INTELLIGENT INFORMATION TECHNOLOGIES FOR BIG DATA

TOPICS:
- Big and Stream Data Analytics
- Spiking Neural Network Computation
- High Performance Neuromorphic System
- Novel Brain-Computer Interfaces (BCI)
- Novel Motion Data Analysis Technology
- Predictive Personalised Modelling of non-Communicable Diseases
- Predicting Response to Treatment
- Personalised Modelling in Bioinformatics
- Predictive Modelling on Ecological and Environmental Data
- Big Data in Radio-Astronomy
- Computer Vision and Image Processing for Dynamic Data Analysis
- Visualisation of Scientific Data
- Novel Human-Computer Interfaces
- Complex System Optimisation
- Collaborative and Distributed Systems Design

Nikola Kasabov (Eds.)
Neelava Sengupta, Elisa Capecci, Joyce D’Mello (Co-Editors)
Preface

The Neuro-Computing and Evolving Intelligence (NCEI) series of conferences/workshops held in New Zealand started with a small workshop of the New Zealand Computer Society Expert Systems SIG in 1992 at the University of Otago. This was the beginning of the ANNES (Artificial Neural Networks and Expert Systems) conferences held in 1993, 1995, 1997, 2009 and 2001 at the University of Otago. NCEI continued this series through years 2002 till today. The NCEI 2015 is the 13th conference from this series.

The NCEI 2015 conference aims at presenting the state-of-the-art in intelligent systems, including but not limited to, brain-like Neurocomputing systems, focusing on big and stream data analysis, modelling-, mining- and understanding for a better decision support. This conference emphasises on the evolving, adapting, learning characteristics of the human-like intelligence that can be modelled in artificial intelligence systems. A novel computational neuromorphic architecture, called NeuCube, is introduced by the KEDRI team as a new generation of computer systems - the spatio–temporal data machines. A range of applications are presented, including: brain data modelling; event prediction in health, ecology, environment, business.

I would like to thank the presenters and participants from New Zealand, China, the UK, Malaysia, Germany, and other countries. I am delighted to have world class researchers and presenters from all universities in NZ. Along with established researchers, this conference provides a forum for young researchers to demonstrate their fresh ideas, but also to learn and to interact.

The book of abstracts incorporates all accepted abstracts that have been peer reviewed. Authors of selected presentations will be invited to submit full papers to a special issue of the Springer journal ‘Evolving Systems’ to be published in 2015.

I would like to acknowledge our sponsoring organisations:
- Auckland University of Technology (the SRIF INTELLECTE project)
- The Faculty of Design and Creative Technologies (KEDRI funding)
- The School of Computer and Mathematical Sciences at AUT (conference funding)
- The British High Commission in NZ (support of 5 UK participants)
- The Ministry of Business, Innovation and Employment in NZ (the China-NZ strategic alliance project)
- Education NZ (the Tripartite programme East China-West China- NZ).

Welcome all to the NCEI 2015 and enjoy the conference!

Professor Nikola Kasabov, FIEEE, FRSNZ, FIITP NZ, DVF RAE UK
General Chair of NCEI (ANNES) conference series, since 1992
Director of KEDRI, http://www.aut.ac.nz, AUT
nkasabov@aut.ac.nz
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Abstracts

NeuCubes: A Neurocomputer for Spatio- and Spectro-temporal Data
Nikola Kasabov, Enmei Tu, Neelava Sengupta

Abstract: In this article, we describe a new type of evolving connectionist system (ECOS) called evolving spatio-temporal data machines (eSTDM). These multi modular computer systems are designed to deal with large and fast spatio/spectro-temporal data using spiking neural networks (SNN) as major processing modules. ECOS and eSTDM in particular can learn incrementally from data streams, can include 'on the fly' new input variables, new output class labels or regression outputs, can continuously adapt their structure and functionality, can be visualized and interpreted for new knowledge discovery and for a better understanding of the data and the process that generated it. eSTDM can be used for early event prediction due to the ability of the SNN to spike early, before whole input vectors (they were trained on) are presented. A framework for building eSTDM called NeuCube along with a design methodology for building eSTDM using it is presented. The implementation of this framework in MATLAB and in PyNN will be presented, the latter facilitating the use of neuromorphic hardware platforms to run the eSTDM.

A NeuCube PyNN simulator and its implementation on neuromorphic hardware
Nathan Scott, Giacomo Indiveri, Simon Davidson

Abstract: As the complexity, detail, and scale of neuromorphic simulation grows, so too does the requirement for computational technologies sufficient to support these new demands. The NeuCube spiking neural network architecture for the classification and interpretation of spatio- and/or spectro-temporal data requires a new approach to its computation, as network size and complexity grows. One such computational technology currently in development is the SpiNNaker massively-parallel neuromorphic supercomputer. This paper will demonstrate the feasibility of implementing the NeuCube spiking neural network data machine on the SpiNNaker neuromorphic hardware device. A benchmark implementation of NeuCube on the small-scale Spin-3 model SpiNNaker device written in the modelling language PyNN will be demonstrated, and applied to a task of classifying spatio- and spectro-temporal brain data. The benefits of combining these two state-of-the-art technologies, including lower power consumption, greater scalability, and accelerated computation time will be shown with reference to traditional Von Neumann simulation. Further avenues of exploration, including embedded applications in robotics and radio astronomy, will be identified.

Unsupervised dimension reduction via local smoothness assumption
Xiaohe Zhang, Chen Gong, Jie Yang

Abstract: With advancing of modern technologies, high-dimensional data have prevailed in computational biology making the subsequent data analyses intractable. Dimension reduction, which aims to project the original high-dimensional data into a low-dimensional subspace, offers a potentially useful avenue to tackle such problem. However, most existing algorithms ignore the geometric distribution of the examples in a local region, so the local structure cannot be precisely preserved after the dimension reduction. In contrast, this paper puts forward the local smoothness term, based on which an effective dimension reduction algorithm is explicitly proposed. By detecting the geometric distribution of the examples in a local region, local smoothness term transfers the neighbourhood structural information carried by the original data to the low-dimensional space. The strength of the proposed method is validated by applying it to face recognition problem on three typical databases, including FERET, Yale and ORL repositories.
**Enterprise big data mining in the cloud: A comparative review and research agenda**

Irina Neaga, Shaofin Liu, Yuqiunge Hao

**Abstract:** Despite a recent 2015 prediction stated that big data paradigm might significantly “erode and begin to vanish” an increased trend could be on revealing hidden/unknown assets in massive amounts of data based on predictive and prescriptive analytics. The big data analytics provide a tangible business value and support companies/organizations to make easier, faster and smarter decisions about different key aspects such as how to better engage with customers and forecasting. However exploring the big data through mining, OLAP, predictive analytics and associated software systems development have continuously evolved based on knowledge discovery in databases discipline. In the context of big data the related aspects have introduced complex, interesting questions for researchers and stimulated software development communities together with business analysts and decision making people. As organizations continue to increase not only the amount of data, but also the need of extracting business values from data formalizing the process of big data analysis and analytics becomes overwhelming.

The paper describes the opportunities and challenges provided by cloud computing to enable the development of big data mining systems, analytics and business intelligence that in fact have the foundation in traditional knowledge discovery applications. Some scholars also stated that big data mining is not new. So this paper should also clarify the associated issues analysing the commonalities elements and differences based on Vs model of big data (volume, velocity, variety, veracity and value).

