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CS 4635 Knowledge-Based AI

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Midterm

Problem 1: Semantic Networks

Semantic networks are a knowledge representation that uses a graph structure to represent the relationships between concepts. Each vertex of the semantic network represents a concept, and the edges that connect these vertices establishes an explicit relationship between the connected concepts. Semantic networks also allow for the use of spreading activation, where the activation of one concept can lead to the activation of its connected neighbors.

There are several reasons why Shakespeare's semantic network could have failed. The most predominant reason is that Shakespeare's semantic network likely contains outdated concepts and relationships, that would require amending. For example, the word 'clue' during Shakespeare's era does not mean what it means today. Today the word means a piece of evidence, however back then the word meant a ball of yarn. Outdated concepts like this would lead to confusion and frustration when Shakespeare tries to communicate with a modern individual, as they both have conflicting understandings of the same concepts. These outdated concepts can further contribute to Shakespeare's issues by wrongful activation during spreading activation, and this can even activate other concepts that do not assist the modern situation.

Problem 2: Means-ends Analysis

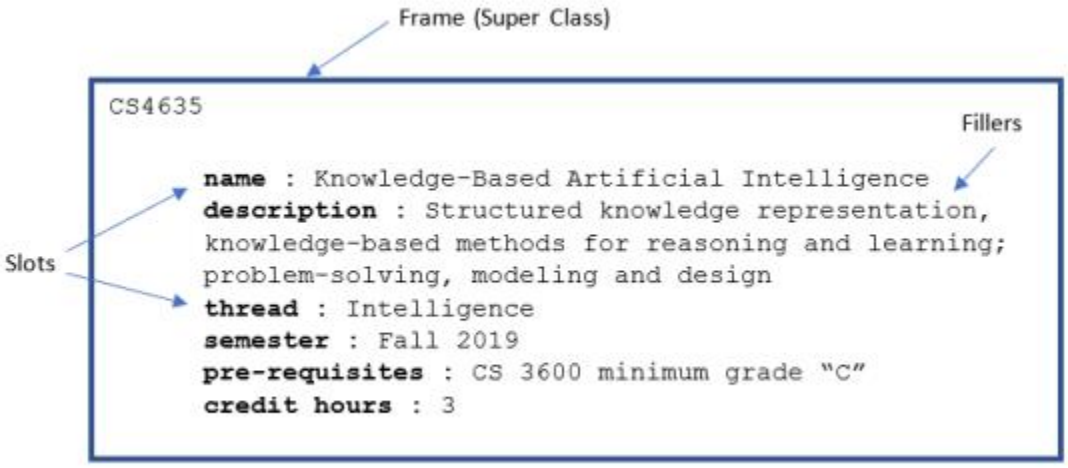
Means-ends analysis is a problem-solving technique where the agent moves through the problem space by examining the difference, or mean, between the current state and the goal state. Means-ends analysis is commonly used with problem decomposition in order to break down a more complicated problem into several smaller subproblems that the agent tries to reach first. Means-end analysis makes no guarantee of success or of the spatial complexity that it may reach. One of the problems that Shakespeare could run into if he used means-ends analysis is that he may get stuck in loops or local maximums. Simply looking for the highest mean-reducing action does not necessarily result in success. Another problem that could be potentially caused by Shakespeare's means-ends analysis is that he could result in cognitive overload. Cognitive load theory explains this phenomenon, which basically says that humans have a limited mental capacity when working within and processing short term memory. So when Shakespeare uses means ends analysis, the problem space may rapidly explode due to the sheer number of actions that could be taken. Once that number reaches a certain point it becomes nigh impossible for him to sort through and examine each possible state to determine its mean and pick the optimal next step. For example, if Shakespeare wanted to use the internet to research a topic, the sheer amount of intermediate states he would have to parse through to reach his final state would be astronomical.

Problem 3: Production System

Production systems are a type of cognitive architecture, in which knowledge is represented in the form of rules. Production systems can be broken down into three main components: a working memory, a rule base, and an inference engine. The working memory contains all the elements that comprise of the domain space of the problem. The Rules base contains various rules that follow the structure of a logical "IF-Then" conditional. An example of a rule that might exist in Shakespeare's mind would be "IF I am hungry THEN suggest I should go to the local bakery to get food" The inference engine determines which of the rules in the rule base have their conditionals satisfied by the elements in the working memory, and then decides which rules to apply. If Shakespeare relied on a production system, then a major hurdle he would face would be rules base becoming outdated. Many of his rules would no longer make sense in our modern day such as "IF I want to listen to music THEN I must go to the opera house" while a more modern rule would be "IF I want to listen to music THEN I turn on the raio."

