1. Consider the developments in the analysis and interpretation of large data sets using AI techniques.
   i. Describe one example of how AI technology is used in online data analytics. (10 marks)
   ii. Discuss the problems that large data sets (Big Data) pose for AI based data analytics applications and give examples to illustrate your answer. (15 marks)

Question 1i: 10 marks. General distribution of marks according to salient features.
Candidates must demonstrate current awareness of an important application of artificial intelligence technology, data analytics.

Learning Outcomes/Assessment Criteria:
1. The learner will understand the main approaches used in AI problem solving. [1.1, 1.2]
5. The learner will know methods used in adaptive computing and understand how to apply them to problem solving. [5.1, 5.2, 5.3, 5.4, 5.5]
6. The learner will know the major AI application areas and understand the AI techniques used within them. [6.1, 6.2, 6.3, 6.4, 6.5]
7. The learner will know how AI technology has been used in real situations particularly on the Internet. [7.1, 7.2, 7.3, 7.4]

Indicative solution
Data mining is now used in intelligent search engines on the web (Google), games, consumer robots with vision systems, handwriting reading in PDA, speech synthesis in word processors, intelligent tutoring, knowledge management, etc. As knowledge working grows, it is expected that such technologies would continue to become more prevalent in the analysis of online generated data.
A major factor impacting on the spread of data analytics is concerns with the manner in which data are collected, interpreted, distributed and manipulated to achieve a competitive advantage. The limits of what is acceptable to the consumer can often be pushed by companies seeking to capitalize on the value of data. As an example, employers these days can and do survey personal data on social network sites, such as Facebook, to glean background data on prospective employees.

Answers should describe how data analytics relies on data mining or neural networks. Answers must consider realistic and timely reasons, e.g. right now technological growth in terms of mobile systems enables data to be stored on location, which can be interpreted to the advantage of marketers.

**Question 1ii: 15 marks. General distribution of marks according to salient features.**

*Candidates must demonstrate current awareness of how the field of intelligent data analytics is developing.*

**Learning Outcomes/Assessment Criteria:**

1. The learner will understand the main approaches used in AI problem solving. [1.1, 1.2]
2. The learner will know methods used in adaptive computing and understand how to apply them to problem solving. [5.1, 5.2, 5.3, 5.4, 5.5]
3. The learner will know the major AI application areas and understand the AI techniques used within them. [6.1, 6.2, 6.3, 6.4, 6.5]
4. The learner will know how AI technology has been used in real situations particularly on the Internet. [7.1, 7.2, 7.3, 7.4]

**Indicative solution**

Answers should consider the problems of data collection, transmission, data storage, as well as the power of available search techniques to work with large data sets. Also, the efficiency of algorithms is an issue, the amount of computer resources needed to deal with large multi-media data sets, and how so much data can be integrated and made sense of are all issues that need to be addressed. Definitions of Big Data should be given, and some real examples of applications that work with Big Data and use AI technology.

**EXAMINER’S REVIEW Q1**

Relatively few candidates attempted this question – probably since it was a new one not appearing on previous papers. For part (1), performance was poor with many answers not identifying the technology underpinning the applications on the web, such as data mining. Where this was mentioned, an explanation of how data mining was used, for example, customer profiling, was not explained in detail. Some answers focused on explaining applications such as marketing and recommended systems without suggesting how they work. Part (2) was sometimes equally off focus with many answers ignoring the problems of large data sets for AI and instead giving generic information on problems with any kind of data analysis, e.g. data integrity. Focus should have been on the added demands on processing power and speed, integration of multiple kinds of data, having to deal with fast changing (expanding) data sets, for example. Few answers explained the concepts of big data and data analytics, or indeed business intelligence.
2. Knowledge elicitation involves modelling the knowledge used by an expert to solve problems. Consider an example application domain and construct a knowledge base for the domain by completing the following tasks:
   i. Describe briefly general methods that could be applied to elicit the knowledge needed to solve a small complex problem. (10 marks)
   ii. Present an example knowledge base using a knowledge representation formalism of your choice. Ensure that it is adequately annotated with a textual explanation of how it could be used to solve suitable problems. (15 marks)

Question 2.i: 10 marks. General distribution of marks according to salient features.
Candidates must demonstrate an appreciation of how knowledge is elicited and acquired for a KBS.

