KE4102: Intelligent Systems & Techniques for Business Analytics: Course Introduction

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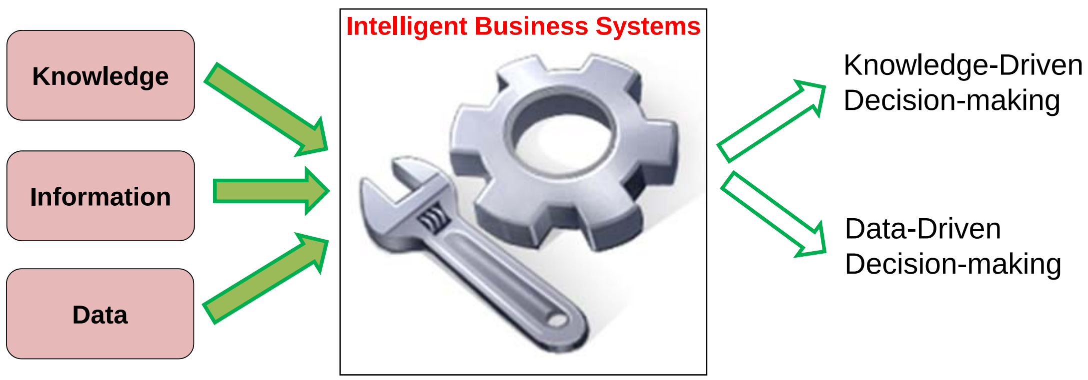
Knowledge Engineering (KE)

- The design and development of **Intelligent Business Systems** – used to drive and **enhance decision-making.**
- Systems that **crunch Knowledge, Information and Data** to solve complex business problems.



Course Objective

- To introduce **Intelligent Systems** and its application for solving business problems
- To introduce and discuss statistical and **machine learning** techniques that are commonly used in data analytics tools and applications
- To develop practical knowledge and skills in Machine Learning techniques and competencies in designing and developing of **Rule-based systems**

Course outline

Summer School	Normal Classes
Day-1: Introduction to Intelligent Systems & Business Analytics	**Day-6:** Machine Learning I
Day-2: Rule Based Systems	**Day-7:** Machine Learning II
Day-3: Search Techniques & Algorithms	**Day-8:** Discovering Knowledge from Data
Day-4: Representation & Reasoning	**Day-9:** ML Modeling and Performance
Day-5: Uncertainty in RBS, Bayesian Nets	**Day-10:** CA Project Presentation Summary

KE4102 Assessment Format

- **Continuous Assessment (Project) 1 40%**
  - team project of 5 or 6 students
  - build a working prototype Intelligent System
  - Due on last day of class: 5th & 10th March (FT & PT)
- **Continuous Assessment (Homework) 2 10%**
  - Individual work using machine learning algorithms
  - Due on last day of class: TBC
- **Final Examination 50%**
  - 3 hours written exam
  - open book
  - 18th Jun 2018 (Monday) 6:30-10:00PM at the NUS-SRC
  - passing mark is 40%

Office Hours

- No specific office hours for student consultation
- Best time to catch me:
  - during lunch/coffee breaks
  - Just before/after class
  - set up a specific date and time
- I find emails are the best way to communicate
  - charlespang@nus.edu.sg
- Don't leave voice mails on my answering machine
  - I haven't figured out how to retrieve my voicemail!
  - Did 6516-8168

Master of Technology in Knowledge Engineering

KE4102: Intelligent Systems & Techniques for Business Analytics: Introduction to Intelligent Systems

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Outline

- What is Artificial Intelligence?
  – History of AI
  – Intelligent Systems
  – Notable Early IS
  – AI is everywhere
- What is Knowledge?
  – Data, Information and Knowledge
- Types of Intelligent Systems
  – Case-based Reasoning
  – Neural Networks
  – Genetic Algorithms
  – Fuzzy-Logic Systems
- Workshop- IS

AI in the recent news …

1-6 January 2017

Japanese company replaces white-collar jobs with AI

NHS trials artificial intelligence app as alternative to 111 helpline

Secret Test of Google AI Bot Stops Top Go Players

Xiaomi Mi TV 4 is 4.9mm thick and has AI content suggestions

Nissan will use artificial intelligence tech from NASA to drive cars

PIQ Sport Intelligence, Everlast Team Up To Bring Artificial Intelligence To Boxing

Toyota's Concept-i car humanizes A.I.

