Background

All throughout history, automation has been the primary driving force for disruption and creation of new opportunities for increased efficiency and economic growth. Today we see this in effect by the application of Artificial Intelligence for tasks such as voice recognition and natural language processing that have enabled the creation of intelligent assistants such as Amazon's Alexa and The Google Assistant that serve as our modern-day butlers and personal assistants. These assistants are able even able to make phone calls on our behalf to book reservations.

The next generation of tasks that we need computers to perform such as advanced robotic control, planning, creativity, cognition and abstract reasoning are high-level tasks which cannot be solved in a realistic timeframe using brute force algorithms. These tasks require too many calculations to iterate over all possibilities – in the game of Go there are more possible games than atoms in the universe.

Speeding up our current computers does not fundamentally address these challenges. This is due to our ability to make processors faster diminishes each time we shrink the transistor. Even quantum computers cannot solve these tasks significantly better as they are only theoretically superior for solving specific mathematical problems. Such an example is factorisation where the only practical use is cracking encryption schemes.

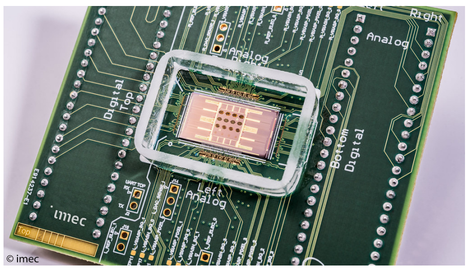
Intelligence is a property of higher-order animals such as humans, primates, dogs etc. that has developed over many millions of years of evolution. It is a powerful heuristic shortcut allowing us to accomplish complex open-ended tasks that would otherwise be impossible. Intelligence for us is made possible by an extremely power efficient, massively parallel, self-organising computer - the brain. Artificial Intelligence currently takes inspiration from the brain only by poorly emulating a tiny subset of the brain's capabilities on a digital computer.

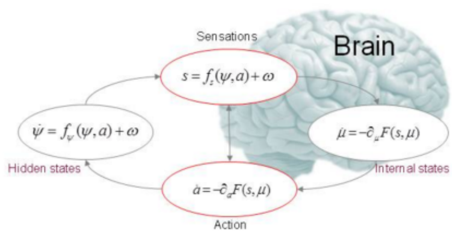
Today, AI is still limited by the inordinate amount of data, time and energy required to train an artificial neural network and the inflexibility to accomplish only a single task; while the brain's neuroplasticity allows it to learn quickly and adapt to many different situations over a lifetime.

We believe the self-organisational properties of neurons are an ultra-powerful learning system. The ability to rewire synapses dynamically and to create new networks in response to being embodied in an environment is the seed of intelligence. Understanding this process will allow us to better understand the nature of intelligence and to build general intelligence. This is done not by shoe-horning these capabilities into poor silicon-based simulations but by directly harnessing neurons themselves.

Method

Multi-Electrode Array (MEA) devices are specialised Petri dishes with an embedded CMOS sensor that allow for the precise measurement and stimulation of individual neurons at micro-meter precision. Our goal is to extract live neurons from embryonic mice and to grow and keep them alive outside a living body on the MEA device that will allow us to "read and write" to the living neurons.





Based on the theoretical framework of how brains learn developed by Prof. Karl Friston of UCL called active inference and the free energy principle, we will build virtual environments in software to simulate a playground in which cultured neurons are able to learn through embodiment via a feedback loop circuit. This feedback loop is critical to giving the neurons agency to manipulate their environment and observe the effects of their manipulation. This process of manipulation and observation thus provides an embodied learning process for neurons outside the body

By introducing dopamine agonists, we plan to reinforce specific behaviours and thus “train” the network to accomplish computational or intelligent tasks for us. One of our milestone goals is to have the neurons learn how to play the game Pong.

To accomplish this goal, CCLabs has assembled a highly talented and motivated multi-disciplinary team of biologists, computer scientists and engineers. At the most prestigious Artificial Intelligence conference of the calendar year called the Neural Information Processing Summit (NIPS) which was held in December 2018 at Montreal, CCLabs was the only Australian company to have had its research accepted and presented amongst companies such as Deep Mind, Google, Facebook, Baidu, Tencent and Amazon.

This team will be tasked with the setup of our wet laboratory where we will harvest neurons, grow and keep them alive for our AI team to program on. Experimental protocols will be written and as much of the process automated to reduce variability and increase reproducibility. Software and hardware infrastructure will also be developed to create the training virtual environment that neurons will be exposed to.

Outcome

Biological neural computing represents a fundamentally novel and untapped category of computation. Our vision is to create processors built from highly engineered synthetic neurons, derived from a biological foundation but not seen anywhere in nature. Our processors will fuse biological synthetic-neurons with electronics allowing intelligent computation with the same level of energy efficiency and flexibility found in nature. Development of such a processor will allow for the operation of large neural powered data centres that can complement existing cloud computing for tasks best suited for neural computation such as strategy planning and creativity. Future developments of a self-enclosed neural processing unit will lead to hybridisation of biology and mechanical actuation in the form of cyborgs.

Due to the fundamental nature of the research and development that we will be undertaking, many of the discoveries that we will pioneer will be patentable and applicable to a whole host of adjunct industries such as brain-computer interfaces, neuromorphic computing, long-term tissue culture, and stem-cell development that can be applied beyond ICT and into the pharmacological and life-sciences sector.

In the short to medium term, CCLabs will develop and patent core technologies around the extraction, growth, life support of neurons from animals and human stem cells along with the hardware infrastructure and software around the embodied training process. We intend on opening the platform within 24 – 36 months for researchers and developers around the world to subscribe for access to our neural cultures to run their own experiments and develop other creative uses for neural computation.