Artificial Intelligence
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Lecture-25
Local Search: Drawbacks of Hill Climbing Part-4

We will continue talking about Local search and if we think about Local search and just remind yourself every word. We defined that we want to solve a problem using a local search setting, which we basically means you are going to search in the solution phase. We will not search in the partial solution phase which we were doing in a systematic solution phase. We are going to search in the solution phase. It is a complete solution phase.

And we will artificially define the neighborhood function which is basically say that two functions are similar to each other. For example, if the context of nth place that my search states let all the queens be placed one in each column. And my neighborhood function was everything any one move, any one queen and move it anywhere is the concept. That is what we defined it as our neighborhood function.

With every local search problem, with every state we will associate data and evaluation function. And in case of n queens, the evaluation function would be the number and phase of queens which are not attractive and in which case we want to maximize particular quantity. And then we define Hill Climbing search, a very local search as of first algorithm. Come on, this is where we start.

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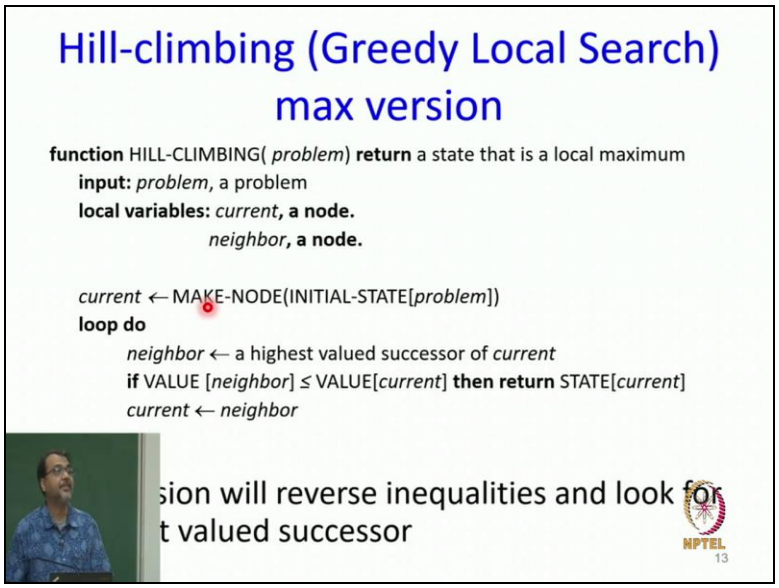

So just to remind you this algorithm was start from any state right, any current state and a loop. In the loop you look at all your neighbors, all the states, all the solutions which you can reach in one step. Evaluate all your solutions; all your neighbors pick the best. And that best is first. And if the value of neighbor is less than or equal to value of current, basically all my neighbors are worst than me, I stopped. Once if the neighbors are better than me, move or I jump to the best neighbor and if time 2:31 neighbor ah is decided at random.

And I repeat. So I am at a point, I look at my neighbor jump to the best neighbor, I look at its neighbors jump to the best neighbors, I look at its neighbor jump to the best neighbor until I reach a state were all neighbors are worse than itself or worst than the middle state and then I say done, this is my solution. This is called Hill Climbing Search.

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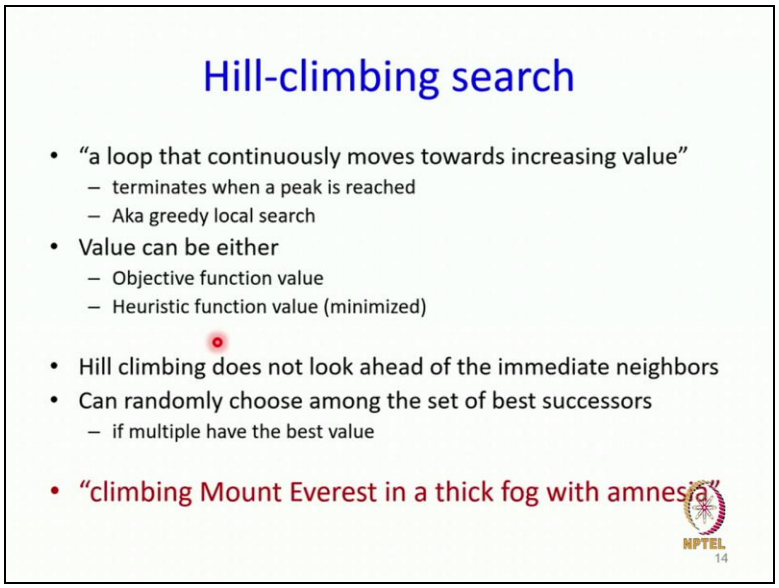

And we discussed it is like climbing Mount Everest in thick fog with amnesia because I am climbing because I am always looking at neighbors and climbing and deciding the next best state. It is like climbing of Mount Everest because I want to maximize the objective function you think of an evaluation function as mountain, we are in a thick fog we are never looking one beyond one step. We are only looking at one step.

