MONASH University

MONASH IT GRADUATE RESEARCH PhD POSTERS

A selection from Innovation Showcases

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INTRODUCTION

The posters in this book illustrate the wide span of research able to be supported and undertaken by our faculty's PhD students we trust you will find them of interest.

Monash is a research-intensive university. Our research focuses on meeting the needs of industry and society today and tomorrow. The Faculty of Information Technology's core values and principles are to positively contribute to society through interdisciplinary research and education, using innovative IT as a vehicle for social good. Thus our research focuses on meeting the needs of industry and society today and tomorrow and addressing the key global challenges of the 21st century.

The Faculty has a strong reputation for excellence in research covering the spectrum of information technology from computer science through to business information systems and social science. Our research strengths are Data Science, Computer Human Interaction and Creativity, Cybersecurity and Systems, Organisational and Social Informatics, and Digital Health. Our PhD research students are finding ways IT can better support and promote health and medicine, productivity and innovation, and social inclusion.

Each year we hold a prestigious event for invited guests at which we showcase the most innovative research being undertaken by our Faculty's academic researchers and research students.
These Innovation Showcases offer our PhD students a unique opportunity to present their research to our guests from industry, government agencies, other researchers and the wider community. The Showcases attract CEOs and CIOs and also provide opportunities for our students to directly engage with these industry leaders. As a result of the connections made students have secured interviews, internships and collaborative research projects. The intention of the posters is to present their research in a manner that is accessible to a 'non-academic' audience, in this way these poster do differ from those presented at academic conferences. The research posters in this book are a selection of those presented by our PhD students at the Showcases.

You can learn more about our Faculty's research and see some of our PhD students in action in these youtube videos Innovation showcase 2016 and Innovation showcase 2015

If you wish to make contact with any of the researchers please email
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For more information about our Faculty please see monash.edu/it

Points of Interest Search on Road Networks: A Journey in Experimentation and Implementation

Tenindra Abeywickrama, Muhammad Aamir Cheema, David Taniar

Monash University, Australia

Start Here!

Real-world points of interest (POI) search retrieves the nearest POI by a "straight-line" (e.g. TripAdvisor). What if we use road network distance?

- Referred to as the k-Nearest Neighbor (kNN) query, defined as:
  Retrieve k closest POIs ("k nearest neighbors") by their shortest path via the road network
- Can lead to more accurate points of interest results (see Example left)
- Also supports other important metrics (e.g. travel time)
- But query time is high – not feasible in practice

Key Points:

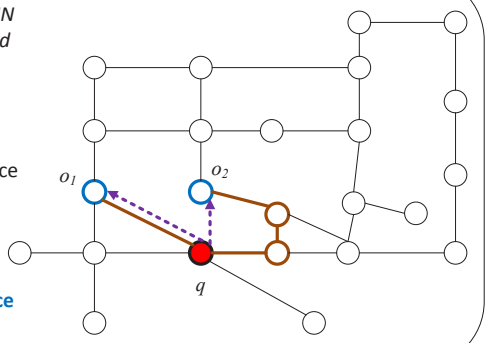
- A thorough fair experimental comparison of existing techniques has never been conducted – do we know the full picture?
- Our experiment investigation suggests a re-think is necessary!

Example

kNN Query: Find 1NN from q where o_2 and o_1 are gas stations

By Euclidean Distance (**Purple**): 1NN is o_2

By Network Distance (Brown): 1NN is o_1

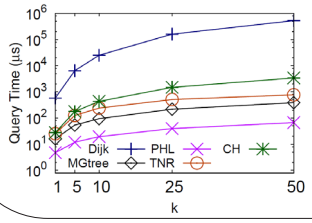


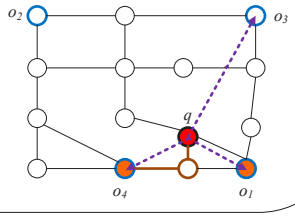
Improving a Neglected Competitor

Incremental Euclidean Restriction (IER) Algorithm

- We found that not all techniques have been fairly evaluated
- IER was among the first techniques to solve the kNN problem
- Uses a simple Euclidean distance heuristic to retrieve "candidates"
- Always worst performing method – long ignored by the community

We improved IER such that it is several orders of magnitude faster than originally thought – need to revaluate against state-of-the-art!

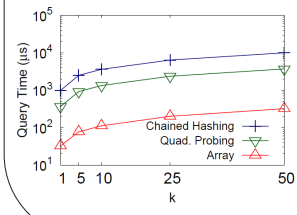




Implementation in Practice

A bad practical implementation of a good algorithm can drastically effect its relative performance[1]

- Cognizant of this we implemented techniques as efficiently as possible for a fair comparison and with best possible query times
- In our journey we found even simple choices can drastically effect experimental performance
- E.g. one algorithm can be implemented using a hash-table or more carefully with an array – but the latter is 30x faster!
  - We show that this was due to better utilisation of CPU cache (which is 20-200x faster than memory)

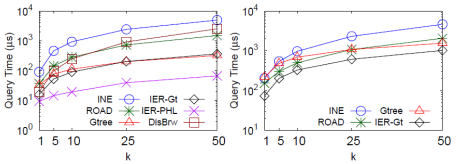


Using illustrative case studies, we compiled a set of guidelines to help developers better implement algorithms to avoid typical pitfalls (applicable to any problem, not just kNN!)

Surprising Experimental Insights

Surprising Performance of Simple Heuristic

- IER-based methods are unexpectedly the overall best performing methods over many different settings and datasets in practice

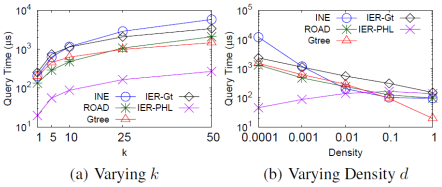


(a) NW Dataset (b) US Dataset

- Suggests **simple Euclidean heuristic is superior** – shows need for improvement and possible direction for heuristics

Travel Time Road Networks

- Past experimental studies have solely focussed on travel distance road networks – we extend experiments for travel time



(a) Varying k (b) Varying Density d

- Expected IER to perform poorly as Euclidean distance is a looser bound for travel time
- True in some cases – but **IER is still best in most cases even for travel times**!

Summary

- A method (IER) using a simple heuristic outperforms all techniques in practice
- Suggest current kNN techniques are not as fast as they can be – re-think required
- Implementing algorithms is challenging even for simple cases – we provide guidelines to assist developers in practice
- Code online for re-use or reproducing results: https://github.com/tenindra/RN-kNN-Exp
- A publication based on this work appeared at the VLDB 2016 conference

References

1. D. Sidlauskas and C. S. Jensen. Spatial joins in main memory: Implementation matters! PVLDB, 8(1):97–100, 2014.

SAVE THE INDONESIAN FOREST :
A KNOWLEDGE-BASED FIRE PREDICTION SYSTEM

MONASH University
Information Technology

Ariesta Lestari, PhD Candidate of IT Faculty, Caulfield Campus, Monash University.
Supervisors : Dr. Grace Rumantir, Prof. Nigel Tapper

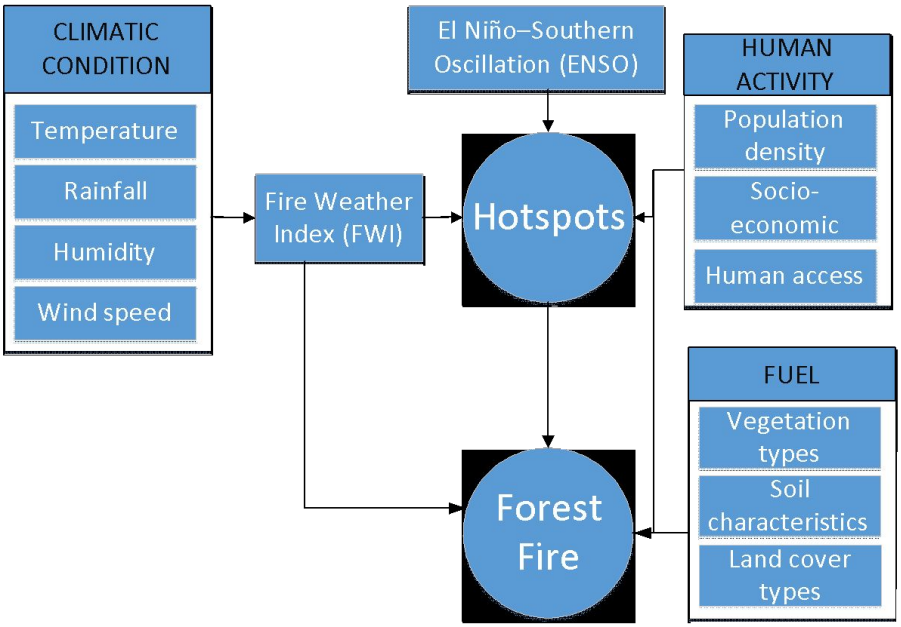
What problems are caused by forest fire in Indonesia:

- Deforestation : 2.6 million hectares of land burned. It is equal with an area two and half times size of Melbourne.
- Pollutant Standard Index 300 times above the norm.
- 500,000 cases of acute respiratory infection and 19 deaths.
- Estimated economic losses and damages of IDR 221 trillion (US$17 billion)

What is needed to prevent the problem of forest fire?

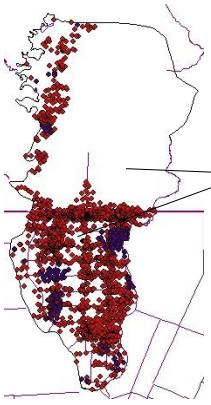
- **A comprehensive understanding on fire behaviour.**
- **A way to predict hotspot escalation to forest fire**
- **A fire escalation prediction model using knowledge-based approach.**

Current Framework for Predicting Hotspot Escalation into Forest Fire



Limitations of the current framework:

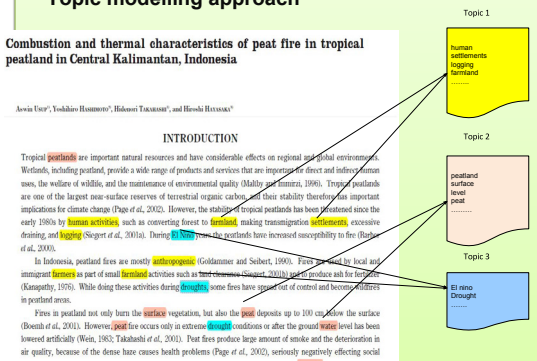
- Lack of accurate information on multiple factors, e.g climatic condition, human activity, fuel.
- **Only 5% of burned areas are currently investigated**



- Therefore, a knowledge based approach is proposed to refine the framework

Our Framework for Predicting Hotspot Escalation into Forest Fire Using Knowledge-based Approach

Topic modelling approach


Combustion and thermal characteristics of peat fire in tropical peatland in Central Kalimantan, Indonesia

INTRODUCTION

Tropical peatlands are important natural resources and have considerable effects on regional and global environments. Wetlands, including peatland, provide a wide range of products and services that are important for direct and indirect human uses, the welfare of wildlife, and the maintenance of environmental quality (Maltby and Immirzi, 1996). Tropical peatlands are one of the largest near-surface reserves of terrestrial organic carbon, and their stability therefore has important implications for climate change (Page *et al.*, 2002). However, the stability of tropical peatlands has been threatened since the early 1980s by human activities, such as converting forest to farmland, making transmigration settlements, excessive draining, and logging (Siegert *et al.*, 2001a). During El Niño years, the peatlands have increased susceptibility to fire (Rieley *et al.*, 2000).

In Indonesia, peatland fires are mostly anthropogenic (Goldammer and Seibert, 1990). Fires are used by local and immigrant farmers as part of small farmland activities such as land clearance (Siegert, 2001b) and to produce ash for fertilizer (Kanapathy, 1976). While doing these activities during droughts, some fires have spread out of control and become wildfires in peatland areas.

Fires in peatland not only burn the surface vegetation, but also the peat deposits up to 100 cm below the surface (Boehm *et al.*, 2001). However, peat fire occurs only in extreme drought conditions or after the ground water level has been lowered artificially (Wein, 1983; Takahashi *et al.*, 2001). Peat fires produce large amount of smoke and the deterioration in air quality, because of the dense haze causes health problems (Page *et al.*, 2002), seriously negatively effecting social

Expected result: factors contributing to forest fire in Central Kalimantan

Fire expert knowledge

Expected result: relationship of each factors

- ❑ Knowledge:
  - documents, reports, articles and form of narratives
  - human expertise and local community knowledge.
- ❑ Topic modelling:
  - a powerful technique in discovering patterns of word use and connecting documents that exhibit similar pattern
  - the words resulted from this topic modelling process will be used as the contributing factor in forest fire.
- ❑ Survey:
  - Elicit fire expert knowledge to figure out the relationship or each fire factors.
- ❑ Result : A refined framework of hotspot escalation to forest fire.

Future Work : To turn the refined framework into an operational fire escalation prediction model

References:

Indonesia Economic Quarterly, The World Bank Report, December 2015
Applegate, G., Smith, R., Fox, J. J., Mitchell, A., Packham, D., Tapper, N., & Baines, G. (2002). Forest fires in Indonesia: impacts and solutions. *Which way forward*, 293-308.
Dubois, D., Hájek, P., & Prade, H. (2000). Knowledge-driven versus data-driven logics. *Journal of logic, Language and information*, *9*(1), 65-89.
Blei, D. M., & Lafferty, J. D. (2009). Topic models. *Text mining: classification, clustering, and applications*, *10*(71), 34.

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Improving Data Analysis through a Psychological Theory

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Psychological theory

Data analysis requires similarity calculations to find similar instances in various tasks. Existing data analysis methods calculate similarity between two instances only focusing on their features. Since 1970's, research in **psychology** has pointed out that this kind of similarity calculation does not possess the key property of dissimilarity as judged by humans. They claim that **when two instances are similar, they should consider their neighbourhood situation**.

For example, two Caucasians will be judged as less similar when compared in Europe (where there are many Caucasians) than in Asia (where there are few Caucasians and many Asians).

Our contribution

We introduce a generic **data dependent similarity measure** based on this psychological theory, such that two instances in a dense region are less similar to each other than two instances of the same interpoint distance in a sparse region.

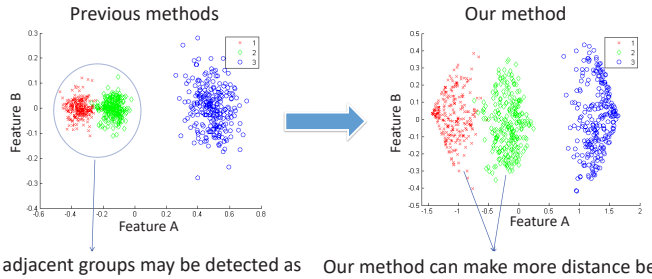
Our new measure will enable existing data analysis methods to gain advantage as it:

1. **Can detect more potential patterns and groups**
2. **Can be more sensitive to unusual and abnormal cases**
3. **Can make a better and more accurate prediction**

Advantages for data analysis

Detecting patterns

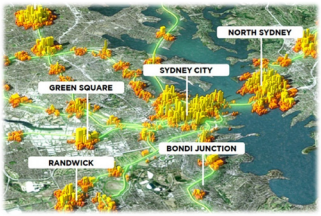
Our similarity measure enables data analysis methods to detect meaningful patterns automatically based on a human view. Algorithms can **easily find more local potential patterns and groups**, thus, we can observe more details for decision making. This can benefit data analysis areas such as market segmentation, topic summarisation, and rule discovery.



The two adjacent groups may be detected as one group by existing data analysis methods.

Our method can make more distance between local groups and detection easier.

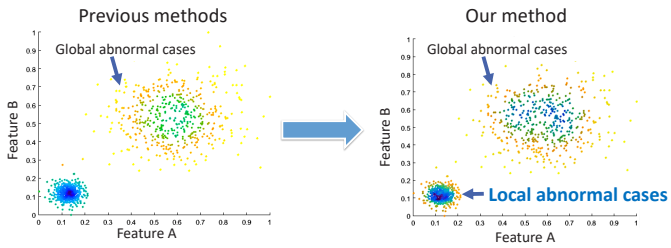
For example, this new measure can improve planning for transportation hubs due to considering more potential commercial areas.



(Image: Urban Taskforce, 2015)

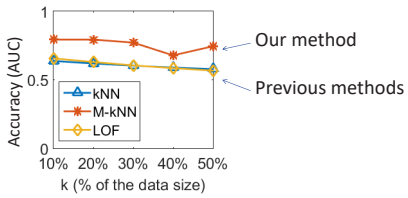
Identifying abnormal cases

Our similarity measure enables data analysis methods to be **more sensitive to abnormal and unusual cases**. This can benefit data analysis areas such as medical disease diagnosis, unusual events detection, and fraud detection.



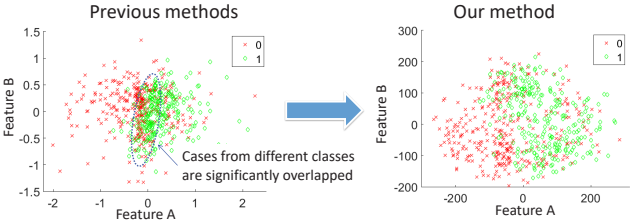
Light colour points indicate the abnormal cases identified. Previous methods usually only find global abnormal cases, which have low probability of occurrence, while our method can detect local abnormal cases based on their neighbourhood situation.

For example, we test our method to determine whether a patient is hypothyroid, based on 29 medical features. Our method outperforms existing state-of-the-art methods with different parameter settings in terms of accuracy.



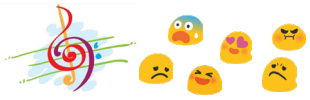
Making prediction

Our similarity measure enables data analysis methods to **make a better and more accurate prediction** based on historic information. This can benefit data analysis areas such as customer target marketing, weather forecast, and asset management.



