The data connection - challenges at the frontiers of Artificial Intelligence research

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Outline

- Intelligent Machines – a reality?
- Artificial Intelligence
- Automated Pattern Recognition and Machine Learning
  - Surveillance and person detection (IT & Coastal Management)
  - Intelligent on-line water quality monitoring (IT & Environment)
  - Biological neuron classification (IT & Science)
  - Computer-based bridge management systems (IT & Engineering)
- The Future of Artificial Intelligence

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Intelligent machines

- Strong words:
  - "Artificial Intelligence pursued within the cult of computationalism stands not even a ghost of a chance of producing durable results…" (Sayre, 1993)
- Far more optimistic words:
  - "When a distinguished … scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong." (Clarke, 1962)

Computers & algorithms

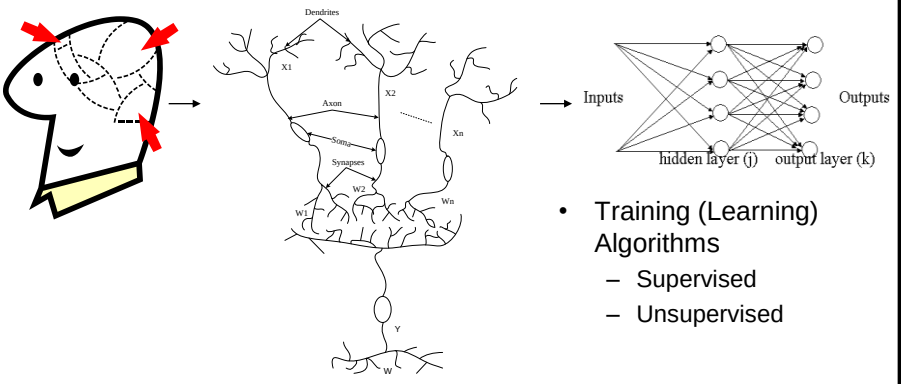
- In general terms an *algorithm* is defined as a set of steps to perform a particular task
- Algorithms form the basis of programs
- Programs execute on a digital computing system step-by-step
- These steps are *blindly* followed!
- Definitely NOT intelligent

Artificial (Computational) Intelligence

- Artificial Intelligence (AI)

- HAL 9000 from 2001: A Space Odyssey
- Passing the *Turing Test*
- Are we there yet?

Artificial Neural Networks (ANNs): Biological Inspiration



- Training (Learning) Algorithms
  - Supervised
  - Unsupervised

Automated Pattern Recognition

- The fields of Pattern Recognition and Computer Vision have incorporated aspects of such areas as:
  - Artificial Intelligence (Machine learning)
  - Digital Image and Video processing

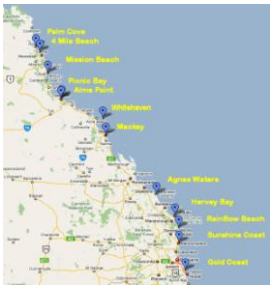
Person detection and behaviour tracking

- Beach imagery can provide important information for tourism and beach safety
- World Wide Web cameras (web cams) are a source of regularly updated beach imagery

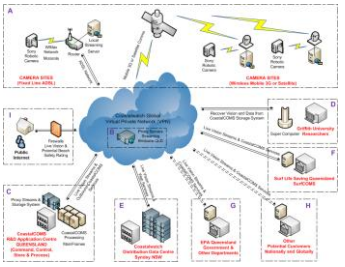
Sample web cam images (courtesy of CoastalWatch)

Camera network and set up

- Data is currently available from 36 cameras located in south east Queensland and in regional northern Queensland as illustrated



- Sites consist of fixed line DSL or wireless Next G / Satellite connected camera locations



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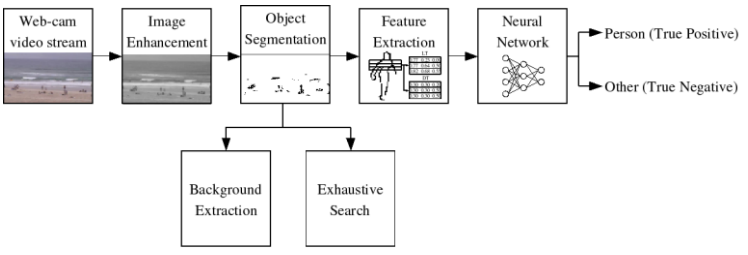
Person detection - system overview



