Introduction to Artificial Intelligence

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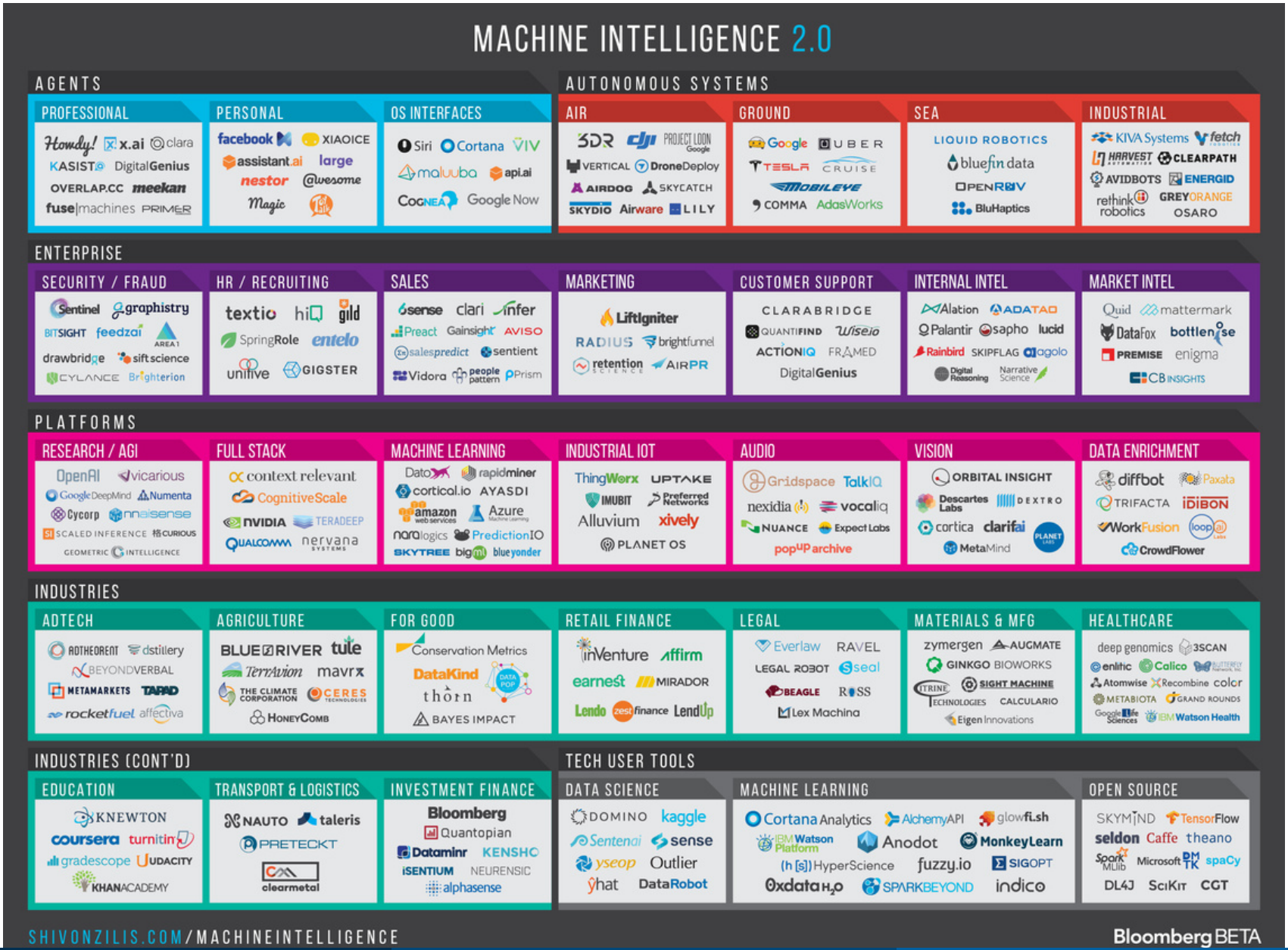
Overview

AI in Practice



Objectives

- Describe artificial intelligence (AI)
- Identify the characteristics, structure, benefits,and limitations of AI and Expert Systems
- Discuss the business value of AI technologies

Why study Artificial Intelligence?

