WESTERN SYDNEY
UNIVERSITY

Computer, Data and Mathematical Sciences

SUITABLE FOR MASTER OF RESEARCH

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Voice-Controlled Clinical Coding

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Research area: Health Informatics

The use of voice assistant devices such as Siri, Alexa, Google Assistant, and Samsung Bixby in the healthcare industry is gaining significant attention. Many healthcare professionals believe that clinically-oriented voice assistant devices will ease the burden of accessing patient information, maintaining documents, and improve the patient experience. This project is aimed at investigating the implementation and validation of a practical voice-controlled clinical coding system, that can assist clinical coders by suggesting most appropriate ICD-10-AM and ACHI codes for a given clinical description through voice commands.

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SUITABLE FOR MASTER OF RESEARCH / PHD

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Internet of Things and Smart Environments: Technologies for Health, Disability, Dementia, and Aging Well

Dr Seyed Shahrestani: s.shahrestani@westernsydney.edu.au

Research area: Internet of Things, Healthcare, Aged care

Internet of Things (IoT), smart homes, buildings, cities, and other environments can vastly enrich human experiences. Our experiences and quality of life are heavily dependent on our senses and our cognitive abilities. Unfortunately, both can be subject to impairments.

The available data indicates that sight and hearing impairments are the two most commonly encountered ones. WHO estimates that worldwide 285 million people are visually impaired. It puts the number of individuals with a disabling hearing loss at 360 million, or around 5% of the world's population. Cognitive abilities vary widely among people. While some cognitive abilities deterioration naturally occurs with aging, some conditions may have more effects on them. Dementia is an example of such conditions.

WHO studies indicate that more than 75 million people are estimated to be living with dementia by 2030.

Technology can play a significant role in improving the quality of life and independent living of the affected people. There are already many devices and technologies that can assist physically or mentally challenged people. However, there is still much room for their improvements. With their potentially ubiquitous nature and immense growths, IoT and smart environments can play leading roles in these improvements. Digital senses, supplied through the permeating nature of the IoT and deployment of smart environments, can be of significant benefit to improving the quality of life for a person living with a sensory or cognitive impairment. The project needs to investigate holistic and translational approaches to enhance the independence and integration of the affected people while supporting their caregivers.

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Cybersecurity of Big Data and Massively Interconnected Systems

Dr Seyed Shahrestani: s.shahrestani@westernsydney.edu.au

Research area: Big Data, Blockchain, Cybersecurity, IoT, Machine Learning, Network Security

The Internet of Things (IoT) is drastically altering the ways businesses and organisations operate and how individuals interact with the world. The utilisation of such massively interconnected systems will result in a considerable surge of data. It is estimated that the IoT-generated data is rising at twice the rate of computer-generated and social-networking data. To remain competitive, organisations must expand their data capabilities in incorporating, automation, and analysis.

The enterprises are beginning to take advantage of the opportunities that the IoT offers by implanting smart sensors and actuators into their goods and services. This is drastically shifting the way businesses function and how people engage with the physical world. The complemented massive surge of data, treated by analytics, while innovative and even revolutionary, brings on many challenging problems. Notably, they can expose organisations to higher security and privacy risks.

Poorly secured IoT devices can be targeted, causing them to a malfunction or be used for cyberattacks on other systems. The IoT and many of its objects are built around machine-to-machine communications and processes that automatically operate without human involvement and awareness. Things can expose user data and information and may have no exact way or protocol to warn the user when security or privacy issues arise. As such, 'things' can cause serious privacy concerns for their users. This project aims to address some of these issues by utilising modern approaches, such as Blockchain and deep Machine Learning. It should provide novel cybersecurity solutions for massively interconnected systems and improve their reliability while generating or handling Big Data.

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Smart Traffic Control for the Era of Autonomous Driving

Associate Professor Dongmo Zhang: d.zhang@westernsydney.edu.au

Supported by: Dr Dave de Jonge

Research area: Artificial intelligence, Multi-agent systems, Game theory, Autonomous vehicles

Over the last decade, research on autonomous vehicles (AVs) has made revolutionary progress, which brings us hope of safer, more convenient and efficient means of transportation. An autonomous vehicle system is an integration of many technologies, including computer vision, graphical processing, navigation, sensor technologies and so on. Most significantly, the recent advance of machine learning technologies enables a self-driving car to learn to drive in any complex road situations with millions of accumulated driving hours, which are way higher than any experienced human driver can reach. However, it becomes a new challenge for road network management once we allow autonomous vehicles to travel mixed with human driving vehicles. The goal of this project is to investigate theoretical models of road network with mixed traffic and new AI technologies for effective and efficient traffic management.

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Designing Robust Network Topologies Against Cyberattacks by Leveraging Complex Networks Theory

Dr Weisheng Si: w.si@westernsydney.edu.au

Research area: Complex networks, Network robustness

Among all the targets of cyberattacks, the infrastructure networks (e.g., the Internet backbone, power grids, etc.) are the most prominent ones. This is because the infrastructure networks attract hackers in the following ways: (1) they were typically not deployed with security as a major concern initially; (2) they are critical for our society, so the impact of getting them hacked is huge.

With the high complexity of infrastructure networks today, the network topologies are increasingly studied using the Complex Networks theory, which is an inter-disciplinary field spanning Graph Theory, Computer Networks and Big Data Analytics. This project specifically plans to leverage the Complex Networks theory to fulfil the following three aims toward network robustness:

1. Developing new metrics that are accurate in measuring network robustness as well as efficient in computation.

2. Designing new algorithms for creating robust network topologies against cyberattacks under various budget constraints.

