Examiners' commentaries 2015–16

CO3310 Artificial intelligence – Zone A

General remarks

This examination was set as a combination of questions that tested candidates' basic knowledge and understanding of the subject ('bookwork'); problem-solving questions that required them to apply their knowledge; and reflective essay questions that involved argumentation and consideration of how artificial intelligence (AI) can be applied to real-life concerns. Candidates are reminded to read each question carefully and address all aspects of the question. In particular, when asked to 'explain', 'describe' or 'justify' something, they should make sure they have done so. Answers should not say: 'I believe/feel' or 'my opinion is…', but should be justified with evidence and argumentation. Students should not argue from authority (e.g. Chomsky says that…) without explaining the substance of the arguments. It is important to write legibly as marks will be lost where examiners are unable to decipher what is written.

Comments on specific questions

Question 1 Search and planning

This question covered some basic concepts in search and planning, including heuristic search, and required candidates to apply this knowledge to simple problems.

Parts (a) and (b) are essentially bookwork, and candidates should not have had much difficulty in tackling them.

Part (c) involved discussing heuristics for solving an 8-puzzle problem. It is important to keep in mind the distinction between a heuristic **function** and heuristic **search**: the former is a means of providing information to a search to choose how to get to a goal, such as choosing the node with the shortest straight-line distance to the goal in a route-finding problem, while the latter is a common term for informed search algorithms that use heuristic techniques.

Part (d) involved writing out a plan in planning domain definition language (PDDL) to solve a blocks-world problem. Some candidates appeared to have grasped the general idea of planning, but gave incomplete specifications of operations, for example, not giving all preconditions and effects. The structure and application of PDDL operations is described in the subject guide, and the problems provided as 'learning activities' should have prepared candidates to tackle this question with confidence.

Several students scored reasonably well on the bookwork but were unable to apply their knowledge to the problems in parts (c) and (d). It is important to practise for questions like this by working through sample questions, whether in the subject guide or from past examination papers.

Question 2 Logic and reasoning

This question tested candidates' understanding and ability to apply logical and probabilistic reasoning techniques. To quote a previous year's Examiner's commentary: 'first order logic is fundamental to all of AI, and at least a workable understanding of it is critical.' A sound understanding of probability is also essential in modern AI.

Parts (a) and (c) were essentially bookwork. The quality of answers was quite variable; in particular, candidates are advised to revise the material on formal logic carefully. Please note that it is important to keep in mind the distinction between soundness and truth: a sound inference scheme can lead to false conclusions if the premises are also false.

Part (b) involved first-order predicate calculus (FOPC). Answers were mostly good but some candidates confused the meanings of particular connectives: it is important to be clear about when to use the implication arrow and when to use the conjunction in expressions that involve universal or existential quantifiers.

Part (d) involved the application of Bayes' Rule, which is a fundamental component of the modern AI toolbox. The level of knowledge required for the calculations in this question should be well within the competence of all candidates, though some answers showed poor understanding. Some candidates misremembered the formula but carried out the calculation correctly, or started their calculation well but then went awry. It is important to show working and clearly explain answers so that examiners can award some credit for partially correct attempts.

Question 3 Natural language

This question involved knowledge of concepts in natural language processing and formal grammar, and the ability to apply this knowledge in analysing the syntactic structure of sentences.

Parts (a) and (b) are bookwork. For full marks in part (a), students were expected to give appropriate examples. There were some good answers but many were rather weak, particularly for (b): this is a topic which students need to revise carefully.

Part (c): answers were generally rather weak, though a small number of students did very well. As the grammar is ambiguous, candidates should have found two syntactic structures for (i). The second part of the question required the grammar to be modified to distinguish various constructions: note that the requirement was to 'explain' how the grammar could be changed, not to write out a complete new grammar. When proposing new grammar rules, it is important to make them maximally general rather than 'flat' and ad hoc, matching only the specified examples. So, for example, while a rule of the form S –> S NP might match example (iii), it is preferable for the elements in a conjunction rule to be of the same category.

Part (d) involved semantic interpretation using the lambda calculus. This topic is explained in the subject guide and has regularly featured in past examinations, but very few candidates got full marks and a number either did not attempt it or only gave partial answers.

Question 4 Machine learning and decisions

This question concerned knowledge of machine learning concepts and techniques, and their applications to a hypothetical real-world problem.

Parts (a) and (b) were bookwork. Credit was given for any reasonable examples of applications in (a). For (b), it is important to remember that a 'reward' can be positive or negative in the terminology of reinforcement learning.

