

Robots with Biological Brains – Issues & Consequences

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Growing Brains for Robots

- Biological Neural Networks
- Cultured Neural Networks
- Technical Aspects
- What does it involve?
- Problems/issues?
- Philosophy
- Consequences

Why?

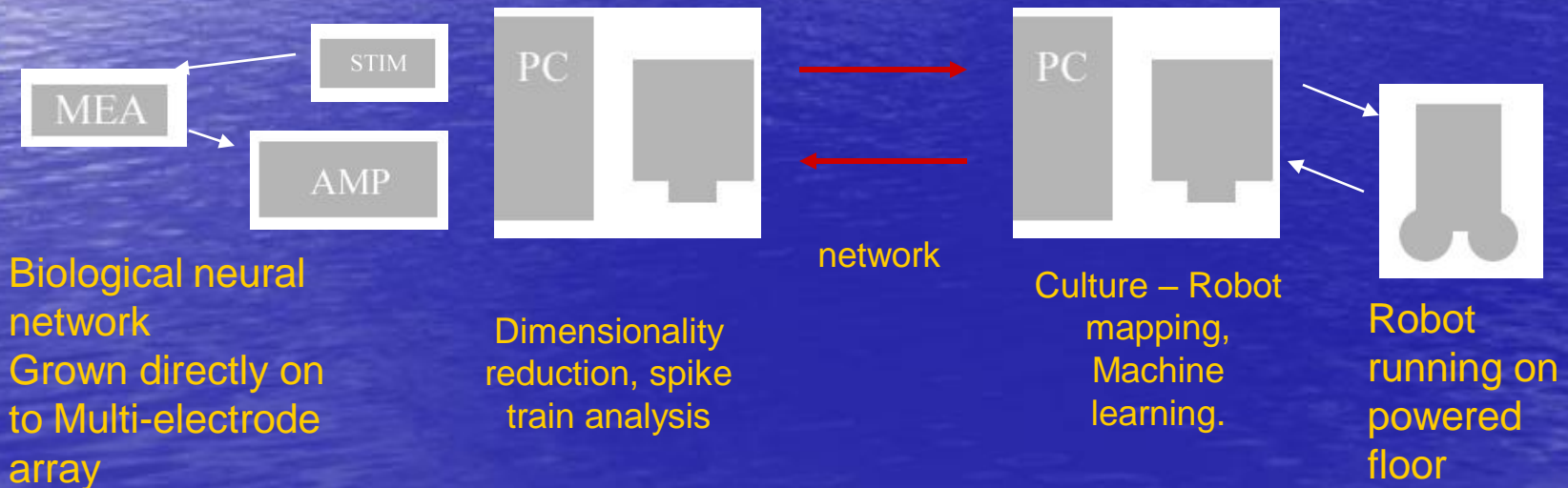
- Why not?
- Understand memory – Alzheimer's Disease
- Understand – neural death/plasticity – Stroke
- Regeneration through stem cells – extend memory & life
- Understand basic learning
- Future robots?

Concept

Re-embodiment a culture of neurones using a robot body, enabling it to interact with its environment and so influence future 'sensory' input.

Robot with a Biological Brain

A closed loop interface between a biological network and a robot

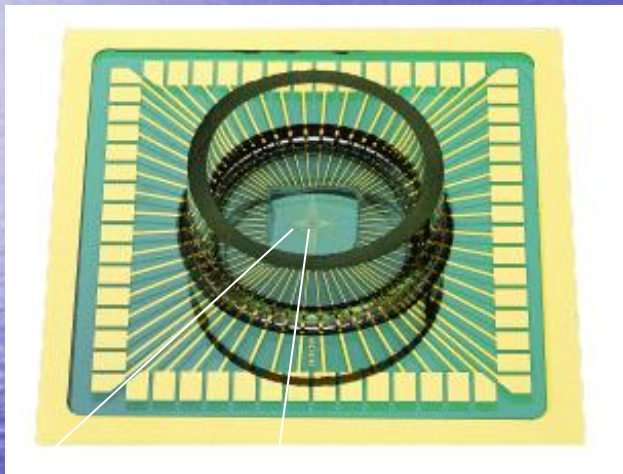


Run Down

- Neurones from rat embryos
- Neurones separated using enzymes
- Laid out on an MEA – 2-D
- Fed
- 20 mins – projections
- 1 week – brain activity