AI Definition (Russell & Norvig)

Systems that *THINK like HUMANS*	Systems that *THINK RATIONALLY*
Systems that *ACT like HUMANS*	Systems that *ACT RATIONALLY*

Horizontal Dimension:

- Top: *thought processes & reasoning*
- Bottom: *behavior*

Vertical Dimension:

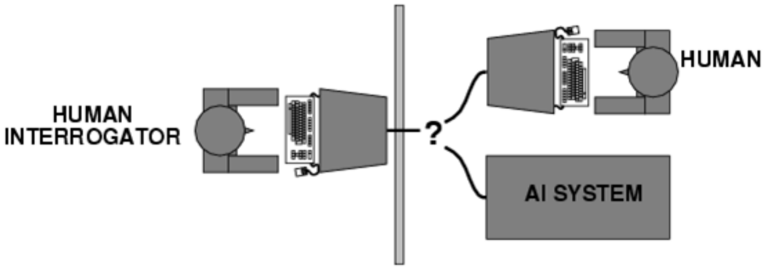
- Left: *success is compared against Human performance*
- Right: *success is based on ideal concept of intelligence or Rationality*

Think Like Humans?

- Requires an understanding of how the human mind works – the focus of cognitive science!
- Or we an approximate how the mind works by observing experts in solving problems – that is what the General Problem Solver (Simon, Shaw & Newell, 1959) computer program did.
- GPS uses means-ends analysis.
- STRIPS (A robot Planner) is an advanced problem solver that incorporates means-ends analysis

Act Like Humans?

- Requires mimicking human (intelligent) behavior
- I.e. a computer program must be able to fool an interrogator into believing that it is a human
- Alan Turing (1950), proposed this test:



- ELIZA (Weizenbaum, 1966)
- Chatbots

ELIZA transcript

ELIZA transcript from Communications of the ACM

Men are all alike.
IN WHAT WAY
They're always bugging us about something or other.
CAN YOU THINK OF A SPECIFIC EXAMPLE
Well, my boyfriend made me come here.
YOU BOYFRIEND MADE YOU COME HERE
He says I'm depressed much of the time.
I AM SORRY TO HEAR YOU ARE DEPRESSED
Its true. I am unhappy.
DO YOU THINK COMING HERE WILL HELP YOU NOT TO BE UNHAPPY
I need some help, that much seems certain.
WHAT WOULD IT MEAN TO YOU IF YOU GOT SOME HELP
Perhaps I could learn to get along with my mother.
TELL ME MORE ABOUT YOUR FAMILY

Think Rationally?

- Requires thinking logically (or the "right way")
- Aristotle was one of the first to codify "right thinking" or irrefutable reasoning process. His syllogism provided patterns for argument structures that gave correct conclusion given correct premises.
- Example: $(\forall x)(man(x) \rightarrow mortal(x))$;
  $man(Socrates) \rightarrow mortal(Socrates)$
- Computer program works by taking a description of the problem in logical notation and find the solution to the problem by applying rules of inference.
- Logic Theorist (Newell & Simon, 1956)

Act Rationally?