Part (c) required candidates to consider some factors that could influence high school graduates' choices of university; one would hope this is a question they may have given some thought to in the past! Factors could include: results of student surveys, independent rankings, graduate earnings, local cost of living, etc. Any reasonable answers were accepted, with credit for clarity and argumentation and for showing knowledge of learning algorithms such as ID3. The question did not ask students to actually draw a decision tree, and it would not have been especially useful to do so without explaining the basis for the decisions. Some candidates gave excellent answers but many did not adequately focus on possible sources of objective data or go into enough detail about machine learning (ML) techniques.

Part (d) involved a reinforcement learning problem. The quality of answers was quite variable: not all candidates seemed to understand what is meant by a 'policy', and some thought the problem involved a single-start position and a single-goal cell, whereas a policy applies to any arbitrary cell. Credit was given for good explanations as well as finding a solution, so candidates could still do well even if they did not provide an optimal solution.

Question 5 Philosophy of AI and social issues

This question covered some well-known issues in the philosophy of AI, as well as asking candidates to address some social and ethical implications of applications of AI techniques.

Part (a): the first part of the question covers bookwork on Searle's Chinese Room argument; this topic has regularly come up in the examination and one would expect students to be well prepared. The second part involved critical evaluation of Searle's argument.

Part (b) asked candidates to comment on some alarming predictions about the future of AI, which were sourced to Professor Stephen Hawking but are quite widely shared. Similar issues are addressed in Chapter 25 of Stuart Russell and Peter Norvig's book *Artificial Intelligence: A Modern Approach*, and, in fact, Russell is a member of the Centre for the Study of Existential Risk (CSER) at the University of Cambridge, along with Hawking.

Candidates who got the highest marks generally showed awareness of commercial, social and ethical issues beyond the scope of the mandated reading for this module. Credit was given for each substantive point made, as well as for argumentation and clarity. It was evident that some candidates struggle to express themselves in the essay form and perhaps have not had much practice in this particular area. It is important to keep in mind that questions of this nature are not 'easy options' but instead require appropriate specialist knowledge as well as an ability to construct arguments and express relatively complex topics clearly and concisely. Candidates will not get marks simply for filling space, for example, by repeating the body of the question before embarking on an answer.

Examiners' commentaries 2015–16

CO3310 Artificial intelligence – Zone B

General remarks

This examination was set as a combination of questions that tested candidates' basic knowledge and understanding of the subject ('bookwork'); problem-solving questions that required them to apply their knowledge; and reflective essay questions that involved argumentation and consideration of how artificial intelligence (AI) can be applied to real-life concerns. Candidates are reminded to read each question carefully and address all aspects of the question. In particular, when asked to 'explain', 'describe' or 'justify' something, they should make sure they have done so. Answers should not say: 'I believe/feel' or 'my opinion is…', but should be justified with evidence and argumentation. Students should not argue from authority (e.g. Chomsky says that…) without explaining the substance of the arguments. It is important to write legibly as marks will be lost where examiners are unable to decipher what is written.

Comments on specific questions

Question 1 Logic and reasoning

This question tested candidates' understanding and ability to apply logical and probabilistic reasoning techniques. Answers were very variable in quality, though some were very good. To quote a previous year's Examiner's commentary: 'first-order logic is fundamental to all of AI, and at least a workable understanding of it is critical.' A sound understanding of probability is also essential in modern AI.

Parts (a) and (c) involved bookwork, requiring candidates to give definitions of various terms which are explained in the subject guide. There were some excellent answers but overall quality was rather low. Candidates should ensure they are thoroughly familiar with standard terms when preparing for examinations in order to avoid losing marks unnecessarily.

Part (b) tested knowledge and understanding of predicate calculus (also known as first-order logic). Some answers were very good but many were rather patchy. This is a topic which future candidates would be advised to revise carefully; in particular, it is important to be clear whether to use the implication arrow or 'and' symbol along with the universal and existential quantifiers.

Part (d) involves the application of Bayes' rule, which is a fundamental component of the modern AI toolbox. A sizeable number of candidates had no problem with this question and obtained full marks. However, some answers showed ignorance of Bayes' rule and a poor understanding of probability, even though the level of knowledge of the latter required for the calculations in this question should be well within the competence of all candidates. Some candidates misremembered the formula but showed some understanding of the working, or provided calculations that went awry somewhere along the line. It is important to show working and clearly explain answers so that examiners can award some credit for partially correct attempts.

Question 2 Search and planning

This question dealt with some basic concepts in search and planning.

Parts (a) and (b) were bookwork concerning fundamental characteristics of search algorithms and planning techniques, which are clearly defined in the subject guide. Good answers to (a) would show understanding of how complexity is calculated, in terms of the *branch factor* (b) in the search tree, *minimum depth* of solutions (d), and the *maximum path length* (m). Most candidates who attempted (a) provided good coverage. Answers to (b) were generally less confident: some got full marks while other candidates did not attempt this part or failed to give an appropriate example.