Difficult problems facing us in the information age (the work place is quite different from the industrial age):

- So much information out there (think social media etc)
- Scarce corporate knowledge
- Too many problems requiring multidisciplinary efforts
- Operations in hazardous environments

What are the Challenges

Modern challenges require us to:

- Understand human intelligence (i.e. the brain):
  - Reasoning
  - Cognition
  - Creativity
- Mimic human intelligence through machines
  - Is this possible?
  - What are the ethical, technical, moral and philosophical challenges?
- Utilize the value of Big-Data (i.e. Data characterized by high volume,velocity, variety and veracity (in terms of uncertainty))
- Leverage the power of emerging technology into the business arena

What is Intelligence

Intelligence is:

- the capacity to learn and solve problems (Websters dictionary)

Main characteristics:

- Ability to:
  - think critically and creatively in problem solving
  - act rationally
  - communicate
  - learn
  - retrieve knowledge
  - goal-directed behaviour
  - self-awareness

Intelligence?

- Ability to interact with the real world
  - to perceive, understand, and act
  - e.g., speech recognition and understanding and synthesis
  - e.g., image understanding
  - e.g., ability to take actions, have an effect
- Reasoning and Planning
  - modeling the external world, given input
  - solving new problems, planning, and making decisions
  - ability to deal with unexpected problems, uncertainties
- Learning and Adaptation
  - we are continuously learning and adapting
  - our internal models are always being updated
    - e.g. a baby learning

What is AI?

Some definitions from various sources:

"a broad set of methods, algorithms and technologies that make software "smart" in a way that may seem human-like to an outside observer" - Lynne Parker: director of the division of information and intelligent systems for the National Science Foundation

"the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages" (simple Google Search)

What is AI?

Some definitions from various sources:

"Artificial intelligence (AI) is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans"

"AI is the part of computer science concerned with design of computer systems that exhibit human intelligence(From the Concise Oxford Dictionary)"

What is AI?

No clear definition (Or maybe, no agreed upon definition)

Artificial Intelligence = Machine Intelligence = Computational Intelligence

AI (or if you want MI/CI) is an umbrella term covering many technologies all geared towards:

- Studying the intelligent part concerned with humans
- Representing those actions using computers

The goals of AI therefore are:

- To make computers more useful by letting them take over dangerous or tedious tasks from human
- Understand principles of human intelligence

What is AI? (AIMA – Russell & Norvig)

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985)
"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998)
"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure: Some definitions of artificial intelligence, organized into four categories

Rationality

- Alternative approach to intelligence relies on the notion of rationality.
- Typically this is a precise mathematical notion of what it means to do the right thing in any particular circumstance.
- Provides a precise mechanism for analyzing and understanding the properties of this ideal behavior we are trying to achieve.
- A precise benchmark against which we can measure the behavior the systems we build.

Rationality

- Mathematical characterizations of rationality have come from diverse areas like logic (laws of thought) and economics (utility theory how best to act under uncertainty, game theory how self-interested agents interact).
- There is no universal agreement about which notion of rationality is best, but since these notions are precise we can study them and give exact characterizations of their properties, good and bad.
- We will focus on acting rationally

NOTE: Acting rationally has implications for thinking/reasoning

Computational Intelligence

AI

AI tries to understand and model intelligence as a computational process.

In terms of computation

Thus we try to construct systems whose computation achieves or approximates the desired notion of rationality

AI $\in$ CS

Other areas interested in the study of intelligence lie in other areas or study, e.g., cognitive science which focuses on human intelligence. Such areas are very related, but their central focus tends to be different

Foundations of Artificial Intelligence?

