Learning Guide Unit 5

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Description

Learning Guide Unit 5

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Overview

Unit 5: Knowledge Representation and Reasoning

Topics:

- Propositional Logic
- Semantics of the Propositional Calculus
- Knowledge Representation
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  - Querying the User
  - Knowledge Level Explanation
- Bottom-Up Procedure
- Prove by Contradiction
  - Horn Clauses
  - Conflicts
  - Consistency-Based Diagnosis

Learning Objectives:

By the end of this Unit, you will be able to:

1. Compare abductive diagnosis and consistency-based diagnosis in the context of an AI project.
2. Write a program in Java or Python that will output a truth table.
3. Translate a natural language (e.g., English) sentence into predicate logic statement.
4. Convert a logic statement into clause form.
5. Examine the five propositional logic connectives: negation, conjunction, disjunction, implication, and biconditional.

Tasks:

- Peer assess Unit 4 Programming Assignment
- Read the Learning Guide and Reading Assignments
- Participate in the Discussion Assignment (post, comment, and rate in the Discussion Forum)
- Complete and submit the Programming Assignment
- Complete an entry in the Learning Journal
- Take the Self-Quiz

Introduction

In this unit, we will be exploring propositional calculus … which sounds like a very scary term. Propositional calculus is simply a language with a grammar that can be used to describe whether something is true or false in a world.

The most basic element in propositional calculus is the atom or atomic proposition. Before we go any further we should define the term proposition. A proposition is a statement offered for consideration.

In propositional calculus, we offer statements and then consider or evaluate their truthfulness. A proposition can be any of the following:

- An atomic proposition … a symbol that is either true or false.
- A compound proposition is a combination of other propositions all of which collectively will evaluate to either true or false using the grammar defined in the following.

Symbolic Statement	Translation
$p \vee q$	p or q
$p \wedge q$	p and q
$p \Rightarrow q$	p logically implies q
$p \Leftrightarrow q$	p is logically equivalent to q
$\neg p$	not p

The following truth table provides examples of how the various symbolic statements are evaluated.

p	q	$p \wedge q$	$p \vee q$	$p \Rightarrow q$	$p \Leftrightarrow q$
T	T	T	T	T	T
T	F	F	T	F	F
F	T	F	T	T	F
F	F	F	F	T	T

A knowledge base is a set of propositions that are given to be true and each element in a knowledge base is called an axiom. Assume that we want to build a knowledge-based for University of the People courses. We want to use our knowledge base to determine if a student can take a particular course.

univ1001.
univ1102.
cs1101.
cs1102.
cs1103.

jane.
joe.

All of these atoms evaluate to true.

You may be wondering why we would be interested in an ability to perform logic evaluation (otherwise known as resolution) as part of a course in Artificial Intelligence. The reason is that artificial intelligence is in its implementation the process of an agent reacting to its environment to achieve its goals. To achieve its objective, an agent must 'reason' about its environment and make decisions on the action or actions that must be taken to achieve its goals. This 'reasoning' must find solutions by evaluating potential alternatives and being able to determine the validity of a solution. Propositional logic helps to accomplish the task of determining valid solutions and reasoning through solution options.

Horn Clauses

Propositional definite clauses are propositional statements that evaluate to true. One of the limitations of propositional definite clauses is that it only be used to prove that something is true. What can be done to determine if a statement or set of statements is actually false? The solution is an ‘extension’ to propositional definite clauses called the horn clause. A horn clause provides the ability to provide by contradiction. One form of the horn clause is with the false statement. A false statement which is known as an integrity constraint has the form:

false $\leftarrow a_1 \wedge a_2 \wedge \ldots \wedge a_k$

In propositional definite clauses, the item on the far left of the statement must be an atom that evaluates to true. In the integrity constraint clause, the left of the statement is the word false evaluating to false and the right of the statement is a series of statements or atoms that must all evaluate to false.

The Horn clause can either be a definite clause of the normal form or an integrity constraint clause of the form defined above.

Complete Knowledge Assumption

Complete knowledge assumption assumes that for every atom within the environment (or world that is the context of the knowledge base) every case in which the atom is true is known. In this environment, an agent can assume that an atom is false if it cannot determine that is true. To have a complete knowledge assumption requires a closed-world assumption. This can be contrasted with an open-world assumption. In the open-world assumption, the agent does not know every case in which an atom is true and as such cannot make any assumptions about the atom because there is a lack of knowledge.

Abduction

There are three terms that we use to describe different forms of reasoning about a world based upon the knowledge that we have of the world.

Deduction – Which is also referred to as ‘top-down’ logic is the process of following a series of axioms to reach a conclusion. Consider the following statement: if A is true and B is equivalent to A then it follows that B must also be true. This statement is an example of such deductive reasoning.

