1. [Start of transcript. Skip to the end.](https://courses.edx.org/xblock/block-v1:ColumbiaX+CSMM.101x+3T2020+type@vertical+block@e70e470f776d4f06bf039c5c55083763?show_title=0&show_bookmark_button=0#transcript-end-3ea77ff13dae4747a8c84336e48c01f1)
2. Let's now revisit the Wumpus world
3. and build the knowledge base for the “reduced” Wumpus world.
4. What we call reduced is when the agent is actually
5. exploring this bottom left corner of the cave.
6. So the agent starts at position 1,1, which
7. is the column one, row one.
8. And we know that this square, or this room is safe.
9. We're going to use propositional logic symbols, such as Pij
10. to represent the presence of a pit in the room ij.
11. So we're going to write Pij would be true,
12. if there is a pit in ij.
13. Likewise, we are going to express
14. that there is a breeze in some room or some square using
15. the symbol B underscore ij.
16. i being the column and j being the row.
17. So Bij would be true, if there is a breeze in the square ij.
18. OK?
19. So the instance starts at the room 1,1,
20. and we know that this is OK, right?
21. There is no breeze.
22. There is no pit.
23. There is no Wumpus, and there is no stench.
24. So we're going to express that there is no pit in 1,1,
25. using the positional symbol P1,1 negated.
26. So it's going to be negation of P11.
27. We also know from the background knowledge
28. that a square is breezy, if and only
29. if there is an adjacent pit.
30. In other words, we're going to express that
31. in this bottom left corner.
32. We will have a breeze in 1,1, if and only
33. if expressed with a bite conditional here.
34. There is a pit in 1,2, or pit in 2,1.
35. So we're going to write B1,1, if and only if, P1,2 or P2,1
36. Likewise, there would be a breeze in 2,1,
37. if and only if, there is either a pit here, here, or here.
38. So we're going to write that as P2,1, if and only if, P1,1,
39. or P2,2, or P3,1, all right?
40. So the agent is exploring this area after the agent moves
41. from room 1,1 to room 2,1.
42. We know that it perceives a breeze in the room 2,1.
43. So we're going to write that as B2,1.
44. And we also know from the beginning
45. that there is no breeze in 1,1.
46. So we're going to write this as the first propositional
47. sentences that express the knowledge that the agent knows
48. about the presence of pits and the breeze,
49. and also about what it perceives from the environment,
50. such as the fact that there is no breeze in 2,1.
51. Let's now call each of these statements
52. in propositional logic as a rule, R1, R2, R3, R4, and R5.
53. And we could ask questions about the knowledge base.
54. For example we could wonder whether there is a pit in 1,2.
55. In other words, does KP entails P1,2, and does KP entails P2,2?
56. So can we say based on what we know already
57. and in terms of perception, and in terms of the knowledge base
58. information, whether we could state
59. that there was a pit in 1,2, or whether there's a pit in 2,2.
60. OK.
61. So we're going to see how we could do that in a bit.
62. But in the meantime, let's clarify first with entailment
63. versus inference.
64. So entailment versus inference, it's
65. important to take a break here to express again
66. entailments and inferences in terms of semantic and syntax.
67. Semantics goes along with entailment.
68. Entailment means determining, whether by model checking,
69. a sentence alpha must be be true,
70. or must hold, in all models in which KB is true.
71. So we'll have to write it as KB models alpha,
72. means that is alpha true whenever KB is true.
73. The syntax goes along with inference.
74. And you know we like to determine entailment by what
75. we call theorem proving.
76. That is apply rule of inferences to the knowledge base
77. to build a proof of alpha without having to explicitly
78. **enumerate all possible models or all truth tables**
79. for KB and for alpha.
80. So we'll have to write this as either KB implies alpha,
81. or KB infers alpha.
82. All right?
83. So it's important to distinguish between these two
84. aspects of logic the semantics and syntax.
