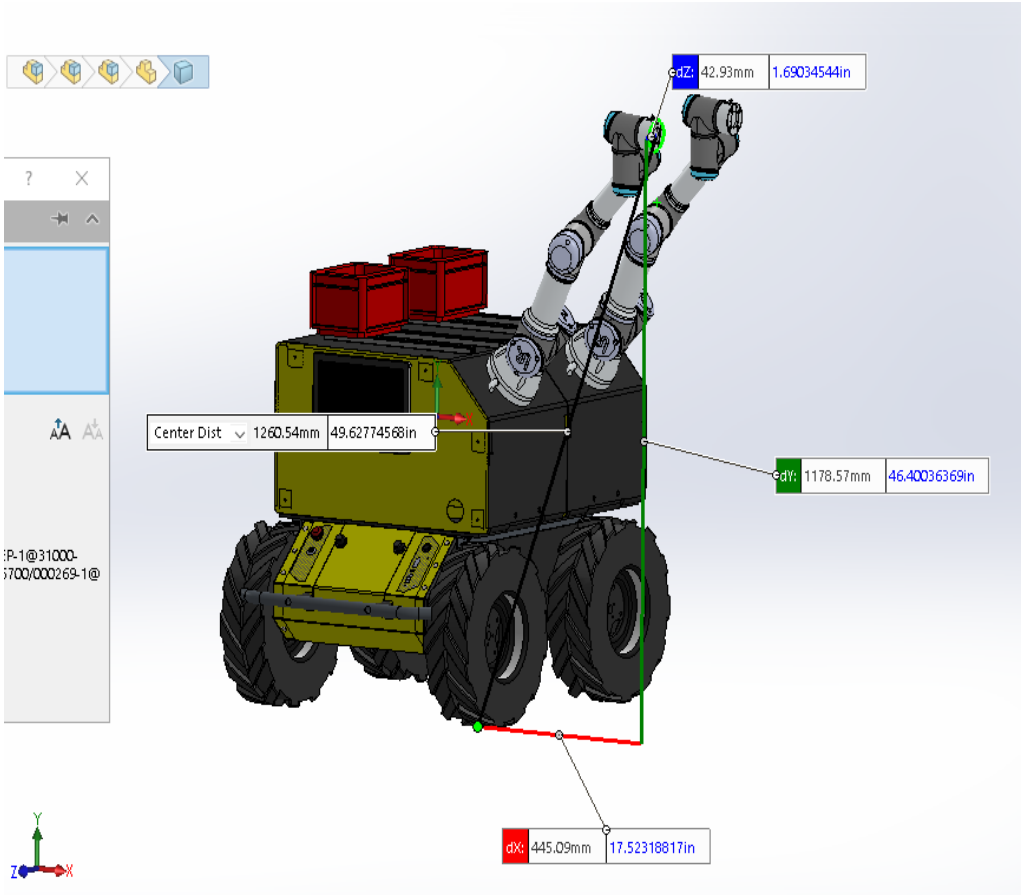
Gripper could be an ATTACHMENT to The Cutter → so they are controlle Jointly → ~~As ut~~