Induction – We will examine inductive reasoning in the next unit as inductive reasoning inherently involves uncertainty. The basic idea behind induction or inductive reasoning is that conclusions are drawn from the strong evidence offered in the axioms (or propositions). In inductive reasoning, we have no absolute proof of the truthfulness of a proposition merely strong evidence (a high probability) that the proposition is true.

Abduction – Abduction is differentiated from both induction and deduction as it might best be described as an educated guess. In abduction, we start from observations of the world, and from these observations, we attempt to fit a theory that explains the observations. Occam’s razor comes into play here because we want to identify the most simple ‘theory’ or hypothesis that fits the data.

Consider the following example:

Assume that we have the observation shoes-are-wet as an atom and we also have the propositions:

grass-is-wet ← rained-last-night
grass-is-wet ← sprinkler-was-on

We might abduce the following:

shoes-are-wet ← grass-is-wet

We have no proof that this proposition is in fact correct and we have no belief in the truthfulness of this proposition (we will define belief in the next unit in terms of a measure using a probability that a proposition is true). What we do have is a simple explanation, a theory, of why the shoes are wet.

Reading Assignment

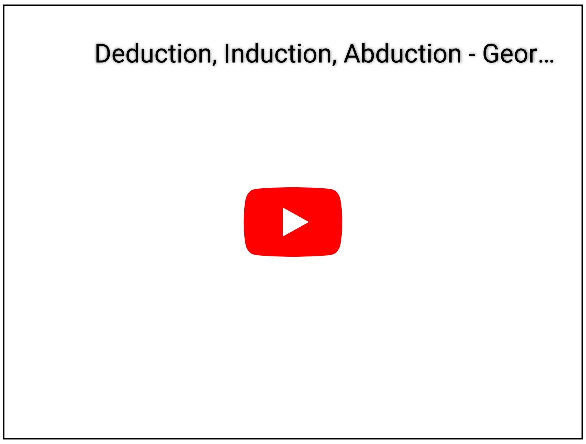
Poole, D. L., & Mackworth, A. K. (2017). *Artificial Intelligence: Foundations of computational agents.* Cambridge University Press. https://artint.info/2e/html/ArtInt2e.html

Read the following chapters:

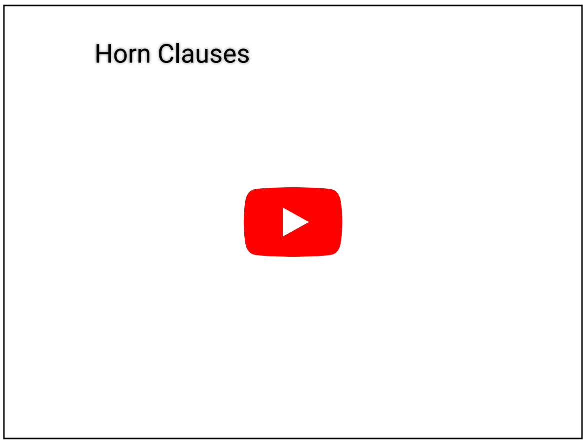
- Chapter 5 - Propositions and Inference

Video Resources

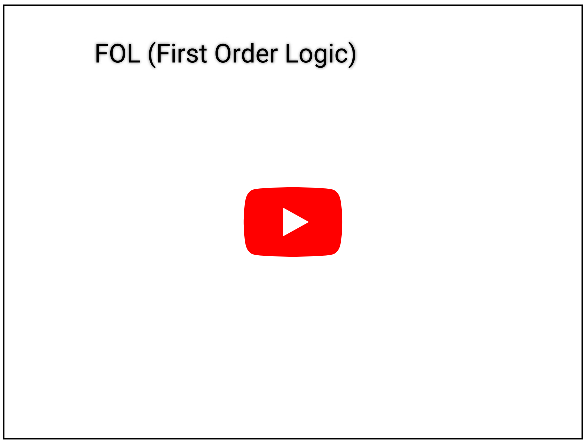
Udacity. (2015, February 23). *Deduction, induction, abduction - Georgia Tech - KBAI: Part 5* [Video]. YouTube.



The Power of Prolog. (2019, October 21). *Horn clauses* [Video]. YouTube.



Iacobelli, F. (2015, July 20). *FOL (First order logic)* [Video]. YouTube.



Discussion Assignment

Suppose, you have a job at a company that is building online teaching tools. Because you have taken an AI course, your boss wants to know your opinion on various options under consideration.

They are planning on building an intelligent tutoring system for teaching elementary physics (e.g., mechanics and electromagnetism). One of the things that the system must do is to diagnose errors that a student may be making.