AI originates from computational sciences, however, it also encompasses many academic fields including:

- Philosophy : Logic, methods of reasoning, mind as physical system, foundations of learning, language, rationality.
- Mathematics: Formal representation and proof, algorithms, computation, (un)decidability, (in)tractability
- Probability/Statistics: modeling uncertainty, learning from data
- Economics: utility, decision theory, rational economic agents
- Neuroscience: neurons as information processing units.

Foundations of Artificial Intelligence?

- Psychology/Cognitive Science: how do people behave, perceive, process cognitive information, represent knowledge.
- Computer engineering: building fast computers
- Control theory: design systems that maximize an objective function over time
- Linguistics: knowledge representation, grammars
- Biology: nature inspired computing (evolutionary biology, neural networks, swarm intelligence

AI: Features

- Symbolic reasoning
- Problems that do not respond to algorithmic solutions
- Problem solving using inexact, missing, or poorly defined information
- Effort to capture and manipulate the significant qualitative features of a situation rather than relying on numerical methods
- Attempt to deal with issues of semantic meaning as well as syntactic form
- Solutions are neither exact or optimal, but are in some sense sufficient
- Large amounts of domain-specific knowledge in solving problems
- Use of meta-level knowledge to effect more sophisticated control of problem-solving strategies

AI: Application areas

- Forecasting: Inferring future occurrences from past observations (i.e. prediction for instance in Stock trade and foreign exchange)
- Diagnosis: Inferring malfunctions
- Design: Configuring objects under constraints
- Planning:Developing plans to achieve goals
- Monitoring: Comparing observations to plans
- Debugging: Prescribing remedies for malfunctions
- Repair: Executing a plan to administer a remedy
- Instruction: Diagnosing and correcting performance
- Control: Managing system behavior
- Optimization: Finding “best” solutions to problems

AI: Success

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- AI program proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- Proverb solves crossword puzzles better than most humans
- Robot driving: DARPA grand challenge 2003-2007
- 2006: face recognition software available in consumer cameras

State of AI Systems in Practice

- Speech synthesis, recognition and understanding
  - very useful for limited vocabulary applications
  - unconstrained speech understanding is still too hard
- Computer vision
  - works for constrained problems (hand-written zip-codes)
  - understanding real-world, natural scenes is still too hard
- Learning
  - adaptive systems are used in many applications: have their limits
- Planning and Reasoning
  - only works for constrained problems: e.g., chess
  - real-world is too complex for general systems
- In general:
  - many components of intelligent systems are "do-able"
  - Over-whelming number of interesting research problems in this domain

AI in Business

- AI continues to improve and evolve
- Scientists and engineers are pushing the limits of what is possible
- In business, there is a better understanding of the capabilities of intelligent systems
- It is important to know which types of problems are suited for humans, and which are suited for computers

Table: Human Intelligence vs. AI

	HI	AI
Use of variety of information	High	High
Ability to acquire large amounts of external information	Medium	High
Ability to solve rapid and complex calculations accurately	Low	High
Ability to disseminate information rapidly	Low	High
Ability to use sensors or senses	High	Medium
Creativity/imagination	High	Medium
Learn from experience	High	Medium
Adaptability	High	Medium
Sentience (capacity to feel, perceive/experience subjectively)	High	?

Table: Artificial Intelligence vs. Conventional Computing

	AI	CC
Processing	Include symbolic conceptualization	Primarily algorithmic
Input	Can be incomplete	Must be complete
Search approach	Rules and heuristics	Based on algorithms
Focus	Knowledge	Data, Information
Reasoning capability	Yes (possible)	No