The paper will also include the definition and discussion of the data as a service, information and knowledge as services as well as new distributed service systems and models such as Hadoop as a service, MapReduce and/or Hadoop Distributed Files System (HDFS). The main contribution of this research and future directions are related the definition of a framework for using the cloud computing approach for the development and deployment of business intelligence applications and logistics services using big data mining and analytics. The paper will discuss some existing approaches and holistically analyse the main issues of big data mining, knowledge, patterns discovery and OLAP in a big data intensive cloud computing environment. The related research will be providing directions of adapting data mining methodologies (i.e. CRISP-DM) for application in collaborative logistics, 3/4PL and supply chain management. It will also include the main aspects of the European strategy on mastering big data driven applications mainly in industry.

**Brain-Computer Interfaces for neuro rehabilitation**

Denise Taylor, Jennifer Chamberlain, Nada Signal, Nathan Scott, Nikola Kasabov, Elisa Capecci, Enmei Tu, Nicola Saywell, Yixong Chen, Jin Hu, Zeng-Guang Hou

**Abstract:** Globally, stroke is a major cause of long-term motor impairment due to hemiparesis and commonly results in the loss of hand function, limiting the patient’s quality of life (QoL) and increasing the burden to society. Brain computer interfaces (BCI) are currently being explored for use in rehabilitation applications. BCI’s interpret brain signals to control a device, bypassing the normal neuromuscular pathways, and providing an opportunity to restore motor function. Integrating BCI’s with functional electrical stimulation (FES), a familiar physiotherapy intervention, may effectively re-establish the sensorimotor loop disrupted by the stroke. A BCI-FES system could be used to facilitate upper limb (UL) motor recovery by combining motor learning principles and promoting activity-based plasticity. This presentation critically reviews protocols that use BCI-activated FES in stroke populations, for promoting UL motor function. Promising results from a proof-of-concept study using NeuCube for the modelling and recognition of complex EEG data will be presented. BCI system variables and issues are examined in the context of the broader field of rehabilitative BCI research.
EEG-based application of the NeuCube framework in addiction research
Grace Y. Wang, Nikola Kasabov, Elisa Capecci, Maryam Gholami Doborjeh, Robert Kydd, Bruce Russell

Abstract: Electroencephalography (EEG) is a non-invasive measure of the brain’s electrical activity, which provides a great deal of information about the function of the brain. Currently, classification and evaluation of EEG signals are limited, and inconsistencies remain on the relationship between difference of EEG frequency bands and the complex forms of mental activity. A new methodology, the ‘NeuCube framework’, based on the connectivity analysis of evolving brain-inspired spiking neural networks (eSNN) models has been proposed. In this project, we investigated the patterns of electrical activity of brain associated with chronic opiate use and methadone maintenance treatment (MMT) during either resting state or task performance, using the ‘NeuCube framework’. Resting continuous EEG (4 minutes) and GO NO-GO task related EEG (5 minutes) obtained from 26 channels of 32 patients undertaking MMT for opiate use, 17 opiate users and 25 healthy volunteers were input into the NeuCube for training and testing purposes. Our results demonstrate that the NeuCube provides better accuracy of classification and interpretation of EEG data compared to traditional statistical and artificial intelligence (AI) methods, suggesting its potential application to neurological clinical research.

Computational modelling of homeostatic synaptic plasticity in the spiking model of hippocampal granule cells
Lubica Benuskova

Abstract: Long-term potentiation (LTP) and long-term depression (LTD) are widely accepted to be synaptic mechanisms involved in learning and memory. It remains uncertain, however, which particular activity rules are utilized by the brain neurons to induce LTP and LTD in behaving animals.

Recent experiments in the dentate gyrus of freely moving rats revealed an unexpected pattern of LTP and LTD from high-frequency perforant path stimulation. Moreover, the magnitudes of synaptic changes depended crucially on the particular temporal pattern of high-frequency stimulation.

In this talk, I will report the results of our study of how key components of learning mechanisms in the brain, namely spike timing dependent plasticity and metaplasticity interact with spontaneous activity in the input pathways of the neuron. Using biologically realistic simulations we show that ongoing background activity is a key determinant of the degree of LTP and LTD of synaptic transmission of freely moving animals. This work helps better understand the computational rules which drive synaptic plasticity in vivo, but also proposes a simple learning rule that can be efficiently implemented in large spiking neural networks.
Design factors affecting blood pressure prediction during general anaesthesia using spiking neural networks

Go Hamano, Andrew Lowe, David Cumin

Abstract: Background: Today, Big Data has become a part of modern medicine. Physiologic data (blood pressure, heart rate etc.) are routinely electronically measured and automatically recorded during general anaesthesia in some hospitals. However, beyond the immediate surgical case, these data are seldom utilised. We explored such data to see if modern computational techniques can help to predict future physiological states so that any deterioration in patient status can be mitigated or prevented.

In this research, we apply a novel spiking neural network model, called Neucube (ST) [1]. Neucube (ST) has been applied to the analysis of spatio-temporal brain data (e.g. EEG) and time-series data without spatial information (for example, stroke occurrence prediction using environmental data [2]).

Neucube(ST) has 3 main functions; 1) unsupervised learning according to a Spike Timing Dependant Plasticity (STDP) learning rule, 2) supervised learning according to a rank order rule, and 3) prediction or classification based on a comparison method, such as Nearest Neighbour Search.

There are a number of design considerations when using Neucube(ST) as a classifier of time-series data: what pre-processing of the raw data is required (pre-processing), how to convert the time-series data into a spike train (input-encoding), which neurons the data are connected to (input-mapping), and how many nearest neighbours to use in classification (classification). However, it is unclear from published literature how sensitive Neucube (ST)-based systems are to perturbations of any of the above.

Aim: The purpose of this work is to explore the sensitivity of Neucube (ST) to different pre-processing, input-encoding, input-mapping, and/or classification settings in predicting physiological values from intra-operative records.

References:

Personalised predictive data modelling methods based on evolving spiking neural networks: a case study on stroke occurrences

Valery Feigin and Muhaini Othman

Abstract: This research present a novel computational architecture and a framework for personalised (individualised) modelling of spatio-temporal data based on evolving spiking neural network reservoirs (eSNNr). The architecture consists of: spike-time encoding module of continuous value input information into spike trains; a recurrent 3D SNNr; an eSNN as an output classification module. This architecture is designed specifically for spatio-temporal pattern recognition (STPR) problems. It transfers spatio-temporal data patterns from a multidimensional input data stream into internal patterns of the eSNNr and these patterns are classified into pre-defined classes. Based on this framework an application was developed and called NeuCube. Utilizing NeuCube, new method of predictive personalised modelling can be done especially for a case study consisting of temporal features. The adaptability of the new application leads towards understanding feature correlations that affect the outcome of the study and extracts new knowledge from hidden patterns that reside within temporal associations. As a case study, this framework is applied on data set for prediction of stroke occurrences on individual basis. The data consists of static personal and geographic variables and dynamic climate, pollution and geomagnetic daily variables. Through this new method, estimation stroke risk at the earliest time point is possible. Comparative experiments were also carried out using conventional machine learning algorithms such as SVM and MLP to prove that our approach can result in much better accuracy level.
Ecological Informatics: modelling bioinvasion
Susan P Worner

Abstract: One of the greatest threats to global biodiversity, environment, international trade, market access, food security and human and animal health are bioinvasions. Both productive and indigenous ecosystems are at risk from damaging pest organisms and diseases that accompany the increasing flow of people and commodities across international borders. Most people are largely unaware of the many thousands of different types of organisms capable of causing immeasurable damage if they invade new areas.

The most cost effective strategy to mitigate bioinvasions is to stop dangerous new organisms crossing international and national borders. Therefore, prioritisation and prevention is a major focus of international biosecurity agencies. However, such agencies need research to provide underpinning science for efficient strategies. While, many decisions made by regulators are expert driven, risk assessors and agency personnel increasingly accept the value of data driven models. But, because many species are involved, any model involves the analysis of high dimensional ecological and spatial data. The array of methods and approaches currently used, while they are applied in many fields of science, is called ecological informatics. Ecological informatics is defined as a discipline that brings together ecology and computer science to solve problems using biologically inspired computation, information processing, and other computer science disciplines such as data management and visualisation.