- Requires acting to achieve the best outcome
- Acting rationally means acting so as to achieve one's goals, given one's beliefs. In this approach, AI is viewed as the study and construction of rational agents.
- Rational Agents act to achieve the best outcome, or when there is uncertainty involved, the best expected outcome.
- Almost all practical AI systems fall into this category

Summary

"The exciting new effort to make computers think ... *machines with minds*, in the full and literal sense" (Haugeland, 1985) "The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (Bellman, 1978)	"The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)
"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990) "The branch of computer science that is concerned with the automation of intelligent behaviour" (Luger and Stubblefield, 1993)

Conclusion (Russell & Norvig)

- The study of AI as **rational agent** design therefore has two advantages
  – it is more general than the ``laws of thought'' approach, because correct inference is only a useful mechanism for achieving rationality, and not a necessary one.
  – it is more amenable to scientific development than approaches based on human behavior or human thought, because the standard of rationality is clearly defined and completely general.

Study of Artificial Intelligence

- AI has its foundations based on contributions from the various disciplines, including:
  – **Philosophy** (foundations of learning, language, reasoning)
  – **Mathematics** (computation, Logic, probability)
  – **Psychology** (cognition & human behaviour)
  – **Neuroscience** (neurons, pattern recognition)
  – **Linguistics** (understanding language, grammar)
  – **Economics** (productivity & profits)
  – **Computer engineering** (processing power)

Brief History of AI (< 1950)

- 1943: Warren S. McCulloch (neuroscientist) and Walter Pitts (logician) proposed a simplified model of a neuron or basic brain cell. Each neuron can be on/off and responds to stimulation by neighbouring neurons (i.e. a Network of neurons). Hence it can compute any computable function using logical connectives. *"A Logical Calculus of the Ideas Immanent in Nervous Activity"-Bulletin of Mathematical Biophysics*
- 1950: Alan Turing published his landmark seminal paper "*Computing Machinery and Intelligence*" [MIND '50]. He began with "Can machines think?" and then argued for the possibility of building intelligent computing systems. He also proposed the "Imitation Game" (now commonly known as Turing Test) as a test to measure if machines can be intelligent.

Brief History of AI (the Birth)

- The 1956 Dartmouth Conference organised by John McCarthy, Marvin Minski, Claude Shannon and Nathaniel Rochester to discuss automata theory, neural networks and study of Intelligence.
- Alan Newell and Herbert Simon presented their *Logic Theorist* - the first AI program to mimic to human problem solving skill. Able to prove theorems from Betrand Russell's *Principia Mathematica.*
- John McCarthy coined the term *"Artificial Intelligence"* for this new field of research.

Brief History of AI (The rise)

- Major AI Centres : Carnegie Mellon, MIT, Stanford and IBM
- Checkers program (Samuel 1952)
  - Program can play a better game than its creator!
- *General Problem Solver* (Newell, Simon, Shaw, 1957)
  - Comes very close to the way (considering sub-goals and possible actions) in which humans approach and solve the same problems
- *LISP* was developed at MIT (McCarthy, 1958)
- ELIZA (Weinzenbaum, 1965) – a Psychotherapist
- *PROLOG* - programmation en logique (1973)
- New Ideas in Knowledge representation, learning algorithms, neural computing, etc.

Brief History of AI (The reality)

- From mid-1950s, AI researchers were making huge promises
  - to build *all-purpose* intelligent machines on a human-scale knowledge base by the 1980s, and
  - to exceed human intelligence by the year 2000
- However, by 1970, they realized that such claims were too optimistic
  - Only a few AI programs could demonstrate some level of machine intelligence in mainly toy problems
  - Almost no AI project could deal with a wider selection of tasks, or more difficult real-world problems

The Impact of Reality

- Many problems were too broad and too difficult
  - General methods employed would never work
- Realized that the problem domain had to be sufficiently restricted
  - The only way to deliver practical results is to solve typical problems in narrow areas of expertise
- This gave rise to a new breed of Artificial Intelligent Systems known as **Expert Systems**