The border between two neighboring regions of different classes is more clear with our method. Thus when predicting the class for a new case, it is easier to refer similar cases in historic data.

The two figures represent data visulisation on a dataset used to predict emotion in music. This data contains 72 music features for 593 songs categorised into one or more out of six classes of emotions. We found that our method can improve 30% accuracy of prediction than previous methods. This is because our new measure can make cases from different classes more distinct.



Publications based on this project:
Y. Zhu, K. M. Ting, M. J. Carman, Density-ratio based clustering for discovering clusters with varying densities, Pattern Recognition 60 (2016) 983-997. **(Rank A* Journal)**
K. M. Ting, Y. Zhu, M. Carman, Y. Zhu, Z.-H. Zhou, Overcoming key weaknesses of distance-based neighbourhood methods using a data dependent dissimilarity measure, in: Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, KDD '16, ACM, New York, NY, USA, 2016, pp. 1205-1214. **(Rank A* conference)**

MONASH University Federation University Australia

Optimal Decisions in an Uncertain Future

David Hemmi
Supervisors: Guido Tack, Mark Wallace
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CSIRO
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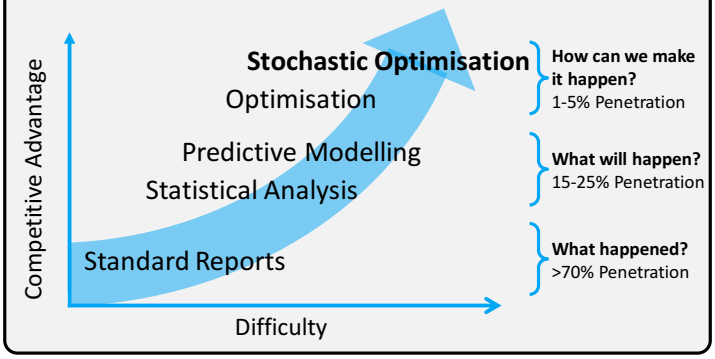
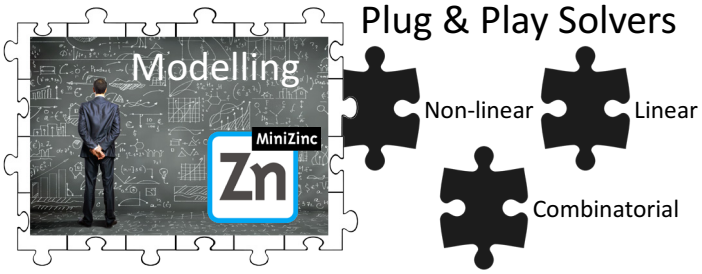
What are we doing?

Supporting Decision-Making:

- We are building a software package to support decision making for business processes and structured problems using mathematical modelling.
- Mathematical modelling of decision problems enables sophisticated analytics and automated decision-making.
- Stochastic optimisation describes the process of finding the best possible decision with respect to an uncertain future.
- We simplify mathematical modelling to enable non-experts to utilise the power of stochastic optimisation for decision-making.

The 3 types of Data Analytics





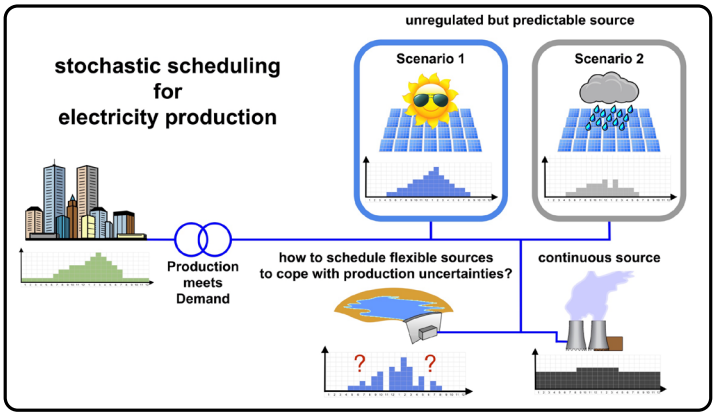
How are we doing it?

Modelling a Decision Problem:

- The software package MiniZinc allows mathematical models to be written simply.
- Non-experts are able to learn the modelling concept quickly.
- A library captures common sub-problems to simplify the modelling even further.

Making the Optimal Decision:

- Every solution to the model represents a decision. Solutions are ranked by quality and the best one is chosen.
- To obtain solutions a Solver that works independently of the modelling, in a plug and play fashion, is employed.
- Different Solvers that specialises in solving certain problem classes, e.g. linear or non-linear models are available.



Why are we doing it?

Small Change, Big Impact:

- Certain decision classes behave nicely; a small change in the input data yields to a small change in the output.
  - A linear correlation between sales and profit.
- Combinatorial problems behave erratic; small changes in the input may fundamentally change the output.
  - Consider a bus with a capacity of 50; whether 50 or 51 people travel makes a big difference.

Considering Uncertainty:

- Predictions, such as weather conditions, economic growth or customer behaviour, are always subject to uncertainty.
- A decision with respect to uncertainty is more resilient.

Applications with Uncertainty:

- Sports Scheduling
- Crew scheduling
- Supply Chains
- Project planning
- Network Layout
- Software integration testing
- Layout design
- Warehouse location

- Data Science
- Robotics
- Entrepreneurship
- Hiking
- Team sports
- Skiing

PhD outcomes:

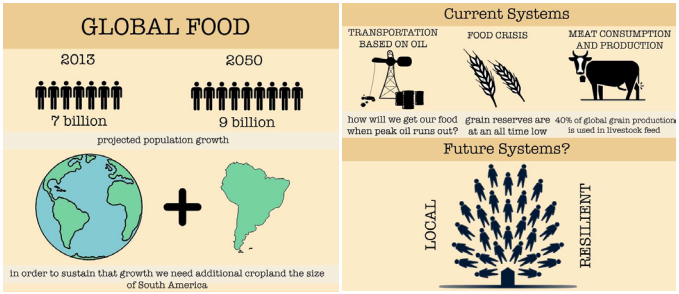
- I am developing a Solver (Algorithm) that specialises in finding decisions for combinatorial problems subject to uncertainty
- Current software packages are either complicated to use or they work only for a specific subset of model classes.
- My research enables the use of Stochastic Optimisation in Industry as I remove the barrier of having to write a specialised algorithm each time a new model is written.

Growing Food in the City: Using Social Media to Promote Pro-Environmental Behaviour

Danny Ardianto (danny.ardianto@monash.edu)
Supervisors: Prof Frada Burstein, Dr Jeremy Aarons, Dr Kerry Tanner

Growing Food in the City

Globally, food security has been a growing concern due to increased number of populations. We need to produce more foods that meet the need of the populations.



Growing food in the city has been considered as one of many sustainable ways to revive food security. Its benefits include:

- Regaining productive use of land in urban spaces
- Reducing 'food miles'
- Providing cheap and accessible foods to more people.

Using Social Media for Social Change

With the growing number of social media users, ***how can we use social media to promote growing food in the city?***

A study is being conducted with Indonesia Berkebun, a large urban agriculture community in Indonesia, which has used social media extensively to promote *food growing in the city as a response to food security*. We examine their communication practices that are transferable to promoting pro-environmental behaviour in general.

Samples of Twitter posts

"@BekasiBerkebun: we can reuse scrap bottles to plant crops in a vertical system.."

"@User150: Greetings @IDBerkebun, allow me to follow you. Feels good to see how "simple" farming is" Our pleasure :D

Founded in 2010, the community's Twitter account has seen an increase of 72% in number of followers from last year's figure.

Patterns of Social Media Use

In addition to being used as platforms for information sharing, Twitter & Facebook were used to diffuse *aesthetic, symbolic, and cultural meanings of urban farming* to the public.

Communication patterns within the community

Fashion Thinking for Persuasion

Fashion is an expression of taste and beliefs that is characterised by aesthetic, symbolic, and cultural meanings (Pan et al. 2012)

- Through the use of social media, growing food in the city is perceived as fun, new, and positive for the environment.
- There was *a deliberate fashion-making process* to make more people adopt this behaviour. This includes (i) involvement of fashion actors (e.g. traditional media, advertisers, consumers), (ii) propagation of content through Twitter celebs, and (iii) expression of values in urban farming through social media contents.
- People reported having a *technocultural* experience from using social media while growing food in the city (e.g. the joy feeling from sharing images of harvesting crops on social media)

"Urban farming: the new urban lifestyle" - the projected meaning of urban farming within the community

Example of deliberate fashion-making process

Conclusion and Implications

- Through the use of social media, the values of urban farming were transformed into new and fun experiences that attracted people (mostly youth) to adopt the practice of growing food in the city.
- Social media and fashion thinking as a strategy along with the championing role of relevant communities can be utilised to promote similar kinds of pro-environmental behaviour (e.g., littering prevention, energy saving).

References

1. Pan, Y., Roedl, D., Thomas, J. C., & Blevis, E. (2012). *Re-conceptualizing fashion in sustainable HCI*. Proceedings of the ACM Designing Interactive Systems (DIS) Conference, Newcastle Upon Tyne, UK.
2. Hearn, G., Collie, N., Lyle, P., Choi, J. H.-J., & Foth, M. (2014). Using communicative ecology theory to scope the emerging role of social media in the evolution of urban food systems. *Futures, 62, Part B*(0), 202-212.

MONASH University

Making Better Decisions Collectively

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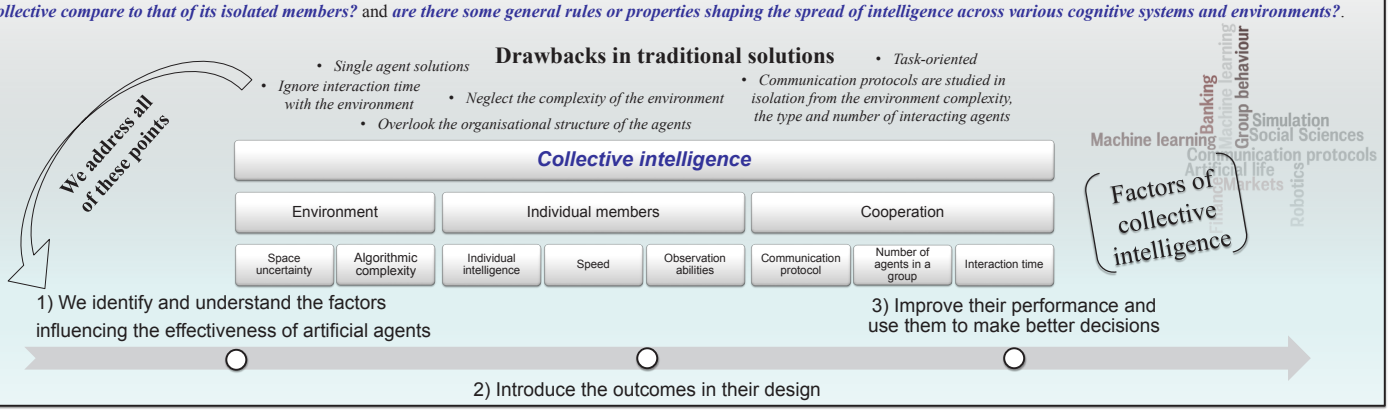
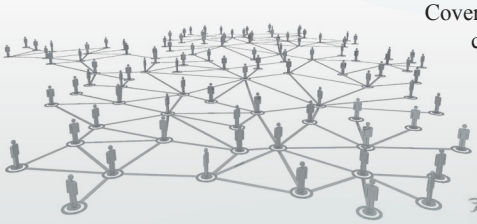
MONASH University
Information Technology

The promise of collective intelligence

The dynamics and characteristics behind intelligent cognitive systems lie at the heart of understanding and devising successful solutions to a variety of problems. In my research I develop the idea of collective intelligence by giving insight into a range of factors influencing the effectiveness of interactive cognitive systems. I answer questions like ***how does the effectiveness of a collective compare to that of its isolated members?*** and ***are there some general rules or properties shaping the spread of intelligence across various cognitive systems and environments?***.



Fields of application



Robotics:
Coverage of spatial environments, coordination, leadership

Financial sector:
Forecasting market behaviour, learning patterns from historical data

Social intelligence:
Small world networks, social media, group diversity

Predictive Analytics:
Predicting the accuracy of artificial agents over cognitive tasks of varying complexities

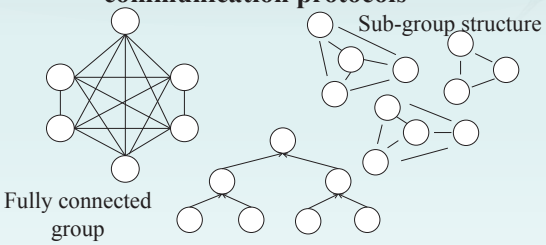
Modelling swarm and animal behaviour:
Predator prey scenarios, foraging for food and shelter

Collective Intelligence

Simulation:
Coalition formation, probing a spatial landscape

We combine our results from mathematical predictive models, machine intelligence tests, and agent-based simulations to build intelligent artificial collectives

Group organisational structures & communication protocols

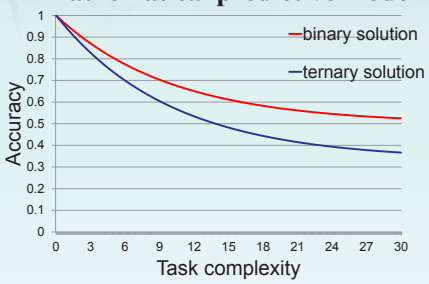


IQ tests

Complete the sequences

K_9 : y,y,x,w,w,v,…
K_{12}: a,a,z,c,e,x,…
K_{14}: c,a,b,d,c,c,e,c,d,…

Mathematical predictive model



Artificial agent behaviours we evaluated over intelligence tests

- Reinforcement learning:
  Machine learning techniques used to find an optimal action-selection policy for any given decision process (e.g., Q-learning and SARSA agents).
- Local search:
  Heuristic method for solving computationally hard optimisation problems.
- Random (action) agent used as a lower bound on performance.
- Oracle (or super-solver) agent used as an upper bound on performance.

Experimental outcomes

- Demonstrated that relying on an expert (super-solver) agent in the group does not guarantee its optimal performance.
- Modelled the effect (on performance) of introducing more agents into the group.
- Showed how the difficulty of the environment (uncertainty and complexity) is a major factor controlling the capacity for intelligence.
- Measured the effectiveness of (the same selection of) agents adopting different organisational and network structures.
- Designed a mathematical model to predict the accuracy of artificial agents over different task complexities and problem settings.
- Provided evidence of the wisdom of the crowd phenomenon in artificial systems.

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Accessible Floorplans for Visually Impaired

Automated Accessible Graphic Generation based on Online Floorplans

Anuradha Madugalla - Faculty of Information Technology, Monash University
Supervised By - Prof. Kim Marriott, A/Prof. Simone Marinai and Prof. Fatih Porikli

Why have Accessible Floorplans?

Independently navigating inside unfamiliar buildings is extremely difficult for a person who is visually impaired. However accessing and exploring a floorplan beforehand (Mobility Training) could build confidence.

Today, most floorplans are freely available on the web, but visually impaired users have problems in accessing them.
e.g: Screen readers only read out the text web developers have included, such as “A Floorplan Image”

Expert transcribers can manually transcribe these floorplans, but it is time consuming and expensive.

Research Goal : To Develop an Automated Tool that can Understand Online Floorplans like a Human and Generate Accessible Versions for the Visually Impaired On-Demand

How to generate Accessible Floorplans

Input - Online Floorplans

Online floorplans can be of various formats. These can be categorised under two major types.
- Raster: Pixel based images
  Eg: .png .jpg
- Vector: Mathemical cordinate based images
  Eg: .svg .eps

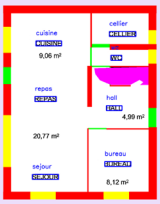
The main challenge in trainscribing online floorplans is the diverse range of:
- Symbols
- Languages
- Image Quality

Solution - Automatic Transcription Process

Text and Wall Identification

Text Identification
- Tesseract Optical Char. Recognition(OCR)
- Floorplan Vocabulary Dictionary
  English, French, Italian

Walls, Doors, Windows Identification
- Connected Component Theory



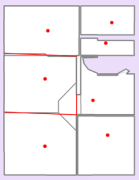
Room Identification

Identify room contours based on walls and text positions. Two types of rooms are identified in this step.
- **Single use rooms**: Rooms containing a single text label
- **Multi use/openplan rooms**: Areas with many text labels. Visually imapired users need to know about possible boundaries for these areas.

Openplan Partitioning

Generate a Heuristic ranking function to partition openplans. Then find a set of virtual lines by
- Extending wall edges
- Generating voronoi lines (partitioning lines that are generated based on text label locations)
- Improving voronoi lines

Select the best line by examining weights assigned based on their performance

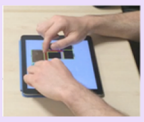


Generate Accessible Floorplan

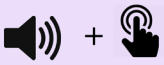
Generate textual outputs for all identified components (rooms, text, doors, windows,furniture)

Process text files later to generate SVG or PNG accessible graphics, as required by the presentation medium

Presentation- Accessible Floorplan



iPad App: GraVVITAS



Tactile Maps

3D Floorplans

Impact of Accessible Floorplans

The automated tool will transcribe online floorplans on-demand for a low cost and will allow the visually imapired to explore building layouts before visiting. **256 million visually impaired worldwide** will therefore be able to navigate with confidence and independence once inside unfamliar buildings.