Gripper SHOULD HAVE Greater Thickness → so it moves more

Gripper will HOLD The Berry Stem while cutter cuts from the Top

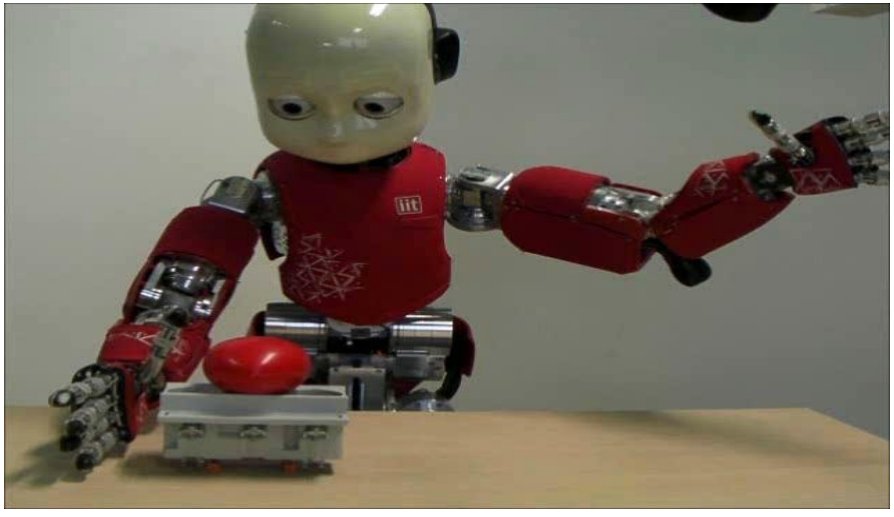
BACK TO THE ACTION SYSTEM- BERRY PICKING IS A BIMANUAL TASK

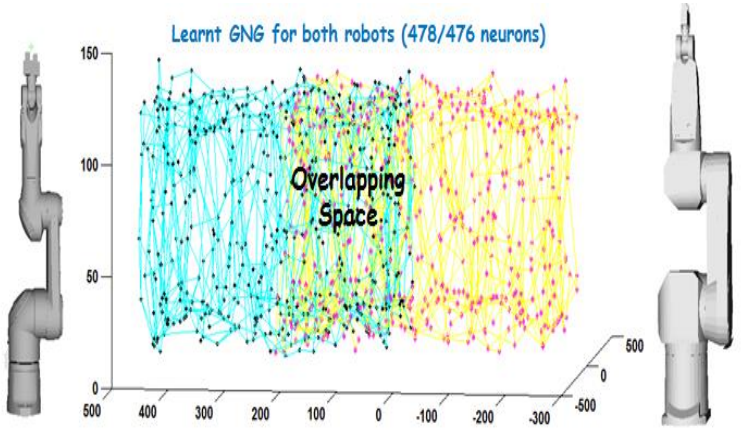
AFTER SEVERAL ITERATIONS (WITH TIPTREE)



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, COLLABOARATION

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

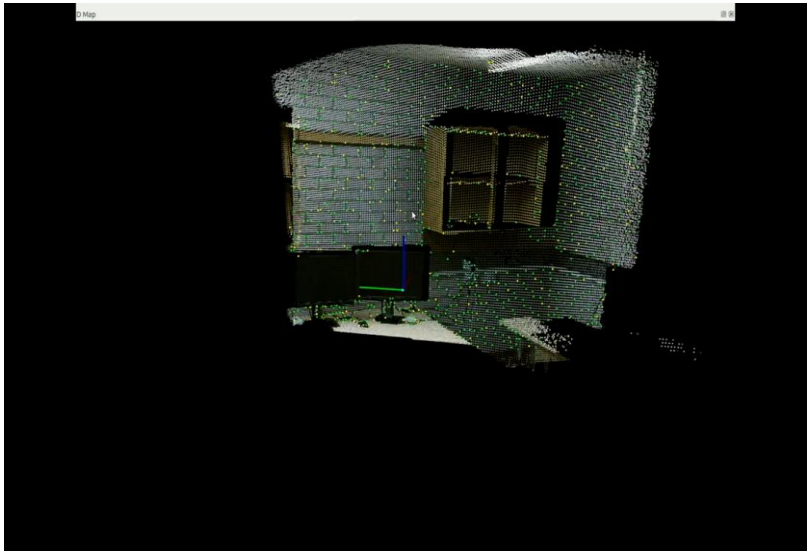
ACTION DRIVES PERCEPTION (BERRY SEEKING VS. BERRY PICKING)

