Artificial Intelligence
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Lecture-6
Constraint Satisfaction Problems: Representation of the atomic state, Part-1

Let us get started; now we have reached a certain land mark point in the course landmark, a milestone is the right word is a milestone in the course. Why? Because, up until now we have been talking about search algorithms, we have said that AI is search we have said that AI can be thought of as problem solving, you would be given a new problem. Whenever you are given a new problem you will define a general purpose problem definition version of that problem.

And that general purpose definition was the atomic agent definition where we are given a set of states but no never given a set of states, there are a set of states but we are only given a starting state, a successor function and a gold test 1 player 2 players does not matter. In the case of 2 player, we are given a test of you know, whether we win or lose or you know, draw whatever and this formulation sort of works in a large number of problem solving scenarios, that is great.

One of the assumptions that the atomic agent made is that the state is indivisible. Now, I would point out that this is not always how we went ahead we relaxed some of these ideas like for example, we talked about domain relaxation. Now, we can only talk about domain relaxation if you know what is inside a state, because then we know what is happening in the domain, we relax it and then we can compute the heuristic function.

So it is not that we always thought state to be a number which we cannot go inside. But we did not have any canonical representation or the canonical way to represent the state. This way of representing the state was in our head which was problem specific and then we created these extremely general purpose algorithms, which whether the state is a number or we have more structure on the state of whatever it is, it will still work.

And we did a lot of search algorithms you know, beat depth first search iterative deepening, depth first search branch and bound a star rated a star we use the local search formulation. We did minimax in the context of games and this is the AI is search mindset, everything in AI is search. Whatever problem you come up with, I will be able to create a search and a log of that and then I will be able to use some of the existing algorithms to solve it.

Now we are going to make a jump from AI is search to AI is the representation, so this is the next big mindset. I would also point out that you know of the very famous mindsets like machine learning and deepening network mindset that has made AI very popular that AI is representation mindset is, you know a little bit old school I am not saying that it is not important it is extremely important in fact, it is still used today in a wide variety of settings.

But it is not the sexiest mindset but we are sort of working bottom up with all the various ideas, prominent ideas in AI and there in that context, you will slowly realize that AI is representation that great mindset to have. Specially, if our goal is to solve many problems at the same time and the reason is that in the atomic search paradigm, atomic agent paradigm, we do not know anything about the state, we cannot go inside the state.

We cannot say that this state is sort of very similar to that state only something has changed. If you think about it, suppose this is where my class is sitting today. You know, I am standing on this podium and Kiran is sitting in the chair number 15 and Vishwajith is sitting in chair number 31 and you guys are sitting where you guys are sitting. Now suppose and let us say we call this state, state number 235 every state has a number.

Now, we make only one change, we get Vishwajith to standard up you know, go from chain number 35 to chain number 38. And that is the only changing making the whole state because now every state was a number we would have to give a new number to this and this new number might be 4012. So now when we make one change in state 235, we get to state 4012 it is nothing wrong with it, but notice that we have completely lost the structure that state 235 and state 4012 are very closed by states they are almost the same states, only one student moved.

Of course the idea of student is not a general idea so, we have to somehow say that however, my state 235 was represented in some general purpose language, state 4012 is almost the same representation there is a small change and this notion of state similarity is not possible in the atomic agent mindset, this requires us to look inside the state look inside the number 235.

And say okay where is Kiran sitting? Kiran is sitting at 15 where is Kashika sitting? Kashika is absent, where is Sukrithi sitting? Sukrithi is sitting whatever, you get the point. So, the point is that we, if we are allowed to look inside the state, we can do more interesting reasoning. We can even reason that our goal is to have Vipul sit on chair 400 and chair 400 is vacant, so, I will just move people to chair 400 is respective of where Vishwajith was sitting.

So, if the 2 states where we Vishwajith was sitting in 35 and 38 had Vipul sitting in the same place which it does, then Vipul will have the same plan to go to chair 400. So if we know the plan from state 235 we also know the plan from state 4012. This intuition, this analysis that these 2 chairs these 2 states are sort of the same for the purpose of the goal at hand is only possible if we are able to look inside the state.

For example, if my question is whether it is going to rain in Delhi today or not and you know, my state I also know whether it rained in New York today or not I can say that it does not matter. Let New York rain today let New York not rain today, who cares from the context of Delhi. So therefore, they will have the same probability these 2 states, all of such possible reasoning's and inferences are possible only when we are allowed to look inside the state.

Now, for the purpose of n queens, you can say queen 1 location 1, queen 2 location 2 is my state for the purpose of an puzzle, we can say tile 1 location tile 2 location is my state for the purpose of this class we can say Vishwajith location and Kiran location is on these chairs. But notice that different kinds of problems will have very different states representations that is not in good, because if everything has a different representation.

