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- ISEL research group
 - 5 academics, 13 research students, 3 research officers
- Expertise
 - Bio-inspired systems, hybrid intelligent systems
 - evolvable hardware, embedded systems
- Proposed Project
 - Bio-inspired self-adaptive perception systems
- Rationale
 - Need high speed adaptable hardware implementations

PARENTS: Perception and Awareness Realisation via Evolvable Neural Network Technologies in Silicon

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Artificial neural networks are being widely proposed for use in a variety of scientific, industrial, and commercial applications. Electronic, software and photonic implementations of artificial neural networks may make it possible to insert low-cost modules into existing and newly developed systems, and facilitate improved performance in signal processing, intelligent control, pattern recognition, sensation and perception, and medical instruments.

While biological systems provided the original inspiration for research into artificial neural networks, limitations in understanding of signal coding, information transfer and other characteristics of such systems, coupled with difficulties in hardware and software design, mean that artificial neurons developed by engineers deviate substantially in structure and operation from their original biological counterparts. Current artificial implementations of neural networks suffer from a number of deficiencies, including opaqueness, lack of generalisation and training methodologies. However one of the major problems relates to the inflexibility of the architectures typically used when neural networks are implemented in electronic hardware.

Researchers are gradually developing an improved understanding of biological neurons in terms of their structure and architecture, interconnections, information coding, firing mechanisms, communication and transient behaviour. For example there is considerable work at present into electronic spiking neurons, which are being used to create hardware models of neural systems which have greater adherence to, and plausibility with, the biological domain. Research is ongoing into modelling techniques that fill the gap between approaches that start from detailed bio-physically motivated simulations but fail to make mathematically exact global predictions, and approaches that are able to make exact statements, but only on levels of description that are remote from biology. One aspect of the improved knowledge of biological neuron structure, which is becoming apparent, is that there is considerable adaptability and evolvability in natural neuron architectures.

User programmable electronic devices such as field programmable gate arrays and field programmable analog arrays are rapidly becoming an indispensable part of the electronic designers' portfolio of tools. These devices have also attracted the interest of the academic community in terms of their capability for implementing adaptable and evolvable hardware structures. As such they are also an ideal medium to study and mimic biological neural architectures.

The research project described in outline in this paper proposes to investigate the most recent models of biological neurons as determined within the cognitive neuro-physiology research community, the identification of critical aspects of such knowledge from an electronic and computational perspective, and the creation of biologically plausible emulations of such models in adaptable and evolvable hardware such as FPGAs and FPAAs. The vehicle for such an investigation relates to the topic of speaker identification.

Very young children rapidly develop the ability to identify their parents' voices, long before they have the language skills to understand the actual message content of the spoken words. Similarly young animals quickly identify their parent's or master's voice. This facility is also robust enough to survive changes in voice due to ageing or in the presence of illness which change the nature of the voiced signal.

Such a facility would be very useful in personalised robotic devices. This project seeks to:

- Determine the most current knowledge in understanding how very young offspring can identify a parent's voices i.e. the neurology involved in communication from the ear to the brain and subsequent parental or master association.
- Determine which aspects of biological neuron structures participate in such understanding.
- Create biologically plausible emulations of such models in adaptable and evolvable hardware specifically FPGAs and FPAAs.
- Determine how such emulations could be translated to mobile robot identification of owner or key users

To do this a number of participants with certain key skills are required, specifically:

- A partner with expertise in auditory information processing for example from a medical or biomedical research group
- A partner with expertise in the design of FPAA technologies (Physics/Electronics research unit)
- A partner with expertise in adaptable and evolvable hardware / FPGAs (we would fulfil this role)
- A partner with expertise in creating biologically plausible models of the relevant neuron structures - e.g. cognitive neuroscientists
- A partner with an interest in robotics

If interested in discussing further please contact:

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