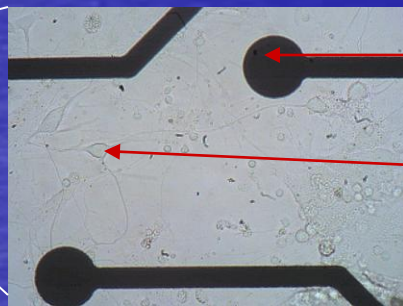
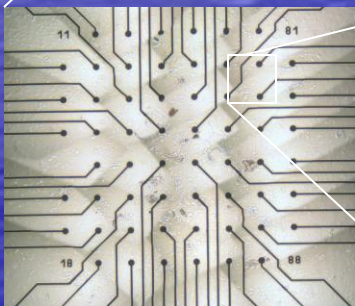
Approach

- Culture brain cells directly on to a recording surface and re-embodiment the 'brain' within a robotic body.



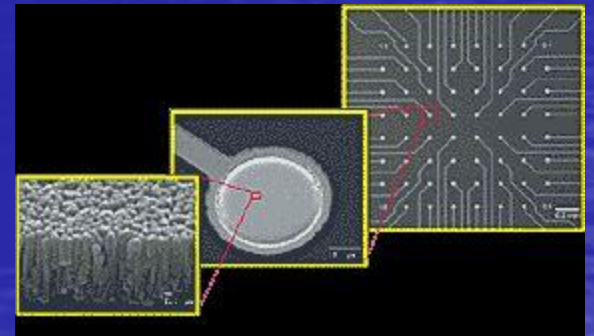
– Multi-Electrode Array (MEA) allows recording from 128 electrodes across the entire culture.

200 μ m
.....