Notable Early Expert Systems

- **DENDRAL** (Stanford, '65) - automated the decision-making process and problem-solving behaviour of organic chemists (Wikipedia); Commercialized
- **MYCIN** (Stanford, '72) - identify bacteria causing severe infections, such as bacteremia and meningitis, and to recommend antibiotics, with the dosage adjusted for patient's body weight (Wikipedia)
- **XCON** (DEC, '80) - assist in the ordering of DEC's VAX computer systems by automatically selecting the computer system components based on the customer's requirements (Wikipedia); First Commercial expert system
- **PROSPECTOR** (SRI, '79) – consultation system to assist geologists working in mineral exploration; represents the knowledge and reasoning processes of experts in the geological domain
- **DELTA** (General Electric, '84)- troubleshooting (multiple problems) and suggest repair procedures of diesel electric locomotives in railroad running repair shops

Early Expert Systems

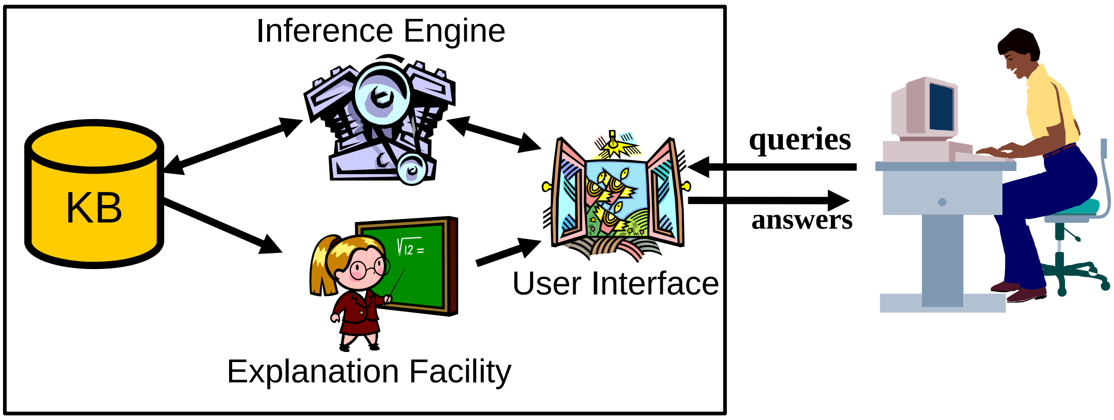
- These applications proved that AI could move successfully from the research laboratory to the commercial environment
- Problem-solving is efficient and successful if it is restricted to specific domains
- Specialized tools were needed - AI languages such as LISP and PROLOG) which needed expensive hardware

How an Expert System works

- Expert Systems are designed to solve problems by applying ***inference*** operations to a specially constructed ***knowledge base.***
- The Knowledge base (KB) is a set of domain-specific expert rules elicited from subject matter experts.
- Expert Systems are also known as **Knowledge-based System** (KBS).
- Expert System typically starts by receiving some input about the problem; it then runs an inference process; and finally output a relevant solution

Basic Architecture of an Expert System

- The four basic components are
  - The Knowledge Base (KB)
  - The Inference Engine
  - User Interface
  - Explanation Facility