System for detection of persons in beach scenes
Green *et al.* (2006)

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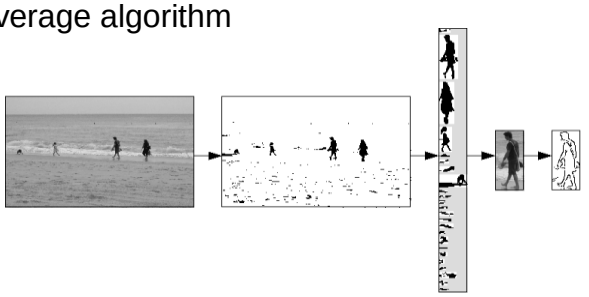
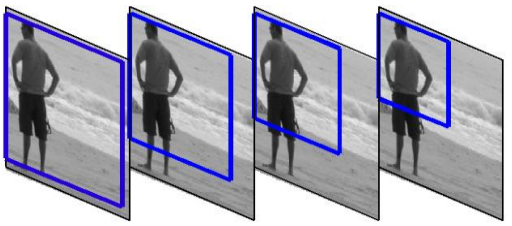
Background Extraction

- Unwanted background information is removed whilst preserving foreground objects – moving average algorithm



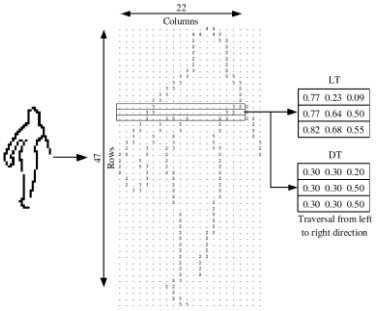
Exhaustive Search

- A search window is passed over the image looking for regions of interest (ROI)



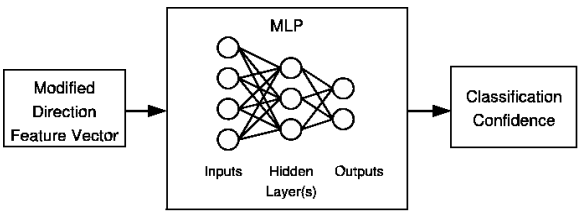
Feature Extraction

- Modified Direction Feature (MDF) for person feature extraction

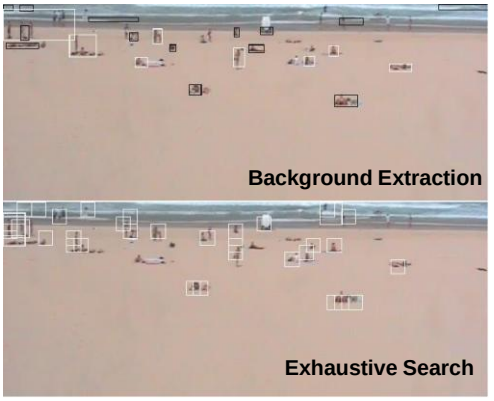


Person Classification

- People were classified into person and non-person categories by using a number of machine learning techniques including:
  - a feed-forward Multi-layer Perceptron (MLP); RBF classifier; SVMs and a Bayesian network



Results



- Person classification accuracy: > 85%

Results (cont.)

- Top Classification Rates Using the MDF Extraction Technique (True Positive TP, False Positive FP)

	Set01		Set02		Set03		Average	
	Person TP	Other FP	Person TP	Other FP	Person TP	Other FP	Person TP	Other FP
MLP								
24 Hidden Units	93.06	13.19	88.89	8.33	86.46	11.11	89.47	10.88
RBF Network	90.97	22.57	89.93	17.01	87.50	17.71	89.47	19.10
SVM Polynomial Kernel								
Exponent = 2	90.63	10.76	89.93	6.94	92.71	11.11	91.09	9.60
SVM RBF Kernel								
Gamma = 0.300	94.10	12.15	89.93	6.94	91.32	6.94	91.78	8.68
Bayesian Network	88.89	16.32	89.58	16.67	90.28	17.36	89.58	16.78

Behaviour detection

- People use beaches for many different activities that can be seen as different behaviours
- This research concentrated on four human behaviours - *running*, *walking*, *milling*, and whether *a person is entering the ocean*
- The milling human behaviour within the bounds of this research is any behaviour other than walking and running, and encompasses a great range of behaviour