Indoor Navigation

Preparation for the visit: Mobility Training

Confident navigations inside buildings

Applicable for different types of floorplans
- House plans
- Public space plans: Shopping Complexes, Train Stations

Purchase Desicions

Visually impaired users can explore a large number of online floorplans before making purchase decisons

For real estate agents, a niche market consisting of visually impaired users will open up

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DATA 61 | CSIRO

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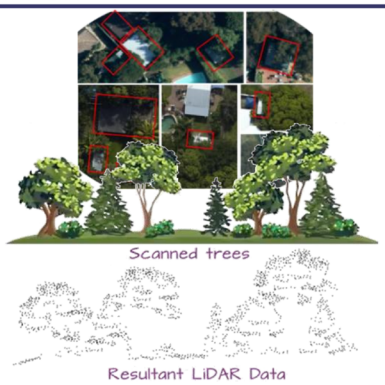
Information Technology

Building Extraction and Regularisation Using LiDAR Point Cloud Data and Orthoimage

Syed Ali Naqi Gilani§ | Mohammad Awrangjeb† | Guojun Lu‡

MOTIVATION

- **Building** is a key urban object
  - Disaster management, real estate, cadastral maps, virtual tourism, urban landscape design, installation of photovoltaic devices
- Existing work **fails** to
  - extract buildings which are small in size, under shadows or partly occluded
  - impose constraints on building height, area, and orientation to distinguish different urban objects and remove vegetation
  - registration error of multisource data



WHAT CHALLENGES US?

- Building shape variability and complex structure
- Surrounding environmental complexity (vegetation)
- Presence of noise, shadows, and small structures
- Misregistration between multisource date (LiDAR and corresponding orthoimage)
- Points are sparse, spatially unorganised and have no connection information
- No guideline on the selection and use of relevant features

WHAT ARE OUR GOALS?

- Building **detection** from complex scenes
  - extract the buildings which are partially occluded or under shadows
  - identify the buildings as small as possible without affecting the larger ones
- Building **delineation**
  - generate the regularised building boundaries to develop accurate building footprints
  - obtain high planimetric accuracy
- **Robust** computation
  - handle registration error between LiDAR point cloud data and orthoimage
  - graceful degradation under lower point density and anomalous data

HOW DO WE DO THIS?

1 - CANDIDATE REGION EXTRACTION

- Feature generation (LiDAR and orthoimage)
- Connected component analysis to detect candidate regions
- Line clustering to eliminate false candidates and footprint generation

2 - BUILDING DETECTION

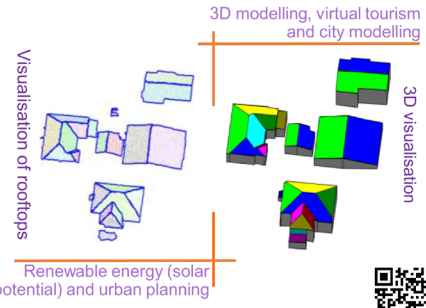
- Distinguish urban objects, eliminate vegetation, and identify buildings partly occluded or under shadows
  - perform grid-based segmentation
- Building area enlargement to overcome misregistration between multisource data

3 - BOUNDARY REGULARISATION

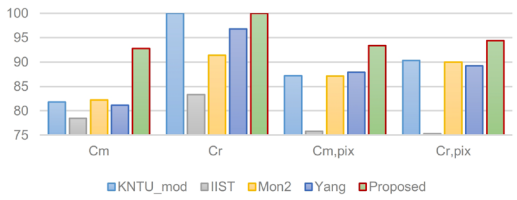
- Building edge selection
- Edge line estimation
- Building footprint generation

WHAT BENEFITS WE GET AND MORE...!

- Extracts buildings, separate buildings parts from connected vegetation and under shadows
- Identify objects with different geometric and radiometric characteristics
- Produce regularised building footprints in contrast to the recent methods
- Free of degeneration issues (many-to-many and over-segmentation)
- Exploits multisource data to handle missing information



PERFORMANCE COMPARISON ANALYSIS



Object level accuracy – 93.7 %
Pixel level accuracy – 94.8%

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Personalised drug development with deep AI

Your genes explain what kind of drug you should take

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[1.] Faculty of Information Technology, Monash University
[2.] Faculty of Medicine, Nursing and Life Science, Monash University

What is personalised drug development?

Personalised drug development is the process of developing more precise drugs for each individual based on their gene information so as to increase desired effects and decrease side effects.

How deep AI can help?

Problems for in vivo and in vitro techniques are,
- ❖ time-consuming
- ❖ expensive

Advantages of computational methods are,
- ❖ pre-select a list of potential candidates with higher successful rate so as to save time; and
- ❖ cheap to run

With deep AI, high abstractive information such as protein structures, drug-target interactions and drug side effects can be predicted with in mini-seconds by only providing individuals' gene information.

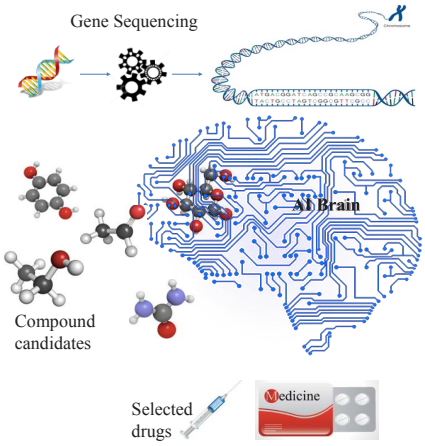


Figure 1 Steps for developing personalised drugs with AI technologies

Architecture Design

An Analogy Application

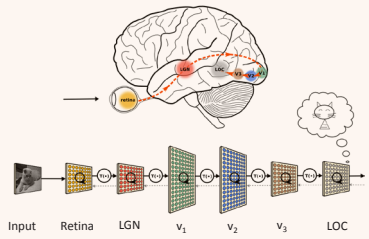


Figure 2 How does human brain recognise objects?

Deep Learning for *Facial Recognition*

The task of facial recognition is to recognise faces from images. To do so,

- ❖ Our visual system processes the *input* through multiple layers of neurons including *retina*, *LGN*, v_1, v_2, v_3 and finally obtain a perception through *LOC* (see Figure 2).
- ❖ Deep AI system imitates the process (see Figure 3 and Figure 4).
  - ❖ Hidden layers 1: it abstracts input pixels into short pieces of edges in the image
  - ❖ Hidden layer 2: edges are further abstracted into parts of objects, e.g. ears, eyes, mouths, noses, etc;
  - ❖ Hidden layer 3: it composes parts of face into areas of face; and
  - ❖ output layer: it decides whether it is a face or not.

Deep AI provides a solution to predict high-level abstractive information only based on low-level pixel information.

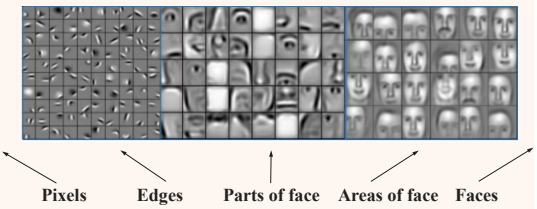


Figure 3 Mappings between hidden layers and facial recognition steps [2].

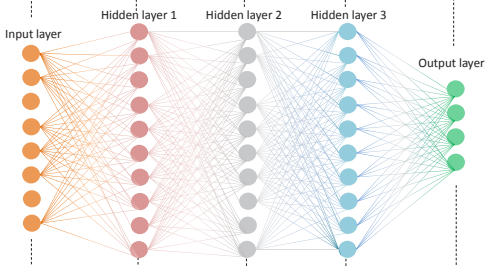


Figure 4 A generic design for deep AI model where each hidden layer represents a higher level of abstraction.

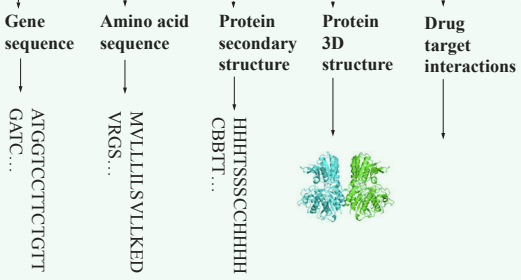


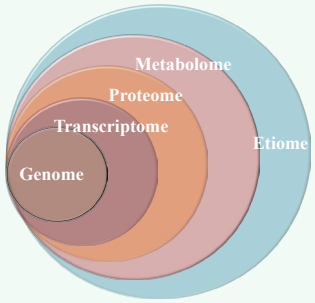
Figure 5 Mappings between hidden layers and drug-targets interaction prediction steps.

Deep Learning for *Drug Development*

SIMILAR to facial recognition, the model for predicting drugs only with gene information has to be 'powerful' enough to describe the problem itself.

The KEY to personalised drug development is to predict drug-target interactions.

- ❖ With deep AI, individuals' omics information (see Figure 6) can be modelled with different hidden layers (see Figure 4 and Figure 5).
  - ❖ Hidden layer 1: it translates gene sequence into amino acid sequence
  - ❖ Hidden layer 2: it predicts protein secondary structure from amino acid sequences
  - ❖ Hidden layer 3: it takes protein secondary structure as input and outputs protein 3D structure
  - ❖ Output layer: it predicts drug-target interactions based on protein 3D structures



Drug Development

Figure 6 Individuals' -omic system.

Discussions

Gene Sequencing

Personal genomics. It is now becoming practical and affordable for individuals to get their genomes sequenced.

A database of gene for multiple purposes
- ❖ unique identification
- ❖ medical diagnose and treatment
- ❖ product design
- ❖ etc

Sequence Embedding

Word embedding [3] 'translates' natural languages into matrixes that can be understood by machine.

Nucleotides/DNA sequences and amino acids/protein sequences can be mapped to AI's world efficiently in a similar way.

Cell Context

Besides gene sequence, other crucial factors for developing personalised drugs include,
- ❖ post-transcriptional modification,
- ❖ cell environment
- ❖ drug-drug interactions

Deep AI can be adjusted to incorporate side information in different hidden layers.

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GOING FOR GOLD!!!

MONASH University
Information Technology

Automated Tactical Analysis for Badminton

Kokum Weeratunga, Dr. Anuja Dharmaratne, Mr. Khoo Boon How

OLYMPIC SILVER IN 2012

At the 2012 London Olympics, the world's no.1 badminton player narrowly lost the Olympic gold. Poor strategies and tactical awareness of his opponent were to blame.

HOW TO MEASURE TACTICS?

Tactics are the strategies used to defeat an opponent in competition.

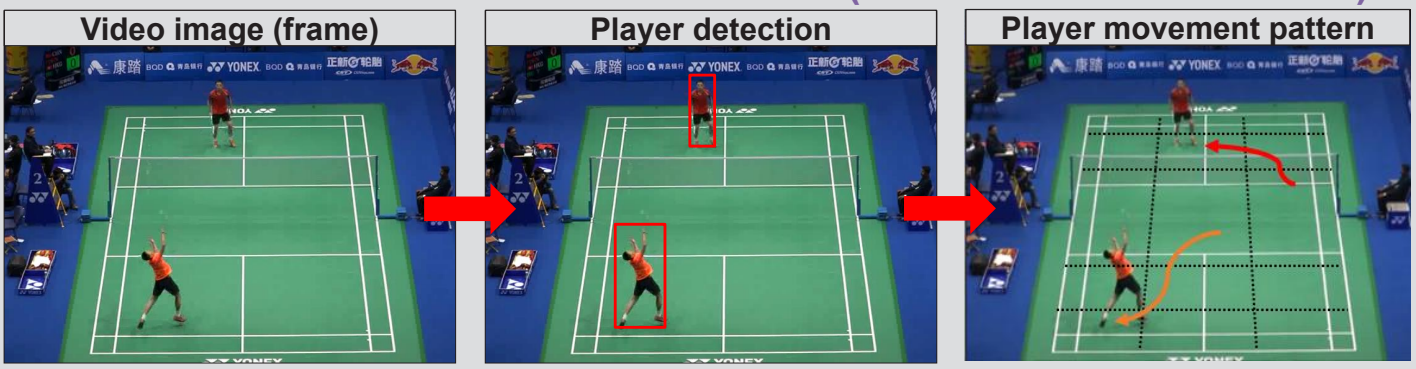
Tactical analysis is the identification of patterns and habits of an athlete or team, to be utilized in the formation of these strategies.

Tactical indicators are variables (action, time, position) that quantify tactical performance of an athlete, allowing objective tactical analysis.

At present, human tactical analysts spend hours on annotation and analysis of these tactical indicators.

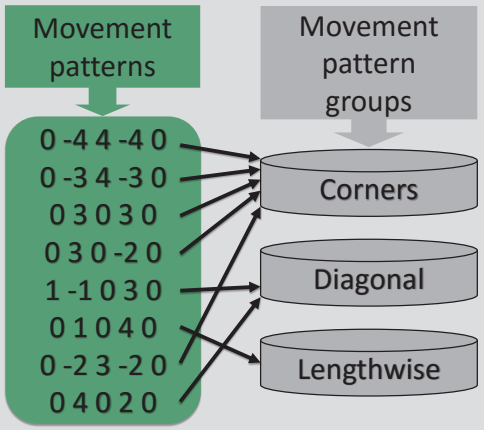
This research aims to find a practical solution for real-time unobtrusive data gathering about tactical indicators at an elite badminton environment, and be the first to automate pattern extraction and analysis in badminton.

EXTRACTING TACTICAL INDICATORS (MOVEMENT PATTERNS)



The above figures illustrate the extraction of tactical (position) indicators at an elite badminton environment. Detection of the players' positions allows us to extract their movement patterns. The movements can then be annotated according to tactical regions on the court.

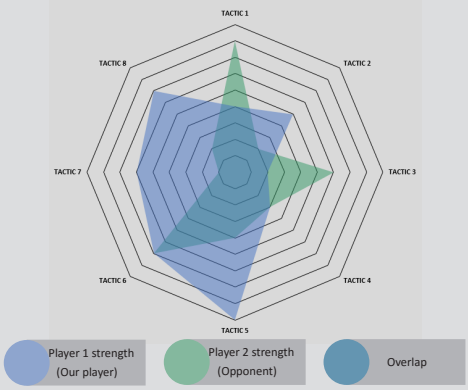
MOVEMENT ANALYSIS



Movement patterns of players transitioning through the tactical regions can be represented as numerical strings of variable lengths.

We aim to develop a model to identify and group similar strings (movements) that are relevant within the context of badminton.

GENERATING TACTICAL PROFILES

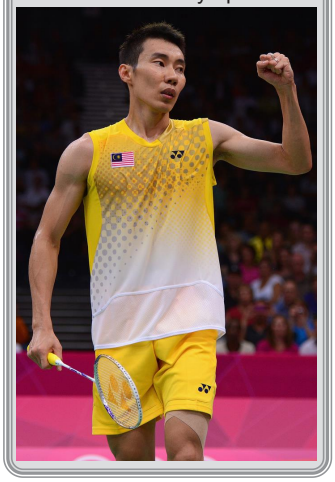


Player tactical profiles allow us to identify tactical overlaps, strengths, and weaknesses of opponents when compared to our own players.

The ultimate goal is to be the first to develop a unique method to automate the manual analysis of a human tactical analyst.

GOLD 2016!

Motivated by the silver medal at the London Olympics, we hope that automated tactical analysis ultimately results in better tactical awareness of opponents and a gold medal at the 2016 Rio Olympics.



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Enabling Non-Invasive Vein Imaging

Providing objective venous segmentation for population studies

Phillip G. D. Ward[1,2], Amanda C. L. Ng[3], Nicholas J. Ferris[1,4], David G. Barnes[5], David L. Dowe[2], Gary F. Egan[1,6], Parnesh Raniga[1]

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Why vein imaging

The ability to visualise veins is crucial when planning surgery, to avoid hemorrhage, and for diagnosis, such as when assessing tumors or arterio-venous malformations[6]. Studies have also found subtle properties of the veins, such as branching patterns, can indicate biological state and disease[8].

There may be many more uses for vein imaging, such as predicting and tracking vascular dementia and Alzheimer's Disease[8]. To identify these uses, thousands upon thousands of volunteers are required and multiple assessments performed over a long period of time.

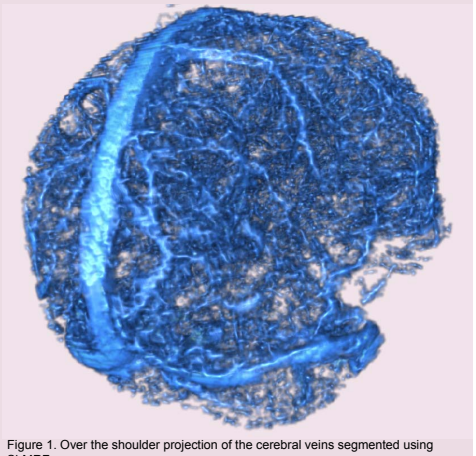

Figure 1. Over the shoulder projection of the cerebral veins segmented using ShMRF.

Challenges to population imaging

The gold standard vein imaging technique is contrast imaging[6], which involves injecting a contrast agent into the blood. The veins are imaged as the contrast flows along them. The procedure is invasive and carries some risk.

The risks involved are justifiable for brain surgery patients when compared to the importance of planning vein-free surgical trajectories and avoiding hemorrhage. However, the invasive nature impedes some large scale population studies where volunteers are involved.