This is insubstantial contrast to the first search and bread first search we are going in depth first search for going in deep but coming back. But this is no such coming back in hill climbing right moment. We are in amnesia and because I completely have no memory where or how I reaching this particular point. This is like Gajini all over again. And then we started talking about the landscapes, search landscapes.

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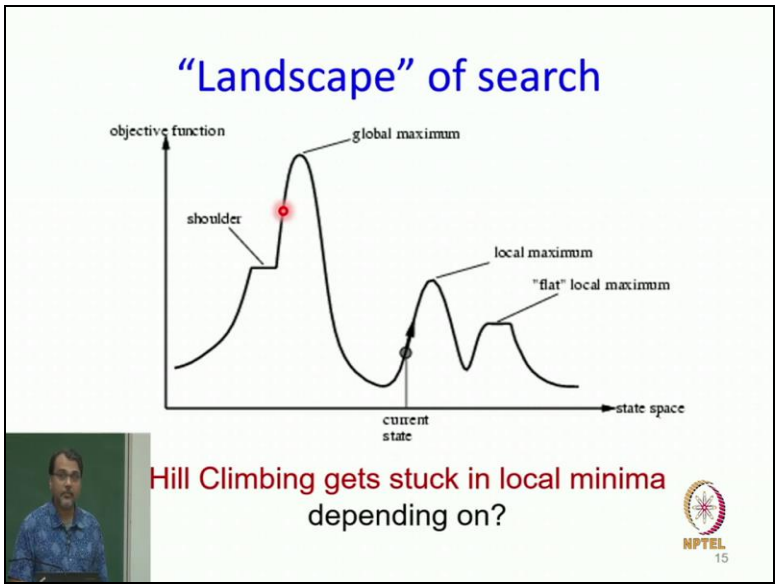

This is sort of a schematic; we started to show you the value of an objective function and different point of states. And let us say it is a one dimensional problem, no problem is one dimensional typically and this is an artificial problem. But let us say it is a one dimensional problem. And let us say we were doing local search. It will always go in two directions, left or right.

And I looked at whichever is the better direction to move as I go. Typically I am going to climb the hill. And so this is the global maximum which I want to reach. But of course, I may not end up reaching this global maximum I may end up reaching a local max or local Optimum if I am in a minimization setting it could be a local maximum. How, what happen, when would I reach local maximum and when would I reach Global maximum? What does it depends on?

It depends on where we start from. If I start on this hill, I will hit a local maximum. If I start on this hill, I will reach a local maximum. It is a flat hill so it reaches local maxima. If I start on this hill at the left side, I may reach a shoulder and end up there because none of my neighbors are better than me. Once I start from this position or this position, then I will reach the global maximum. So as we said, Hill climbing get stuck in local minima depending upon the local optima where I start. Let us look at simple example.

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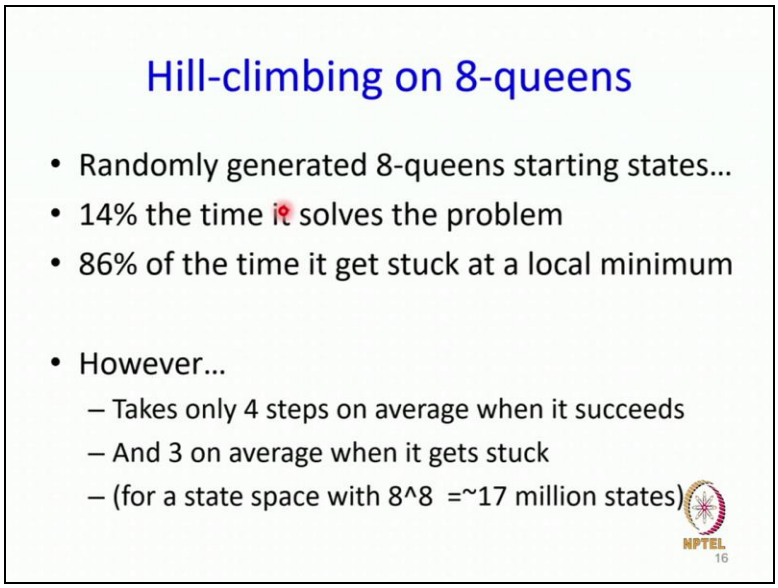

Hill climbing on 8-queens: Now we have to ask how do I start the process so we can let start with random initialization. Random initialization is every column place the queen random. We have placed a queen's random every column. And when you start hill climbing, using the neighborhood function that we define 14% the time it was the problem. 8% is hard enough for the problem 14% of the time it solves the problem in 4 steps; In 4 steps it solves the problem in 14% of the time.