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Behaviour interpretation

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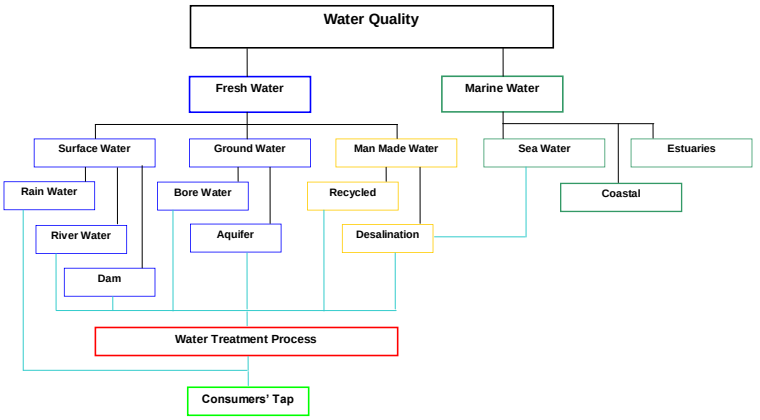
Intelligent Water Quality Monitoring



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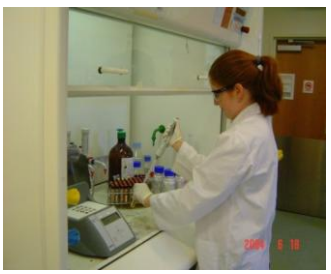
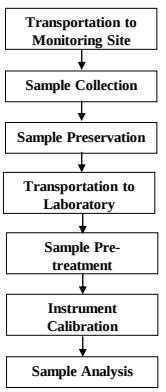
Why are Standard Methods Unsuitable?



- Not suitable for a preventative water management approach



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Example: Large Scale Water Quality Monitoring

- Potential for cost effective on-line monitoring spread across a wide area
- Necessity for suitable high-speed networking infrastructure
- Key to preventative water management in the future
- Need reliable sensors

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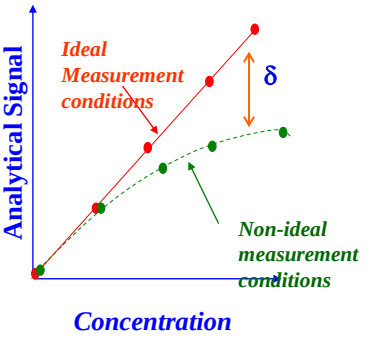
Problems with current on-line monitoring methods

- Rely on one highly selective sensor to detect one compound
- Inherent problem - requires strictly controlled measurement conditions to obtain analytically valid results
- Unreliable measurements due to the fact real world is not controlled
- Requires frequent maintenance and calibration → try to maintain reliable performance



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What Industry/Governments want

- Autonomous operation in the environment > 1 year
- Analytically valid results to detect changes → avoid panic
- Reliable and robust
- Development of low cost devices suitable for mass implementation
- Reducing environmental pollution
- Low cost of maintenance e.g. limited reagents and calibration
- Easy to operate and maintain

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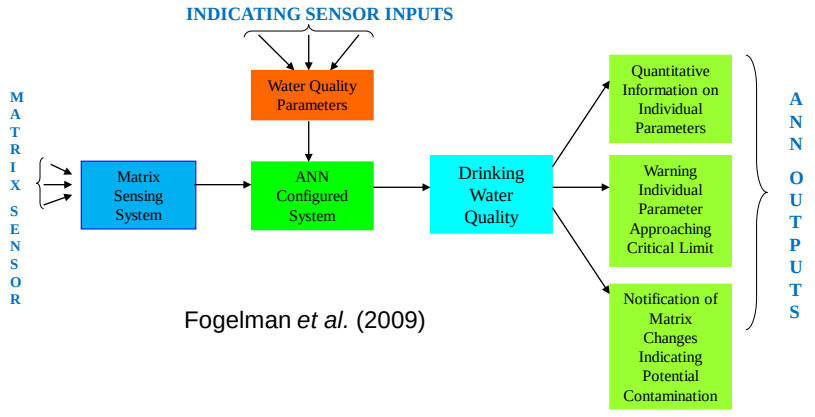
New Analytical Method for Continuous Water Monitoring Applications