Learning Outcomes/Assessment Criteria:
1. The learner will understand the main approaches used in AI problem solving. [1.1, 1.2]
2. The learner will be able to critically compare and contrast various knowledge representation systems. [2.1, 2.2, 2.3, 2.4, 2.5]
3. The learner will understand methodological approaches to developing knowledge based systems. [3.1, 3.2, 3.3, 3.4]
4. The learner will know methods used in adaptive computing and understand how to apply them to problem solving. [5.1, 5.2, 5.3]

Techniques such as interviewing, observation, repertory grid, and automated elicitation systems, machine learning, user maintenance should be discussed. Appropriate methodologies could be discussed too, such as KADS. Suitability of methods for task and situations should be explained.

Question 2.ii: 15 marks. General distribution of marks according to salient features.
Candidates must demonstrate an understanding of the criteria that makes a problem or task suitable for a KBS approach, and show an ability to solve a problem using KBS methods.

Learning Outcomes/Assessment Criteria:
1. The learner will understand the main approaches used in AI problem solving. [1.1, 1.2]
2. The learner will be able to critically compare and contrast various knowledge representation systems. [2.1, 2.2, 2.5]
3. The learner will understand concepts and appreciate the significance of issues relevant to adaptive computing. [4.1, 4.2, 4.3, 4.4]
4. The learner will know methods used in adaptive computing and understand how to apply them to problem solving. [5.1, 5.2, 5.3, 5.4, 5.5]
5. The learner will know the major AI application areas and understand the AI techniques used within them. [6.1, 6.2, 6.3, 6.4, 6.6]
6. The learner will know how AI technology has been used in real situations particularly on the Internet. [7.1, 7.2, 7.3]
**Indicative solution**

A clear explanation of the task must be provided from which it should be possible to understand that it requires an intelligent approach to solve it, and further, that the solution method is sound.

Candidates may choose any recognized knowledge representation formalism, e.g. rules, cases, frames, logic, etc. A clear explanation of the knowledge base must be provided from which it should be possible to understand how the KB would be utilised to solve problems.

For example, a rule based approach could be used and should include a set of self-consistent production rules: IF antecedent Then consequent

**EXAMINER’S REVIEW Q2**

Methods described in Part (1) focused mostly on extracting information from experts and documentation, but neglected the elicitation aspects of automated methods. Answers should have focused on manual entry, machine discovery and extraction/learning. Poor performance on Part (2) was due mainly to not providing detailed walk-through of the sample knowledge base. Often answers comprised unstructured lists of rules (sometimes in natural language) without any narrative on how these would be used to solve the given problem. Alternatively, programming style code segments were included without relation to chaining; for instance, use of loops to search every rule will find the right one if it exists, but the principles of goal driven/data driven reasoning should be related to this kind of algorithm. A logical walk-through of the reasoning process was required rather than presentation of an algorithm in any particular programming language (such as python).

3. There is a growing concern today about sustainable systems and green IT as these issues can affect the choice of systems built and manner in which they are operated and managed.
   i. Develop an argument either in favour of or against the preference for KBS over conventional IT systems. The discussion must be justified by appeal to sustainability principles and green IT issues. (15 marks)
   ii. Discuss the broad implications for KBS arising from the introduction of cloud computing techniques that provide intelligent computing power over the Internet. (10 marks)

**Question 3.i: 15 marks. General distribution of marks according to salient features.**

Candidates must demonstrate an appreciation of sustainability and green IT issues and show the impact that these issues have on KBS and intelligent systems.

**Learning Outcomes/Assessment Criteria:**

2. The learner will be able to critically compare and contrast various knowledge representation systems. [2.1, 2.2, 2.3, 2.4, 2.5]
3. The learner will understand methodological approaches to developing knowledge based systems. [3.1, 3.2, 3.3, 3.4]
4. The learner will understand concepts and appreciate the significance of issues
relevant to adaptive computing. [4.1, 4.2, 4.3, 4.4]

7. The learner will know how AI technology has been used in real situations particularly on the Internet. [7.3, 7.4]

**Indicative solution**

There are many perspectives that can be taken, for instance, issues regarding the comparative amount of resources needed to develop KBS and the need to maintain/update systems will draw on sustainability issues. Also, higher levels of labour involved in the development need to be balanced with lower levels of labour required for subsequent use.

*Autonomy*, where the autonomous nature of embedded KBS systems over the operator-dependent design of conventional systems saves resources. Similarly, with *Reusability* in the context of software components (rule base/object oriented). *Efficiency* through better usability (e.g. intelligent interfaces) reduces operating time and energy usage, *Flexibility*, where for instance agile approaches may be seen to be more sustainable for re-design and maintenance than overly rigid and intensive development methods in some cases, etc.