Many different classes of models and approaches are applied to the integration of the high dimensional range of climate, distribution and biotic information required to gain greater predictive precision for bioinvasions. While these models offer much potential, there are important issues that still need to be resolved to improve the models, to establish good practice and sensible modelling protocols for risk assessment and prediction.

Association rule mining for big Darknet traffic data
Tao Ban, Daisuke Inoue, Koji Nakao, Shaoning Pang

Abstract: Global darknet monitoring provides an effective way to observe cyber-attacks that is significantly threatening network security and management. In this paper, we present a study on characterization of cyberattack patterns in the big stream data collected by the NICTER darknet project using association rule mining. With each unique source IP address observed in the darknet treated as an attacking host, frequent attack patterns are extracted for the attaching hosts on a daily basis. Then, significant association rules, which usually correspond to special attacks from certain hosts, are generated from these frequent patterns.

The experiment shows that association rule mining in the darknet stream data can support strategic cyberattack countermeasure in the following ways. First, statistics computed from malware-identifying rules can lead to better understanding of the global trend of cyberattacks in the Internet. Second, strong association rules between variables can lead to further insights into the nature of the attacking tools and hence speed up the malware countermeasure process. Then, the discovery of emerging new attack patterns may lead to the early detection and prompt prevention of pandemic incidents, preventing damage to the IT infrastructure and extensive financial loss. E.g., when a peculiar combination of destination ports are found to be associated with a special attack, countermeasures such as firewall rules and IDS signatures could be enforced to prevent the network from future malware intrusion. Finally, exploring the knowledge in the frequent attacking patterns can enable accurate prediction of future attacks from analysed hosts, which could improve the performance of honeypot systems to collect more pertinent malware information using limited system and network resources.
Imputing missing data with evolving connectionist systems

Michael J Watts

Abstract: It is a consequence of the digital age that enormous amounts of data are being produced at ever-increasing rates. A recent estimate by IBM held that the total volume of data produced in 2013 exceeded two and a half exabytes per day. Data mining is concerned with finding molehills of meaning in the mountains of data being produced. So that data mining algorithms can make the most of this data, we need a method of handling missing values.

The process of automatically generating replacement values for missing data is known as data imputation. A paper by Silva-Ramirez et al (2011) used multi-layer perceptrons (MLP). In that paper, MLP were trained to reproduce input values. When values were missing from the input vectors, the generalisation capability of the MLP allowed them to impute the missing values. Performance was measured as the Mean-Squared Error (MSE) between the imputed and original data set. While MLP gave results that were useful, MLP suffer from the significant drawback of being unable to adapt to further data, such as found in an online system, due to the well-known phenomenon of catastrophic interference.

The work reported in this paper applied Evolving Connectionist Systems (ECoS) (Kasabov, 2003; Watts, 2009) to the task of data imputation. As constructive ANN, ECoS networks avoid the problem of catastrophic forgetting by growing (evolving) their internal structures in response to new data. Two ECoS models were investigated to perform the imputation: the classic Evolving Fuzzy Neural Network EFuNN (Kasabov, 1998); and the Simple Evolving Connectionist System SECoS (Watts, 1999). The datasets investigated were the benchmark iris, ionosphere, wine, sonar and Pima Indian diabetes classification problems.

References

Immersive visualisation of 3-dimensional neural network structures

Stefan Marks, Javier Emmanuel Estevez, Nathan Scott

Abstract: Recent development in neural networks has led to an increase in performance, but also complexity and size of neural networks. This poses a significant challenge for the visualisation of the spatial structure and temporal behaviour of networks.

While there are several projects for the 3D visualisation of neural networks on screen, those largely focus on the exploration of the spatial structure alone, using standard 2D screens and mouse and keyboard interaction.

This paper presents a framework for an immersive 3D visualisation of neural networks in virtual reality using a motion capture setup for full freedom of motion of the users. It enables intuitive navigation and exploration of the spatial as well as the temporal behaviour of the network. Millions of neurons including their connections and temporal activity can be rendered stereoscopically in real-time. Structures can be explored by thresholding, slicing, connectivity usage visualisation, and other analysis metaphors. Temporal behaviour can be explored by play/pause/rewind/fast forward metaphors, using real-time simulated or recorded spiking activity.

The paper further presents a comparison of the original orthographic visualisation of NeuCube, a 3-Dimensional Spiking Neural Network, to the presented novel immersive 3D visualisation, including success stories where the latter lead to improvements in the analysed networks.

Finally, the paper will discuss further venues of development and alternative render methods that are currently under development and will significantly increase the visual accuracy and realism of the visualisation.

Evolutionary Computation Research and Applications

Mengjie Zhang

Abstract: Evolutionary Computation is an interdisciplinary field that can be used to solve complex problems in real-world applications. Over the last decade, this field attracts considerable attention in both research development and applications. This talk will overview recent research and developments in Evolutionary Computation. The focus will be on Evolutionary Computer Vision and Image Analysis and Evolutionary Feature Reduction using Genetic Programming, Particle Swarm Optimisation and Learning Classifier Systems. The applications will be focused on classification, regression, and optimisation in machine learning, data mining and big data.
Intelligent Information Technologies for Healthcare
Hamid GholamHosseini

Abstract: The rapid increase in the aging population especially of the 65+ has been witnessed a similar increase in the incidence of chronic disease and healthcare costs worldwide. Intelligent information technology will play a significant role in implementation of delivery of intelligent healthcare across many applications such as patient monitoring, medical imaging, real time location and remote monitoring/therapy systems.

Point-of-care diagnostics is evolving as a handheld device using a network of wireless wearable sensors that continuously monitors patient health, recording of vital signs, medical history as well as the provision of decision support feedback. This technology allows both real-time and continuous monitoring of patient health.

Moreover, intelligent medical image processing, diagnostics and therapy play important role in the prevention and treatment of chronic diseases by enabling early detection of health related problems such as melanoma.

Increasingly, there will be applications using RFID tags, olfactory systems, mobile based patient monitoring and fall risk assessment as well as automated diagnostic of medical imaging for a more intelligent delivery of healthcare.

A tablet-based remote patient monitoring system has been developed for fall risk detection/predication in a hospital setting and the findings were compared with those of traditional fall risk monitoring and assessment systems.

A new k Nearest-Neighbor (kNN) algorithm for nonlinear manifold distributed data classification
Enmei Tu, Jie Yang, Nikola Kasabov

Abstract: k Nearest Neighbours (kNN) is one of the most widely used supervised learning algorithms to classify Gaussian distributed data, but it can hardly achieve good results while applied to manifold distributed data, especially when very limited labelled samples are available. In this paper we propose a new kNN algorithm which can effectively handle both Gaussian distributed data and manifold distributed data. The proposed algorithm first constructs a graph and computes the constrained Tired Random Walk (TRW) on the graph. Then the nearest neighbours are identified according to the TRW and the class label of a query point is determined by the sum of all the TRW of the nearest neighbours. Comparison experiments are conducted on both synthetic data sets and real-world data sets to demonstrate the validity of the proposed new kNN algorithm and its improvements to other version of kNN algorithms.
**Neucube-M: A neuromorphic spiking neural network architecture for multimodal neuroimaging data analysis**

Neelava Sengupta, Nikola Kasabov

**Abstract:** In the recent years, there has been a huge focus on the study of intelligent data analysis of the functional and structural brain images acquired by neuroimaging tools like fMRI, EEG, DTI etc. These data analysis not only allow for understanding of behavior, cognition, perception etc. by relating neural activity with tasks, but can also be used for prediction purpose.