The boss has heard of consistency-based diagnosis and abductive diagnosis but wants to know what they involve in the context of building an intelligent tutoring system for teaching elementary physics.

For each of the following, answer the explicit questions and use proper English. Answering parts not asked or giving more than one answer when only one is asked for will annoy the boss. The boss also does not like jargon, so please use straightforward English.

1. Explain what knowledge (about physics and about students) is required for consistency-based diagnosis.
2. Explain what knowledge (about physics and about students) is required for abductive diagnosis.
3. What is the main advantage of using abductive diagnosis over consistency-based diagnosis in this domain?
4. What is the main advantage of consistency-based diagnosis over abductive diagnosis in this domain?

Your Discussion should be at least 250 words in length, but not more than 750 words. Use APA citations and references for the textbook and any other sources used.

Programming Assignment

A set of symbols is commonly used to express logical representation. Let's define the semantics of each propositional symbol:

- P means "It is hot"
- Q means "It is humid"
- R means "It is raining"

Examples of Propositional Logic (PL) sentences

- (P ^ Q) => R (meaning "If it is hot and humid, then it is raining")
- Q => P (meaning "If it is humid, then it is hot")
- Q (meaning "It is humid.")

Using the "weather" sentences from above, consider the following Knowledge Base (KB)

KB = (((P ^ Q) => R) ^ (Q => P) ^ Q)

Corresponding to the three facts we know about the weather:

1. If it is hot and humid, then it is raining.
2. If it is humid, then it is hot, and
3. It is humid.

Now let's ask the query "Is it raining?" That is, is the query sentence R entailed by KB.

Using the truth-table approach to answering this query we have.

P	**Q**	**R**	**(P ^ Q) => R**	**Q => P**	**Q**	**KB**	**R**	**KB => R**
T	T	T	T	T	T	T	T	T
T	T	F	F	T	T	F	F	T
T	F	T	T	T	F	F	T	T
T	F	F	T	T	F	F	F	T
F	T	T	T	F	T	F	T	T
F	T	F	T	F	T	F	F	T
F	F	T	T	T	F	F	T	T
F	F	F	T	T	F	F	F	T

Hence, in this problem there is only one model of KB, when P, Q, and R are all True, and in this case R is also True, so R is entailed by KB.

For this programming assignment, you need to write a program in Java or Python which will output the above truth table. Here are the detailed requirements.

1. Your program must be complete, compile able, and produce output.

2. Your program will not take any input.

3. You will have three variables P, Q, R, and dynamically generate those 8 combinations.

4. You will define an efficient data structure which will hold the values of result variables:
   (p ^ Q) => R, Q=>P, KB, and KB=>R

5. In your algorithm, you must define the rule for the conjunction (^) and implication (=>) operator, so that given two operands, they produce the correct result.

6. In the above truth table, Q and R columns appeared twice because of convenience. In your output, you don't have to have these duplicates.

7. You don’t have to display the output in a table with borders, however, consider proper alignment, padding, and formatting for each row and column.

8. Make sure your output matches with the above table.

You will be graded on the following:

1. Does the program compile?
2. Does the program dynamically generate those 8 combinations?
3. Does the data structure used to hold the values efficient enough?
4. Does the algorithm set the rule for conjunction (^) and implication (=>) operator?
5. Does the program output correctly for (p ^ Q) => R, Q=>P, KB, and KB=>R?
6. Does the output follow proper alignment, formatting, and padding?

Learning Journal

The Learning Journal is a tool for self-reflection on the learning process. The Learning Journal will be assessed by your instructor as part of your Final Grade.

Your learning journal entry must be a reflective statement that considers the following questions:

1. Describe what you did. This does not mean that you copy and paste from what you have posted or the assignments you have prepared. You need to describe what you did and how you did it.

2. Describe your reactions to what you did.

3. Describe any feedback you received or any specific interactions you had while participating discussion forum or the programming assignment, discuss how they were helpful.

4. Describe your feelings and attitudes.

5. Describe what you learned. You can think of one or more topics from your week's lesson and explain your understanding in writings. Feel free to add any diagram or coding example if that helps you explain better.

6. Did you face any challenges while doing the discussion assignment or the development assignment? Were you able to solve it by yourself?

The Learning Journal entry should be a minimum of 400 words and not more than 750 words. Use APA citations and references if you use ideas from the readings or other sources.

Self-Quiz

The Self-Quiz gives you an opportunity to self-assess your knowledge of what you have learned so far.

The results of the Self-Quiz do not count towards your final grade, but the quiz is an important part of the University's learning process and it is expected that you will take it to ensure understanding of the materials presented. Reviewing and analyzing your results will help you perform better on future Graded Quizzes and the Final Exam.

Please access the Self-Quiz on the main course homepage; it will be listed inside the Unit**.**

Checklist

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