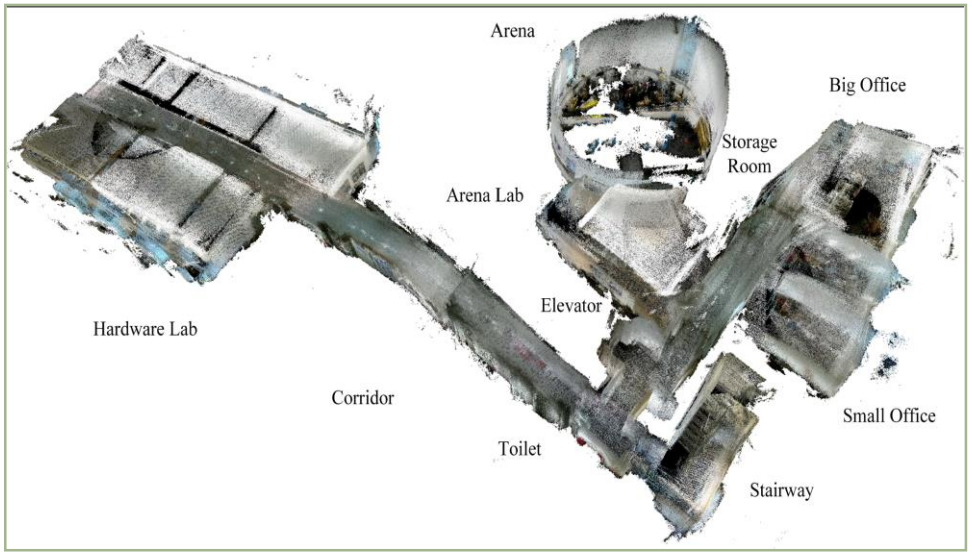
HUMAN ACTION PERCEPTION, COLLABOARATION

- DOMAIN AGNOSTIC (AGRI SURGEON)
- PLANT AGNOSTIC...
- BIOMIMETIC..(GOING BACK TO HUMAN)
- LOW COST..(3D PRINTING)
- MODULAR..
- HUMAN IN LOOP...

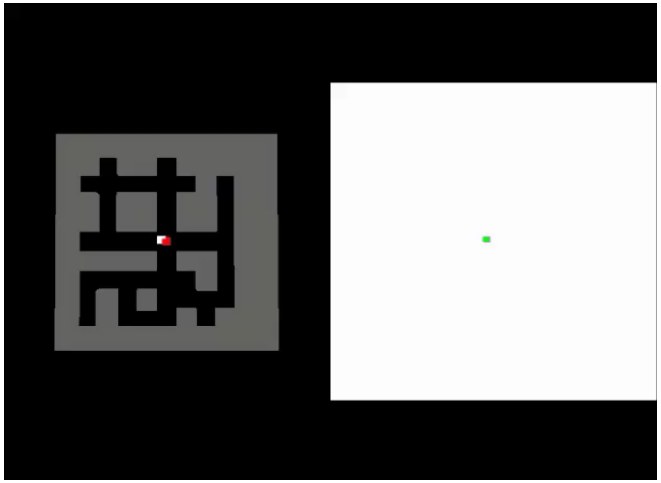
AUTONOMOUS NAVIGATION (MONITORING, TRANSPORING, PREDICTIVE YEILD ANALYTICS)

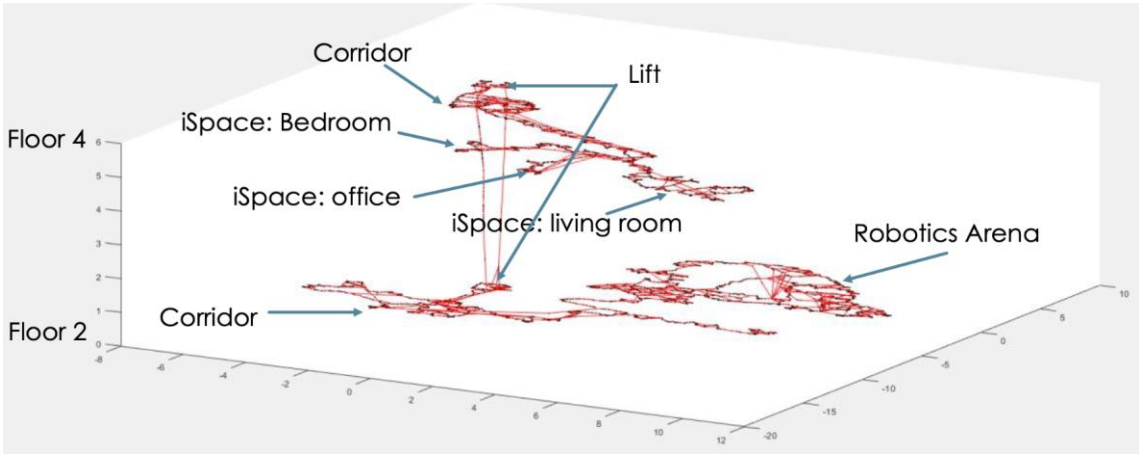
DEEP LEARNING SLAM (PROF DONGBING GU)