Research in this area have concentrated on analysis of a single mode of data (eg. EEG), due to issues like technical problem in sampling multiple modes of data simultaneously, heterogeneous spatiotemporal structure of the different modality etc. Recent advances in the neuroimaging tools has enabled us to sample multiple modalities at the same time. In this article, we propose a neuromorphic spiking neural network architecture Neucube-M, derived from Neucube [1] that can integrate connectivity and activity information from the neuroimaging modalities like fMRI, EEG and DTI. We propose a DTI driven probabilistic connectivity generation algorithm, for generating the connection adjacency matrix during Neucube-M initialization. A case study has been performed on classification of clozapine treatment response of Schizophrenia patients, and initial experiments have achieved best cross validated accuracy of 73.3% with a standard deviation of 5% after parameter search.

**References**


**Evolving spiking neural network for predictive data modelling**

Muhaini Othman, Enmei Tu, Valery Feigin, Rita Krishnamurthi, Nikola Kasabov

**Abstract:** This paper proposes a new model of a dynamic Evolving Spiking Neural Network (deSNN) for spectro-spatio temporal data (SSTD) regression problems. The proposed deSNN model will be integrated into NeuCube for SSTD analysis and processing. The proposed deSNN model extend the previous deSNN by incorporating wkNN algorithm to create additional layers for calculating the output value from the new neuron created after the supervised learning process in deSNN. In NeuCube system, the continuous value of SSTD will be transformed into high-dimensional spiking patterns to be learnt through unsupervised learning methods and then output values of the patterns will be predicted through supervised learning layer using proposed method called deSNN_wkNN. Through the extension of this model, $k$ selected nearest neurons to the new neurons will be given a weight value depending on the distances of the neurons. The higher value of the weight will be consider as the closest neuron and the new neuron output value will be calculated based on the value of selected neuron. The proposed method is evaluated on ecological problems concerning Aphids infestation during spring seasons. A comparative analysis will be done to discuss the result of this model with other types of machine learning methods.
A computational neuro-genetic NeuCube model
Elisa Capecci, Josafath I. Espinosa-Ramos

Abstract: Over the past few decades, the complex machinery that regulates the mammalian central nervous system (CNS) has been the subject of study for several scientists. The number of questions raised, the increasing number of people affected by neurological disorders and the consequent amount of brain data collected have made information scientists’ contribution fundamental. They have been developing new techniques and computational models that emulate the human brain in order to understand and analyse the information available. Particularly, the complex process that regulates the learning and spiking activity of the brain has been inspiring several computational model, among which Spiking Neural Network (SNN).

Neural activity and learning processes in the CNS are regulated by the transmission of ionic currents, which are regulated by complex biochemical processes. At a synapse, the balance of two opposite forces controls the functioning and the synaptic plasticity of the CNS. The Glutamate and the GABA neurotransmitters, and their receptors are intrinsically related with the spiking activity among neurons, inducing excitatory and inhibitory post synaptic potentials respectively. Regarding the glutamate receptors, the AMPA mediate a fast excitatory synaptic response while NDMA a slow one. On the other hand, the GABAa and the GABAb receptors regulate a fast and a slow inhibitory synaptic transmission respectively. These receptors are related with the learning and memory in the hippocampus.

Some cognitive processes are implemented in SNN using Hebbian learning rules. An important mechanism in Hebbian learning is the competition among different synapsis, i.e. when some synapses are strengthened due to pre-synaptic action potentials other are weakened. Some studies related with temporal pattern recognition have successfully implemented the Spike-Timing-Dependent synaptic plasticity (STDP) as the way of competition for control of the timing of postsynaptic action potentials [1]. However, this competition can also be implemented through dynamic mechanisms involving non-Hebbian synaptic growth or decay terms. In this context, we propose a synaptic scaling way to model the synaptic plasticity of a Computational Neurogenetic Model (CNGM) [2] according to the dynamics between the excitatory and inhibitory receptors. These model can automatically balance the synaptic strengths making postsynaptic firing irregular but sensitive to presynaptic potentials such as the STDP like rules.

After a spike is emitted by a neuron \( n_i \) and received by a neuron \( n_j \), the activation of excitatory molecules in a neuron \( n_j \) increases up to a maximum threshold, otherwise, it decreases up to a minimum threshold according to the time elapsed after the last spike is received. In this proposal, we modelled the dependency of the AMPA receptor over inhibitory macromolecules, and the dependency of the NMDA over the AMPA receptor. A probability of exclusion determines the activation and the speed of inhibitory macromolecules, therefore, the probability of the GABAa occurrence is higher than the GABAb probability, being this last one the probability complement of the first. The dynamics of the model are presented in Figure 1.

Figure 1: Experimental results obtained. (a) A recurrent SNN network where \( n_1 \) and \( n_2 \) are input neurons emitting different spike trains, and \( n_3 \) and \( n_4 \) are the excited neurons. (b) The dynamics of the excitatory and inhibitory molecules between a presynaptic \( n_1 \) and a postsynaptic \( n_3 \) connection. (c) The synaptic weights change due to macromolecules activation. (d) The action potential produced by the changes of the synaptic weights.
References


Artificial neural network based currency authentication

Guang Yu Wang, Wei Qi Yan

Abstract: The security issue of currency has widely attracted awareness from the public due to its important role in nations' economy stability. Despite the development of applying various anti-counterfeit methods on currency notes, cheaters are still able to produce illegal copies and circulate them into markets without being detected. By reviewing and utilizing previous researches on currency security, the focus of this project is on conducting a comparative study of available feature extraction and classification methods of currency authentication. Our contribution is to design and implement a forward propagation ANN algorithm for currency identification in three different ways, the evaluations will also be presented.

Analysis of EEG spatio-temporal brain data from a BCI data-base using Neucube

Sonia Mohammadyari, Denise Taylor, Elisa Capecci, Nikola Kasabov

Abstract: BCI (Brain-Computer Interface) systems enable a direct relationship from the brain to an output device. These systems utilise brain signals to allow users to control different devices, for example to control a computer cursor or a wheelchair. BCI systems have the potential to replace or supplement neuromotor functions and could provide exquisite control choices for neurologically impaired patients [1]. Many BCI systems employ electroencephalography (EEG) devices to record brain signals from the scalp. EEG has limited spatial resolution but provides good temporal information within the millisecond range [1]. For that reason, EEG systems have been used to facilitate a better understanding of the brain processes related to recovery of neural function.

In this proof of concept study, we have classified and analysed spatio-temporal EEG data obtained from the BCI Competition IV website. In contrast with traditional machine learning methods used in the competition, the computational model we applied on the data was based on the spiking neural network architecture known as NeuCube for spatio-temporal brain data modelling, learning and classification [2]. We selected the data set1 from the Calibration data, as it presents EEG trials recorded from healthy subjects while performing a motor imagery task. The EEG was recorded using 59 electrodes, however, for our analysis only 3 electrodes were selected (C3, Cz, and C4). In the literature, these three electrodes appear to be associated with limb imagery movement tasks that produce bilateral activation of the sensorimotor areas related with them [3]. Out of the seven subjects’ data available from the data set1, two subjects were chosen, as they were the only ones to perform the imaginary movement task of interest (i.e. mental rehearsal of a movement of the left-hand or a foot). We randomly selected 40 samples out of the 200 collected during an 8 second period at a sampling rate of 100Hz (800 data point per task/sample), obtaining 20 samples for class 1, ‘left hand’, and 20 samples for class 2, ‘foot’ (either right or left foot, arbitrarily chosen by the subjects during the task).

