CS3243 : Introduction to Artificial Intelligence

Tutorial 7

NUS School of Computing

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Admin

- A note on projects!

Review

- **Knowledge Base**
- Knowledge Base (KB) is a set of logical rules that model what the agent knows, things like game rules, constraints
- These rules/statements/sentences are written using a certain language (or syntax) and use a certain truth model (or semantics which say when a certain statement is true or false)
- In this class, we use propositional logic to govern our *syntax* and *semantics*

Review

- **Propositional Logic**
- In Propositional Logic, sentences are defined as :
  - Atomic Boolean Variables, example S_1 and S_2, are sentences
  - If S is a sentence, then so is $\neg S$
  - If S_1 and S_2 are sentences, then so are : $S_1 \wedge S_2$, $S_1 \vee S_2$, $S_1 \Rightarrow S_2$, and $S_1 \Leftrightarrow S_2$

Review

- **Entailment**
- $A \models B \;\; === \;\; M(A) \subseteq M(B)$
- All models (sets of values) that satisfy (sentences in) A also satisfy (sentences in) B (ie. A models B)
- $M(A)$ is the set of all value assignments to variables in A for which A holds true

Review

- **Inference Algorithms**
- An inference algorithm $\mathcal{A}$ is one that takes as input a knowledge base KB and a query and decides whether is derived from KB, written as KB $\vdash_{\mathcal{A}} \alpha$
- KB $\vdash_{\mathcal{A}} \alpha$: "Sentence α is derived from KB by inference algorithm $\mathcal{A}$", or "$\mathcal{A}$ inferred α"

Review

- **Soundness and Completeness**
- $\mathcal{A}$ is sound if KB $\vdash_{\mathcal{A}} \alpha$ implies KB $\models \alpha$
- For all sentences inferred from KB by $\mathcal{A}$, KB entails them
- $\mathcal{A}$ is complete if KB $\models \alpha$ implies KB $\vdash_{\mathcal{A}} \alpha$
- For all sentences entailed by KB, $\mathcal{A}$ would be able to infer them

Tutorial Question 1

- Verify the logical equivalences
- Idea : To use the rules of logic to proceed

Tutorial Question 1(a)

- $\neg(p \vee \neg q) \vee (\neg p \wedge \neg q) \equiv \neg p$

Tutorial Question 1(a)

- $\neg(p \lor \neg q) \lor (\neg p \land \neg q) \equiv \neg p$

- Let's solve the LHS
- $(\neg p \land q) \lor (\neg p \land \neg q)$
- $\neg p \land (q \lor \neg q)$
- $\neg p \land \mathbf{true}$
- $\neg p$
- Which is logically equivalent to RHS

Tutorial Question 1(b)

- $(p \wedge \neg(\neg p \vee q)) \vee (p \wedge q) \equiv p$

Tutorial Question 1(b)

- $(p \wedge \neg(\neg p \vee q)) \vee (p \wedge q) \equiv p$

- Let's solve the LHS
- $(p \wedge (p \wedge \neg q)) \vee (p \wedge q)$
- $((p \wedge p) \wedge \neg q) \vee (p \wedge q)$
- $(p \wedge \neg q) \vee (p \wedge q)$
- $p \wedge (\neg q \vee q)$
- $p \wedge \mathbf{true}$
- Which is logically equivalent to RHS

Tutorial Question 2

- Three friends : Alice, Ben, and Cindy
- Constraints given
- Cindy comes to the party only if Alice does not come
- Alice comes to the party if either Ben or Cindy (or both) comes
- Cindy comes to the party if Ben does not come
- Using propositional logic, determine who attends the party

Tutorial Question 2

- Translate the constraints to propositional logic statements (like statements in the Knowledge Base)
- Let's say we define these binary variables
- C: Cindy comes to the party, A: Alice comes to the party, B: Ben comes to the party, and use them to formulate the constraints

Tutorial Question 2

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- $C \to \neg A$
- $(C \vee B) \to A$ translates to $C \to A$, $B \to A$
- $\neg B \to C$

Tutorial Question 2

- $(C \to \neg A) \land (C \to A)$
- $(\neg C \lor \neg A) \land (\neg C \lor A)$
- $\neg C \lor (\neg A \land A)$
- $\neg C \lor \mathbf{false}$
- $\neg C$
- Cindy ain't coming to the party! Now onto the rest...

Tutorial Question 2

- $\neg B \to C$
- $\neg C \to B$
- Using $\neg C$
- $\neg C \wedge (\neg C \to B)$
- B
- Ben is coming to the party!

Tutorial Question 2

- $C \wedge (C \to A)$
- A
- Alice is also coming to the party!

Tutorial Question 2

- **Resources**
- English to Logic by UofMiami
- Stanford's Truth Table Tool

Tutorial Question 3

- The knowledge base
- “All firetrucks are red”
- “All firetrucks are cars”
- “All cars have four wheels”

Tutorial Question 3(a)

- A_1, that takes the query sentence "a ferrari is a red car" and infers "a ferrari is a firetruck"
- Complete? Sound? Both?
- Any thoughts?

Tutorial Question 3(a)

- A_1, that takes the query sentence "a ferrari is a red car" and infers "a ferrari is a firetruck"
- Complete? Sound? Both?
- Any thoughts?
- As the inferred statement is not entailed by the knowledge base the algorithm cannot be sound
- Moreover, it could still be complete, as the question doesn't state if the algorithm inferred anything else

Tutorial Question 3(b)

- A_2 is given the query sentence "a ferrari is a red car"
- Which property(s) would guarantee that A_2 would infer the sentence "a ferrari has four wheels"?
- Complete? Sound? Both?
- Any thoughts?

Tutorial Question 3(b)

- A_2 is given the query sentence "a ferrari is a red car"
- Which property(s) would guarantee that A_2 would infer the sentence "a ferrari has four wheels"?
- Complete? Sound? Both?
- Any thoughts?
- Completeness ensures that everything that is entailed by the knowledge base will be inferred, as the statement is entailed by the KB completeness guarantees its inference

Tutorial Question 3(c)

- "Two agents with the same knowledge base and different inference engines, both of which are complete and sound, always behave in the same way".
- True or False?
- Any thoughts?

Tutorial Question 3(c)

- "Two agents with the same knowledge base and different inference engines, both of which are complete and sound, always behave in the same way".
- True or False?
- Any thoughts?
- False
- The behavior of an agent describes its interaction with the environment
- Different complete and sound algorithms will (given the same KB) result with the same inferences and a difference in how they derive that doesn't imply a difference in behavior
- However, the behavior of an agent is not only dependent on its knowledge to different agents might have completely different objectives and hence act differently even with the same knowledge.

Thank you!

If you have any questions, please don't hesitate. Feel free to ask!
We are here to learn together!