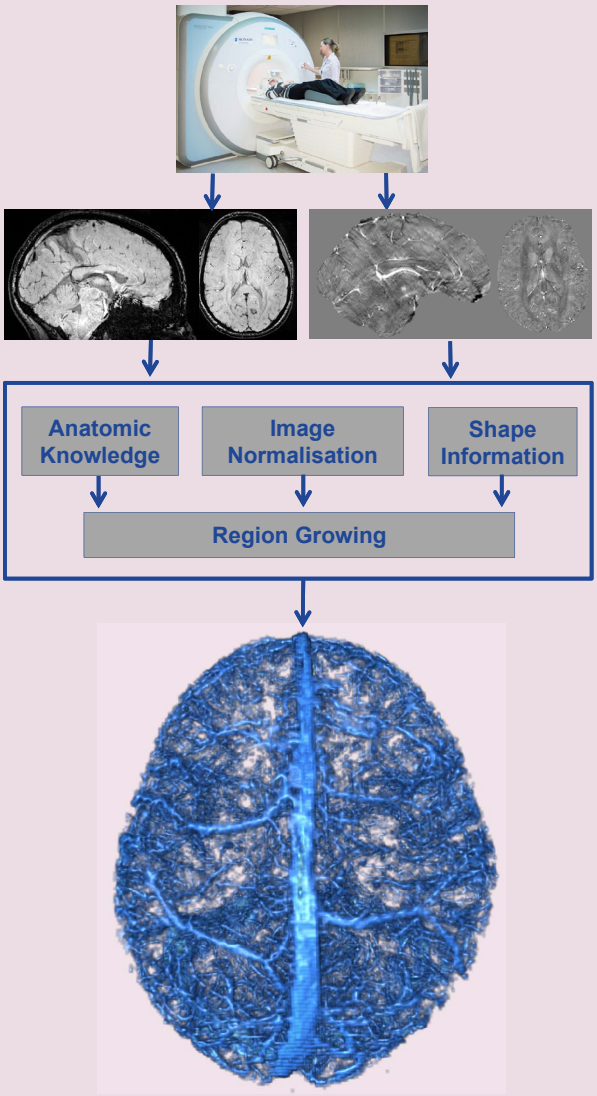

Figure 2. ShMRF workflow. The top two layers depict the MRI scanner and the two input images, SWI (left) and QSM (right). The blue rectangle in the middle is the ShMRF. The bottom is the ShMRF output, a 3-dimensional map of the cerebral veins.

Overcoming the challenges

There is a need here for a less invasive alternative, and magnetic resonance imaging (MRI) provides an opportunity for one.

The iron in blood has distinct magnetic properties which influence MRI images. Two methods exist to image this iron, susceptibility-weighted imaging (SWI)[4], and quantitative susceptibility mapping (QSM)[7].

SWI is very sensitive to small veins but confuses veins with some non-vein substances. QSM can better distinguish veins, but does not enhance small veins as much. These characteristics make both techniques unsuitable as a direct replacement for contrast imaging.

This project proposes a technique called the Shape-based Markov Random Field (ShMRF) which performs automated segmentation of the cerebral veins using both SWI and QSM.

ShMRF in detail

The two images are normalised separately, using *Gaussian mixture models*. *Anatomic knowledge* is used to merge the two images, taking into account the strengths and weaknesses of SWI and QSM in different regions of the brain.

Shape information[2] is then introduced to resolve uncertain voxels and non-cylindrical shapes within a region growing routine, a *Markov Random Field (MRF)*[5].

Performance

Ten subjects were scanned at Monash Biomedical Imaging. Veins were manually identified to created an expert ground truth.

ShMRF was then compared with other leading techniques across a range of metrics to assess relative performance in segmenting veins.

ShMRF outperformed all alternatives on a range of metrics (Table 1).

	ShMRF	MRFA	VNS	VNQ
Accuracy	90%	89%	87%	75%
Dice similarity score	42%	40%	35%	19%
Matthews correlation	37%	36%	31%	11%

Table 1. ShMRF compared with other leading techniques including an anisotropic MRF[1] (MRFA) and a vesselness filter[3] applied to SWI (VNS) and QSM (VNQ).

Acknowledgements

The Alzheimer's Australia Dementia Research Foundation and the Victorian Life Sciences Computation Initiative supported this work.

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SWARM OF DRONES FOR OUTDOOR 3D MAPPING

Brian Ramirez Espinosa

Supervisors: Dr. Jan Carlo Barca & Dr. Hoam Chung

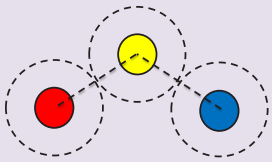
3D OUTDOOR MAPING

For a single drone mapping and navigating an unknown outdoor GPS restricted environment is a complex task due to its limited capabilities, while a swarm robotic system is robust against failures and efficient in achieving objectives. The project formulates a cooperative simultaneous localization and mapping algorithm (**Co-SLAM**), for a distributed swarm of drones that will work in outdoor GPS restricted environments, such as under trees and in deep valleys.

SWARM ROBOTICS

Autonomous swarm robotics systems will soon play a major role in tasks like search and rescue, surveillance in hostile environments and environmental monitoring. This is due to the extended capabilities that multiple robots offer, with respect to a single robot for the same task. Some of the advantages of robotic swarms are: **robustness against failures, better area coverage and shorter mission completion times.**

In order to perform these applications the swarm needs to **explore** and **map** a large outdoor area, in a **coordinated** fashion to achieve **efficiency**. One of the most popular branches of autonomous robots to perform these tasks, are **Quadcopters**.



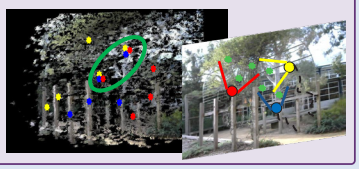
Co-SLAM ALGORITHM

In an large outdoor environment, cooperative SLAM is used by a robotic swarm to explore and map. Each robot collects information about the environment and its own position, through external and internal sensors. In this setting each individual drone creates a **local map**, which contributes to construction of one common **global map**. In this situation, two problems need to be solved:

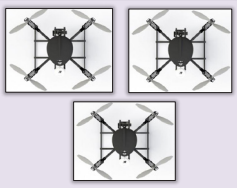
1) How to detect distinctive natural landmarks, in different outdoor conditions?
2) How can the robots in the swarm remain localised without GPS, so they can detect landmark **overlaps** within the different local maps?

The components needed in each drone to create an autonomous swarm system, that can cooperatively map a large outdoor area, are:

1) Autopilot
2) Central processing unit
3) Communication module
4) SLAM visual sensor

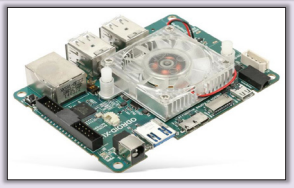


SELECTED HARDWARE

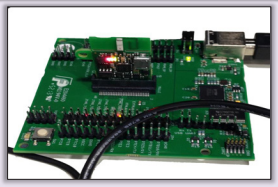


Swarm of Quadcopters
Xaircraft X650

AutoPilot
Pixhawk



Central Processing Unit
Odroid XU3-Lite



Communication Module
Mulle Platform

SLAM Visual Sensor
Stereo Camera

APLICATION AREAS

Areas where autonomous swarms of quadcopters , which can map and explore large GPS denied outdoors, are needed:

SPACE INDUSTRY
- Planetary exploration
- Space exploration

AGRICULTURAL AND MINING INDUSTRY
- Terrain mapping
- Environment assessment

LAW ENFORCEMENT
- Search and rescue
- Surveillance

IT INDUSTRY
- Creation of "street view" like maps of natural environments

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IT HURTS!

WHY, WHAT, WHERE AND WHEN?
Examining the Patient's Context for Chronic Pain Management

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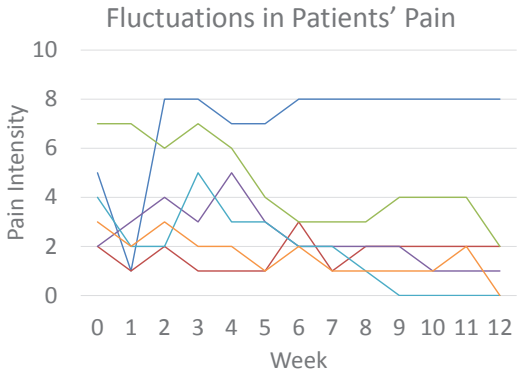
MONASH University
Information Technology

Chronic Pain in Australia

- Affects 1 in 5 Australians
- Subjective as no two people have the same pain
- Not much is known about the nature of pain
- Currently, most research focuses on relieving pain using medication and procedures
- This research uses a different approach and seeks to better understand the context of the pain

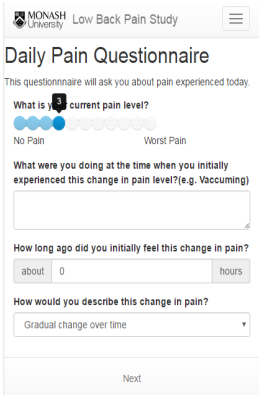


The Problem

- Our pilot study
  - Identified unknown fluctuations in pain
  - Collected contextual data at sparse intervals
  - Maintained data collection costs
- We believe that
  - Identifying the reasons causing fluctuations can lead to a better personalised management of pain
  - Data about and around the patient *(the Context)* during changes in pain is insufficient or not currently collected

Capturing Pain Fluctuations and the Patients' Context

- We designed a descriptive contextual model[2] allowing classification of contextual information for Chronic Pain
- We use secure purpose-built web applications[3] with context-driven questionnaires without increasing data collection costs
  - To collect Contextual Data at High Frequencies
  - To allow Patient Reporting of Changes in Pain
- We are studying Tennis Elbow and Low Back Pain



The Impact

- Our work improves decision making and outcomes through
  - Identification of factors contributing to pain for each patient
  - Higher accuracy of data provided to doctors by patients
  - Meaningful analysis of patient contextual data
  - Higher frequency collection of contextual data without increasing data collection costs

Future Work

- Develop an evidence-driven, patient-specific clinical decision support tool
- Give patients control over their data
- Design a better evidence-driven treatment and/or pain management plans

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[1] Goh, T.Y., Burstein, F., Delir Haghighi, P., Buchbinder, R., Staples, M. (2016). Accepted for presentation at the 27th Australasian Conference on Information Systems.

[2] Goh, T. Y., Delir Haghighi, P., Burstein, F., & Buchbinder, R. (2015). Developing a contextual model towards understanding low back pain. In A. Kankanhalli, A. B. Jones, & T. Teo (Eds.), PACIS 2015 Proceedings. (pp. 1 - 11). Atlanta GA USA: Association for Information Systems.

[3] Goh, T.Y. (2015). A Context-aware Pain Trajectory Framework for Low Back Pain Management. Presented at the 19th Pacific Asia Conference on Information Systems. Department of Information Systems, National University of Singapore

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Faculty of Information Technology

Mapping the Unknown without GPS

SLAM in an Indoor Environment with a Swarm of Aerial Robots

Ilankaikone Senthooran, J.C. Barca, H. Chung J. Kamruzzaman, and J. Murshed

Application

Autonomous flying robots have numerous indoor applications, most of which involve mapping an unknown area without access to GPS.

Search & Rescue | Disaster relief | Mine exploration



The Problem

What does the world look like?

Where am I?

The paradox

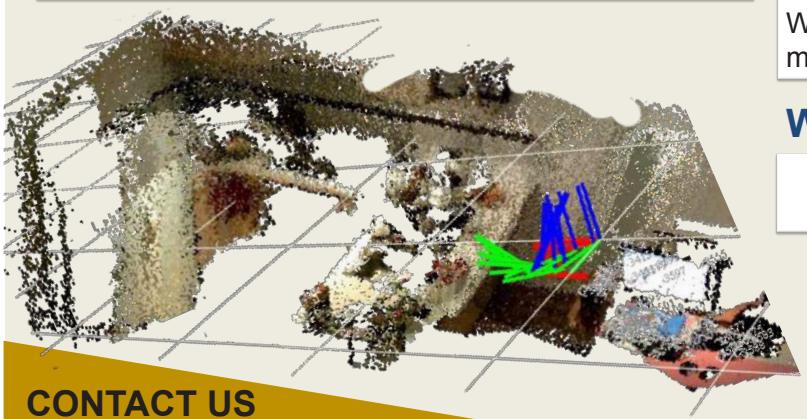
To build a map, we must know our position
To determine our position, we need a map

An Old Problem

Ancient world explorers faced the same problem
Dead reckoning: estimate velocity and extrapolate over time to calculate position
Landmarks like the North Star to correct their estimates

→ Robots use the same idea to estimate their position while building a map

This is SLAM



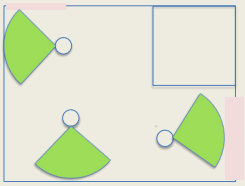
Swarm of aerial robots

A single robot will not do…

Cannot map a large area
Can fail
Can get trapped

→ A large team of robots can solve these problems
→ Ideally a swarm robotic system

Scalable Robust Flexible



Challenges

Existing methods need a lot of computational power and heavy/expensive sensors, but aerial robots can't carry much.
Complicated robot has higher probability of failure.

What we have achieved so far

Developed an efficient algorithm to estimate the position of a robot in an unknown environment using a few lightweight, inexpensive sensors: *range camera and attitude sensor*
We have achieved **92% speed-up** over traditional methods[1].

What's next…

- Efficient map representation
- Merging maps from different robots

Reference: [1] Senthooran, I., Barca, J C., Kamruzzaman, J., Murshed, M. and Chung, H. (2015) An Efficient Pose Estimation for Limited-Resourced MAVs using Sufficient Statistics. To appear at: IEEE/RSJ International Conference on Intelligent Robots and Systems, Hamburg, September.

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DYNAMIC PRICING TO REDUCE ELECTRICITY COST

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Electricity Peak Demand is a Problem

There is a significant short time peak in daily electricity demand (Figure 1). Unlike water, electricity cannot be stored and needs to be produced when needed. Hence, meeting short term peak demands requires construction of additional electricity generators and power networks which are idle during off-peak times. In effect, building additional infrastructure increases the electricity cost for both electricity providers and consumers. Managing peak demand is challenging for electricity suppliers and grid operators.

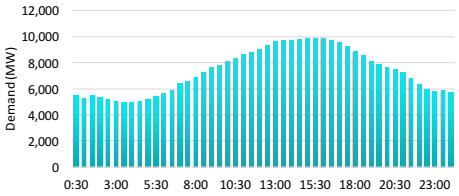

Figure 1: Averaged half-hourly demand of Victoria[1]

Reducing Peak Demand with Dynamic Pricing

Future smart electricity grids will see the proliferation of sensors on the grid, such as smart meters at households (Figure 2). These smart meters enable two-way communications between consumers and electricity providers. This allows electricity providers to monitor consumers' demand and set a dynamic price in real time. This allows providers to manage the peak demand while consumers can proactively manage both their electricity usage and their electricity bills.

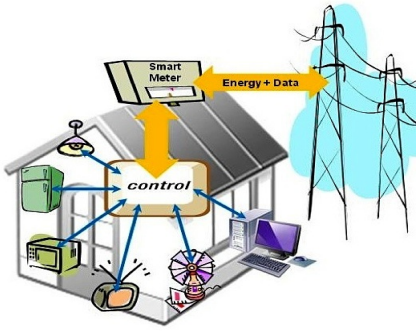

Figure 2: Two-way communication via smart meters[2]

Challenges in Using Dynamic Pricing

To let consumers effectively and easily manage their usage and electricity bills, electricity providers need to provide predicted prices a day ahead. However, it is difficult to set those prices in a way that off-peak demand increases, leading to lower prices and reduced peak demand. At the same time, the price scheme needs to avoid the creation of a new peak. With an increased number of households, this optimisation problem becomes significantly more challenging to solve.

Smoothing Peak Demand

My dynamic pricing model can predict the best prices based on consumers' demand and providers' supply capability, so that it can:

- avoid high concentration of demand at cheap times,
- maximise social utility for large communities from suburbs to an entire city,
- balance energy costs and individual preferences.

My dynamic pricing model reduces consumer cost by 22% and peak demand by 16%:

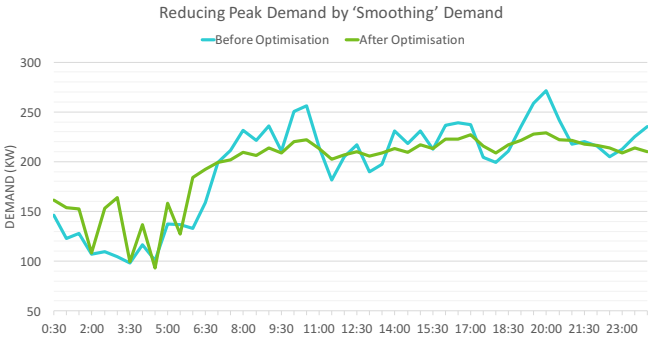

Figure 3: Initial and optimized half-hourly demand of 1000 households.

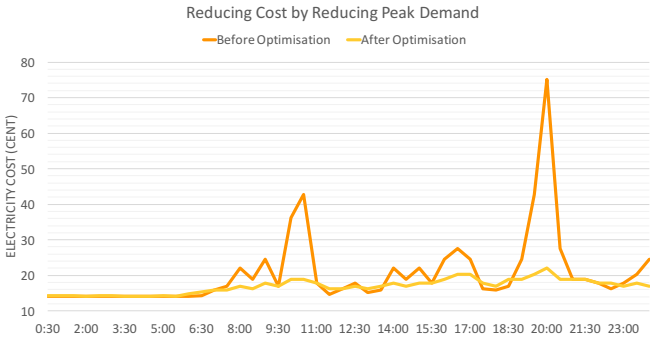

Figure 4: Initial and optimized half-hourly price for 1000 households.

Table 1: Initial and optimized total cost, peak demand and PAR (peak-to-average ratio) of 1000 households.

	BEFORE OPTIMIZATION	AFTER OPTIMIZATION	DIFFERENCE IN %
Total Cost (Dollars)	207.45	161.72	**22%**
Peak Demand (KW)	271.5	228.78	**16%**
PAR (Peak-to-average Ratio)	1.39	1.17	**16%**

Conclusion

By modelling demand and pricing, I developed a price prediction model that will save consumers 22% of their electricity bills and reduce 16% of the peak demand. Combining smart meters and dynamic pricing offers a powerful way for cheaper and more sustainable electricity production.