By using a Neucube-based model, we were able to achieve a classification accuracy of 80%, using 50% of the data for training and 50% for testing, while running a 100 loop grid search on two of the parameters’ settings (Address Event Representation encoding method and the Spike Time Dependent Plasticity learning rate). Other results on the same data set are reported in the literature, however, these results vary depending on the number of subjects, classes and samples chosen, as well as employing different classification techniques. Our results indicate that the Neucube could be used efficiently as a BCI-based control device and as a tool for the prediction and understanding of the recovery from brain related injuries.

References:


fMRI data analysis with NeuCube based on spikes and STDP learning rule

Lei Zhou, Maryam Gholami Doborjeh, Nikola Kasabov, Jie Yang

Abstract: In conventional methods, the functional parcellation of fMRI data is usually done by analysing its statistical characteristics. However, these statistical characteristics are mostly static, so only the spatial relationships averaged over time are extracted, neglecting the dynamics of the spatial relationships which we call spatio-temporal relationships. In order to analyse the spatio-temporal relationships in fMRI data, we implant the data into the NeuCube architecture[1], which is a good model for learning and understanding of the spatio-temporal brain data.

As the NeuCube is one kind of the Spiking Neural Network (SNN), which uses spike trains in computation, we need first encode the fMRI data into spikes. There are many kinds of spiking encoding algorithms, and each of them is suitable for certain specific situations. Here we propose a new kind of spiking encoding algorithm to express the hemodynamic response in the brain. For a given fMRI signal $S(t)$ of one voxel, first we find the time $t_m$ when the signal reaches the minimum value $S_m$, and then we consider only the time period from $t_m$ to the end time of the signal. Let $B_{tm} = S_m$ be the baseline for the signal value at time $t_m$. For the coming time $t_{i+1}$ ($i \geq m$), if the signal value $S(t_{i+1})$ exceed this baseline, we encode a spike at time $t_{i+1}$ and the baseline is updated as $B_{ti+1} = \alpha S(t_{i+1}) + (1 - \alpha)B_{ti}$, where $\alpha$ is a parameter to control how fast the baseline go up when the signal increase. Otherwise, if $S(t_{i+1})$ is below $B_{ti}$, then no spike is encoded at this time and $B_{ti+1} = S(t_{i+1})$. After encoding, the successive spikes generally reflect the increase of the fMRI signal while the absence of a spike reflects a significant decrease of the signal.

Then after obtaining the spike trains of each voxel in the brain volume, we need to establish the connections between every two voxels. We allow every two voxels within a certain distance to have bidirectional connections. That is to say, if voxel $i$ and voxel $j$ satisfies the condition that $D_{ij} \leq T$, where $D_{ij}$ is the distance between voxel $i$ and voxel $j$ and $T$ is the maximum distance allowed for connection between two voxels, connections $w_{ij}$ (connection from voxel $i$ to voxel $j$) and $w_{ji}$ can be established. All the connections’ weights are initialized as zero. Then the STDP learning rule can be used for learning all the connection weights[2]. As there are bidirectional connections between two voxels, we only use the positive change of synaptic weight in STDP learning rule. To be specific, if voxel $i$ and voxel $j$ are connected, and voxel $i$ has a spike before the spike emitted from voxel $j$, only $w_{ij}$ will be increased by STDP and $w_{ji}$ will not be decreased. Otherwise, $w_{ji}$ will be increased and $w_{ij}$ remains unchanged.

To measure the functional activities in the brain, we take the maximum weight of the two connection weights as the final connection weight between every two voxels. And the activity level of each voxel is measured as the degree for all inwards and outwards connection weights. Therefore the higher degree of one voxel represents that it is more activated due to the stimulus.

In the experiment, we investigate the StarPlus fMRI dataset. To analyse the difference between seeing a picture and seeing a sentence in the brain activity, we take the first stimulus segments in the 40 trials as samples (20 trials for each class), and each segment lasts 8 seconds including 16 snapshots. Some experimental results are shown below.
Figure 1. The difference in brain activities between seeing a picture and seeing a sentence. In the first row, (a), (b), (c) show the evolution of voxels’ degrees when the subject is seeing a picture, and in the second row (e), (f), (g) show the evolution of voxels’ degree when the subject is seeing a sentence. (d) and (h) show the functional activities averaged over trials for seeing a picture and seeing a sentence respectively, as the degrees of voxels are normalized by the same minimum and maximum value, we can easily see that voxels are more activated when seeing a sentence especially in CALC region.

References:


A scheme for face recognition in complex environments

Wei Cui and Wei Qi Yan

Abstract: In this project, we propose a scheme for human face recognition in complex environments. The proposed scheme consists of three phases: moving object removal, face detection and face recognition. It could be applied to certain specific environments such as computer users in office, shopping mall, and reception or pokie machine gamblers in casinos. In these environments, the target human face for recognizing will be considered as the foreground and the moving objects as the background. The objective of this project is to implement a scheme for human face recognition so as to improve recognition precision and reduce false alarms. The scheme can be applied to prevent computer users or gamblers from sitting too long in front of the screens in offices or pokie machines in casinos. To the best of our knowledge, this is the first time face recognition in complex environments has been taken into consideration.

BP-Neural Network for Plate Number Recognition

Jia Wang, Wei Qi Yan

Abstract: Our purpose of this project is to develop an event driven traffic ticketing system which will implement five important functionalities, namely (1) Event detection from video frames (2) Digital images processing (3) Artificial neural network based plate number recognition (4) Database management (5) Information notification. As the most crucial part of our project, plate number recognition based on Artificial Neural Networks (ANN) needs to be designed carefully and the results should reach a very high recognition precision. This poster reflects our work in plate number recognition based on BP-ANN. Back Propagation (BP) neural network is one type of Multilayer Feed Forward neural networks which use backward propagation learning algorithms to find out the input weights. It is composed of input layer, output layer and hidden layer (can be more than one). The specific processes will be introduced and our results from the0 experiments will be presented.
Abstract: Age group estimation has many real world applications, such as human computer interaction, where age based entry is restricted. In this paper we propose a new method for Age group classification based on NeuCube (ST). This study has been conducted for the first time by using spatiotemporal data for age group classification. We used simulated video (Daniel.mp4), converted it into frames and divided these frames into three age groups, Young, Adult and Old by using subjective approach. The NeuCube is using spiking neural network reservoir (SNNr) and dynamic evolving spiking neuron network (deSNN) classifier. NeuCube (ST) is an integrated environment including data conversion into spike trains, input variable mapping, and unsupervised learning in the SNNr, supervised classification learning, activity visualization and network structure analysis. NeuCom has also been used to measure the performance of traditional techniques Support Vector Machine (SVM) and Multi-Layer Perceptron (MLP). Finally, the Comparative results were prepared and it was found that better accuracy were achieved by NeuCube (ST).

Dynamic 3D Clustering of Spatio-Temporal EEG Data Streams in the NeuCube Spiking Neural Network Architecture

Abstract: The paper introduces a new method for dynamic clustering of EEG brain data streams through STDP learning in the NeuCube SNN architecture [1].

We discuss first the principles of clustering of static vs. dynamic spatio-temporal data. Clustering in general is defining groups of similar entities by defining the cluster centers and the membership of the entities in each cluster. Evolving clustering as discussed in DENFIS [2] creates and modifies clusters on-line from a continuous stream of input vectors (no temporal relationship between the vectors is considered and learnt). Here we introduce a new generic method for dynamic 3D clustering and temporal visualization of a continuous stream of EEG spatio-temporal data, where the cluster centers are defined a priori by the location of the EEG input data channels in the SNN cube, but the shape of the clusters reflect on the spatio-temporal patterns in the data. The clusters are evolving, i.e. they are adapted continuously and may change over time reflecting on the spatio-temporal brain processes and the recorded data. During the learning procedure, the spike communication within the SNNc is considered as the similarity feature for the dynamic neurons clustering. The SNNc clustering is based on the spreading algorithm [3] in which the input neurons are labelling with neuron spiking activity and then iteratively propagating or "spreading" that activation out to the other neurons linked to the source neurons (input neurons). Therefore, in addition to the spatio similarity (e.g. neuron connections created after NeuCube unsupervised learning), we need to consider the temporal similarity as well (spike-timing relationship of data). The results are dynamic 3D clusters containing the most evoked neurons by corresponding cluster’s centroid. The 3D clusters may grow bigger or scale down with respect to the temporal information of the input data patterns.