AI: Current Technologies

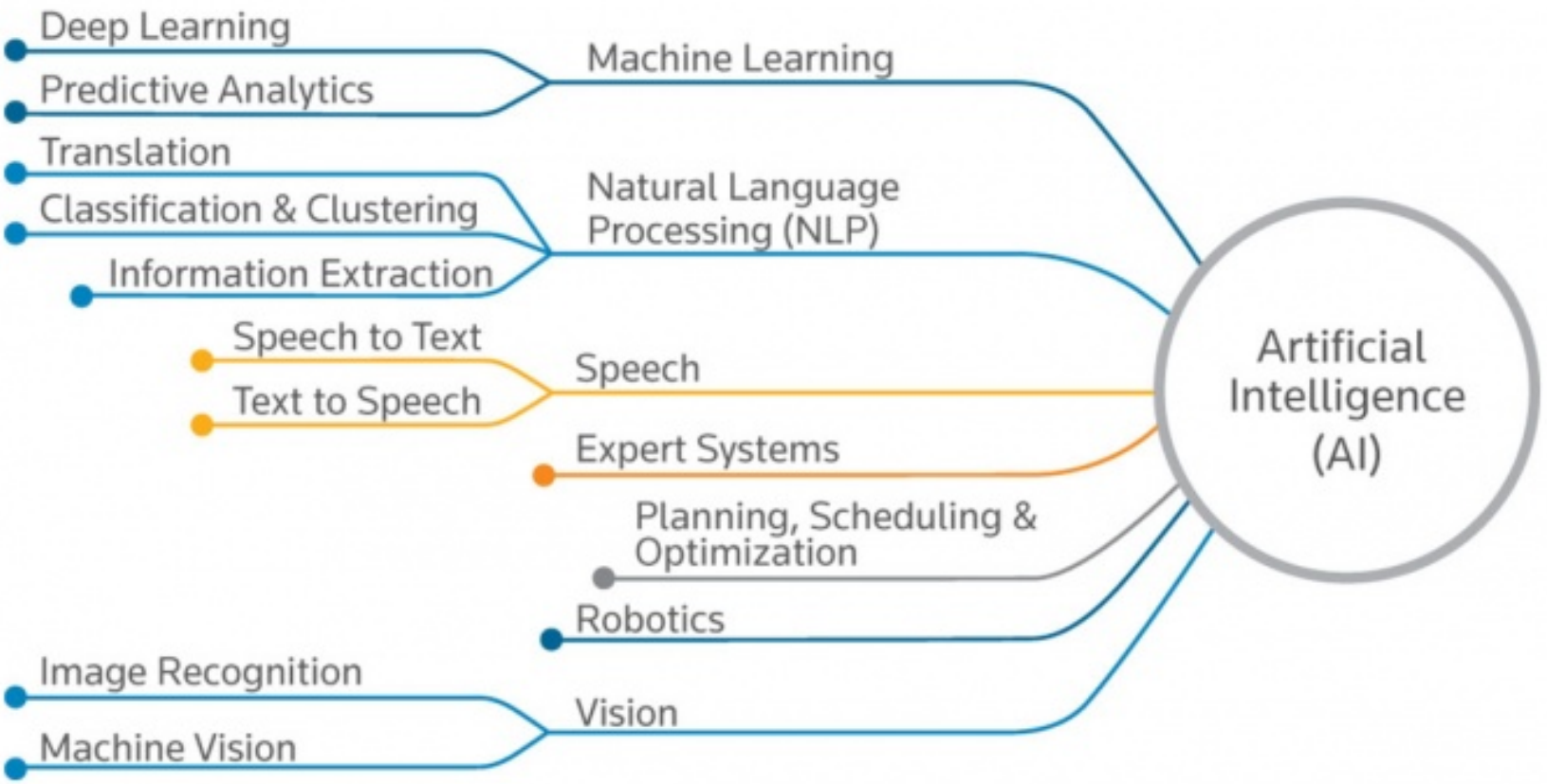


Figure: Artificial Intelligence technologies

AI: Current Technologies

- Expert Systems: Diagnose, respond and act like a human expert
- Robotics: Mimic physical human processes
- Natural-Language Processing: Mimic human communication
- Intelligent Tutorial Systems: Facilitate human learning
- Computer Vision: Mimic human sensory(visual) process
- Virtual Reality: Mimic human reality inside a computer
- Gaming: chess, go, Serious Games (Games targeted towards a skill acquirement)