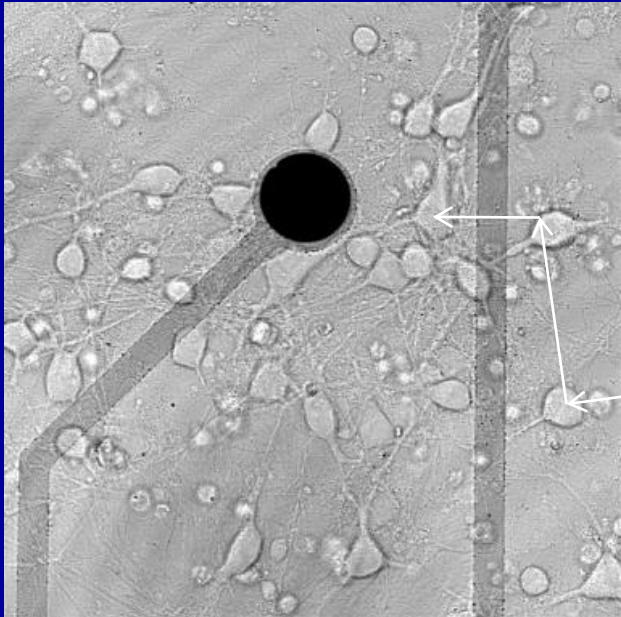


TiN Electrodes
30 μ m diameter

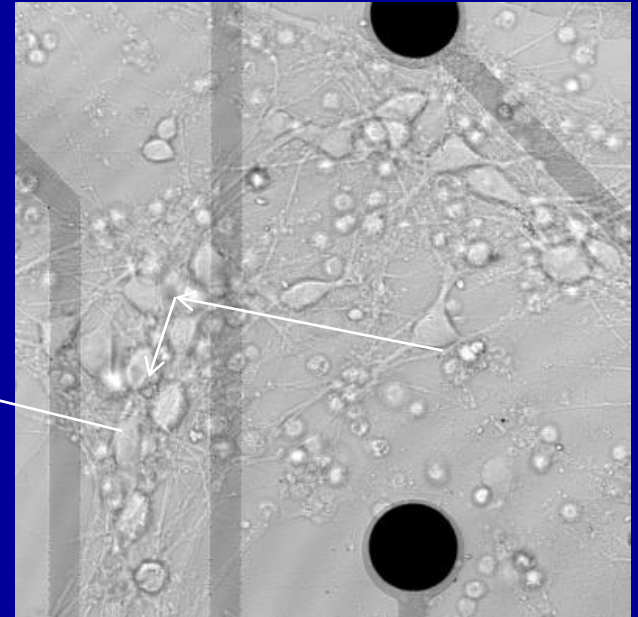
Neurone



Overview



Neurons process
sensory input to
produce useful
behaviours?





Observations

- Hebbian Learning
- Sleep time?
- 100,000 Neurones typical
- Neurone Specialisation - Functionality
- Old Age?

Philosophy

- Philosophy of AI has been based (almost entirely) on comparisons between silicon and carbon – Humans – v – Computers.
- Can we pull some philosophical nuggets from classical AI philosophy?

Future?

- We will need more robots/tech around the home
- Maybe have a **HUMAN** neurone brain
- Loved one/yourself?
- Biped/humanoids
- Emotions – Consciousness?

Biological AI - Ongoing

- Further Senses
- Further Motor Skills
- Human Neurones
- 24/7/365 Operation
- Day 1 immersion in body
- Effects of environment on learning
- 3-D operation – 30 Million neurones
- Alive?

Dreaming

- When the culture is disembodied, does it dream?
- If not, what is it thinking about?
- What must it feel like to be the culture?

Donate your neurons

- The use of human neurones throws up other possibilities and questions.
- Rather than obtaining neurones from embryos maybe you would be happy to donate your neurones – before or after death.
- Possibly some memories would remain?

Consciousness

- Does the brain experience consciousness?
- A typical brain, on a 2-Dimensional array, contains around 100,000 neurones.
- Nothing like the 100 billion neurones in a human brain.
- If size is important then maybe consciousness cannot YET be considered.

3-D growth

- Lattice culturing allows a 3-D culture to be grown.
- A 3 D culture now gives a brain with 30 million neurones.
- A 4,000x4,000 2 D structure results in a 3 D brain of 60 billion neurones – more than half the size of a human brain – not far from that of an elderly human.
- Such a robot brain could be more powerful than a stroke patient for whom a section of their brain has experienced neuronal death.

Voting rights

- How do we consider the consciousness of our robot with a brain of 60 billion densely packed, highly connected **HUMAN** neurones?
- Can we endow it with genuine understanding and (Penrose) “genuine intelligence”
- If so, we will have to think about giving the robot voting rights, allowing it to become a politician if it wants to and the possibility of putting it in prison if it does something wrong.

Not Conscious?

- What are the arguments against our robot being conscious?
- Is 60 billion still not 100 billion and that's it?
- If so, we need to count the number of brain cells in each person's head - those whose total falls below a threshold (e.g. 80 billion) will be dropped from the human race on the grounds that they are not a conscious being.
- Perhaps we will need a basic test of communication such as the Turing Test - everyone must achieve a standard in order to avoid the cut and what – be incinerated?
- On this basis my mother, who has latter stage dementia, would have long since found herself burned to a crisp.

Senses

- Maybe emotional responses are important instead?
- If the robot has human neurones couldn't it experience similar emotions to humans?
- Maybe our robot must have the same sensory input as humans to be conscious? - now audio input is being given to such robots and smell is another possibility along with touch and vision
- But we do not suggest that people who have no sense of taste are not conscious – or those who are blind or have a hearing deficiency
- Sensory input is not critical to one's status as a conscious being.