Then we present a case study of EEG data recorded for the task of GO/NOGO across different groups of subjects and interpret the meaning of the clusters related to spatio-temporal process in the brain. The use of the proposed method for other brain data modelling and for the understanding of complex brain processes is discussed as future work.

References:

Spatiotemporal analysis of Earthquake Aftershocks based on change detection algorithms
Reggio Hartono, Nikola Kasabov

Abstract: Large earthquakes are associated with aftershock sequences, the temporal decay rates of which follow the modified Omori’s law. The relationship between the magnitude and frequency of the aftershocks over time can also be described using the Gutenberg-Richter law. However, the established models used in aftershocks analysis usually ignore the spatial aspect. This paper proposes a novel approach of aftershocks analysis using change detection concepts that incorporates both spatial and temporal information. Initially, the aftershocks are mapped and discretized into a spatiotemporal map that enables the data to be treated as a linear stream of data. A change detection algorithm is then applied to the transformed data to cluster and differentiate between concept drifts that occur throughout the duration of the aftershocks. The proposed technique is empirically demonstrated on the aftershocks data from four big earthquakes of the Canterbury region of New Zealand from the year 2010 and 2011. Experimentation results show that the approach is able to capture the spatiotemporal decay of the aftershocks and has the potential to be the basis of more interesting applications such as aftershocks modelling and knowledge extraction.

Enhance memory / measure happiness of a subject by providing Neuro-feedback through a simple gaming environment.
Wriju Bhattacharya, Nikola Kasabov

Abstract: Neurofeedback can be described as a technique of training behavioural aspects of a subject by enforcing positive reinforcement by providing them some form of rewards so that the subject learns and improves their brain activities. Traditional EEG systems can capture volumes of data about brain activities by measuring brain signals of subjects. This data is then studied by scientists for analysis/prediction/classification of brain signal patterns. Although a lot of studies have been done in the past by collecting such data and then studying them, not many studies have been attempted to provide real-time neuro-feedbacks to subjects by reading their brain signals and then providing some sort of feedback in real time. This study aims to collect EEG data through Emotive (a cost effective 14 channel EEG) and then classify the data using Neucube which is a spiking neural network architecture for learning, mapping and understanding of spatio-temporal brain data. The subject interacts with a gaming environment where there are green balls which turns red in a predefined sequence. The subject is first trained on this sequence and later when he plays the game, is expected to remember the sequence form his training. Points are awarded if he can remember the correct sequence. The current version of the game is a prototype version can be used to demonstrate the concept and further development work will be undertaken once the prototype is successful to incorporate more complexities to the game. The idea behind this game is to help subjects with Attention Deficit Hyperactivity Disorder (ADHD) as well as can be used to improve one’s memory.

Dynamic personalised modelling for detection to genetically based disease
Vivienne Breen, Nikola Kasabov

Abstract: It is possible that further understanding from existing genetic data (SNP’s mostly) may aid in determining some of the missing heritability of many genetic diseases. Dynamic personalised modelling shows promise in relation to flexibility of model and attribute selection for an individual which can result in a more accurate model of susceptibility. The ability to dynamically perform attribute selection allows for the increasing amount of genetic data available resulting in a more scalable model for susceptibility.
ERP Evidence for Predicting Consumers’ Preferences to Beverage Logos

Zohreh Gholami Doborjeh, Maryam Gholami Doborjeh, Nikola Kasabov

Abstract: In human behaviour study, subjects are not always honest; they may say what they want other people to hear, rather than what they really believe. While the human language can vary from culture to culture, the language of the brain maintains stable in results. The goal of neuro-marketing is to study the physiological response of the brain to advertising and marketing strategies. In order to evaluate the effectiveness of these strategies, the brain activity from this phenomenon is monitored and measured using neuro-imaging techniques. By peering directly into the brain, the hope of some (and the fear of others) is that we could cut through the messiness and analyse the real human attentions against the marketing stimuli. Assessing distinct patterns, functional pathway, evoked neurons, and spiking neurons could be more understandable by taking advantage of an accurate machine learning method.

In this study, we plan to analyse the EEG data already collected from 26 participants, to recognise their brain activity patterns corresponding to their attentions against the presented marketing stimuli (different drink’s brand). The results of the ERP data are evaluated by statistical analysis of repeated measurements RANNOVA to check individual brand preferences to the products, in 2 categories (familiar – unfamiliar). Eventually, the Correlation Statistical Method (CSM) applies to assess the experiments. Also, regression method is used in order to predict the consumer’s preferences to the brands.

Finally, a visual comparison of the brain activity patterns related to the familiar versus unfamiliar brand is captured using a dynamic evolving spiking neural network architecture [1] called NeuCube [2]. Also, the data classification into familiar versus unfamiliar marketing brand classes is done using dynamic classifier and the results are compared with traditional machine learning methods.

References:


Feasibility analysis of using the NeuCube Spiking Neural Network Architecture for Dispersed Transients and Pulsar Detection

Nathan Scott, Reggio Hartono, Mahmoud Mahmoud, Sergei Gulyaev, and Nikola Kasabov

Abstract: With the introduction of the Square Kilometre Array Project, a revolution in the data available to radioastronomers is occurring. Of particular interest is the identification of distinctive spectral patterns known as dispersed transients (single, bright pulses of unknown extraterrestrial origin) or dispersed pulsars (characteristic signals given off by the rotation of pulsar stars). These signals, if identified and analysed correctly, can have major implications towards our understanding of relativistic physics, and therefore, our understanding of the fundamental forces at work in our universe. However, these signals are highly infrequent (1:10,000 samples measured are pulsars, the rest noise), highly unpredictable in terms of signal characteristics, and buried in noise. The current state of the art approach requires a brute force search in terms and is untenable in the face of the volume of data the SKA will produce (data stream rate of 1.5-2.5 TB/s). An alternative approach using neuromorphic principles as a first line candidate selection system is proposed here, and some very preliminary feasibility analysis is conducted. In particular, we seek to apply the NeuCube
EEGRotor: A virtual Quad-Copter based on Brain Computer Interface
Akshay Raj Gollahalli, Nikola Kasabov

Abstract: A Quad-Copter is a flying drone, which has four fins which are bolted to four brushless motors each. There are three types of movement in flying drones/flight; Pitch, Yaw and Roll. These movements are controlled by a small controller called “Flight Controller”; which has its sensors such as 3-axis gyros, accelerometer, barometer and many more to make sure that there is a stabilised flying drone. Usually these are controlled by a remote control kit. What if we could control it through our brains? Then comes NeuCube and a 14-channel EEG device. In this experiment rather than using a real model I will be using a virtual environment to move this drone in four directions; Front – Class 1, Back – Class 2, Left – Class 3 and Right – Class 4. For every class a facial movement was taken into consideration that is for Class 1 – Left eyebrow, Class 2 – Right eyebrow, class 3 – Left eye closed class 4 – Right eye closed. The data collected were 20 samples for each sample, making total of 80 samples.