AI: Current Technologies

- Machine learning: focuses on prediction, based on known properties learned from the training data (wikipedia).
  - Supervised learning: Uses a known set of input data and known outputs (of the data), and trains the model to generate predictions for the response to new data (Techniques: Regression trees, k-Nearest Neighbors, SVM for classification/regression, Regression Ensembles, ANN)
  - Unsupervised learning: Technique for finding hidden patterns in data (Techniques: k-Means, Gaussian mixture models, ANN (self-organising maps), Hidden Markov Models)
  - Reinforcement learning: Uses a reward feedback (reinforcement signal) to allow machine/software agents to automatically determine the ideal behaviour within a specific context, in order to maximise its (agents) performance. (Techniques: Markov decision processes etc)
- Data mining: focus is on discovery of unknown properties in the data

Decision Support

- Integrating the advantages of AI with Human Intelligence.
- More intelligent interfaces
- More intelligent processing for massive data

Information Retrieval

- Automatic simplification for massive data
- Natural language technology: computer can speak our language (think Google Now, Siri, Amazon Echo (Alexa)etc)

Virtual Reality

VR is an interactive, computer-generated, three-dimensional graphics, delivered to the user through a head-mounted display

- Medicine: Better training environment for doctors, surgeons etc
- Manufacturing: Worker training, design testing and virtual prototyping, Simulation of assemble, production and maintenance
- Transportation: Virtual aircraft mock-ups, new-car design and testing for virtual accidents
- Finance: View stock prices and characteristics
- Architecture: Display of buildings and other structures
- Military: Training and battlefield simulation
- Marketing: Electronic shopping, store and product display

Robotics

- Bringing the precision and speed of computers into the physical world
- Goes beyond manufacturing and assembly lines to baggage inspection, bomb removal, replacement limbs.

AI company in SA: dataProphet

Figure: data Prophet

- Uses machine learning tools to develop bespoke actionable AI solutions
- It is based in Capetown
- Visit: www.dataprophet.com

Products

- Agent Lead Matching Algorithm (ALMA): ALMA learns how each agent interacts with each different lead from historical data. Once ALMA has been trained, it will then understand for each individual agent, what type of lead they excel at selling to, as well as how good each agent is at selling
- Priority Lead Identification Algorithm (PLIA): learns the relationship between leads and sales based on historical data. Once PLIA has been trained, it understands with a high degree accuracy exactly which factors influence sales and how those factors interact