85. In the semantics we talk about truth tables, models.
86. And in syntax we talk about inference rules, et cetera.
87. But how does entailment and inference relate to each other?
88. This is a good, important question
89. to understand how these two aspects can be put forward
90. to build an intelligent agent.
91. So you want to build an inference algorithm that
92. is actually sound and complete.
93. So some of this refers to what?
94. It refers to the fact that we don't
95. want to infer false formulas.
96. That's pretty much it.
97. That is, we want to use some inference algorithm can only
98. derive entailed sentences.
99. So we can write this is as follows
100. using said builders-- we need to find, actually,
101. a sound inference algorithm, such that all
102. the inferred sentences using syntax
103. must be a subset of the entailed sentences alpha,
104. using the knowledge base.
105. All right?
106. So the inferred formula must be, actually,
107. a subset of the entailed formulas.
108. In other words, we want all provable
109. formulas, or propositions, to be actually true.
110. Completeness refers to deriving all entailed sentences.
111. In other words, we really don't want
112. to miss any true proposition that could be derived
113. from the knowledge base.
114. We write this using, again, set builders as follows.
115. We want to have that actually.
116. Now the show formulas must be actually derived from KB.
117. In other words, the entailed sentences, alpha from KB
118. must be a subset of the inferred formula.
119. Right?
120. So in other words, all true propositions must be provable,
121. must be provable using the inference algorithm.
122. So this is a powerful way to see the connection
123. between inference and entailment,
124. and do this bridge between the syntax and the semantics.
125. Just also for the sake of completing our terminology,
126. let's talk about validity and satisfiability.
127. A sentence is called valid.
128. So remember what we discussed in the previous slides,
129. the notion of tautology, if it is true in all the models.
130. Example, true, p implies p.
131. p and p implies p implies q.
132. So if you the truth table of this different proposition,
133. you will see that, actually, this truth table would
134. lead to true everywhere, no matter what the value of p is,
135. the value of q is, it will always be true.
136. For true it's a constant, so if there's a tautology as well.
137. Validity is actually connected to inference
138. via what we call the Deduction Theorem, in which we say
139. that KB entails alpha, if and only if KB implies alpha
140. is a valid proposition.
141. A sentence is satisfiable if it is true in some model,
142. for example p or q, for p or q is some sort of contingency,
143. and it could be satisfiable in some model.
144. r, also by itself or a simple proposition,
145. could be also satisfiable.
146. A sentence is unsatisfiabile if it is false, actually,
147. no matter what the propositions are.
148. In other words, it is true in no models.
149. If you build the model with the truth table,
150. you won't find this true anywhere.
151. For example p and not p, knowing that the connective conjunction
152. would be, putting these two propositions
153. together, would be always false.
154. These sentences would be unsatisfiable,
155. no matter what p is.
156. Finally, satisfiability is connected to an inference
157. via the following.
158. So we say that KB entails alpha, if and only if.
159. If you take KB and not alpha, you
160. will find it to be unsatisfiable. apples So
161. if you want either to prove KB implies alpha,
162. or if show that KB and the negation of alpha
163. can't be satisfiable.
164. In other words, this can be proven by a contradiction.
165. In other words, you could prove that KB entails the formula
166. alpha by contradiction, by showing that, actually,
167. KB and the negation of alpha cannot be satisfiable,
168. or is and unsatisfiable.
169. Now let's go back to how to determine entailments,
170. given the knowledge base that is expressed as a set of sentences
171. in propositional logic.
172. And, given a query alpha, we want
173. to know whether KB entails alpha.
174. All right?
175. So we, see as we announced earlier,
176. that we could do that in two ways,
177. either using the semantics, using model checking--
178. that is enumerating all the models, truth tables--
179. or using what we call inference rules,
180. also called proof checking, or theorem proving,
181. in which we are going to use purely the syntax to see
182. whether we could infer alpha offer from the knowledge base.