Fogelman *et al.* (2009)

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Results

	Standard Methods	Commercial On-line Methods	Environmental Configuration Method
Continuous, real-time Measurements	✗	✓ (online) / ✗ (inaccurate)	✓
No Daily Calibration	✗	✗	✓
No Reagent / Maintenance Free	✗	✗	✓
Matrix Independent	✗	✗	✓
Zero Secondary Pollution	✗	✗	✓
Operational Costs	✓ (grab sample) / ✗ (continuous)	✓ (small scale) / ✗ (large scale)	✓

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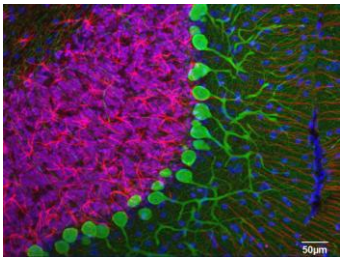
Biological neuron classification

- Neural networks and pattern recognition for classifying types of biological neurons



Cerebellar neurons and astrocytes

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Medical applications

Gold Coast Bulletin

03/04/09

Hi-tech hope in brain cell disease fight

by Matthew Killoran
technology reporter

GROUNDBREAKING Gold Coast research could help scientists to prevent and treat diseases such as Parkinson's and Alzheimer's.

The eye of the international scientific community has been drawn to the Griffith University School of Information and Communication Technology, which has developed a computer program that identifies neurons, or brain cells, with greater accuracy than human experts are able to determine.

Associate Professor Michael Blumenstein said he and other researchers had been invited to publish and present their work at the respected International Joint Conference on Neural Networks, which will be held in the United States in June.

Professor Blumenstein said that about two years ago the National Centre for Adult Stem Cell Research asked the school to work with them in developing the program.

The end result was School of Information and Communication Technology honours and masters students training a 'learning computer' to identify three different types of brain cells by their size, shape and structure.

While there are hundreds of different types of neural cells, Professor Blumenstein said the three the computer could identify were related to the onset of motor neuron diseases such as Parkinson's and Alzheimer's.

He said the computer program was able to identify the cells with 91 per cent accuracy, compared to human experts' success rate of 73 per cent.

"In my opinion, this is the first step in the holy grail of this research," he said. "We want to use this technology to look at the degeneration of neural cells in the brain.

"The idea is to track the degeneration over time to see if there's a pattern to how these cells degrade."

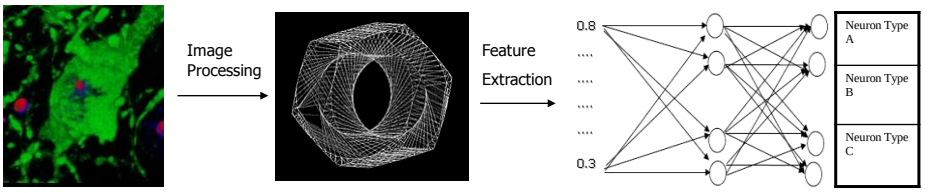
He said it would be about two to five years before this "holy grail" was reached.

"The overall goal is prevention and treatment, but our goal is to create the technology to make those things happen," he said.

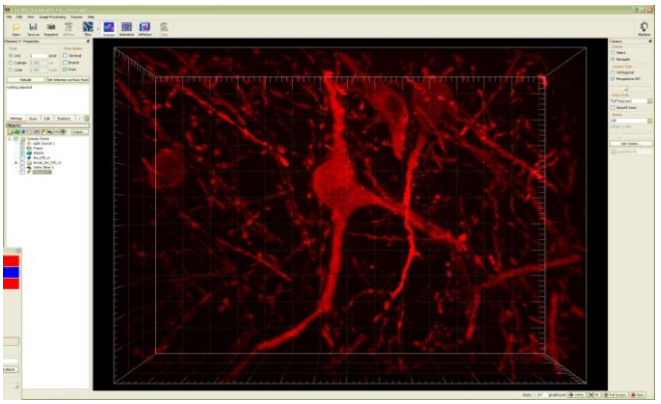
Practical applications for humans are still years away.