**Question 3.ii: 10 marks. General distribution of marks according to salient features.**

*Candidates must demonstrate an appreciation of cloud computing concepts and show the potential for this technology to support KBS and intelligent systems usage.*

**Learning Outcomes/Assessment Criteria:**

3. The learner will understand methodological approaches to developing knowledge based systems. [3.3, 3.4]

4. The learner will understand concepts and appreciate the significance of issues relevant to adaptive computing. [4.1, 4.2, 4.3, 4.4]

6. The learner will know the major AI application areas and understand the AI techniques used within them. [6.1, 6.2, 6.3, 6.5, 6.6, 6.7]

7. The learner will know how AI technology has been used in real situations particularly on the Internet. [7.1, 7.2, 7.3, 7.4]

**Indicative solution**

This is a relatively new area so candidates will need to rely on general knowledge of KBS and the IT industry if they have not studied the topic. *Sustainability* issues - a paramount concern as without the need to develop personal copies of software a large positive environmental impact can be produced. *Applicability* issues - relating to the relevance of generic KBS to specific company related tasks need to be addressed. *Generality* issues - relating to how the knowledge in a KBS can be represented in general forms so as to be usable by different organisations. *Robustness* issues - greater usage places more strain on the limits of a KBS. *Maintenance* issues - particularly with CBR approaches may be enhanced with the wider coverage that comes from a larger user base (over the internet). *Confidentiality* - associated with company and task sensitivity. Etc.
EXAMINER’S REVIEW Q3

Many reasonable answers to this question were received, primarily because it has appeared before and candidates have obviously reviewed the indicative answers from previous papers. Where answers are limited to brief notes, marks have been constrained. Some answers focused on advantages of KBS over conventional (part 1) without consideration of the drawbacks of KBS. Others misunderstood the question and regarded the application of KBS in environment oriented systems, such as controlling heating intelligently, which was not the requirement – rather the implications of following sustainability principles in the design, development and running of KBS. Part 2 answers also tended to re-present basic bullet point notes with little additional comment. Description of generic capabilities of cloud computing were covered without application to KBS.

4 Consider the nature of human intelligence and
i. Describe five characteristics of human intelligence that can be applied in knowledge based systems and artificial intelligence systems. (15 marks)
ii. Rank your chosen characteristics in order of importance and explain why you consider one to be more important than another for the development of intelligent computer systems. (10 marks)

Question 4.i: 15 marks. 3 marks for each aspect of human intelligence identified and related to KBS.
Candidates must demonstrate an appreciation of intelligence in humans and show the impact that human characteristics have on KBS and intelligent systems.

Learning Outcomes/Assessment Criteria:

4. The learner will understand concepts and appreciate the significance of issues relevant to adaptive computing: [4.1, 4.2, 4.3, 4.4]
6. The learner will know the major AI application areas and understand the AI techniques used within them. [6.1, 6.2, 6.3, 6.4, 6.6]
7. The learner will know how AI technology has been used in real situations particularly on the Internet.[7.3, 7.4]

Indicative solution

Some possibilities include:

- Ability to temporarily alter behaviour according to environmental stimulus (adaptability)
- Ability to permanently alter behaviour as a result of accumulated experience with environmental stimuli (learning)
- Ability to deal with ill-defined and ambiguous situations (uncertainty)
- Ability to prioritise and focus (goal directedness)
- Ability to bring to bear subjective insight (judgement)
- Ability to deal with complexity and recognise relevance (abstraction)

Application of these traits to a medical diagnostic KBS should consider the points outlined below.
Adaptability: an investigative procedure can be refined as new symptoms emerge and new test results become available.

Abstraction: the most significant symptoms will be considered, and those may be considered as special cases of more general categories of symptoms. Connections between symptoms and causes may be established at the general level, e.g. fever is one of the flu-like symptoms, and flu-like symptoms could point to influenza, pneumonia, viral infection, etc.

Goal directedness: the diagnostic system has a main goal: to identify the cause of the symptoms; and will plan procedures that progress towards achieving that goal.

Judgement: recommendations and decisions will be based on experience with previous patient cases; thus, different experts may have different judgement (c.f. second opinion).

Learning: procedures for selecting and conducting tests are based on treatment of previous patients (with similar symptoms). Results of the treatment fed back to the KBS will be used to influence future decisions.