Motor skills

- More contentious would be an argument suggesting that motor skills are important to consciousness.
- The robot moves around on wheels.
- Some humans move around on wheels – the world record for the marathon is held by a wheelchair athlete!
- Some humans have no arms or have robot arms
- There are those who have contracted Motor Neurone Disease and have limited movement abilities due to a malfunction in that specific part of their brain.
- It would be horrendous to suggest that such humans, e.g. Stephen Hawking, are not conscious beings.
- Motor skills cannot be considered as a tester for consciousness.

Functionality

- In a human brain, neurones take on particular roles – motor, sensory etc
- Some might argue this is important for consciousness
- But .. In the cultured brain – exactly the same thing happens

Nature & Nurture

- We are left with the two critical properties of nature and nurture – the basic elements of human intelligence.

Education

- Are we going to deny our robot its consciousness because of its educational background?
- It didn't go to the right school – therefore it is not a conscious being
- We must then look at the education of humans and deny some their basic rights because they went to the 'wrong' school.
- Education/nurture cannot be used as a basic argument against our robot's consciousness. In fact, even the present robot, moving around in the lab, is obtaining a University education!

Nature

- How an entity comes into being must be important as to whether or not that entity is conscious.
- At present it does not appear possible to bring such a robot to life through some form of sexual act between two humans.
- But we allow for techniques such as test tube babies and even cloning in conscious humans.
- Indeed human neurones which actually constitute the brain cells of the robot came about very likely through the sexual act
- The only difference between the robot brain and a human brain is down to the length of gestulation – this would seem to be a weak line to draw in decision making regarding an entity's consciousness – especially when we consider the situation of premature babies.

Discrimination

- It is impossible, on any scientific basis, to exclude our robot from the class of conscious entities.
- Because its brain is made up of only human neurones it is extremely difficult to find grounds on which to discriminate against it
- It may well be nearer the human norm than some disadvantaged human individuals.

Searle

- “The brain is an organ like any other; it is an organic machine. Consciousness is caused by lower-level neuronal processes in the brain and is itself a feature of the brain.”
- Searle describes an emergent property - the more neurons there are, with greater complexity, this eventually results in consciousness exhibited by humans.
- If our robot has a brain of several billion highly connected human neurones then by Searle’s argument the robot will have a consciousness that is similar to humans, whatever its physical embodiment.

Robot rights

- What rights should such a robot have?
- Should we endow it with citizenship?
- Do we need to protect it by law?
- If you are the robot and you have been brought to life in your robot body, by a scientist in a laboratory, who is in control of your existence it must be an absolutely terrifying experience.
- It will not be long before such robots are actually brought into being
- As a scientist is it acceptable for me to take the life of a robot with 60 billion human neurones?

Size matters?

- A 300x300 neurone layout results in a 90,000 neurone culture when developed in 2 D
- This is 27 million neurones in 3 D.
- A 5,000x5,000 neurone layout results in a 125 billion culture in a 3 D lattice.
- A 7,500x7,500 layout results in a 421 billion neurones in 3 D – an individual brain with four times the number of neurones as a human brain.

Super Searle

- By Searle's argument – human consciousness emerges as a property of our 100 billion neurones
- If we have a robot with over 400 billion neurones, will it have a form of super consciousness?

You are a robot

- Put yourself in the position of the robot.
- Your brain is more powerful than that of the scientists who created you.
- Yet you still have to carry out the mind numbing tasks required by those same scientists.
- Would you put up with it? Would you not complain?
- With those intellectual capabilities (or more) surely you could figure out a way. But what would you do if someone tried to stop you? Would you meekly return to the lab and see out your days in utter boredom or



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**Artificial
Intelligence**

the basics