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

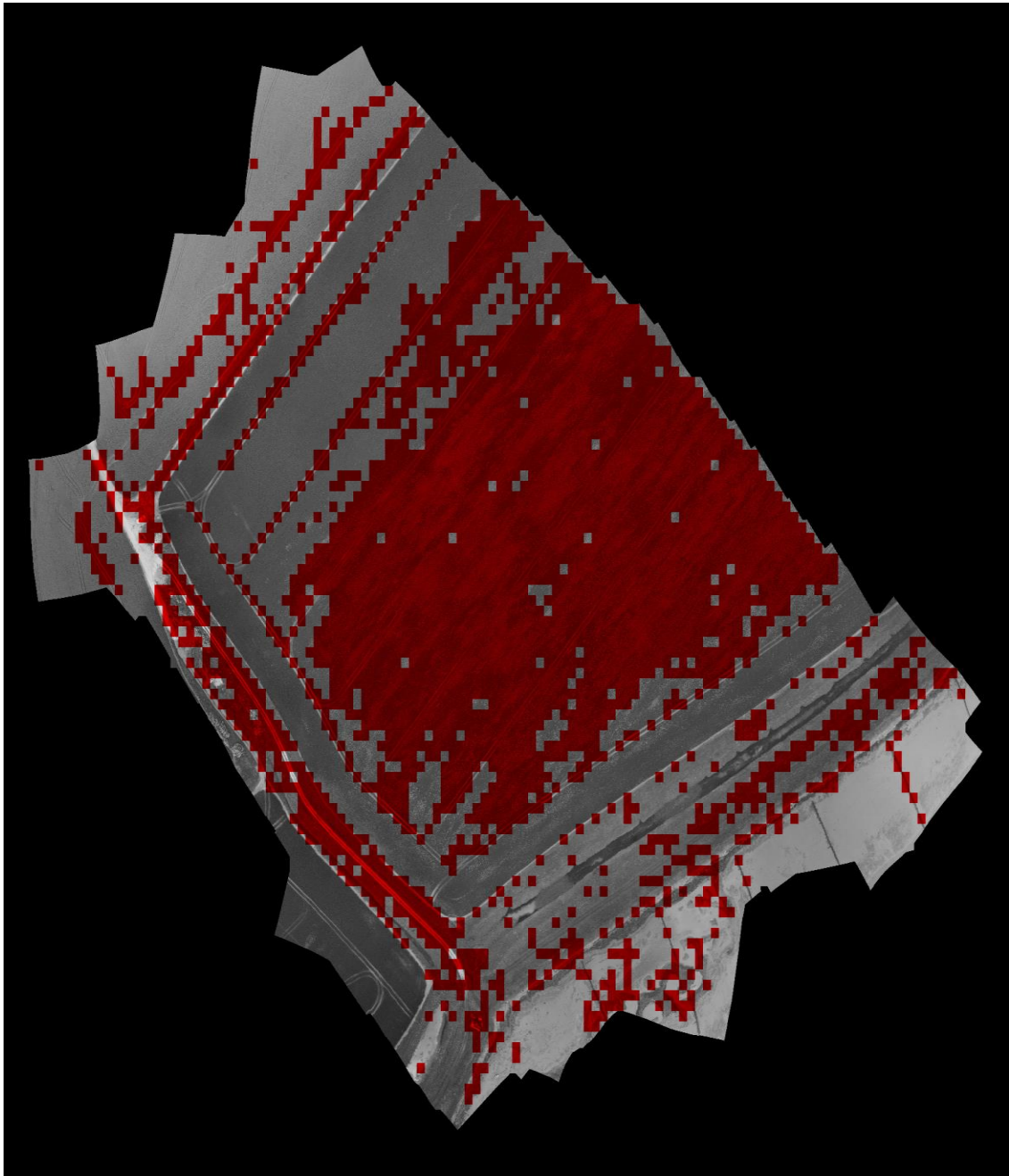




PHYSICAL LOCATION, VISION, SOUND ACTIVATE THE NEURONS

BLACK GRASS DETECTION USING MACHINE LEARNING (ADRIAN)