Fig 1: EEGRotor-workflow

Simple heuristics & subsumption in computational models of economic systems
Paul Davidson, Nikola Kasabov

Abstract: The ‘Subsumptive Heuristic Adaptive Agent-Based Preference architecture’, SHaaP, is a novel agent-based experimental platform in which subsumption as a central, structural meta-heuristic is used in a principled, population-based approach to bottom-up, computational modelling of economic systems and preferences.

The SHaaP architecture allows key functional behavioural elements of economic agents to be identified and set in a hierarchical, population-based structure. In addition to core preference behaviours, a number of other structural and heuristic preference modifiers are commonly present in economic agents but generally ignored in academic studies. These modifiers are recognised by practitioners as having a significant role in overall economic preference expression and operational resilience.

Since the global financial crisis (GFC) the role of simple heuristic behavioural rules as uncertainty mitigation structures has become an important research area (Haldane 2012). The work here investigates these heuristics using the SHaaP architecture.
Network-based method for inferring cancer pathways and tumor progression from cross-sectional mutation data

Hao Wu, Nikola Kasabov

Abstract: Large-scale cancer genomics projects are providing a wealth of somatic mutation from a large number of cancer patients. One of the most challenging questions arising from the data is to infer the temporal order of somatic mutations in a cancer, because it is very difficult to obtain several samples with the temporal order from one patient. Only one sample can usually be obtained from one patient, so inferences are commonly executed from cross-sectional data across many patients. In this work we present a network-based method to simultaneously infer cancer pathways and the temporal order of their mutations from cross-sectional data across many patients without any prior information, leveraging on the exclusivity property of driver mutations within a pathway and the linear progression property between pathways. We firstly construct a gene network based on the approximate exclusivity between each pair of genes using the cross-sectional somatic mutation data from many cancer patients. Secondly, we find all the cliques in the network, and then we determine the driver pathways which meet the linear progression between pathways. To assess the robustness of our method, we apply the method on simulated data with different levels of noise. To further verify the performance of the method, we apply it to analyse somatic mutation data from three real cancer studies, including two studies from The Cancer Genome Atlas (TCGA) on colorectal cancer and glioblastoma cancer with large number of samples. The models reconstructed with our method do not need to assign the number of driver pathways, and also provide new insights on the temporal order of somatic mutations at the pathway level rather than gene level.

Design of a Neurorehabilitation Robot for Upper-limb Training of Post-stroke Patients

Liang Peng, Zeng-Guang Hou, Long Peng, Weiqun Wang

Abstract: With the rapid growth of stroke population in the last two decades over the world, robot-assisted rehabilitation is promising to be widely adopted to alleviate the shortage of physical therapists and release their physical burdens. Though robot-assisted rehabilitation has been proven to be effective by some pilot studies, more novel systems and further studies are needed to improve their clinical applicability and training outcomes.

Our design integrates a virtual reality training environment into a haptic interface, and the combination of visual/audio and force feedback is believed to be more efficient to enhance the active participation and motor recovery of poststroke patients. Meanwhile, the system is compact in size and low in cost, which is more applicable for use both in hospital and at home.

- Mechanical Design: The mechanical design of the robot features a five-bar closed-chain parallel structure and cable transmission system. This robot is much stiffer but lighter in weight than serial robots, meanwhile it has no backlash and high-backdrivable, which is appropriate for safe and comfortable operation of patients with motor disorders.
- Power Source and Sensors: The robot is actuated by two DC motors and hysteresis brakes, whose torque outputs can be controlled continuously, and the patient can receive an assistance or resistance depending on the rehabilitation protocols and their motor abilities. Optical switches and encoders are used to obtain the robot’s configuration in real time, and the handle at the end of the robot is equipped with a two-axis F/T sensor to record the interaction force between robot and the patient.
- Control Methods: In order to guarantee a safe and compliant interaction between robot and the patient, impedance control method is used to simulate simple mechanical impedance characteristics (mass, stiffness, damping, etc.), where the impedance parameters are programmable.
Virtual Training Environment: A virtual reality training environment is developed with different functional modules, and visual rendering and haptic rendering are conducted synchronously. Based on 3D programming library (OpenGL), daily activities exercises like object reaching, path tracking, etc. are integrated into some interesting games, which can improve attention concentration and motivation of the patient.

sEMG-Torque Estimation of Intention Recognition for Robotic-Assisted Lower Limb Rehabilitation

Long Peng, Zeng-Guang Hou, Nikola Kasabov, Jin Hu, Liang Peng, Wei-Qun Wang

Abstract: Robot-assisted devices aim to help users move their limbs and restore limb functionalities through rehabilitative processes. sEMG has been widely used as human-machine interface. sEMG is rarely used in torque estimation of lower limbs because the signals are weaker than the signals of upper limbs. And the existing studies are often constrained to single-joint movement. An accurate model is important in biomechanics and physiology, but could be possibly unnecessary for providing effective movement assistance to users with robot-assisted devices. In order to implement a multi-joint coordinated active training, a practical sEMG-torque model is proposed to estimate the net muscle torques of lower limbs.

The system identification method is used to obtain the net muscle torques that reflect human motion intention. The dynamics of human-robot hybrid system is expressed as a linear equation with respect to the undetermined dynamic parameters \( \phi \), written as follows

\[
Y(q,q'q'') = \tau_r + \tau_h
\]

where \( \tau_r \) is the vector of joint actuating torques generated by the robot; \( \tau_h \) is the vector of net muscle torques. Before the identification, lower limbs are carried by the robot to perform the movement of exciting trajectory, while the subject is required not to generate any active effort, so the \( \tau_h \) is set to zero. Then the least square estimation method is employed to identify the parameters \( \phi \), given by

\[
\hat{\phi} = \left( Y^T Y \right)^{-1} Y^T \tau_r
\]

Therefore, the net muscle torques can be obtained by

\[
\tau_h = Y(q,q'q'') \hat{\phi} - \tau_r
\]

sEMG samples are acquired from eight muscles, which are gluteus maximus (GM), iliopectoas (IL), rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), biceps femoris (BF), semitendinosus (SE) and gastrocnemius (GA). The raw sEMG samples were full-wave rectified and filtered first, and a fourth-order Butter-worth filter with cutoff at 2 Hz was selected for the envelope processing. The sEMG samples were sub-sampled to 50 Hz through a sliding window. Then the signals divided MVC of corresponding muscles for normalization.

Two BP neural networks are used to estimate the net muscle torques at hip and knee joints respectively. sEMG signals from five muscles (GM, IL, RF, BF and SE) were employed to estimate net muscle torque at hip joint. Similarly, sEMG signals from six muscles (RF, VL, VM, BF, SE and GA) were employed to estimate net muscle torque at knee joint. The number of neurons in the hidden layer was selected as \( 2n+1 \) (\( n \) is the length of input vector) on the basis of empirical law. The structure of hip model is shown in Fig. 1. The structure of knee model is similar to that shown on Fig. 1.

Fig. 2 shows one trial of net muscle torque estimation results. The blue solid line shows the identification torques and the red solid line represents the BP estimation torques. The root-mean-square error is 3.71 Nm for hip joint and 2.92 Nm for knee joint. It can be seen that the well-trained neural networks can estimate the subject’s active
motion intention in real time. The subject’s torques are time-varying because he exerts his effort randomly. This can prove that the following performance of neural networks is well.