Parts (c) and (d) required candidates to go beyond bookwork and explain how to address particular search and planning problems.

Question (c) involved discussing heuristics for solving an 8-puzzle problem. It is important to keep in mind the distinction between a heuristic **function** and heuristic **search**: the former is a means of providing information to a search to choose how to get to a goal, such as choosing the node with the shortest straight-line distance to the goal in a route-finding problem, while the latter is a common term for informed search algorithms that use heuristic techniques. A few candidates gave excellent answers but many did not attempt to answer, and the overall standard was rather weak.

As with (c), many answers to part (d) were poor or absent though some were very good and a small number achieved full marks. Several candidates appeared to have grasped the general idea, but gave incomplete specifications of operations, for example, not giving all preconditions and effects. The structure and application of Planning Domain Definition Language (PDDL) operations is described in the subject guide, and the problems provided as 'learning activities' should have prepared candidates to tackle this question with confidence.

Question 3 Machine learning and decision problems

This question concerned knowledge of machine learning (ML) concepts and techniques, and their applications to a hypothetical real-world problem.

Parts (a) and (b) were essentially bookwork, testing candidates' understanding of classification, regression and training methods. Most answers to (a) were acceptable, though a sizeable minority of candidates did poorly; answers to (b) tended to be weaker overall.

Part (c) required candidates to consider some factors that could influence a lifestyle decision, and how ML techniques could assist in this decision. Answers were generally rather weak. Credit was given for: sensible suggestions of factors that could influence such a decision, particularly those for which quantitative historical data might be available; for clarity and argumentation; and for showing knowledge and understanding of learning algorithms such as ID3. As with a similar question in the previous year's examination, many answers did not adequately focus on possible sources of objective data or go into enough detail of ML techniques.

Part (d) involved reinforcement learning. The quality of answers was quite variable: some candidates received excellent marks while others did not attempt this part or showed poor understanding. Not all candidates seemed to know what is meant by a 'policy', and some thought the problem involved a single-start position and a single-goal cell, whereas a policy applies to any arbitrary cell. Credit was given for good explanations as well as for finding a solution, so candidates could still do well even if they did not provide an optimal solution.

Question 4 Natural language

This involved knowledge of concepts in natural language processing and formal grammar, and the ability to apply this knowledge in analysing the syntactic structure of sentences.

Part (a) was bookwork, and involved explaining some technical terms which were covered in the subject guide. Some candidates achieved high or full marks but others did poorly or did not even attempt the question.

Results were very variable in part (b), while generally better than (a). Good answers identified the different sources of ambiguity such as lexical, referential, structural (Prepositional Phrase (PP)) and logical scope, and discussed how common sense or world knowledge might be used to identify the most likely reading.

Parts (c) and (d) involved solving syntactic and semantic problems. Answers to this were quite variable, though a few candidates did especially well. Generally candidates were able to follow grammar rules in order to analyse sentences and construct tree diagrams well enough, but showed less confidence in proposing new rules. It is important for proposed rules to be maximally general and concise, rather than tailored to the particular examples given in the question. For example, a rule S –> S 'and' VP might match example (v), but it is preferable for conjuncts in a coordination rule to be of the same grammatical category. Part (d) required a simple semantic interpretation using the lambda calculus: this is explained in the subject guide and regularly comes up in examinations, so candidates should have been well prepared. A few gave complete and correct solutions, but many did not attempt this question or only gave partial answers.

Question 5 Philosophy of AI and social issues

This covered some well-known issues in the philosophy of AI, as well as asking candidates to address some social and ethical implications of applications of AI techniques. Marks for both parts were given according to: demonstration of familiarity with Alan Turing's paper 'Computing Machinery and Intelligence' and other relevant specialist knowledge; clarity of expression; organisation of material and argumentation; presenting evidence for and against a thesis; and reaching a conclusion.

Part (a): this question is essentially bookwork involving Turing's 'Imitation Game' argument. This is a topic which regularly comes up in the examination, and one would expect students to be well prepared. Students were required to critically evaluate some elements of Turing's thesis. This was adapted from a learning activity in the subject guide, so again, students should have been well prepared. In fact, answers were generally rather weak: many did not attempt this part at all, while others showed poor awareness and understanding of Turing's arguments.

Answers to part (b) were generally stronger than those for (a), but still disappointing overall. Candidates who got the highest marks generally showed awareness of social and ethical issues beyond the scope of the mandated reading for this module. It was evident that some candidates struggle to express themselves in the essay form, and perhaps have not had much practice.

It is important to keep in mind that questions of this nature are not 'easy options' but instead require appropriate specialist knowledge as well as an ability to construct arguments and express relatively complex topics clearly and concisely. Candidates will not get marks simply for filling space, for example, by repeating the body of the question before embarking on an answer.