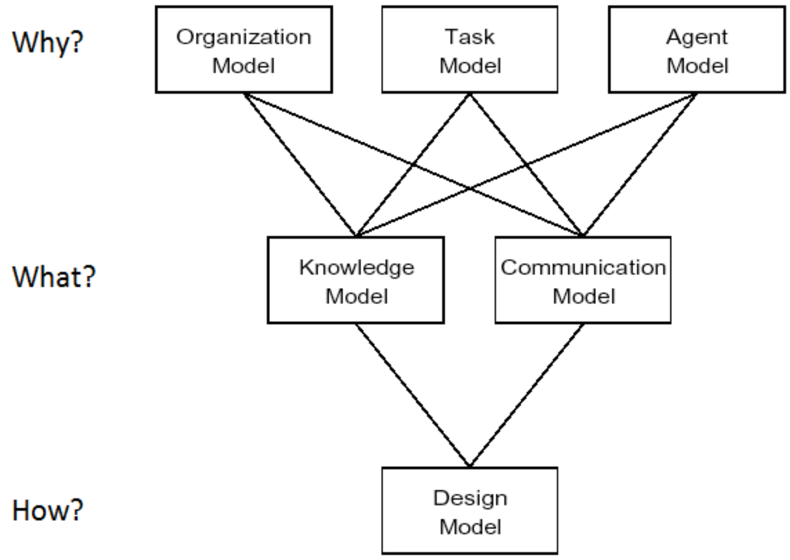


How are Expert Systems built?

- Expert systems are build using a process called "**Knowledge Engineering**"
- Knowledge Engineering involves the following major steps:-
  - Problem Assessment
  - Knowledge Acquisition
  - Knowledge Modeling
  - Task Modeling
  - Design Modeling
  - Development
- The Expert System developer is known as a "Knowledge Engineer"

Commonkads Methodology

Knowledge Acquisition and Documentation Structuring (KADS)



What is Knowledge?

- A highly abstract concept
  - Can be defined as (oxforddictionaries.com)
    - facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject
  - More specifically …
    - It is having actual experience with
      - languages, concepts, procedures, rules, ideas, abstractions, places, customs, facts, and associations
    - and also coupled with an ability to
      - use these experience effectively in modeling different aspects of the world

☝ *the use of knowledge is an important kind of knowledge*

Wisdom Quote

"No one who really has knowledge fails to practice it. Knowledge without practice should be interpreted as lack of knowledge."

"Knowledge is the beginning of practice; doing is the completion of knowing "

Wang Zang-Ming (王陽明), 1472-1529

(Chinese general/philosopher during the Ming Dynasty)

http://www.humanistictexts.org/wang.htm

Knowledge and Intelligent Systems

- Knowledge is the key component of Intelligent Systems
  - Intelligent behavior is determined not only by the reasoning and processing mechanisms but also the *knowledge* that it possesses
- **Knowledge Acquisition** is the way to obtain knowledge for building Intelligent Systems
  - eliciting knowledge from subject matter experts
  - Inducing knowledge from past cases
  - knowledge representation & modeling