We introduced the neural networks to the control system of a horizontal exoskeleton and position-based impedance control is used to transform the active effort to actual motion. Fig. 3 illustrates the real-time movement trajectory when the subject performs active training. The black solid line represents the desired motion path and the red solid line shows the actual motion trajectory.

\[
\sum_{i}^{\text{input layer}} W_{ij} \sum_{j}^{\text{hidden layer}} W_{jk} \sum_{k}^{\text{output layer}}
\]

Fig. 1  Fig. 2  Fig. 3

Predictive modelling on falls risk assessment for hospitalized older adults

Hamid GholamHosseini and Mirza Mansoor Baig

Abstract: Falls are among leading causes of unintentional injury-related deaths in older adults. Falls also may lead to critical injuries including long term disability and therefore contribute to longer hospital stays and huge hospital costs. The aim of this study was to develop a robust multifactorial model for falls risk assessment which incorporates real-time vital signs, motion data, falls history and muscle strength in a fuzzy logic based system. The model identifies the risk of falls in individuals during their daily living activities (ADLs). It was tested at a controlled-environment in hospital with 30 patients and the findings were compared with those of traditional fall risk monitoring and assessment systems such as the Morse fall scale. The simulated results show the proposed model achieved an accuracy of 100\% (forward fall), 90\% (backward fall), 85\% (left-side fall) and 95\% (right-side fall) among a total of 80 intentional falls and 40 ADLs. The ultimate aim of this study is to extend the application to elderly home care and monitoring.

Computer Vision and Image Processing For Diagnosis of Melanoma in Clinical Images

Hamid GholamHosseini and Peyman Sabouri

Abstract: Computer aided diagnosis of medical images can result in (better) detection and early diagnosis of many symptoms to assist physicians and therefore reducing the mortality rate. Realization of an efficient handheld device for semi-automatic diagnosis of melanoma would greatly enhance the practice of medical image classification scheme and make it useful in clinical contexts. In this work, an interactive object recognition methodology is adopted for border segmentation of clinical skin lesion images. Moreover, the performance of various supervised classifiers such as support vector machine (SVM), K-nearest neighbours (KNN), random forest, multi-layer perceptron, decision tree, Naïve Bayes, radial basis function (RBF) Network and fuzzy rule are investigated and compared with the proposed classifier. This study was performed by considering shape, colour and texture features of the skin images for discriminating melanoma from benign nevus. A cascade classification strategy was proposed to improve reliability as well as the accuracy of the system. The proposed system achieved sensitivity of 84.21\% and specificity of 98\% with overall accuracy of 92.40\% for better diagnosis.
A framework for monitoring backups and their properties for a vast number of heterogeneous systems in a business cloud computing environment

Anne Wendt, Krassie Petrova

Abstract: With the increasing popularity of cloud computing technologies, the expectations towards cloud providers increase not only in terms of functionality, cost, and service delivery speed, but also for the security of the customers’ data that is stored remotely. Cloud providers can be certified for their compliance with established industry standards for data security; however, there is minimal research published on how to design internal processes to achieve this goal. The objective of this thesis is to address this gap by providing a framework that can be used by cloud providers to create a process for monitoring customer data backups. The area of backup and restore is an important part of data security, as it ensures data integrity and availability. In order to address the research objective, the Design Science methodology is combined with the software development lifecycle so that a specific software-based instantiation of the framework can be designed, implemented and evaluated.

The first outcome of the research is a set of 36 requirements for the software tool that are collected by interviewing business experts who work for SAP, a cloud provider and the partner of this research. It was found that the most important aspect of monitoring backups is to create a flexible input option for adding new system types. An intermediate outcome of the research is a method of discovering interconnections between requirements by using post-it notes that are placed on a whiteboard so that they can be positioned in relation to each other by drawing arrows and lines between them. The second major outcome is the software tool that is developed based on the findings from the requirements and is assessed for utility by a sample of users. The aspect of flexibility is addressed by basing the data collection on a search query that can be configured according to the users’ specifications. By generalising the workings of the software tool, a framework is developed as the final outcome that is independent from the underlying technical base. It consists of four stages (system analysis, solution design and development, process operation, and communication) that should enable an implementing company to create a reliable backup monitoring process.

Event based microsleep detection using echo state networks with leaky integrator neurons

Sudhanshu Ayyagari, Richard Jones, Stephen Weddell

I. INTRODUCTION

Long-haul truck drivers, train drivers, and commercial airline pilots routinely experience monotonous and extended driving periods in a sedentary position, which has been associated with drowsiness, lapses in responsiveness, microsleeps that can result in a serious accident. A complete loss of attention, microsleeps even for a few seconds, while engaged in a critical task such as driving a vehicle or landing an aircraft can have consequences ranging from minor injuries to multiple fatalities. Microsleeps are brief involuntary events of lapses in attention or responsiveness, associated with events such as prolonged eye closure which usually last from 0.5–15 s [1]. The aim of this study was to identify reliable physiological cues indicative of lapses, related to microsleep episodes, from the EEG, which can in turn be used to develop a real-time microsleep detection (or better still, prediction) system. A novel approach using a cascaded, recurrent neural networks, specifically echo state networks (ESNs) with leaky integrator neuron architectures [2] have been used.

II. METHODS

ESNs are an innovative approach to the supervised training of a recurrent neural network (RNN). RNNs are mostly used for modelling dynamical systems because of their intrinsic memory states. ESNs usually incorporate sigmoidal activation functions as opposed to the leaky integrator model in which the temporal characteristics of a learning task can be exploited by using the individual state dynamics of the system [3]. This leaky neuron approach can be used to study and exploit the long-time dependencies in the transient signals and attain higher memory spans. ESNs with leaky neuron configurations contain additional ‘global control parameters’ [4], such as the spectral radius of the reservoir weight matrix and a leaking rate (leakage factor) that can be optimized particularly for low-frequency temporal dependencies. In this research, we compare the sigmoidal ESN and cascaded ESN based classifier with leaky integrator models to other traditional approaches, such as linear discriminant analysis.
(LDA) in detection of microsleeps in EEG data. As the LDA was used to form classifier models capable of detecting microsleeps in our previous work [5] it was considered as the baseline for comparison.

EEG, facial video, and tracking behavior were recorded from eight normal healthy male volunteers aged 18–36 years (mean = 26.5) while the subjects performed a visuomotor tracking task while the EEG was recorded from electrodes at 16 scalp locations and digitized at 256 Hz (bandwidth 0.1–100 Hz) [5]. Models based on EEG power spectral features, such as power in the traditional EEG bands and ratios between those bands, were developed to detect the change of brain state during the microsleeps. Each EEG channel was processed by rejecting epochs contaminated with substantial artefacts, followed by transforming the signal into z-scores relative to the baseline of the signal. Principal component analysis (PCA) was used to reduce the redundancy in the features extracted across all the EEG derivations. Linear discriminant analysis (LDA) and echo state networks with standard sigmoidal inputs and leaky integrator neurons were used to form individual classification models capable of detecting microsleeps using data from all the subjects.

III. RESULTS

Performance was estimated in terms of ability to detect microsleeps (in 1-s epochs). Our best performance was achieved using the classifier modules of the cascaded ESNs with leaky integrator neurons with a mean Phi correlation ($\phi$) of 0.40 ± 0.03 and an accuracy of 67.3%. In contrast, the classifier modules of the ESN with sigmoidal inputs and LDA resulted in a $\phi$ of 0.18 ± 0.04 and a $\phi$ of 0.23 ± 0.04, and accuracies of 48.5% and 53.6%, respectively.

IV. DISCUSSION & CONCLUSIONS

Results showed that the performance of the prototype microsleep detection system was modest. However, using the ESNs with leaky integrator neurons proved to be the most consistent approach yielding encouraging results and suggesting that the memory effect can indeed be exploited using this model. In addition, there is strong evidence indicating that combined classifier modules (ensemble classification) may lead to a better classification rates [4, 5]. Hence, further research is needed to develop classifier modules incorporating several sophisticated ensemble learning techniques which may lead to a state-of-the-art microsleep detection system capable of detecting and/or predicting microsleeps.

REFERENCES