Uncertainty: prognoses about illnesses are often predictions that are based on incomplete information about the progression of the illness in the patient. That is, there can be incomplete information about the disease and about the patient.

Question 4.ii: 10 marks. General distribution of marks according to salient features.
Candidates must demonstrate an appreciation of relative importance of intelligence in humans for the development of KBS.

Learning Outcomes/Assessment Criteria:
1. The learner will understand the main approaches used in AI problem solving.[1.1, 1.2]
2. The learner will be able to critically compare and contrast various knowledge representation systems. [2.1, 2.2, 2.5]
3. The learner will understand methodological approaches to developing knowledge based systems. [3.3, 3.4]
4. The learner will understand concepts and appreciate the significance of issues relevant to adaptive computing. [4.1, 4.2, 4.3, 4.4]

Indicative solution
Some possibilities include:
Creativity and imagination are currently not well understood, and are thus, difficult to describe in an executable computer model. An ability to recognise faces and differentiate between male and female faces is another area where clear rules are difficult to elicit because the relevant knowledge is not easily brought to conscious attention. In general, activities that could be better described as skills (opposed to knowledge) are not amenable to knowledge based systems. Answers must consider the relative merits of each chosen characteristics of intelligence and evaluate them for their suitability in developing intelligent systems.
For instance, an answer might consider Learning to be the most important, and therefore, it should present an argument in favour of Learning ability over, say, “judgement”.

EXAMINER’S REVIEW Q4

Part 1 was answered well, probably because this question is well rehearsed on the programme from previous examination papers. Most answers correctly identified appropriate traits, but not all answers discussed these sufficiently well. Some explanations were brief and failed to fully describe the trait. Part 2 was less well answered (it was a question on a new topic). Most answers managed to rank traits but failed to provide justification for the ranking. In particular, there was little evidence of a systematic evaluative analysis of the necessity of each trait for intelligent systems, and particularly, there was insufficient comparative analysis between the traits. No answers stated the important caveat that the nature of the task would influence the relative importance of intelligence traits, i.e. there is no one best ranking.

5 Neural Network technology has successfully found applications in the commercial world. Discuss how it has made the transition from research laboratory to business applications. Focus on the real business problems that the technology addresses and the benefits perceived to have been realised. (25 marks)

Question 5.i: 25 marks. General distribution of marks according to salient features.
Candidates must demonstrate an appreciation of commercial usage of Neural Network technology, and how application tools have been developed for use by the non-technical business user.

Learning Outcomes/Assessment Criteria:
1. The learner will understand the main approaches used in AI problem solving. [1.2]
2. The learner will understand concepts and appreciate the significance of issues relevant to adaptive computing. [4.1, 4.3, 4.4]
3. The learner will know the major AI application areas and understand the AI techniques used within them. [6.1, 6.2, 6.3, 6.4, 6.6, 6.7]
4. The learner will know how AI technology has been used in real situations particularly on the Internet. [7.1, 7.2, 7.3, 7.4]

Indicative solution
Neural Network technology is often used in business, particularly on the web, to provide support for the “implicit web,” in which personal information about the user is indirectly “discovered” from their normal interactions. Such valuable knowledge enables tailoring and personalization of services.
With the increased power of Web 2.0, in which users are generators of data and not just consumers, many new opportunities have emerged for technologies that can make value of the available data. Neural Network technology as employed in business intelligence systems and data analytics are means by which Strategic management is implemented. The knowledge derived from analysis of data using Neural Network technology helps a decision maker understand the nature of the problem better and supports better informed decision making. Neural Network technology enables the systems to learn behaviours. In the business world, neural network technology is used extensively for personalized marketing, e.g. for profiling consumers by learning their buying behaviour.

EXAMINER’S REVIEW Q5

Neural networks are a standard subject in the examination and have appeared over the years in several examination papers, so expectations were high that students would perform well. However, answers were not of high quality for the following reasons: (a) candidates focused on explaining the technology rather than its applications; (2) applications were not explained in depth to show how ANNs contributed; (3) little consideration was given to the cause-effect relationships responsible for the success of ANN (e.g. availability of large amounts of data on the cloud, and the facilitating infrastructure provided by the internet); (4) lack of a narrative conveying the progression from research to practice. Answers glossed over the benefits of ANN specific to an application. Where worked examples were given, these were generic and bore little relevance to the stated scenario. Answers needed to consider the particulars of the scenario and incorporate these in any worked example.