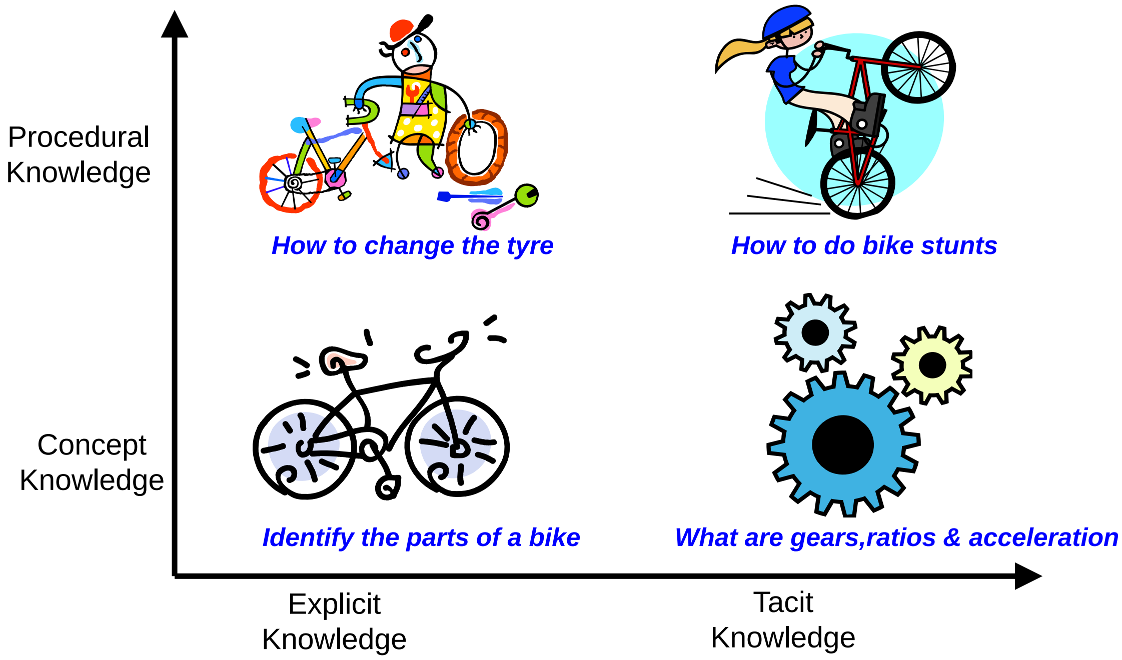
Knowledge and Inference

- Knowledge:
  - Tequila is a strong alcohol
  - If you have drunk more than two glasses of a strong alcohol then do not drive
- Data:
  - I have drunk four glasses Tequila
- Inference:
  - The ability to generate the advice
    "I should not drive"

Types and Forms of Knowledge

- The difference between types and forms of knowledge can be found in several ways:
  - ***Declarative*** knowledge is passive knowledge expressed as statements of facts about the world
    - "What is" knowledge, Explicit, Classification-oriented
  - ***Procedural*** knowledge is compiled knowledge related to the performance of some task
    - "How to" knowledge, Implicit, Task-Oriented
  - ***Explicit*** knowledge is knowledge that can be easily expressed
    - "Externalized", expressed by language, written, documented
  - ***Tacit*** knowledge is accumulated through experience
    - "Internalized", unexpressed by language

Types and Forms of Knowledge (cont.)



Domain Knowledge

- Knowledge that is used to solve a specific problem is referred to as ***Domain knowledge***
- Domain knowledge can have different levels of abstraction:
  – ***Shallow*** knowledge is the heuristic, experiential and is learned after solving a large number of problems in that domain
    - e.g. *Coffee makes me more productive*
  – ***Deep*** knowledge refers to the basic laws of nature and the fundamental structure and behavioral principles of that domain which cannot be altered
    - e.g. *Coffee contains caffeine which is a stimulant*

Types of Domain Knowledge

- When designing Intelligent Systems, it is useful to distinguish the following types of knowledge:
  - ***Rules*** are used to represent more deterministic and abstract knowledge, by certain relationship between the antecedent and the consequent
  - ***Cases*** are useful to describe knowledge gained from previous experience, which will tell us the appearance of related factors without us knowing clearly which is the cause and which is the effect.
  - ***Patterns*** (compared with rules and cases) are usually used to store less abstract and sometimes less complete knowledge

☝ *the difference between types of knowledge may not always be absolute*

Data, Information and Knowledge

- **Data**, **information** and **knowledge** are often used interchangeably and causing confusion when developing Intelligent Systems or performing Business Analytics
- Data and Information are commonly associated with Business Intelligence (BI) & Analytics (BA), whereas Knowledge is usually associated with Intelligent Systems (IS) and Knowledge-Engineering (KE)
- In practice, intelligent systems (e.g. smart nation applications) makes complete use of data and knowledge.

What is Data?

- Data comprises of facts, observations, or perceptions
- Data refers to collection of raw numbers; results of measurements
- Data is the lowest level of abstraction - devoid of context, meaning or intent
- Can be easily captured, stored and communicated
- Example:
  – Customer data collected by transaction systems
  – Diaper sales = $1 million; Beer Sales = $5 million