Expert Systems

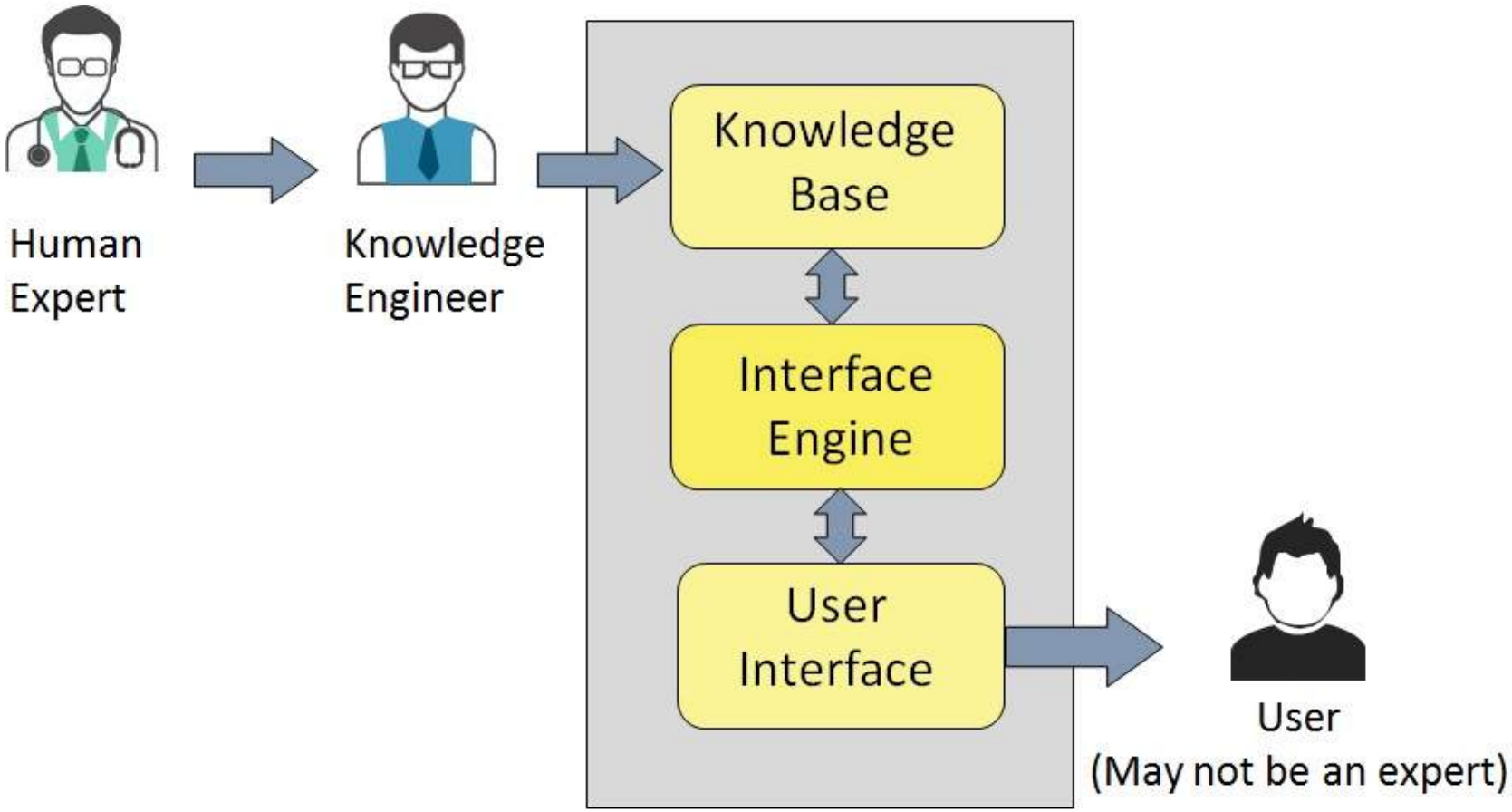


Figure: Expert Systems

Goal of ES

- The idea is to inject expert knowledge in to a computer system.
- The primary purpose is to automate decision making.
- The decision environments have structure
- The alternatives and goals are often established in advance.

Table: Expert Systems Vs Decision Support Systems

Expert Systems	Decision Support Systems
Inject expert knowledge in to a computer system	Extract or gain knowledge from a computer system
Automate decision making	Facilitates decision making
The decision environments have structure	Unstructured environment
The alternatives and goals are often established in advance.	Alternatives may not be fully realized yet
The expert system can eventually replace the human decision maker.	Use goals and the system data to establish alternatives and outcomes, so a good decision can be made

ES: Application domains

- Financial decision making
- Information management and retrieval (Knowledge publishing)
- Process monitoring and control
- Help desks and assistances
- Employee performance evaluations
- Virus detection
- Planning and scheduling

Components of an ES

- Knowledge acquisition/base (facts)
- Knowledge representation ("if", ..., "then")
- Inference Engine (or a synthesiser - controls how the conditional rules are applied towards facts)
- Language understanding

Knowledge Base

- Contains the systems knowledge
- Expert systems are also known as knowledge-based systems

Knowledge representation

- Knowledge is represented in a computer in form of rules (production rules)
- Conditional IF statements
- Chaining of IF-THEN rules forms the line of reasoning: two forms exists:
  - Forward Chaining: Facts driven
  - Backward Chaining: Goal driven

Inference engine

- Derives answers from the knowledge base
- It is the "Brain" of the expert system: i.e.provides methodology for:
  - Reasoning about the information in the knowledge base
  - Formulating conclusion