Then we cannot do anything general purpose there so a goal of AI is to come up with general purpose representations extremely general purpose, which allow you to represent your problem in that representation effectively.

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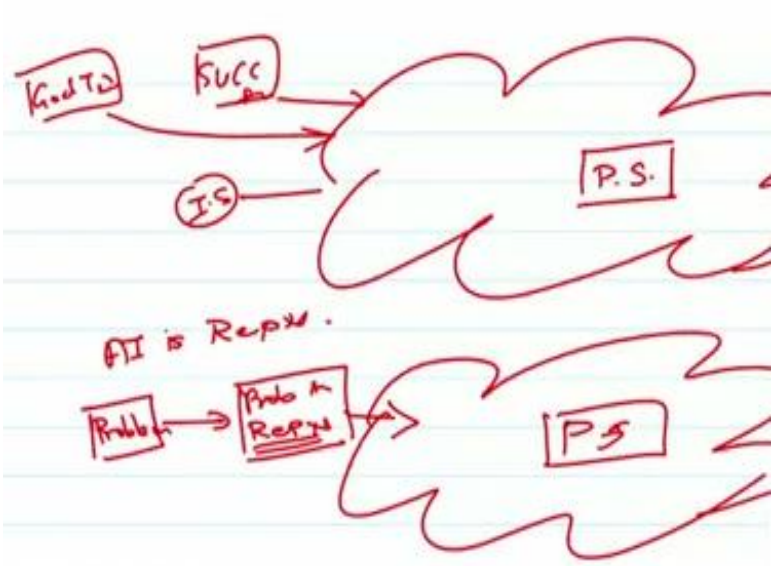

So if you think about it let us say this is my brain Sorry, this looks like a cloud but let us say it is my brain. And now, this is the part inside the brain which does problem solving, it runs the minimax algorithm, it runs the a star algorithm, it runs all of those algorithms, that is the core of AI, because every problem that needs to be solved, may require some search and may require some other algorithms, general purpose algorithms, these are those general purpose algorithms.

Now, how would I tell my problem to the brain? How do humans tell the problem to a human they use words, they use language. Language is the fundamental means of communication. I mean, it can be sign language, but it is language of some sort. How do we communicate with a computer language you write the program in C++ or Python or Java, it is the language that we understand and the computer understand it has to be a common language.

Now, up until now, how have we been specifying the problem to the machine? We have been saying I will have a goal test I will have a successor function I will have an initial state which is a number and all these things will be given to you as code as binaries as function calls. Now, this is not a language this is a procedural view where my machine can make an API call my machine can make a system call say okay, is this goal or not.

And then the gold test will represent the answer yes or no I may not even know the actual problem. I do not know that you know, we have students sitting on chairs, I do not know whether we have we are playing chess, I do not know whether we are playing tic tac toe, it does not matter to the from the purpose of the brain. The brain is simply learning that algorithm and making those tests and successor function and finally giving you the result.

But let us say we want to give the problem to the brain, let us say we want to do interesting more interesting inference. So, in that situation, you will still have a problem solving component in the middle. But let us say want to write down my problem to the brain not give it as a code. In such a situation, we need to come up with a language, a language in which a human can have a problem in mind and he or she writes down this problem in a given representation.

That machine and human both understand this representation is my language and then this representation goes into the brain and now the brain can obviously run the basic atomic agent problem solving scenario here or it could say you are giving me a problem in language one, I will use the properties of language one to understand something about the new problem the new domain and actually reduce the search, you can always use the basic search but this search will never scale for you but if you are given a specific representation.

A specific language and you were able to use properties of this language, you might be able to save tune, remove parts of the search and make it much faster and much more scalable. Therefore, there are some people who believe that AI is a representation? AI is thinking about in what language should the problem be given to the machine and in then using those properties of the language to reduce the amount of effort I need to do as a machine to solve the problem.

So this is a very high level description for you and I will tell you honestly, this AI representation view took me some time to recognize, realize and appreciate. So, if you are thinking that what is this very high level I do not understand what is going on we will fix that problem and we will fix that problem by 3 examples of this and I hope that by the end of those different 3 examples, you will have some intuition of what I mean when I say using the properties of the representation.

To reduce the total search space so, what are the 3 representations that we are going to study in the class, we will study the representation of constraint satisfaction problems it is a very simple representation. The most interesting representation that we are going to study is propositional logic. Now, you all know Boolean logic it will be very similar, but we will see what more we can do with Boolean logic.

By the way, logic used to be the defecto standard for presenting new problems in AI for 30 years or 40 years, right up to 90's I would say, logic or variants of logic and then towards the later part of AI probability started to come in and so we will, learn one representation of probabilistic AI and that will be Bayesian networks. So that are the 3 next steps that we are going to study we are going to study constraint satisfaction, propositional logic and Bayesian networks and in all cases, you will know looking inside the state.