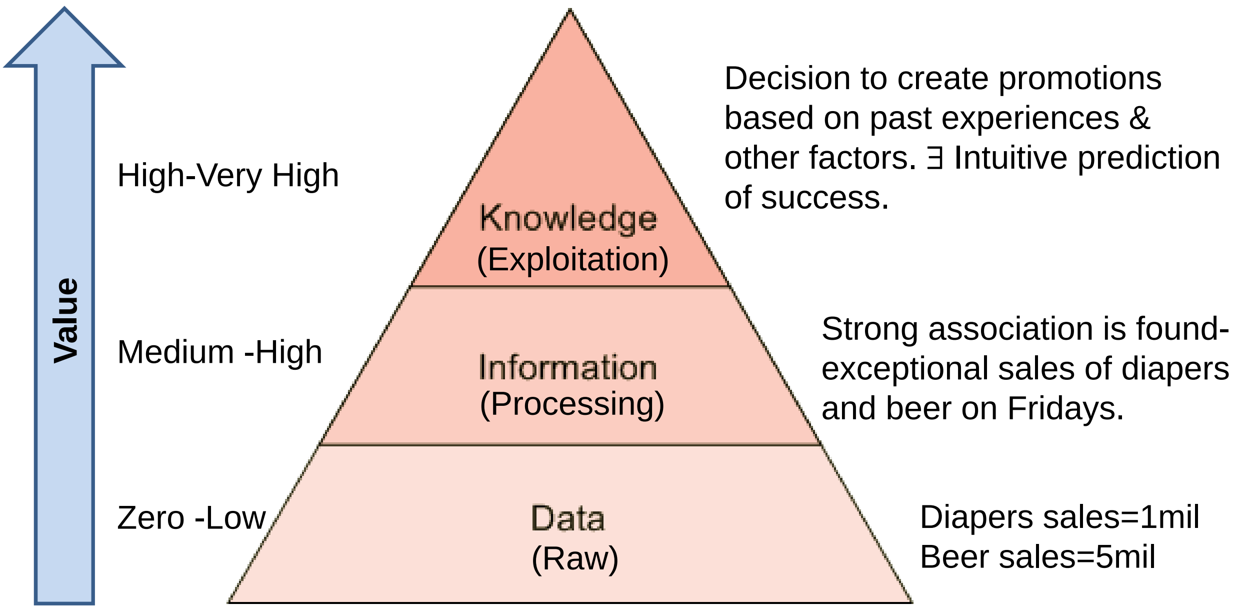
What is Information?

- Information is distilled from raw data (i.e. *processed* data) – incorporating context and relevance
- Information involves manipulation of raw data – e.g. data mining.
- Example:
  – Average amount spent by Customer-X on Product-Y during Month-Z
  – Spike of Diaper and Beer sales on Friday. Males aged 25-30yrs spent $25 more on Diapers & Beer on Fridays compared to other days of the week.

What is Knowledge?

- A justified true belief (Nonaka and Takeuchi)
- Knowledge is exploitation of information for making decisions
- Knowledge is at the highest level in the hierarchy and is the deepest & most valuable of the three
- Knowledge drives decision-making
- Example:
  – since there is a strong association between baby diapers and beer, we should create a diaper-beer Gift-Pack and distribute coupons to young parents.

DIK Pyramid



☝ *the boundary of DIK is not always crisp*

Types of Intelligent Systems

- Early Expert Systems were **Rule-based Systems**
  – Used human knowledge and expertise in the form of specific rules
  – Clear separation of the knowledge and the reasoning mechanism
- Expert Systems had limitations:
  – Difficult to build due to knowledge acquisition bottlenecks
  – Unable to learn from experience
  – Limited ability to handle uncertainty
- Other Intelligent Systems paradigm were introduced

Other types of Intelligent Systems

- Other problem-solving paradigms :-
  – Case-based reasoning (CBR)
  – Artificial Neural-networks (NN)
  – Genetic Algorithms (GA)
  – Fuzzy-logic (FS)
- Re-emergence of statistical & mathematical techniques under the umbrella of Business Analytics
  – Data Mining
  – Machine Learning