User Interface

- Enables user to communicate with an expert system

ES: Example

LITHIAN: Gives advice to archaeologists examining stone tools

DENDRAL: Used to identify the structure of chemical compounds. First used in 1965

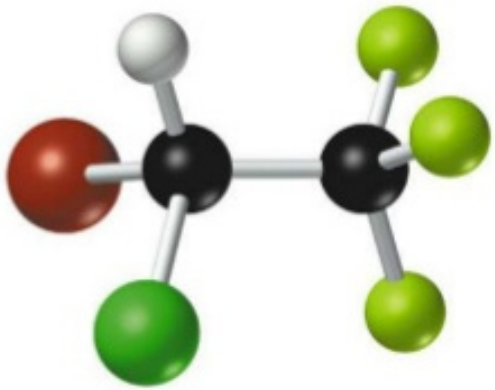
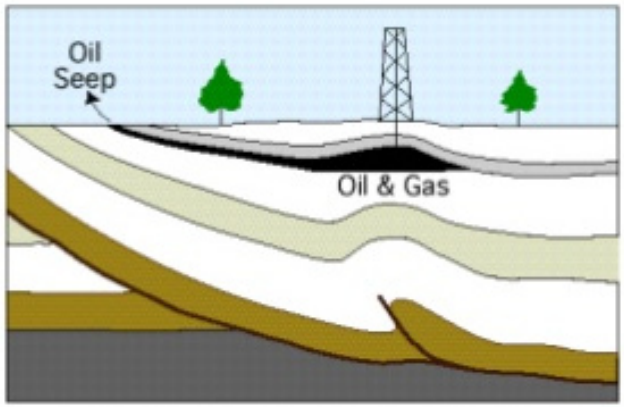


Figure: ES Examples

ES: Example



PROSPECTOR:
Used by geologists
to identify sites for
drilling or mining

PUFF:
Medical system
for diagnosis of
respiratory conditions

Figure: ES Examples

ES Development: Issues to be considered

- Does the task require knowledge available from human experts
- Are human experts too expensive or scarce
- Is the problem domain well-structured?
  - No common sense reasoning (i.e. facts must be able to be reduced to rules)
  - Problem domain must be well defined
- Can the problem be solved by traditional computing techniques?
  - Is so, then possibly there is no point of developing a heuristic-based solution

ES Development: Issues to be considered

- Is human expertise available?
  - Expert must be able to articulate reasoning process with high degree of confidence
- Adequate management support (management must be on-board)
- Available technology must be able to handle required knowledge base efficiently
- Is development cost justifiable?
- Is the solution found likely to remain viable for several years
- The cost (and availability) of the human expert needs to be compared with the cost of developing ES
- Will there be adequate infrastructure and management support for ES maintenance in future?

Expert System development in SA: Merlynn Intelligence

ES: Merlynn Intelligence

- They use TOM (Tacit Object Modeller) technology to create virtual experts.
- Virtual experts replicate the decisioning performance of the top experts in an organization
- Virtual experts have near limitless capacity and can be integrated and deployed in pretty much any operational environment
- As a bank, TOM delivers the ability to monitor transactions in real time as though through the eyes of your top risk assessors.

visit: www.Up2TOM.com and http://www.merlynn.co.za/tom

ES: Summary

- Perform services and boost productivity
- Encapsulate and “immortalise” knowledge
- They are delivery modules for AI techniques
- Constructed using special “knowledge-engineering” tools e.g ES shells and expertose transfer programs

AI: Ethical Issues

- Ethical and society issues related to intelligent systems
  - The Laws of Robotics
  - Virtual Reality
    - Peoples behavior in a world where the distinction between the real and the virtual is unclear
  - Privacy
- Legal and ethical Issues
  - what is the value of an expert opinion when the expertise is encoded in a computer?
  - who owns the knowledge in a knowledge base?
  - should royalties be paid to experts who provide the knowledge to ES, and if so how much?
  - can management force experts to contribute their expertise?
  - who is an expert? what if several experts disagree?

The End