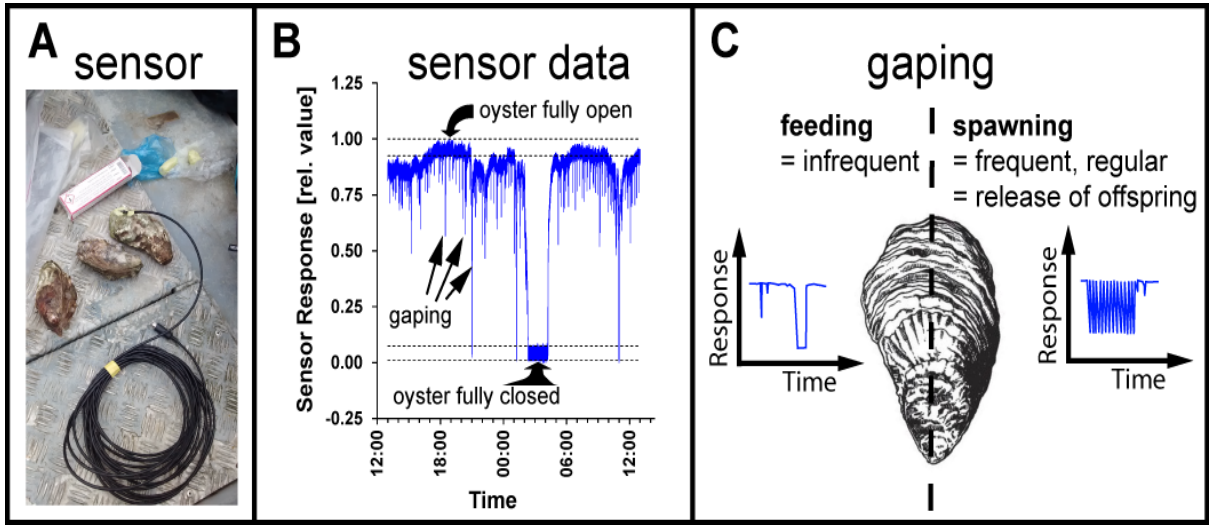
VISIBLE AND NIR WAVEBANDS AND THE BLACK GRASS IDENTIFIED USING MACHINE LEARNING

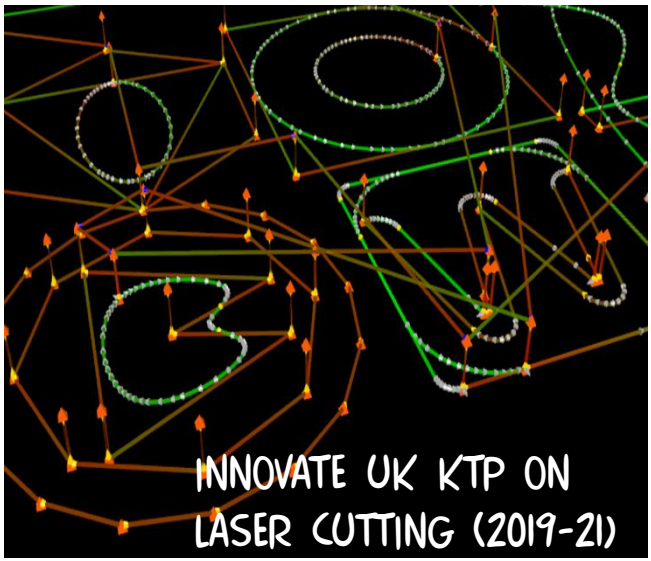


NOSY - NON-INVASIVE OYSTER SENSOR (JOHN WOODS)