Classification process

- Neural network and pattern recognition procedures to extract features from patterns
- Developing a technique to extract information from a 3D image of a biological neuron
- Categorization of neurons based on morphological features



Processing neural images



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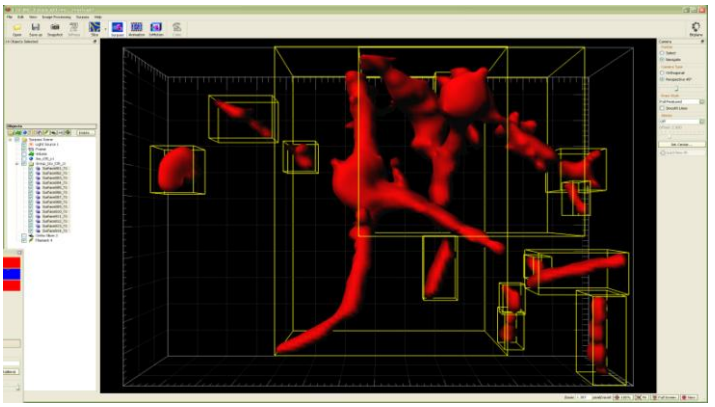
Isolating neural components



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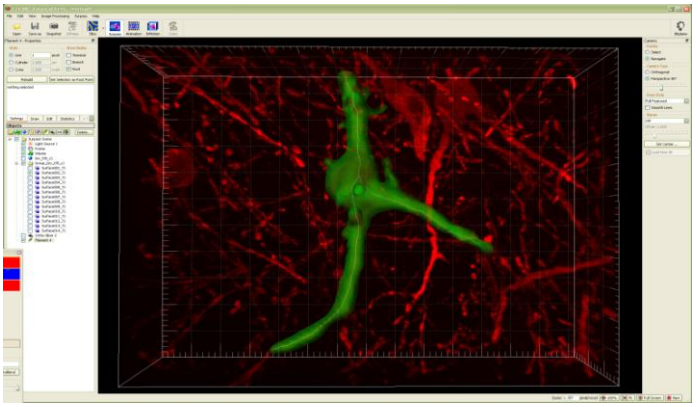
Segmenting neurons



Some recent results

- Artificial neural networks are used to classify different biological neurons
- 91% accuracy has been achieved
  - As compared to 72% achieved by human expert
  - Research presented at the International Joint Conference on Neural Networks (IJCNN 2009) in June.

Future issues for consideration

- Health informatics and telemedicine
  - Synergy with Gold Coast University Hospital
- The need for transferring/sharing large volumes of medical data e.g. 3D imagery
- Taking advantage of the NBN rollout

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Computer-based Bridge Management Systems

- Supported by Queensland Transport and Main Roads and the Gold Coast City Council:
  - The research aids in decision-making using AI techniques that assures the long-term health of large bridge networks
  - Assists in predicting the best possible maintenance strategy that ensures an adequate level of safety at the lowest possible cost

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The Australian – *01/07/08*

Electronic path to bridge safety

Artificial intelligence will monitor and manage 10,000 Queensland bridges

Jennifer Foreshew

AUSTRALIAN researchers are developing a bridge management system that incorporates an "electronic brain" to predict the safety of 10,000 bridges across Queensland.

The artificial intelligence techniques will predict long-term performance of individual bridges and entire bridge networks.

Griffith University School of Information and Communication Technology head Michael Blumenstein said the technology would be rolled out to 10,000 bridges across Queensland to improve maintenance strategies and minimise costs.

"We are trying to incorporate new technology into a bridge management system for the purpose of assisting predictions of bridge deterioration, inspection and maintenance," Dr Blumenstein said.

National statistics indicate that bridge maintenance expenditure in 2004-05 jumped to $521 million, up 27 per cent from 2002-03.

Dr Blumenstein said the technology could result in a saving of between 10 per cent and 20 per cent on bridge maintenance expenditure.

The project has recently been awarded about $420,000 over three years from the Australian Research Council.

It has also received $300,000 from the Queensland Department of Main Roads and the Gold Coast City Council.

Dr Blumenstein is a chief investigator on the project, which includes Professor Yew-Chaye Loo and Dr Hong Guan from Griffith School of Engineering, and recent engineering PhD graduate Dr Jacbo Lee.

He said the goal of the project was to develop a bridge management system that used an electronic brain, called an artificial neural network, to learn from the historical performance of a bridge and predict future problems.