86% of the time it gets stuck in a local optimum it is not a solution. You know that there are some coincident acting but I cannot make another hope to that particular solution. And when it gets stuck it will only get stuck in 3 steps. Basically what happens hill climbing, you start and it either one of 7 times either you solve the problem or you are stuck but it **(()) (6:44**) your first step. Now think about the power of local search and weakness of local search.

On the other hand, if you are doing depth first search, depth first search of branch and bound, it will take to a huge free expansion before you find a valid one during it because you will make mistakes and then it will attract and then you would make an early mistake and then you will backtrack on the full subtree before going into the next subtree etcetera. So you will be spending a large amount of time doing search and local search and you assume stop.

You stop with a solution or stop without a solution but stop. And now what I would like you to think at the back of your mind, I do not want a suggestion right now. What I would like to think at the back of your mind is how do I fix? Can I improve local search somehow, so that this 86% failures can be reduced. That is our first job for today.

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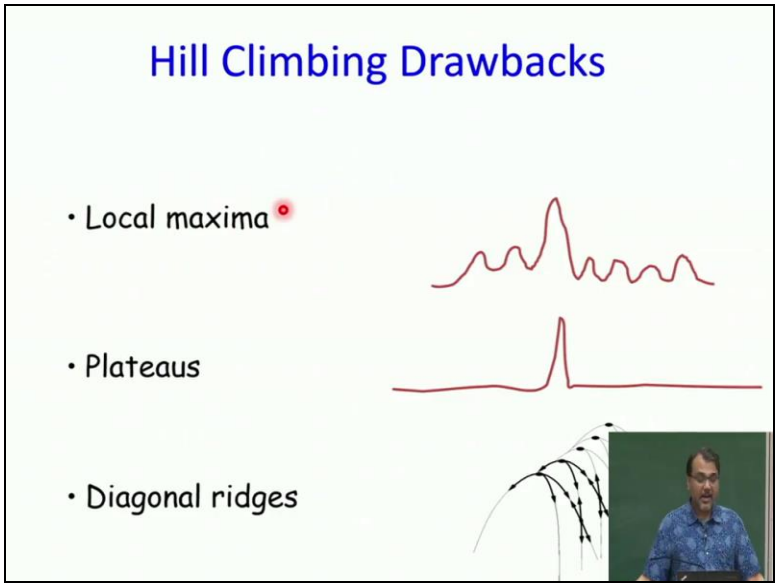

And the typical drawbacks of Hill Climbing are local maxima, Plateaus and other structure which lead you to not reaching the Global maximum. For example we already defined what a local maxima is. This is one local maxima this is one local maxima and this is one local maxima. But plateau is the, my neighbors are not improving, they are exactly equal. They are exactly equal regions where not much is happening.

I mean solutions are changing but the costs are not changing. And then there are many other characteristics. There is something called Diagonal ridges. Diagonal ridges says you are at this state of local optima, the only way you can get to this next local optima if in one direction you make downward move and in the other direction you make upward move. Complicated stuff? But in general in life, you think about it.

This is actually this is true to all of us. This is really you have to ask. In our life, do we do Depth first search, breakfast first search, isolating deepening search, Astar search or local search. What do we say? What is the closest? I know that we do not do any of this search but what do you say?

Which is the algorithm that we live our life closest to? Do we ever go back in time? Can we ever backtrack our life? We can never backtrack our life. Whoever say button you can have a reset button he is only making metaphorical statement. The time never comes.

The whole time is gone. We are always leading a life and we are always looking at our neighbors. But there are one step action taken in our life and we jump to that particular action. Can we go there? We never backtrack neither do we keep track of many different states and keep jumping between them like a breadth first search nor do we restart from childhood and go down and then we find a solution behind and restart from the childhood and we do not do this. We do not do isolated deepening search.

We only lead one life and we lead our life only in one direction always we do local search. And now there is an important thing. It is a, it is simple metamorphical question. If I am stuck in a local maxima and I want to reach the global maximum, what do I have to do. It is obvious I have to go down. I need to know where the local maxima is a good question. We may have more information right that is why I said they do not exactly do local search.

But let us look at the intuition local search gives about our life. We are stuck at a point and now it just happens in a wide variety of settings. You are writing a paper this happens to me all the time. We write a paper there is issues in it and we improve, there some issues in it let me improve, improve, improve, improve. We are now stuck somewhere. The paper is not getting accepted. The reviewers do not like it. What is happening is he is getting stuck in some way near the local optima.

He cannot jump to a better solution from here, we have made lot of choices in the way we have structured the paper and because of which our paper is not a place where small improvement are not going to improve it further. If we really have to jump to a better solution what we do, we have to do? Can you guess? Start at first. We have to rewrite it. This man writes a second draft. This is true for your code.