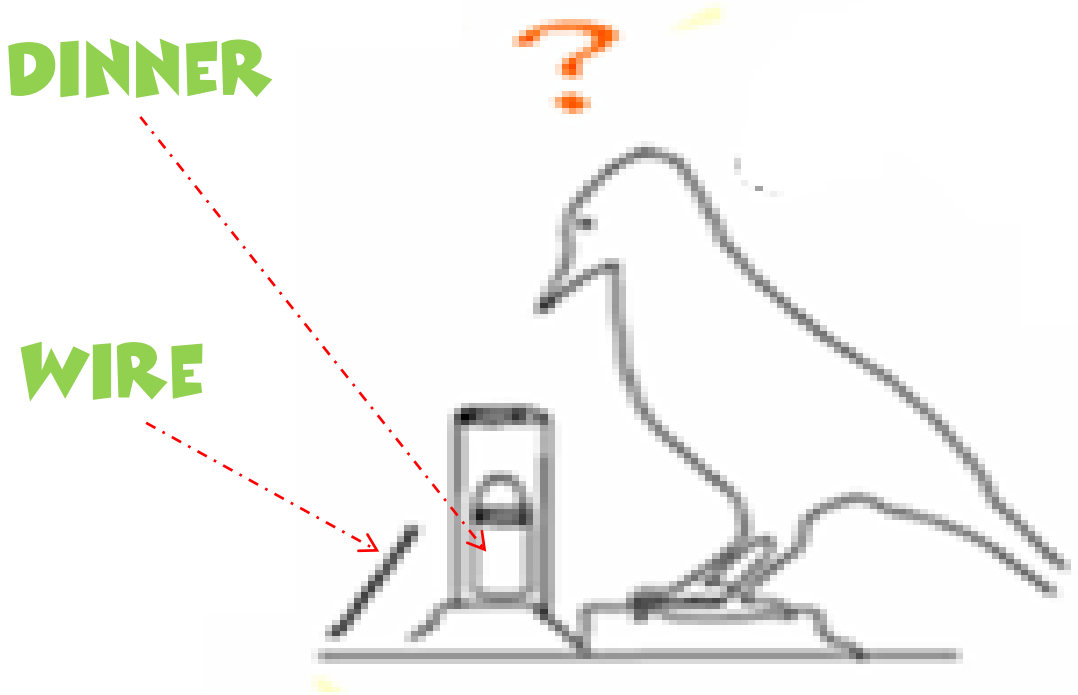
s being used on oysters

Cultch-laying off Mersea Island.





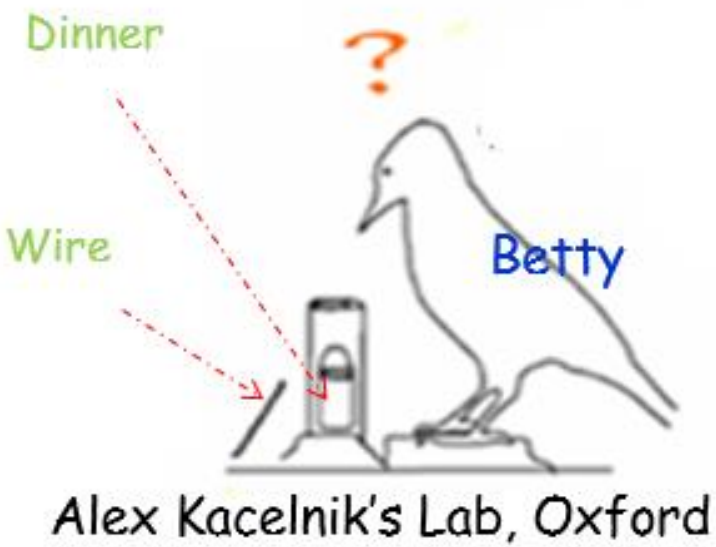
THE END- NECESSITY IS THE MOTHER OF INVENTION: THE STORY OF BETTY



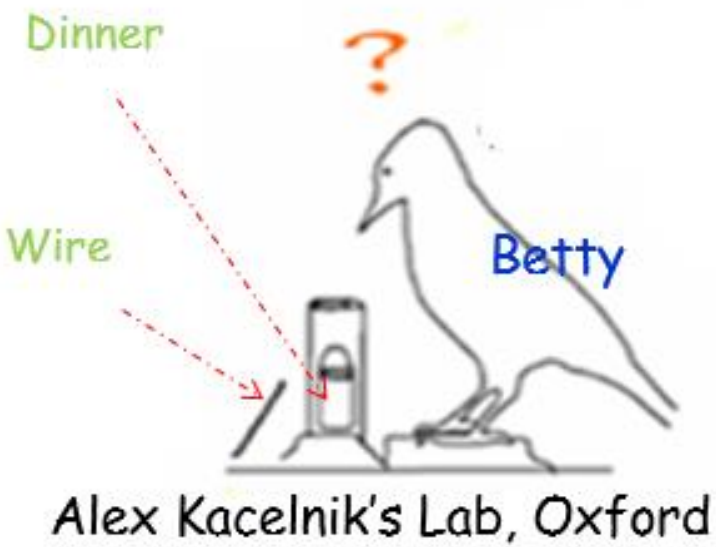
ALEX KACELNIK'S LAB, OXFORD

Necessity is the mother of invention: the story of Betty

WHAT IF - BETTY WAS A ROBOT INSTEAD ??



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 !!!!!