Problem 4: Frames

Frames can be thought of as a type of data structure, they are comprised of substructures, based off of stereotype situations, called slots. These slots represent the many attributes that comprise the totality of the concept they are trying to represent, the values that fill these slots are referred to as slot fillers. To better illustrate this concept, an example frame is shown below for the concept of the class CS 4635:



From the above image you can see that CS 4635 is the super class, which is the subject of the frame. For each of its slots there is an attribute type, with the corresponding filler information. Frames also have the additional property of being able to be used hierarchically. This means a frame could have "child" sub-frames which, depending on the rule system implemented, can inherit values from the parent or be automatically filled with other default values. Shakespeare could face problems in the modern world where his stereotyped slots no longer match the modern-day interpretation of the concept. For example, tying back into the differences between the modern interpretation of the word "clue" and the one that Shakespeare would have had during his era, his frame for the concept "Clue" would have slots like "thread count" which don't match the modern day definition.

Problem 5: Case Application

Case application is a problem-solving method, where upon encountering a new problem the agent looks through their memory and retrieves a solution to a similar problem in order to answer the unfamiliar question. If Shakespeare uses case application to solve the problems he faces in the modern world, then he will have difficulty retrieving and applying memory cases that could help him deal with modern problems. It will be challenging for Shakespeare to find cases from his memory that properly correspond to modern problem. For example, Shakespeare will have no cases explaining to him how to operate a car. Furthermore, the few cases that he may be able to retrieve won't accurately equip him to face a drastically different modern landscape. For example, if Shakespeare applied the same renaissance solution to sanitation, he would improperly throw out collected trash into the street rather than waiting for the trashman to pick it up during the week.

Problem 6: Case Adaptation

Case adaptation is a problem-solving process, where in order to solve a new problem such that the agent doesn't possess a corresponding case in memory, they adapt an existing but different case to address the new problem. Cade adaptation can be broken into 4 key steps, retrieval, adaptation, evaluation, and storage. Retrieval is the process where in order for the agent to solve a problem, they first search their memory for the closest corresponding case. This is because we as people generally operate on the assumption that similar problems have similar solutions. The retrieved case is then modified to best fit the new case, this involves relaxing or tightening the constraints that define the case. After the case is adapted, it is then evaluated to see its accuracy. If the adapted case properly addresses the problem, then the case is stored back into memory for further reuse. Shakespeare could find problems within the modern world when he tries to adapt a seemingly similar case from his era to the modern-day case. However, the cases are actually quite different in ways of problem solving.

Problem 7: Classification

Classification is the process of mapping sets of percepts to equivalence classes that establish a particular instance of a concept. This allows the agent to think in terms of mapping classifications to actions, rather than percepts to actions, a much more mentally costly exercise. Concepts fall across a spectrum ranging between formal to less formal; where the more formal the concept, the more well defined the classification conditions are. There are three types of concepts that exist along this sliding spectrum, Axiomatic, Prototype, and Exemplar. Axiomatic are heavily formal where the concepts are defined by a set of necessary and sufficient conditions, such as geometric shapes. Prototype concepts are less formal than axiomatic, having base concepts that can sometimes be overridden, such as chairs all having ‘4’ legs. Exemplar Concepts are the least formal, being defined by implicit abstractions of instances, concepts like beauty and grace belong to this type. Many of Shakespeare’s classifications would be out of place when compared to more modern groupings. For example, during Shakespeare's era, natural elements were wrongly classified and organized by alchemists.

Problem 8: Incremental Concept Learning

Incremental concept learning is a method of learning in which examples are used to extend the existing model's knowledge. This happens in a three-step process, the agent is shown an example of a concept. The agent then variabilizes the example, which makes a more abstract notion of the example. And finally, the answer is revealed, and the agent adapts to fit the example into their current understanding of the concept. If the example provided does not conflict with the agents existing model, nothing is done. However, in the case where there is a mismatch the agent can use Generalization or Specialization to adjust their model to take the new example into account. Generalization is the process of loosening the constraints that define the variabilized model, while specialization does the opposite and tightens them. How exactly the agent specializes or generalize is determined by the specific Heuristics they will be using.

If Shakespeare relied on incremental concept learning when faced with the modern world, he would likely suffer from the problems of overgeneralizing or overspecialization concepts. Similarly to when a child may call any furred animal they see a “dog” because in their mind they have overgeneralized the concept of dog to include any animal with fur; Without proper guidance Shakespeare would likely do the same to many of the unfamiliar modern concepts he would encounter. For example, if Shakespeare saw an airplane, he may wrongly attribute the concept of “airplane” to any man-made device that fly, which overgeneralizes to include things such as helicopters and rocket ships.