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[2] ISJ, US Purtek LLC (2010, Nov. 7). Smart Grid – The Money Saver [Blog]. Available: http://www.uspurtek.com/?p=230

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Exploit me if you can

Towards Secure Code Execution

Sepehr Minagar (sepehr.minagar@monash.edu)
Supervisors:
Dr. Phu Le and Professor Bala Srinivassan

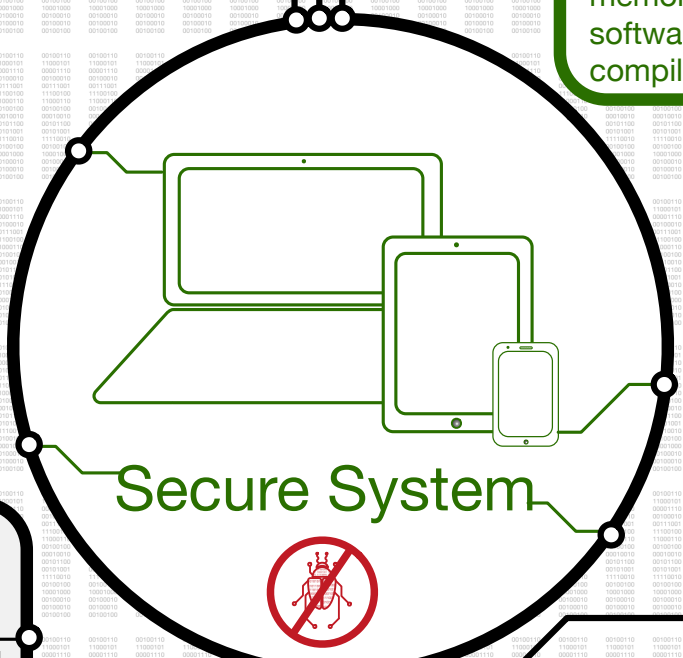
MONASH University

Malicious Code

Such as worm/virus or tools used by cyber criminals to attack systems has two requirements:
Vulnerability
Exploitation

Focus of Research

Prevent Exploitation
This is achieved by verifying authenticity of the code and protecting the integrity of the flow of execution.
Potential implementations are through hardware (processor, memory controller), and software (operating system, compilers).



Applications

The outcome of the research is also applicable to programs that are capable of running scripts/code, and can verify the authenticity and flow of execution of these scripts/code.

Cryptographic Coprocessor

Assists processor by performing cryptographic functions such as digital signature verification and providing secure non-volatile memory
(e.g. Trusted Platform Module).

Secure Processor

Implements the two requirements of secure code execution:
Authenticity of the code
Integrity of the flow of execution.

With the help of cryptographic peripherals such as TPM, code authentication can be performed efficiently.

To achieve integrity of flow of execution the jump instructions must have built-in capability to verify the destination address.

Operating systems and compilers take advantage of the secure processor instruction set to assure this in software.

Compiler

Adds necessary instructions to executable code to take advantage of the secure processor instruction set which assures the integrity of the flow of execution.

Implementation of code execution authenticity via compilers is one of the possible scenarios in this research.

Secure OS

Dynamically verifies authenticity of code in memory before execution.

This is done by using the services of peripherals such as TPM as well as built-in capabilities of secure processor in assuring the authenticity of executable codes and integrity of the flow of execution.

MONASH University
Information Technology

When is ‘nearest’ actually ‘near’?

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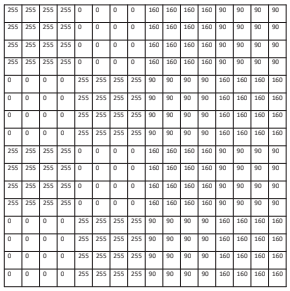
Supervisors: Andrew P. Paplinski, Peter Tischer and Sudanthi Wijewickrema

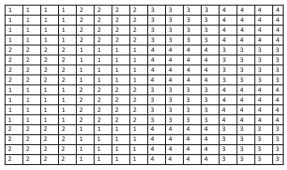
Motivation

This is how cameras see the world!



A 16 X 16 grayscale image
(**Large data**)

This is how we want program to see the world!

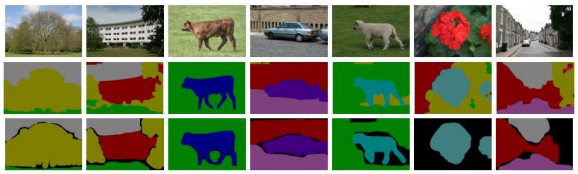


The segmentation map
(**Less data**)

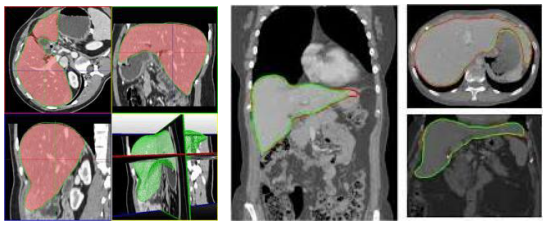
- Segmentation map helps to reduce the image information and compact it
- Consider the same scenario for colour and higher dimensional images!
- Our contribution is to create hierarchical segmentation maps for image segmentation and registration

Applications

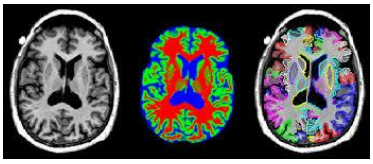
- 2D image segmentation



- 3D or higher dimensional medical image segmentation



- Segmentation-based multimodal image registration



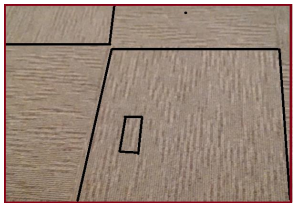
- Change detection in multispectral image

Approach

- We have **pixels**, we want to recognize **objects**
- We start by grouping pixels into **primitive** segments
- At the later stage, we group segments into objects

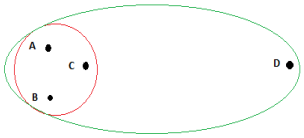
Challenges

- Segments can be inside segments
- Objects can be inside objects



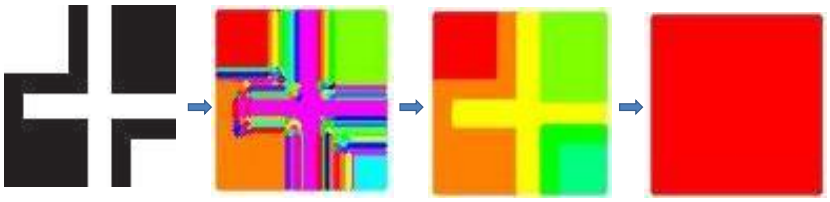
Solution: We help the user to choose the level of segmentation using a hierarchical methodology.

How Many Groups 1 or 2?



C is the nearest neighbour of D, should D be part of C’s group?

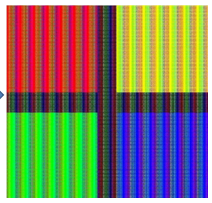
Our Methodology



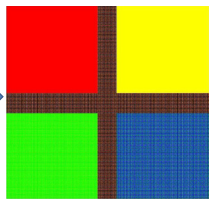
Original image | Level 1 | Level 2 | Level 3

- We have a quick segmentation approach that produces a hierarchical segmentation
- User can select: **level** and **affinity**
- By adjusting **level** we can go from having every pixel in its own segment to having all pixels belong to the one segment
- By changing **affinity** we can say when the nearest neighbour belongs to a different group

Zero affinity: every pixel is in its own segment



Eight affinity: More compact neighbourhood



- We might end up with neighbours segments that are so different**, but our technique will never combine them**

Our Strength

- Our method can handle colour, texture, multispectral/aerial data
- It can also handle 2D, 3D and higher dimensional data
- It is threshold-free
- We will apply Minimum Message Length (MML) to choose the level and affinity values automatically
- Our methodology can be implemented in parallel computing environment
- GPU-based implementation can also be possible for faster computation of 3D or higher dimensional data

Research Outcome

- A quick, cheap and efficient segmentation method for segmenting natural as well as specific (medical) images
- Multimodal medical image registration based on the proposed segmentation methodology

Looking at Business Intelligence through Chinese Eyes

Ms Yutong (Yuri) Song

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Supervisors: Emeritus Prof David Arnott; Dr Shijia (Caddie) Gao

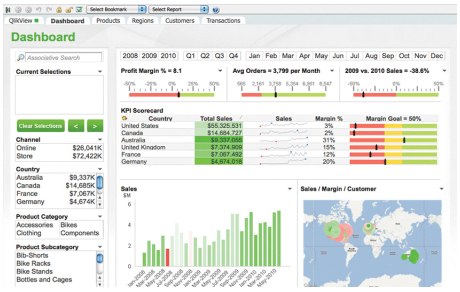
Why Business Intelligence (BI)?

BI has been ranked as one of the top ten technology priorities by CIOs continuously during the last decade (Gartner 2015). BI as a decision support systems innovation has been founded on western values and philosophies. Managers are the major BI users.

What is this Project about?

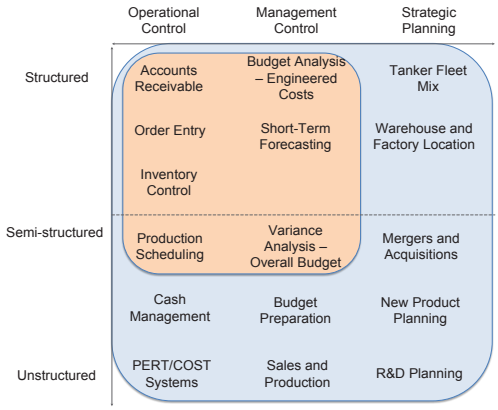
This project looks at the difference between Chinese BI and Western BI, especially in relation to the cultural impacts on BI use in large Chinese organisations.

If CIOs, BI vendors, consultants, analysts, and developers do not engage Chinese constructs to tailor their products, western BI in China is unlikely to succeed.



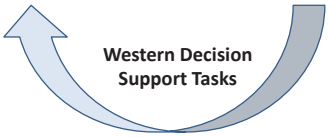
Typical Western BI dashboard (Qlik 2015)

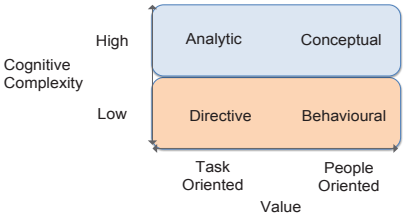
Recent Western BI dashboard (Yellowfin 2015)



Classic Decision Support Task Framework

Chinese BI dashboards (Alibaba 2015)





Western Versus Chinese Decision-Making Style

Western Versus Chinese Decision-Making Styles

Western managers tend to make business decisions based on a considerable amount of data, careful analysis, creative, broad focus, and seek independence.

Chinese managers tend to be more aggressive, act rapidly, use rules and intuition, and prefer communication and discussion in their business decision-making process.

Chinese BI dashboard (Alibaba 2015)

What do Chinese Managers Look for in BI?

The researcher conducted semi-structured interviews in two indigenous large Chinese organisations (Chinese Insurance Company and Alibaba Group) during the exploratory phase of the project.

It is crucial that the nature of a BI system aligns with the nature of the decision task in order to support managers in making effective business decisions. BI systems ease of use is differently conceived in Chinese firms.

A composite research construct – **Factor X** – have been identified as having great impact on BI systems and decision tasks alignment and perceived ease of use of BI systems. Factor X is consists of **generation**, **working and education experience**, **trust** and **closeness**.

How is this Project Moving Forward?

This project is currently investigating the cultural related Factor X. All factors inside Factor X have different settings compared to west counterparts.

Chinese Generation Y (1980-1995) are more technology savvy than Generation X (1965-1979). Generation Y perceive easier use of BI systems, and better alignment between BI systems and decision tasks than Generation X.

Employees, who had working and/or education experience overseas, have acquired skills that make them different in using BI systems compared to other employees.

Trust and closeness are the focus of next phase of the research, plus the complex interactions among these four factors.

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UNDERSTANDING AND PREDICTING SWARMS

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Why care about swarms?

Insect swarms play a significant environmental role: as pollinators; crop pests; soil turners; or as invaders, damaging local biodiversity.

Beyond environmental considerations, they have an impact on the producing industry: bees pollinate most commercial crops; locusts damage farmland and cattle grazing ground; ants interfere with livestock production and farming.

$240Bn / year[1]
Crop production world wide

$1Bn / year[2]
Damages in Australia

$2Bn / year[3]
Damages in the USA

What is the challenge?

Despite small body size and limited intelligence of individual insects, swarms of insects show highly complex behaviour. This unexpected complexity from limited individuals is termed “swarm intelligence”. It is hard to predict swarm behaviour based solely on the understanding of the behaviour of an individual.

The challenge is to build mathematical models that capture this complexity for the prediction of swarm behaviour.

In my research, I investigate self-organised infrastructure construction behaviour in American leaf-cutter ants.

Ant highway carved through rainforest undergrowth. Trail construction is self-organised, without planning staff or centralised knowledge about the environment

How to decipher swarm behaviour? – Infrastructure construction in Ants

Under what conditions are the above trails built? How does a swarm without central intelligence make these decisions? To answer these questions, I artificially obstruct cleared trails and build mathematical models based on the swarm response.

From Nature ...

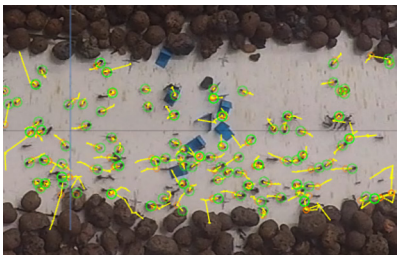
Based on observations in nature, I conduct laboratory experiments to trigger road clearing behaviour:

Observation of cleared trail in nature

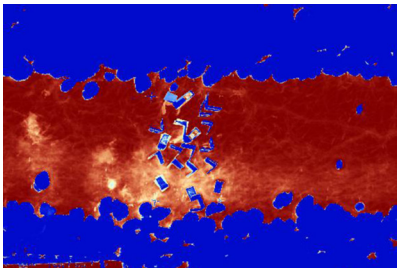
Simulated cleared trail with obstructions in the laboratory

... to Data ...

From experiment and field recordings, I extract behavioural data via image tracking and visualisation techniques:



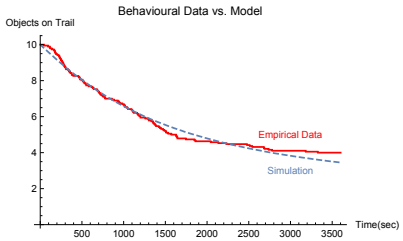
Tracking of ant position and speed



Visualisation and measurement of ant density over time

... to Mathematical Models

By matching observations of trail clearing with conditions under which they occur, I build stochastic models of the swarm’s trail clearing behaviour:



Matching simulation to behavioural data, showing gradual process of trail clearing

As a result of my research, I can predict occurrence and location of swarm level infrastructure construction.

The tools I develop are tailored to this behaviour – but the methods used are applicable to understanding a wide range of swarming species and behaviours.

FOR FURTHER INFORMATION
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2) Millist, Nicola, and Ali Abdalla. "Benefit–cost analysis of Australian plague locust control operations for 2010–11." *ABARES report prepared for the Australian Plague Locust Commission* (2011).
3) Pimentel, David, et al. "Environmental and economic costs of nonindigenous species in the United States." *BioScience* 50.1 (2000): 53-65.

ACKNOWLEDGEMENTS

This project is supervised by Bernd Meyer (Monash, IT) and Martin Burd (Monash, Science). We thank our cooperator Christoph Kleineidam at the University of Konstanz, Germany, and DATA61 | CSIRO for additional funding.

Accelerating Forensic Analysis

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MONASH University
Information Technology

Why?

TOO MUCH DATA!

- **Quantities** are growing - the average person now has multiple devices - PC, tablet, smartphone, laptop.
- **Bandwidth** is increasing and getting cheaper - we now can download and store far more stuff than we ever did before.
- **Uncertainty**: We don't know *exactly* what we're looking for - MD5/SHA1 etc will tell us if something is *identical*, but not *similar*.
- **Time** isn't easy to come by!

Let's Play a Game

Taking a guess is only bad if you can't learn from the results. **Monte Carlo Tree Search (MCTS)** is designed just for this. Build a tree with your available moves:

- **Take a guess**: No idea which option to take? Spin the wheel!
- **Score your move**: Measure your success (or lack of it)
- **Learn from it**: Add your score to each 'parent' move. Use this score to select your next move!

Tune Your Game

Like chess, **no two games are alike**. Sometimes we just want to find **something quickly**, other times want **everything**.
Fine! Just place a value on whether you want **exploration** or **exploitation**, or some point in between. Let's call it **c**.

Learn From Experience

A smart player learns from past games. Find a way to measure this experience and add it to your techniques!

- **TIEBREAK**: Instead of randomly picking two identically scored choices, pick the one you think might be best.
- **ADD2SCORE**: "Boost" the value of options you think are better, if only for a few turns.

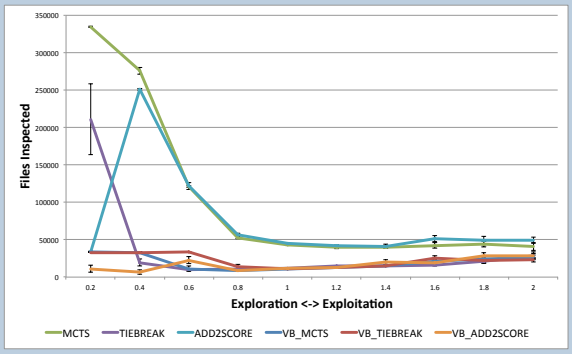
Prove it!

A Macintosh Air containing **2,298,863** files is found, with a stash of 42 pornographic images located somewhere within. We know 2 of these images, and the rest are similar. How do we find them more quickly than the average random search result of around 1.15 million?

Learning from Experience

- **Filenames** can be a hint. We built a classifier from pornographic file names and known "clean" files. It's not totally reliable, but it's good enough for taking a guess.
- **Similarities** can help - we tend to store like with like. Instead of looking for identical files, let's use a similarity based hashing mechanism (DHash).