The technology could even reconstruct the past by generating missing historical performance data on older bridges, he said.

"We are taking data that is available from inspection records and we are using that to back-predict and fill in the gaps to produce a larger historical record so we can predict future deterioration issues for bridges in Queensland," Dr Blumenstein said.

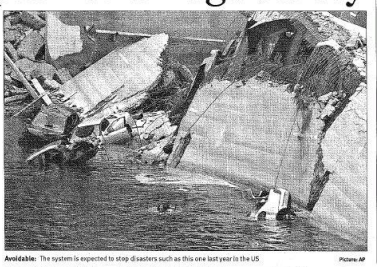
The computational system would be used in conjunction with routine inspections and would be able to generate data to fill in the large missing gaps between inspections.

The aim would be to input variables such as bridge location, construction and material type, climatic conditions or traffic volume to predict the structural conditions of bridge elements, Dr Blumenstein said.

The team has already performed successful trials of the technology using data obtained from offshore sources, particularly the Maryland Department of Transport in the US.

"The ultimate goal is to have a working system that will be tested on all Queensland Department of Main Roads data and all Gold Coast City Council data to be available for deployment in three years," Dr Blumenstein said.

"While all this is going on, we would look for other partners nationally and then internationally."



Available: The system is expected to stop disasters such as this one last year in the US. Picture: AP

INSIDE THE

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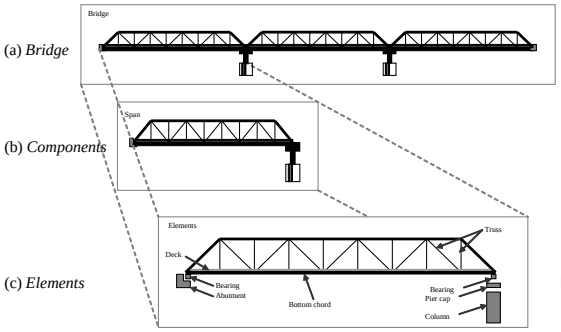
Data collection (manual)

- Element level bridge inspection (Level 2 Inspection)
  - Most common quantitative data collection method for bridge asset management practice



- ✓ The bridge-element condition ratings from 1 (Excellent) to 4 (Poor) in ascending order of condition states (CSs).
- ✓ Uniform condition assessment of bridge elements.

Definitions in PONTIS (Milligan et al., 2004)

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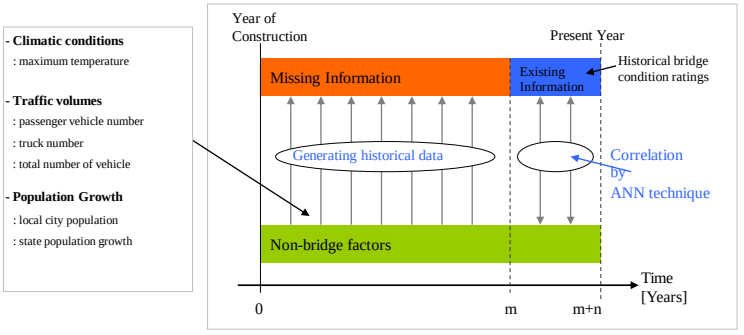
Backward Prediction Model (BPM)

- Based on Artificial Intelligence techniques (ANNs);
- Establishing comprehensive condition rating database using very limited datasets;
- Improving the accuracy of deterioration module (which in turn improves reliability of all BMS outcomes)



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Future of automated bridge management?

- Sensors monitoring bridge 'health' in real-time instead of manual data collection
- Processing of data received from the entire bridge network
- Speed and storage issues?

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Other AI and Pattern Recognition applications

- Automated Document Analysis
  - Cursive handwriting segmentation
  - Off-line cursive character recognition
  - Signature Verification
    - Biometrics and security

Clever computers and thinking machines

- What is missing?
  - Demonstration of competency in a variety of areas
  - Learning from experience and formulating new concepts
  - Context and background knowledge
  - An excellent command of a human language

The future of Artificial Intelligence

- Intelligent systems and Robots that can interact with their environment to gather information for themselves
- Digital/flesh hybrids - Cyborg implants
- Full-scale ‘brains’ represented in software and microchips
- Creative computers

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End

Thank you for your attention.

Questions?

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