Case-Based Reasoning

- Case-Based Reasoning (Roger Schank, Yale U., 1980s)
  - Methodology for solving problems by utilizing previous experiences
  - An alternative to rule-based systems in many situations
  - Relief of the knowledge acquisition bottleneck
  - More tolerant to incomplete, imprecise and inconsistent knowledge by allowing partial matching (similarity) in reasoning
- Applications:
  - Helpdesk – Microsoft, GE, HP
  - Configuration – Lockheed Autoclave
  - Diagnosis – British Airways, GE
  - Medical – disease recurrence prediction

Artificial Neural Networks

- Neural Networks (Frank Rosenblatt, 1958)
  - Methodology for solving problems based on pattern recognition
  - In some knowledge-poor situations, ANNs can be trained to solve problems
  - Able to approximate complex non-linear decision surfaces
  - Human experts cannot always express their reasoning
  - Tolerance to incomplete, missing or noisy data
- Applications:
  - Credit-worthiness: JPMorganChase
  - Diagnosis-Prediction: Aston Martin
  - Datamining: Predictive modeling

Genetic Algorithms

- Genetic Algorithms (Holland, 1975)
  - A methodology for solving problems based on generate-and-test
  - Works by simulating a population of individuals, evaluating their performance, generating a new population, and repeating the process a number of time – search for optimization
  - Problems are represented as genes and chromosomes
- Applications:
  - Criminal Identification – NMSU
  - Aircraft Design – GE, Boeing
  - Spacecraft antenna design (NASA)

Fuzzy Logic

- Fuzzy Logic– (Zadeh, 1965)
  - A method to encode and apply human knowledge because of the many imprecision in problem-solving
  - non-probability based technique (based on fuzzy-set theory)
  - use of *fuzzy values* to capture imprecise meanings
- Applications:
  - Train operations – Sendai Line
  - Quay Crane control – PSA
  - Intelligent appliances – fridge, washing machine, camera

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Artificial Intelligent Today

- AI had gone from a high-expectation (1960's) to a low-disappointment (1970's) but is now hot (2014) with huge expectations. The core technologies and engines remain similar. So what has changed?
  - Availability of huge volumes of data
  - Increased processing speed
  - Opportunity
- AI Systems most talked about:
  - IBM Watson
  - Google Deep Learning
  - Apple SIRI
  - Self driving cars
  - Facebook face recognition

IS Developed by KE Students

- Insurance Quote Comparison (Local Insurer)
- Regulatory Knowledge Based System (Sennheiser)
- Storm water drainage design (Jurong Consultant)
- Prediction of Colorectal cancer recurrence (TTSH)
- Prediction of Duodenal re-bleeding (TTSH)
- Wafer Diagnostics Pattern Failure (GlobalFoundries)
- Weather forecasting system (MINDEF & NEA)
- Career Management system (Singapore Navy)
- Intelligent Online Grocery Store (supermarket)
- Project Progress Forecasting (Rig builder)
- Hand Gesture Recognition Using Machine Learning Techniques (Astar)
- Side Face Feature Detector (Astar)

In-class Exercise & Discussion

Find an application example of intelligent system (by online search), and make a summary for the case study

- Team work with 2-3 persons
- Search using keywords: artificial intelligence, case-based reasoning, fuzzy systems, etc.
- You will be required to make presentation in the class
- Use the Powerpoint template provided

Homework

Last

- The State of Artificial Intelligence:
  - https://www.youtube.com/watch?v=VBceREwF7SA
- 5 Predictions for Artificial Intelligence in 2017
  - https://www.technologyreview.com/s/603216/5-big-predictions-for-artificial-intelligence-in-2017/
- 6 Ways AI Will Evolve In 2017 (And How Business Owners Should Prepare)
  - http://www.forbes.com/sites/jaysondemers/2017/01/05/6-ways-ai-will-evolve-in-2017-and-how-business-owners-should-prepare/#64c44158502d