Scenario 1 - Needle in the Haystack

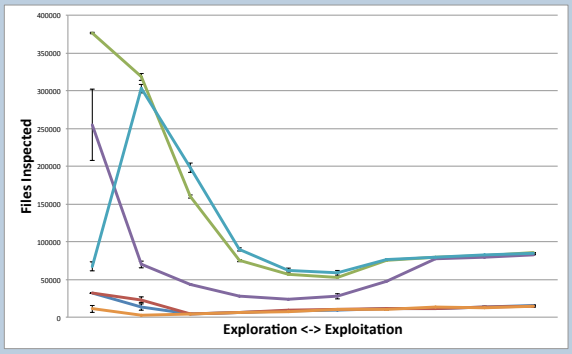


Location:
/Users/[user]/Pictures/iPhoto Library/Masters

Is our method smart enough to not get bogged down by the 1000+ similar files (photographs) around or target?

best: 6,725 files
worst: 334,723 files

Scenario 2 - Unsorted

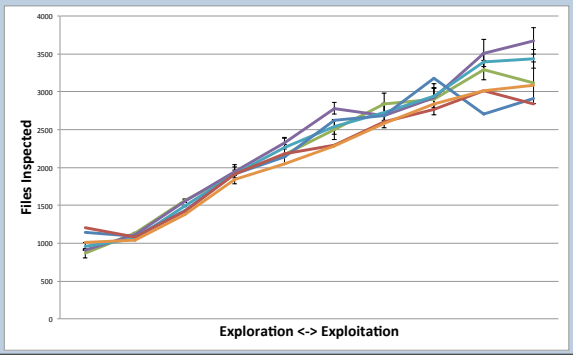


Location:
/Users/[user]/Downloads

What if our targeted stash is located amongst a jumble of all kinds of files?

best: 2,992 files
worst: 376,268 files

Scenario 3 - Diamond in the Rough



Location: /Private/var/lib

Will our searcher spend enough time looking in a seemingly uninteresting place, or will it stick to mediocre results?

best: 870 files
worst: 3,669 files

It Works!

At best, we only needed to check **0.04%** of files, making this approach over **1000 times faster** than an arbitary search. At worst, we **never looked at more than 16%** - just over 3 times faster.

MONASH University
Information Technology

Continuous Clustering Model for Growing Databases

Kasun Gunawardana
Supervisors: Dr. Jayantha Rajapakse, Dr. Damminda Alahakoon

1. Problem

Grouping data meaningfully which is known as clustering is a way of pattern recognition. Traditional clustering mechanisms which assume invariant databases, become inefficient with continuously growing modern databases.

- **Demand:** **With the rapid rate of data growth in contemporary databases, enterprises demand continuous and fast clustering solutions.**

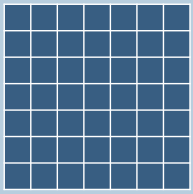
- **Social Media**
- **Online Marketing**
- **Network Security**
- **Weather Patterns**

2. Proposed Model

Traditional methods require re-execution of the entire process in each time new data arrives. **Modern methods** which address this limitation lack the usability aspects.

- **Complex Routines**
- **Number of Parameters**
- **Data Specific Controllers**
- **Memory Consuming**

Our solution is a grid like artificial neural network model. Cells are used to group continuous data flow.

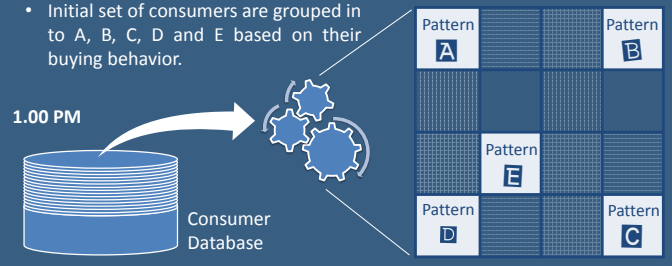


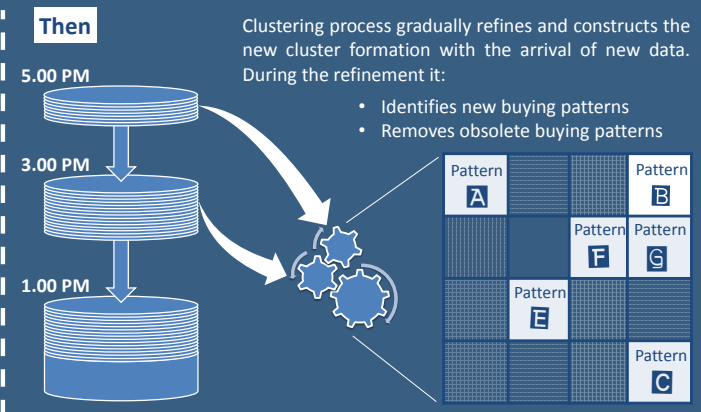
- Each data point is a stimulus
- Each cell represents a neuron
- A stimulus excites a neuron and triggers signal propagation
- The grid can be used to visualize data relationships

3. An Application Scenario: Consumer Buying Patterns

Assuming a database with consumer purchase data, our clustering process:

- Starts with data which is available at the beginning
- Consumes one data point at a time
- Incrementally constructs the initial cluster formation
- Initial set of consumers are grouped in to A, B, C, D and E based on their buying behavior.





Clustering process gradually refines and constructs the new cluster formation with the arrival of new data. During the refinement it:

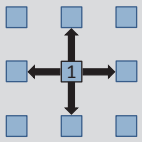
- Identifies new buying patterns
- Removes obsolete buying patterns

4. Execution Process

The clustering process executes two procedures for each data point.

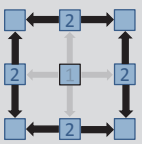
1. Initiation

- Decides the starting cell
- Adjusts the starting cell
- Transmits the signal to all immediate neighbors



2. Propagation

- Decides the excitability
- Adjusts an exited cell
- Transmits the signal to all immediate neighbors

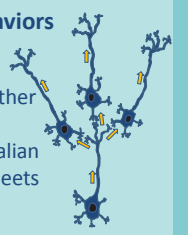


5. Brain-inspired

Inspired from Brain Behaviors

- Excitability of a neuron
- Fire together – Wire together

Cerebral cortex of mammalian brain is also organized as sheets of ordered neurons.



Self Organizing Artificial Neurons

- Artificial neurons organize themselves to represent the data space.
- Autonomous neurons control their 'Stability & Plasticity'.

6. What We Bring

A Novel Artificial Neural Network Model for Continuous Clustering

- Simplicity – Brief Routines
- Memory Efficient
- Quick Execution
- Accommodates Unlimited Data
- Less Number of Parameters

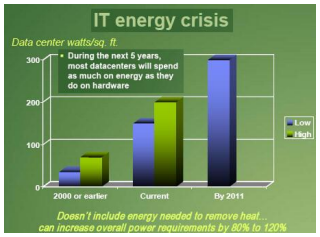
Fits with Modern Data Environments

- Continuously Growing Databases
- Large Scale Fixed Databases
- Data Streams

Greening up Big Data: Reducing Energy Costs

Nidhi Tiwari, Faculty of Information Technology
Dr. Maria Indrawan (Monash University, Australia, Prof. Umesh Bellur (IITB, India) and
Prof. Santonu Sarkar (BITS-Pillani, Goa, India)

Motivation



http://www.djurdjevic.com/Bulletins2008/07_IBM_Z10.html

- Data-centers have clusters of machines, running MapReduce systems, to process big data jobs.
- Increase in size of the data-centers has led to many-fold increase in their energy consumption.

- **MapReduce (MR) systems efficiently** process Big Data to provide useful insights for decision making.

http://commons.wikimedia.org/wiki/File:Big_data_cartoon_t_gregorius.jpg

"Your recent Amazon purchases, Tweet score and location history makes you 23.5% welcome here."

MapReduce (MR) systems:

- run (map) a process on data distributed across machines, then collate (reduce) results of distributed processes, for efficiency.
- use data replications for fault-tolerance and reliability

MapReduce systems can be energy inefficient due to [1]:
- data replication
- re-execution of tasks
- under-utilized nodes (due to high peak-to-mean).

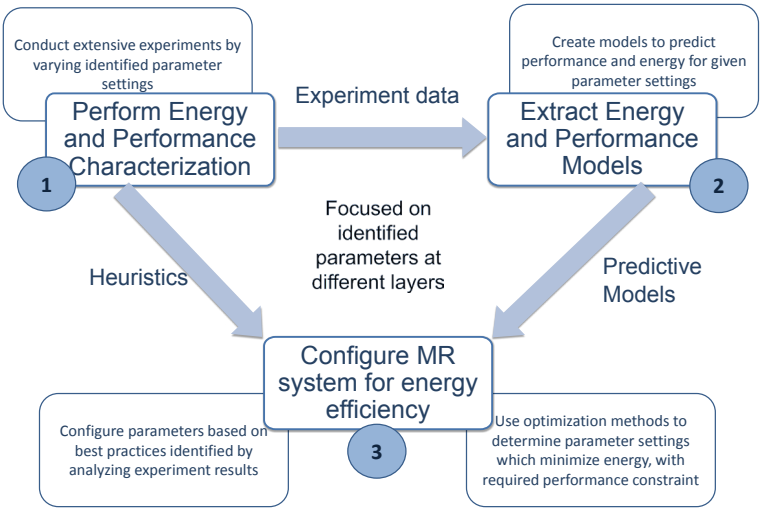
Objective

Tune the configuration parameters to reduce energy consumption without compromising on performance.

components of MapReduce systems

	Configuration parameters identified for tuning
MapReduce	• No. of Map/Reduce slots • Data Compression
Data File System (DFS)	• Replication factor • Block size
Hardware	• No. of nodes • No. of cores • CPU frequency

Approach Used



Current Results

- ✓ **10-15% reduction in Energy of CPU and IO intensive jobs** [2]
  - Using reduce slots setting heuristic
  - Using frequency setting heuristic
- ✓ **10% reduction in Energy of CPU intensive jobs** [2]
  - Using frequency setting heuristic
- ✓ **35% reduction in Energy of IO-intensive jobs** [3]
  - Using optimization techniques with CPU frequency based models

Future Work

Energy Characterization	Use Design of Experiments (DoE) for further parameter screening
	Conduct experiments for Data File System (DFS) parameters
Predictive Models	Extend models by adding more configuration parameters
	Validate models on different clusters
Energy Efficient Configuration	Derive heuristics for DFS configuration parameters
	Extend the optimization problem using multiple regression models

Benefits

- Sustainability of data centers
- Greening-up of data-centers with reduced carbon foot-print
- Significant savings in operation costs at Big Data data-centers
- MapReduce system configuration tools for system administrators

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3. *N. Tiwari, S. Sarkar, M. Indrawan, and U. Bellur. DVFS based energy characterization and models of MapReduce jobs. Submitted In ICDCN, 2015.*

Know-it-alls and Gurus:

Recognising expertise in online communities

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Supervisors: A/Prof. Henry Linger (Monash Uni.), Prof. Timothy Baldwin (Uni. of Melbourne)

Seeking experts online

It is hard for organisations to find expertise online. Search engines find documents but not people. Most current expertise finding software is only designed to work *within* organisations. They do not consider that the "Expert" role is a social label based on how experts and communities interact.

Main research question

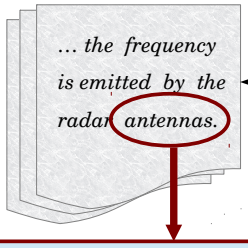
Can someone's expertise be automatically determined from their participation in an online community?

The Duality of Expertise is a relationship between a community and an individual, such that

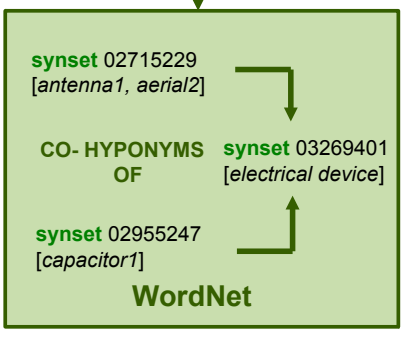
- ***the individual makes expertise claims*** to the community
- ***the community forms an opinion*** on those expertise claims through interactions with the individual.

Task: Evaluate the automatic recognition of expertise within an online forum when using the Duality of Expertise and various linguistic and search methodologies.

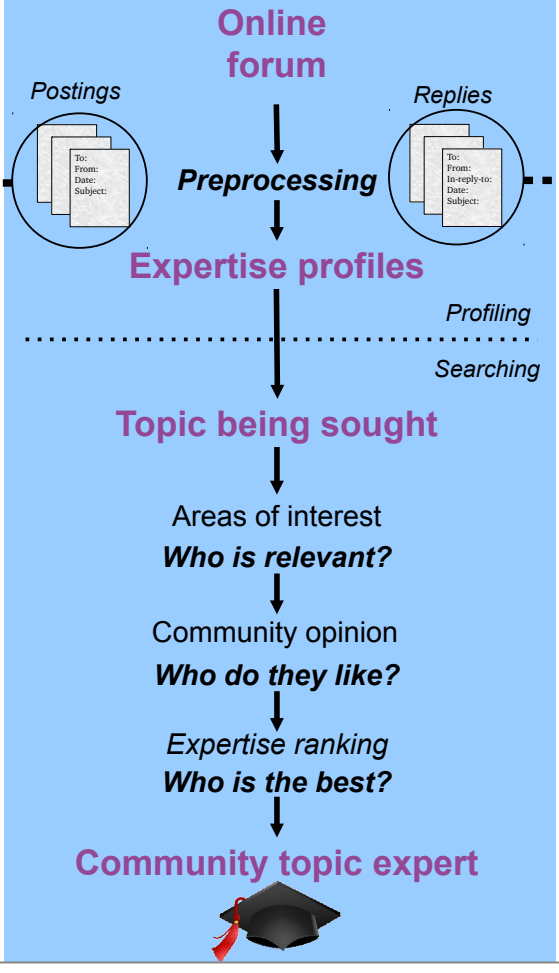
Reviewing an author's expertise claims through linguistic analysis of their postings



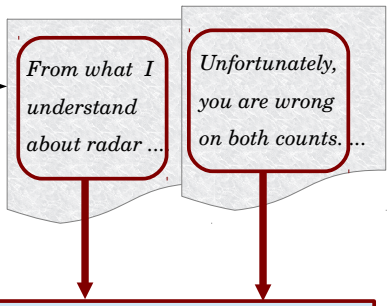
Raw term = *antennas*
Part Of Speech = *noun*
Lemma = *antenna*
Senses = [*antenna1, antenna2, antenna3*]



My Expertise Model



Determining the community's opinion from the dialogue acts in the reply postings



Positive act	e.g.	*Sounds consistent, Okay*
Negative act	e.g.	*I disagree, Not right*
Inform act	e.g.	*It is an antenna*
Query act	e.g.	*Why is it easier?*
Other acts	e.g.	*Hi*, urls, coding

Dialogue acts

Important references

- Austin, J. L. (1975). How to do things with words, Clarendon Press, Oxford, England.
- Mieg, H. A. (2006). Social and Sociological Factors in the Development of Expertise. In *The Cambridge Handbook of Expertise and Expert Performance (chapter 41)*, 743-760.
- Weigand, E. (2010). Language as dialogue. *Intercultural Pragmatics*, 7, 505-515

Research Process

My Expertise Model was developed after analysis of the *20 Newsgroups* corpus and the *Corvus* corpus I created from five mailing lists. The model was evaluated through experiments conducted using the *TREC 2006 Expert Search* test-set.

Using my Expertise Model in an automated system allows ...

- Analysis of social media users' reputations according to community discussions, rather than just "*likes*" or "*+1*".
- Forum content to be searched on the basis of the quality of its authors, not just which postings seem relevant to the search topics.
- Organisations to automatically alert the relevant experts to any new query posts in their community forums.
- Expertise profiles to be dynamic, updated after any new posts by the community.

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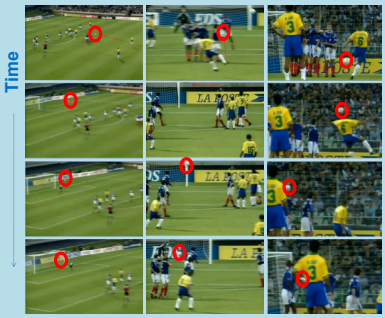
Enabling Free-view Video Technology With Limited Bandwidth

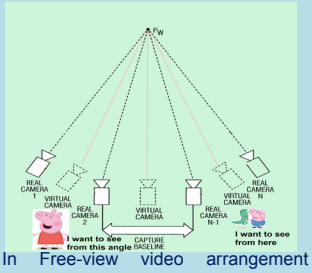
Shampa Shahriyar, Faculty of Information Technology, Monash University
Supervisors: Manzur Murshed, Mortuza Ali, Manoranjan Paul, Sue McKemmish

1. Free-view Technology



A tale of an impossible goal:
In 1997 there was a match between Brazil and France. In that match an impossible goal was shot by Roberto Carlos. The ball looked way off target to the right, but at the last moment it swerved dramatically inside the post and into the net. As it was so unexpected France's goalkeeper, Fabien Barthez, did not even move from his position. As in the live telecast only single view architecture was used, viewers could not "see" the goal.

With free-view technology, it would have been possible to see that goal. But transmission problems related to limited bandwidth prevent widespread application of free-view technology.



In Free-view video arrangement viewer can interactively control the viewpoint and can generate new views of a dynamic scene from any 3D position.

- Current video coding and transmission systems use only single view architecture.
- Free-view technology will provide larger viewing angle support and allow users to make interactive, flexible viewing choices.
- Communication channels (Wi-Fi, narrow band, cable modem) have bandwidth limitations to support multiple views.
- We need efficient compression techniques with high quality pictures to support free-view technology.

Research Goal: Design efficient data compression techniques to support transmission of free-view with high quality video using depth map coding.

2. Application Scenarios

- **Sports Industry:** Real-time interactive view selection will create live 3D experience of a match.


- **Health Industry**: Interactive dynamic view selection and generation will help remote surgery in tele medicine.