3. Developing high-quality software that implements our new metrics and algorithms, and contributing it as open source software to the public domain.

Students are expected to be proficient in Graph Theory, algorithms, and Python programming.

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Enhancing Answer Set Programming with Deep Learning

Professor Yan Zhang: yan.zhang@westernsydney.edu.au

Supported by: Dr Vernon Asuncion and Associate Professor Yun Bai

Research area: Artificial intelligence, Knowledge representation and reasoning, Machine learning, Neural networks

Learning and reasoning are two most important features of Artificial Intelligence (AI). In recent years, research on both machine learning and knowledge representation and reasoning has made significant progress in both theories and applications. In particular, deep learning has become one of the predominant machine learning approaches and has applied in many real-world domains, while knowledge representation and reasoning has developed expressive and efficient systems for various problem solving tasks.

This project aims to develop a formal foundation and a practical system to integrate learning and reasoning for complex problem solving. In particular, by enhancing the Answer Set Programming (ASP) - the main programming language for knowledge representation and reasoning, with probabilistic extensions, we will be able to perform dataset training in deep neural network learning with ASP-based reasoning capability.

The project contains three main research components: extending ASP with probabilities over atoms, which are treated as training outputs from neural networks; developing a practical solver for this extended ASP; and undertaking extensive experiments for various learning and reasoning tasks.

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Intelligent Photography Curation Using Deep Learning

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Supported by: Dr Vernon Asuncion

Research area: Artificial intelligence, Deep learning, Image recognition, Computational photography, Neural networks

As one of the most predominant machine learning approaches, Deep Learning has been widely applied in various complex image classification and recognition tasks. One such task is to automatically curate photographs taken by human, based on Human's

aesthetic criteria. However, the main challenge for doing this is how to develop a system which can learn such aesthetic criteria. In recent years, some research works have been done in this area, but they generally have major limitations in one way or another.

The aim of this project is to develop an advanced photograph curation system, by using the deep learning approach. By formalizing critical aesthetics in photography, using precise and declarative logic and mathematic formulas, the system will employ a designated deep neural network to learn such aesthetic criteria, such as colours, lighting, compositions and creativity, from many large photography datasets. It is expected that resulting system will perform serious photo curation tasks at the level of professional art curators.

We need to highlight that Professor Yan Zhang is not only an international leading AI researcher, but also a renowned landscape photographer with an international reputation. This is an ideal research project bringing AI and Art together.

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Challenges in the Transition from Cloud to Edge Computing

Dr Rodrigo N. Calheiros: r.calheiros@westernsydney.edu.au

Supported by: Associate Professor Bahman Javadi

Research area: Cloud computing

Cloud computing has been around for nearly 10 years. During this time, different advances in unrelated areas changed considerably the landscape of cloud computing. For example, Internet of Things (IoT) is now a reality, and thousands of sensors are generating huge amount of data that need to be stored and processed somewhere. More important, the analysis of this data needs to be processed quickly so the information can be actioned, and for that, the latency in connecting to usually distant cloud data centres causes unacceptable delays in the processing. Even when latency is not an issue, the volume of data (for example, streaming from different cameras) make the cost of data transfer to cloud data centres prohibitive. In summary, the model of centralized data centres seems to be reaching its limits in terms of adequacy for emerging applications.

Edge computing is emerging as a solution: in this model, part of the data is processed closer to the user, reducing the amount if data and computation that goes to the cloud. Besides reducing latency and costs of using clouds, this model offers extra advantages in terms of data privacy (as data can be kept on the edge rather than on the cloud).

This project will investigate solutions for challenges observed in this emerging model, including:

- How to reduce the high complexity of using edge platforms, so end users can benefit from it?

- How to enable integration of different IoT sensors and edge devices?
- How to port existing applications to this new model?
- How to integrate emerging computation models, such as serverless computing, to the edge?

You will be developing new algorithms and system architectures to address the above challenges.

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SUITABLE FOR PHD

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Logical Foundation and Implementation of Strategic Reasoning

Associate Professor Dongmo Zhang: d.zhang@westernsydney.edu.au

Supported by: Professor Laurent Perrussel

Research area: Computer science, Artificial intelligence, Multiagent systems, Logic, Knowledge representation and reasoning

The intelligent agent technology has been used in many sophisticated computer systems and robotics. The biggest challenge to develop an intelligent agent system is how to enable the system to make decisions strategically in response to dynamic and competitive environment. This project is to take the challenge by developing a logical foundation for strategic reasoning and implementation technologies for building smart software agents that are capable of generating, combining, comparing strategies, and applying the strategies in game playing and economic activities. The outcomes of this project can be directly used in business intelligence and game industry. The new theory will enhance our understanding of general intelligence of human beings.

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Efficient Non-negative Sparse Models for Large Scale Spectral Data

Associate Professor Yi Guo: y.guo@westernsydney.edu.au

Research area: Computational statistics

Developing a fully parallelisable algorithm for non-negative sparse models so that it can be applied to large scale spectral data such as remote sensing data. It is primarily parameters free although it is based on sparse regularisation and sparse regression. Also, it is able to utilise spatial and temporal correlation among observations for automatic and robust model selection. The method is expected to be used in remote sensing unmixing (image processing), blind source separation (signal processing), and other machine learning-related areas.