- **Video surveillance**: In most current video surveillance systems, intruders can try to check camera position while committing a crime, but in free-view, virtual camera scenes can be generated to detect any unusual events with 360° viewing angle.

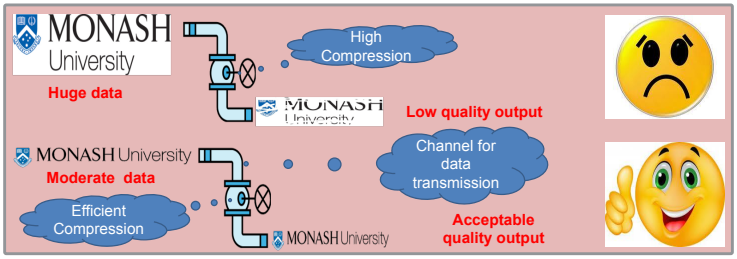
- **Navigation:** Using free-view technology better navigation facilities can be added in self-driven smart cars. Free-view will give better surrounding view with limited number of cameras.

- **Computer Games:** Using free-view technology immersive virtual reality and augmented reality can be added to create more realistic video games.

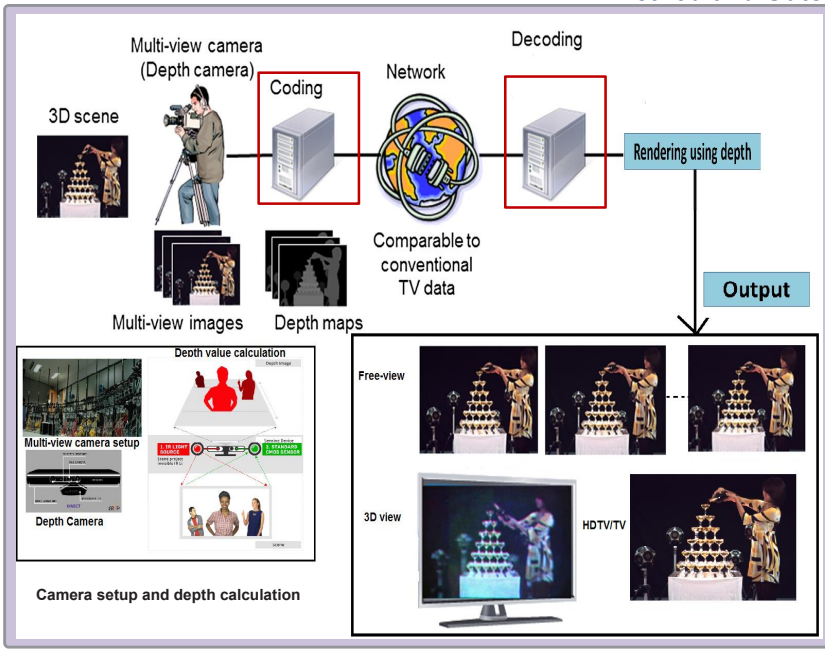
- **Accident scene investigation :** Free-view technology can help in simulating the accident scene to assist the investigators.

ARhrrrr is an augmented reality shooter for mobile camera-phones.

3. Research Challenge



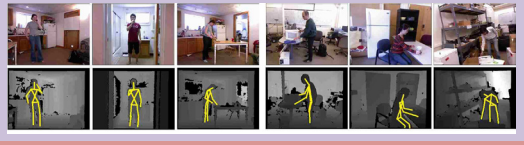
4. Method and Outcome



Camera setup and depth calculation

- ❖ Optimal camera setup design.
- ❖ Redefine existing video codec (encoding and decoding) architecture for overlapping information exploitation.
- ❖ Use of depth information for dynamic scene generation in any 3D position.
- ❖ Efficient compression technique for texture and depth to support free-view with limited bandwidth[1].

Outcome:
➢A codec to support free-view video transmission.
➢Free-view videos can be used for scene analysis, navigation and other applications highlighted in the **Application Scenarios** above.
➢Encoded depth can be used in various detection scenarios, along with texture video, to enhance human gesture, action and emotion detection.



Reference: [1] S. Shahriyar, M. Murshed, M. Ali and M. Paul, "Inherently Edge-Preserving Depth-Map Coding Without Explicit Edge Detection and Approximation,", IEEE International Conference on Multimedia and Expo Workshop (ICMEW 2014), Chengdu, China, July 14 – 18, 2014.

Towards simpler and faster optimisation

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Combinatorial Optimisation technology is used to solve important **real-world problems**. However, it can also be difficult to use. Our goal is to lower the barrier by helping users to create **good models** and find **good solutions**.

Optimisation Technologies

- Find an **optimal** set of decisions that satisfy some constraints with respect to some **objective**.
- Many different powerful techniques are available.

But: Selecting the best technique requires a high level of expertise.

High-Level Modelling

- High-level modelling languages like MiniZinc [1] allow domain experts to model **complex decision problems** in an intuitive way.
- A high-level model can be automatically compiled to use different solving techniques, allowing users to quickly discover the best one.
- Thus, advancements in solving techniques can be exploited quickly.

But: Implementing good models can also be quite challenging.

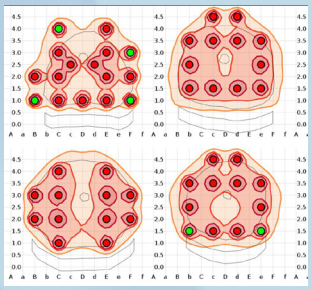
Optimisation can have a Big Impact!

- **UPS** has saved **$87 million** (and anticipates **$189 million** more over ten years) by optimising the planning of their aircraft network [2].
- **Ford** reduced annual costs by **$250 million** by optimising the development of prototype vehicles [3].
- **Tip Top Bakeries** optimised its delivery network to improve efficiency and cut its annual road travel by more than **one million kilometres** [4].

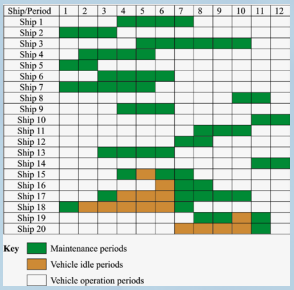
Many Applications

```
array[Sources] of var int: quantity;

constraint forall(s in Sources)
  quantity[s] <= max_source[s];

constraint forall(p in Product)
  sum(s in Sources)
    (yield[p] * quantity[s])
      >= requirements[p];
. . .
var int: cost = sum(s in Sources)
  price[s] * quantity[s];

solve minimize cost;
```

Example of a MiniZinc Model



Radiation Therapy Planning



Ship Maintenance Scheduling

Fleet Logistics

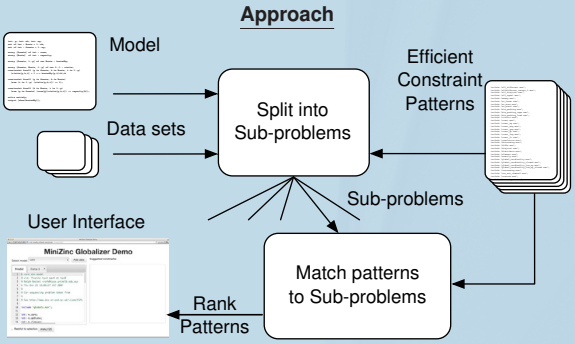
Research Goals

The goal of my research is to make modelling and solving combinatorial optimisation problems easier and more efficient.

MiniZinc Globalizer [5] helps users implement better models.

Precode helps improve models during compilation.

Globalizer: Finding Efficient Patterns in Models



Problem
- MiniZinc supports many constraints that capture common **combinatorial structure** or **patterns**.
- **Efficient algorithms** are available for these patterns.
- Models that fail to use these patterns cannot exploit these algorithms.

Result
- Globalized models are more **concise** and **efficient**.
- **Hidden structure** is exposed by discovered patterns.
- Globalizer **successfully detected** patterns in many models.

Progressive Party	Naive	Globalized
Runtime	8.739s	**1.238s**
Constraints	1037	**983**

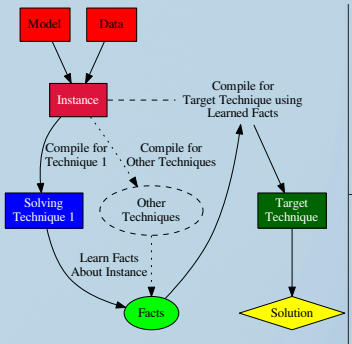
Problem	Found Pattern
Warehouse Location	✓
2D Bin Packing	✓
Car Sequencing	✓

Precode: An Iterative Approach for Improving Model Compilation

Problem
- Solving techniques have different strengths and weaknesses.
- Complementary techniques are difficult to integrate as they require problems to be compiled in different ways.

Approach
- **Iteratively compile** using the strengths of different techniques:
  1. Compile the problem for several solving techniques.
  2. Use these techniques to learn facts about the problem.
  3. Use these facts to compile for the target solving technique.

Result
- **Compilation is faster**, skipping redundant parts of models.
- Optimal solutions are **discovered sooner** (Figure 1).
- Memory usage is reduced due to **fewer constraints** (Figure 2).



Precode Approach

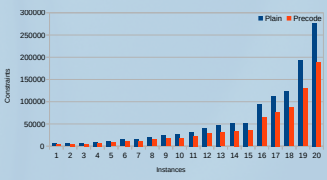


Figure 1. Fewer Constraints

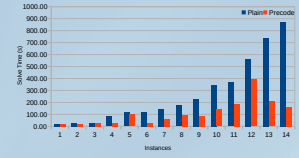


Figure 2. Faster Solving

[1] www.minizinc.org
[2] pubsonline.informs.org/doi/pdf/10.1287/inte.1030.0060
[3] www.informs.org/Sites/Getting-Started-With-Analytics/Analytics-Success-Stories/Case-Studies/Ford-Motor-Company
[4] www.nicta.com.au/media/previous_releases3/2013_media_releases/nicta_and_tip_top_anz_make_the_most_of_last_mile_with_smart_logistics_technology
[5] www.minizinc.org/globalizer

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Information Technology

Modelling Home Appliance Operation Patterns

Dwi A.P. Rahayu, Caulfield School of IT
Shonali Krishnaswamy, Maria Indrawan-Santiago, Cyril Labbe, Tanuja Ganu*
*IBM Research Lab India

Aims

This project aims to build a model that learns the characteristics of the appliance operational patterns based on its power consumption. This deep and accurate understanding of operational patterns is crucial for applying demand response initiatives which include:

- malfunction detection,
- energy wastage reduction (e.g. by cutting standby duration),
- automatic appliance scheduling.

This model is built using resource-efficient machine learning algorithms that can run on embedded computing devices. This decentralized approach avoids communication latency and costs, and preserves data privacy. This can be an effective and inexpensive solution for depicting and controlling home appliance usage.

Challenges

Building a model that can be deployed in small embedded computing device such as smart plug has some challenges. The model needs to consider limited computation and storage resource that the smart plug has. The challenges are:

- Using small sample data on learning phase
- Developing a computationally inexpensive algorithm
- Enabling incremental learning phase

Approach

This model analyzes the pattern of power (active and reactive power) consumed by the appliance. These power consumption patterns accurately represent the appliance's operation states.

Operation States Clustering – Each appliance's operation state has distinct level of power consumed. Figure 1a shows the power consumed by an observed air conditioner. The Hy-Carce clustering algorithm divides these consumption levels into four well-separated clusters using small (10-20%) random data sample corresponding to its operation states (Figure 1b).

Duration Based Cluster Refinement - Appliances complete their tasks within a well-defined range of durations. In some cases, a specific state has different range of time durations although the power consumption levels are similar. Hence, we developed local density maxima algorithm that considers these two operations as two different sub-states based on their durations.

Operation State Transitions Matrix - Appliances execute the tasks associated with its function in one or more of a small number of pre-programmed sequences. We developed first order Markov model based matrixes which record transition probability from one state to the other states.

Data set - In collaboration with IBM Research Lab India and Radio Studio, a set of data was collected from 40 appliances used at 10 different households. The appliances include air conditioners, refrigerators, washing machines and water heaters.

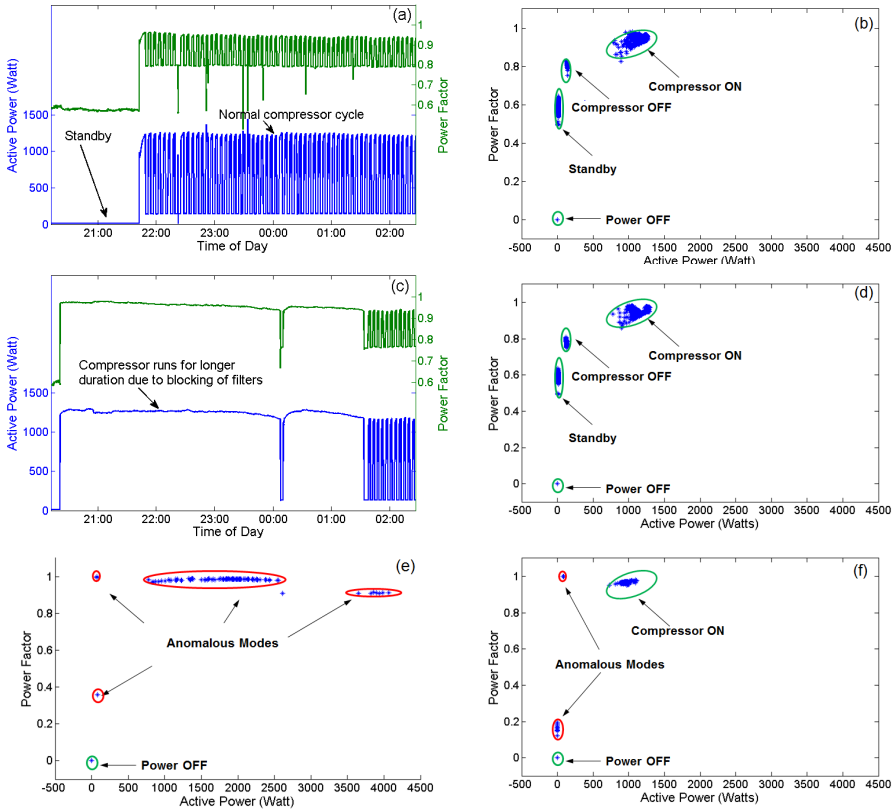

Figure 1: (a) Active power and power factor of an air conditioner in different states, (b) Clusters of power consumption levels of an air conditioner, (c) and (d): air filter blocked air conditioner (states remain same but the periodicity of states changes), (e): fan not working (change in states) (f): blower not working (change in states)

Sample Application of Appliance Operation Model

Malfunction Detection

When an appliance is not functioning properly due to either ambient conditions or incorrect usage or broken components, its power consumption would be different from its usual consumption patterns. Below are air conditioner malfunction detection scenarios and results:

- **Blocked Filter** - When the filter was blocked with a piece of cloth, the airflow was constricted. In this condition, as shown in Figure 1b and 1d, the power consumption levels (states) remained similar but the compressor was running for much longer duration as seen on Figure 1c.
- **Disconnected Fan** - When the condenser fan that exchanges heat with environment was disconnected, the condenser coils got extremely hot and the operational states changed significantly as shown in Figure 1e.
- **Disconnected Blower -** When the blower was disconnected, the cold air was not blown into the room and the operational states are changed as shown in Figure 1f.

Other Applications and Future Work

This model can be further used to:

- spot and reduce energy wasted in standby states by automatically turn off the appliance if it reaches standby state,
- automatically turn on and turn off the appliance based on appliance time of use patterns.

The model can be further enhanced to accommodate unsupervised learning techniques for identifying appliance classes so it can customize its analysis to appliance-specific characteristics.

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MONASH University
Information Technology

QoS aware query processing for sensors in Internet of Things

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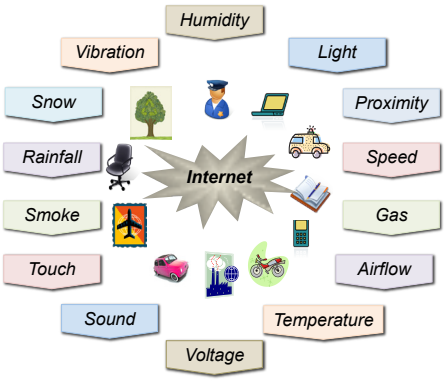
Supervisors: Dr. Joarder Kamruzzaman and Dr. Gour Karmakar

A. Internet of Things (IoT)

Example application of Internet of Things (IoT): Smart Traffic Emergency Handling [1]

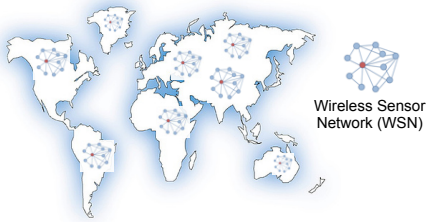
Connectivity for Anyone and Anything in Anytime and Anyplace

B. Role of Sensors in Internet of Things (IoT)



Sensors are attached with the objects in IoT to monitor their conditions on different attributes

C. Necessity of Query Processing for Sensors in Internet of Things (IoT)



Large-scale and Heterogeneous Wireless Sensor Networks (WSNs) are Globally Distributed all over the world producing Ocean of Sensor Data

Query processing is needed to extract the required information
- in real-time
- within time constraint and
- with acceptable accuracy

D. Quality of Service (QoS) Requirements: Delay and Accuracy

Fire Detection

Delay Sensitive Application
Example: To locate any sudden fire, it is enough to know that whether the temperature is more than 40 ◦c or not as quickly as possible. Exact temperature (55 ◦c / 60 ◦c) is not important.

Food Value Control

Accuracy Sensitive Application
Example: In sensitive applications like food value control system, some delay can be tolerated to retrieve as much accurate query response as possible. Here slight variation in original sensor data may cause severe disaster like damaged / spoiled food.

E. Our Proposed Solution: Sensor Data Model

Sensor Data Model

Hierarchical	**Scalable** solution with sensors at bottom & applications at top
Representative Data	Generated by **grouping similar sensor data**
Adaptive	**Up-to-date** with the change in real environment
Self-reorganising	Detect the modifications needed to keep the model consistent and perform accordingly
Trade-off between Delay & Accuracy	Model is **adjusted dynamically** according to the application requirement

Hierarchical → Sensor selection
Representative Data → Query response generation

F. Performance Benefits

Data representation allows less data transmission	Energy Efficiency
Hierarchical model allows retrieving response quickly	Less Delay
Our proposed data merging technique ensures improved data representation	Better Accuracy
Application is provisioned to alter the QoS requirement as ❖ Delay or ❖ Accuracy or ❖ a combination of both	Dynamic QoS Requirement

G. References

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2. Shaila Pervin, Joarder Kamruzzaman, Gour Karmakar, "Delay-Aware Query Routing Tree for Wireless Sensor Network", IEEE NCA (ERA Rank A), 2012
3. Shaila Pervin, Joarder Kamruzzaman, Gour Karmakar, "Quality Adjustable Query Processing Framework for Wireless Sensor Networks", IEEE NCA (ERA Rank A), 2011
4. Shaila Pervin, Joarder Kamruzzaman, Gour Karmakar, A K M Azad, "Hybrid In-network Query Processing Framework for Wireless Sensor Networks", IEEE ICC (ERA Rank B), 2011
5. A K M Azad, Joarder Kamruzzaman, KH Alam, Shaila Pervin, "Query Processing over Distributed Heterogeneous Sensor Networks in Future Internet: Scalable Architecture and Challenges", International Conference on Advances in Future Internet, AFIN, 2010

A probabilistic approach to in silico protein design

Liguang Zhu[1], Benjamin Porebski[2], Ashley M. Buckle[2], Geoffrey I. Webb[1]

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[2]*Department of Biochemistry and Molecular Biology, Monash University, Victoria 3800, Australia*

Introduction

Increasing protein efficacy and stability has always been a challenge within pharmaceutical and biotechnology industries. We propose a novel protein design approach: by applying suitable probabilistic models to a multiple sequence alignment of a protein family, we are able to design a protein that is most representative of its family.

Hypothesis

The known examples of a protein family can be considered to have been drawn from a distribution, where the probability of the occurrence of a specific example is associated with its efficacy and stability.

If the hypothesis should hold, it would enable us to design a protein around specified regions. e.g. The active site is rationally designed for substrate and the rest of the enzyme is designed by this approach to increase its stability and efficacy.

Design Process

Multiple Sequence Alignment Construction

- The quality of the multiple sequence alignment is critical
- Selective sequence candidates avoid having too many gaps

Protein Sequence Optimization

- Apply probabilistic models of joint distribution
- Maximize the joint probability of a protein sequence given amino acids combination

Experimental Verification

- Molecular dynamics simulation
- Protein expression and purification
- Biophysics
- Crystallography

Conclusion and Future work

- The consensus model created a superstable FN3 domain with a *Tm* of 94.3°C and a thermostable serpin with interesting changes.
- The Markov model appeared to reduce thermal stability.
- The chordalysis model highlighted a few potentially important amino acid sites within a correlation network, which is planned to be tested experimentally.

References:

1. Petitjean, F., Webb, G.I. (2013). Using chordal graphs to scale up log-linear analysis to datasets with hundreds of variables. In press
2. Irving *et al* (2000). Phylogeny of the Serpin Superfamily: Implications of Patterns of Amino Acid Conservation for Structure and Function. Genome Research, 10(12), 1845-1864

Probabilistic Models

$P(X)$ denotes the estimated joint probability of a protein sequence $P(X_1, X_2, \ldots, X_{n-1}, X_n)$, where X_i represents an amino acid (and a gap) assignment at site i

The Consensus Model

- Assume probabilistic independence of amino acid site
- $P(X) = P(X_1)P(X_2)P(X_3)\cdots P(X_{n-1})P(X_n) = \prod_{i=1}^{n} P(X_i)$

The Markov Model

- An amino acid site is considered conditionally dependent on its preceding site and its following site
- $P(X) = P(X_1)P(X_2|X_1)P(X_3|X_2)\cdots P(X_n|X_{n-1}) = P(X_1)\prod_{i=2}^{n} P(X_i|X_{i-1})$

The Chordalysis Model

- Considers multiple sites correlation based on statistical significance
- Applies Chordalysis[1] to construct a chordal graph, where each amino acid site is a vertex in this graph, each edge represents the correlation between two sites
- $P(X) = \frac{\prod_{C \epsilon \mathcal{C}} P_C(X)}{\prod_{S \epsilon \mathcal{S}} P_S(X)}$
- C denotes a maximal clique and S denotes a minimal separator in the graph. $\mathcal{C}$ and $\mathcal{S}$ denotes the sets of maximal cliques and minimal separators, respectively.

Results

- We have chosen 2123 FN3 domain sequences and manually constructed an FN3 alignment.
- We use 219 homologous sequences from serpin superfamily[2] to create a serpin alignment.
- Molecular dynamics simulations on the result proteins of FN3 domain show that the consensus model increases rigidity whilst the Markov model decreases rigidity.
- The consensus FN3 shows *Tm* of 94.3°C and the Markov FN3 shows *Tm* of 45.9°C
- The consensus model serpin (Conserpin) shows *Tm* of 75.2°C. The crystal structure of conserpin has been determined. In depth analysis shows hydrogen bonds and salt bridges changes. It appears unlike most thermostable proteins.
- We mapped the chordal graph of the chordalysis model to a wild type FN3 domain. As Figure1 shows, Met201, Val203 and Val254 have great statistical impact over others.

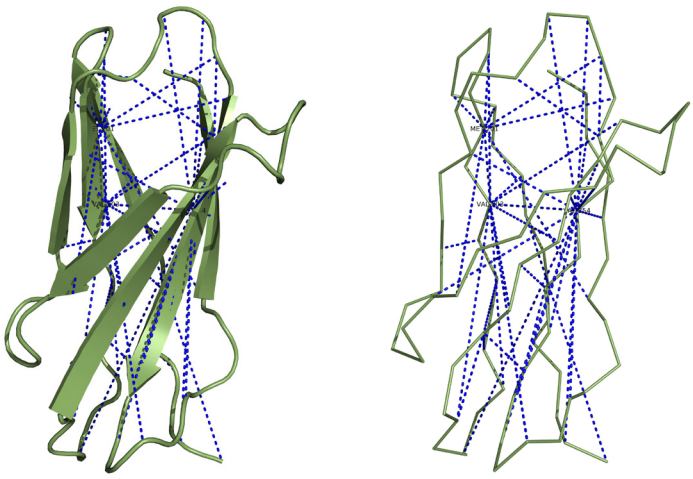

Figure 1: Chordal graph generated by chordalysis mapped on wild type FN3 (PDB ID: 2GEE)

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Information Technology

Identifying Spatial Region for Finding Nearest Objects

Kiki Maulana Adhinugraha, David Taniar, Maria Indrawan Santiago

1. Introduction

Finding nearest objects have many real life applications. One of possible applications is targeted marketing campaign. Consider the example in figure 1 where an area has several restaurants. A restaurant owner assumes that potential customers for the business will reside in addresses that closer to the competitors compared to the distance to the restaurant. How would the restaurant owner identifies these addresses so that special marketing leaflets can be sent for targeted campaign?

2. Identifying Potential Customers

There are some method that can be used:

A. Consider the restaurant as a point, calculate the distance to all addresses in the area. Do the same for all the restaurant in the area and find all the addresses that have closest distance to the competitors. (kNN query)

B. Consider each of address as a point. Calculate the distance to all restaurants. Sort the results based on the distance and find all addresses that have closest distance to the competitors. (RkNN query)

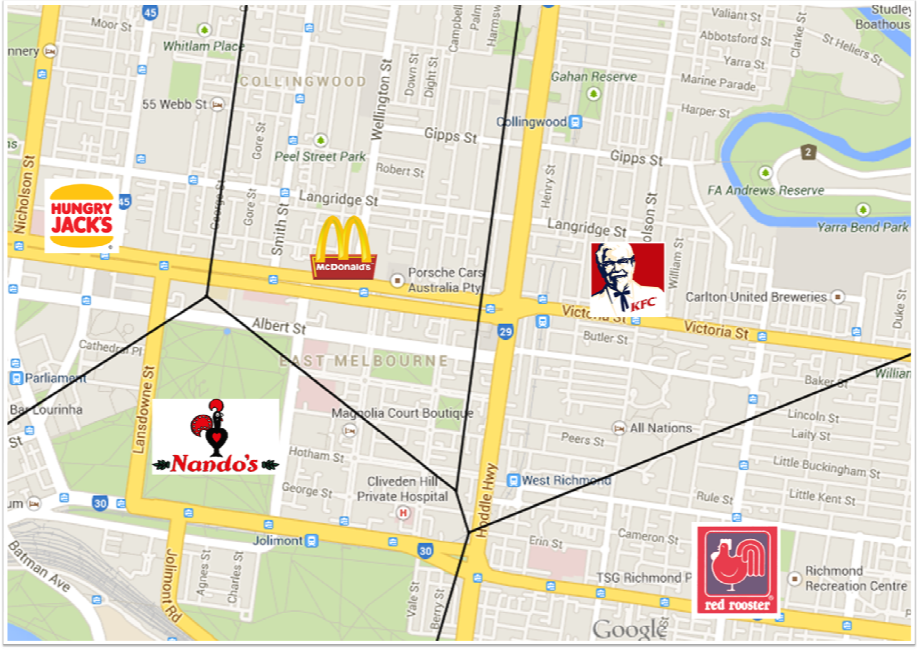

Figure 1 – Region of the restaurants where each region represent nearby residences to a specific restaurant

3. Problems & Solution

Creating solution based on approach A and B are time consuming. Distance from each address has to be calculated to all restaurants. The calculation need to be done for all addresses.

A better approach is to identify a region that can guarantee any given point or address will consider a restaurant to be the closest without the need to perform all calculations in approach A or B.

4. Method

Our algorithm is created based on geometry theories Halfspace and Voronoi Diagram. The algorithm produces region that can guarantee an area where any point located in the area will consider Q as its closest point in comparison to other points (points p_i).

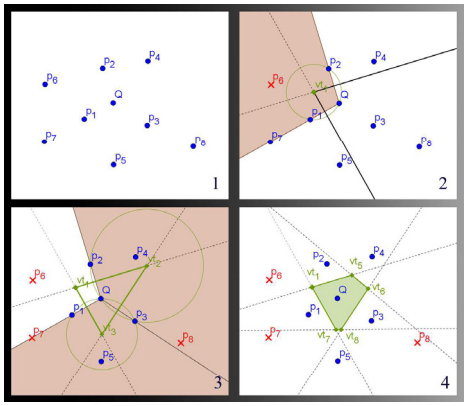

Figure 2 – Algorithm to determine the region for a specific point by considering surrounding competitors.

5. Evaluation (Figure 3)

The algorithm has been tested and shows good performance. It has a good performance and has the potential to be ported in mobile devices to assist moving/mobile region identification. Further testing is currently underway in the performance of the algorithm in mobile devices.

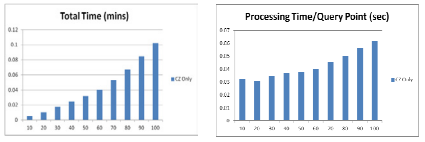

Figure 3 – Performance Evaluation of Region Generator

6. An example of Mobile Application

Consider a number of food trucks that travels in an area. They have a system that can report the position of each truck. Each truck has his own region and has to serve the nearest customer during his movement. While in some circumstances, each truck should be able to help next nearest trucks who have overloaded orders in their area.

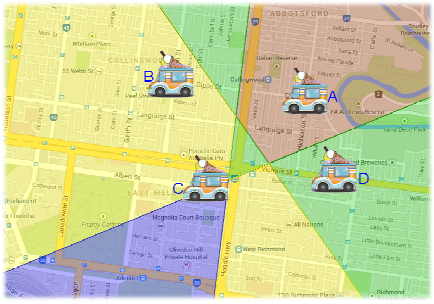

Figure 4 – Region priority of Vending truck A. Red is 1st nearest, green is 2nd nearest, yellow is 3rd nearest and blue is 4th nearest

7. Conclusion

We have proposed a region approach that can identify objects ranking in terms of their distance to specific point in light of the positions of other competing points. The proposed approach has the following benefits compared to the existing approaches:

- Computationally it is less expensive.
- It can identify not only the 1st nearest, but also other level (2nd, 3rd, …,nth) in single creation of regions. No other approach has done this.

9. Contact

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Intuitive Human Robot Interaction with Augmented Reality

Eranda Lakshantha, Dr. Simon Egerton, Prof. Michael Weber

1 Introduction

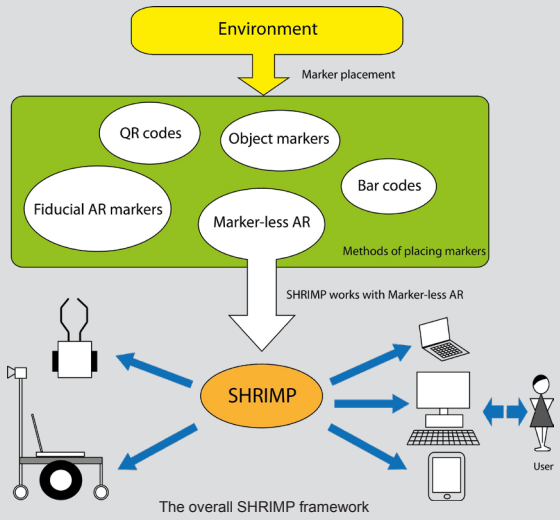
In many cases, robots are operated by people who have little practical experience with those complex machines. A successful Human Robot Interface (HRI) system should,

- Reduce the operator workload
- Make the collaboration more intuitive and seamless

We propose a model, Spatial Human Robot Interaction Marker Platform (SHRIMP) to enable an intuitive HRI experience through an Augmented Reality (AR) framework.

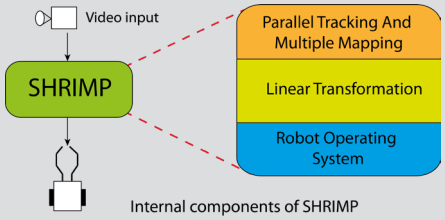
- We view diagrams as a mechanism for referencing physical space with markers and instructions.
- These diagrams translate into 3D 'maps' rendered in physical space with AR Technology.
- Users interact with any robot through the placement of AR markers within the environment.

Our platform uses a novel marker-less AR approach to mark out 3D points in space.

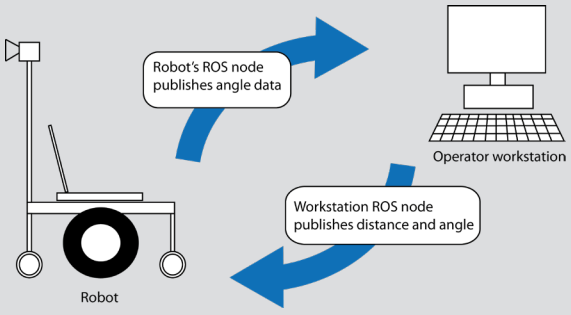


The overall SHRIMP framework

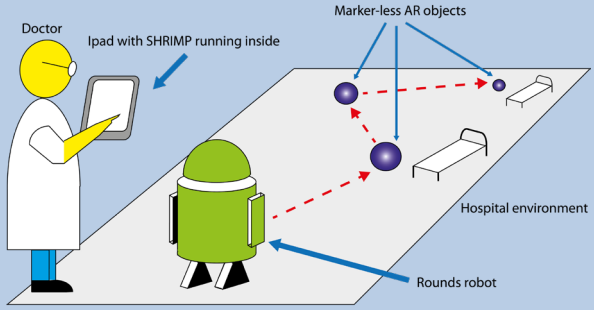
SHRIMP's internal structure and its integration with a robot are illustrated below.



Internal components of SHRIMP



2 Application Scenario

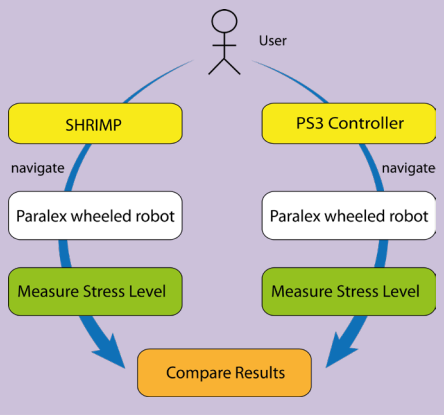


Application scenario: Planning virtual routes for a rounds robot in a hospital using SHRIMP

3 A Case Study: Navigation

Illustrated below is a comparative case study we performed using SHRIMP against a PS3 gamepad. In this case study our robot client is a Paralex wheeled robot. The case study addressed the following hypothesis,

H1: Does the SHRIMP framework improve the HRI experience for the average person?

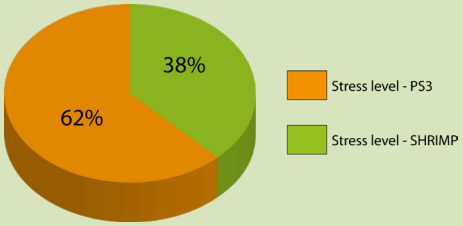


4 Results & Analysis

The stress level results are summarised in the pie chart below.

The results indicate that the average stress-levels with SHRIMP (38%) are approximately halved compared to the PS3 (62%).

The raw results are statistically significant against a paired t-test and a p value 0.05.



These results strongly suggest that our hypothesis is true, that our HRI platform offers a more intuitive and less stressful approach to interacting with a robot and guiding it through a complex task.

References

Castle, R., Klein, G. & Murray, D.W., 2008. Video-rate localization in multiple maps for wearable augmented reality. 2008 12th IEEE International Symposium on Wearable Computers, pp.15–22.