You start writing the code you write the code you write the code you are finally done with the code and then you feel like ok I have understood a lot about my problem while writing the code. But now I am sort of stuck. If I have to really do a better job a more efficient job a more structured code, report, I have to start again. You are having a relationship with somebody. You are married to somebody. Ok. Slowly you have developed a co-dependence.

The husband takes care of the income tax and the wife takes care of the, you know, whatever, ok I making these are stereotypical, I apologise. The wife does not know how to take care of income tax husband does not know how to cook. They are very unhappy with each other. This happens to not cooking and income tax. But this scenario happens to apparently to a large fraction of a population. It is said that 5% of people in a marital relationship are have. I am not making this up.

And in the West we have 49% divorces. What happens? So, you have reached local optima in these relationships. You are gaining something from this relationship. So you are aiming not to do Income tax or not doing cooking or whatever it is, you are not able to do and you delegated to the other person. But you are unhappy because there is no satisfaction, there is no this there is no that the person is blablabla's ok. We have all seen many people in our friend's family or friends circle who are in this kind of a situation.

In order to get to a better optimum, they cannot start moving up. There is no ladder from the local optima to the global maximum. The only way to reach a better optimum is if you first mess up your life even more. That is just the reality of this. Intelligence is based on what you see long term and how do you treated of the short-term. A lot of people in an Indian set for example are never able to take the leap of divorce or separation anything like that because there is one person in the family who does not feel financially secured or does not have the confidence to take these steps.

The low, the going down it is too much risk for them that the potential reward in the future, does not feel strong enough even though they wanted. They are not able to take that game. In life meet whatever situations ok these are all example. One more gloomier than the other writing a paper is

ok we can write a better paper. But this is all always we do in life. We always have to take a step back and say ok I have reached a certain local optima is this the local optima I am happy with, if I am not happy with it then is there a hope that I will be happier in a different place. But this is something that a local search cannot do.

But we are human and can do. And if so we should be willing to let go of the nicest things in the local optima which they asks some always because it is an optimum of choice. Have to go down have to deal with the repercussion of going down. If I start up with writing a paper afresh, if my deadline is within 2 hours, that is a terrible idea. If my deadline is 2 weeks down the line Ok we have actually time to enough time to actually have time to fix and try to do Hill climbing.

So first reach rock bottom. As they say something you know there are some people who say you cannot go anywhere rock bottom it is only upward from here right it is sort of, some famous way of saying for people who are not doing well but then once you hit that point then you start climbing and If you do this more carefully, you have a good chance that you will hit a better optimum. Alternatively you may reach optimum and realize oh man this is even worse that we have restarted now. That is also possible.

So we have to be careful. But this is what the local search teaches us. That from a local optimum we only have to go to global optimum is to potentially do go down ok. With that perspective in mind, let us see if we can do hill climbing. Let us start with a easy, easy problem. Let us say we are in a plateau. We are on a plateau which means our next neighbors are all in equal value. What is the easiest thing we can do in the hope that we would avoid the, we would be able to get over the plateau and even better.

What should we do? Anybody? Instead of saying that my neighbor, the my next neighbor should be greater than me just simply say that my next neighbor is greater than equal to me. Which is also called as sideways move?

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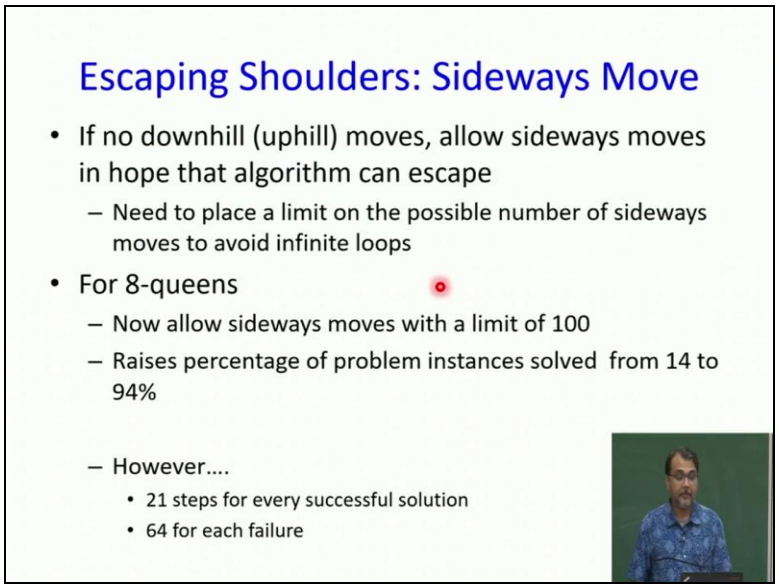

Yet there is no downhill or uphill moves, allow sideways moves in the hope that the algorithm can escape. What is the hope? The Hope is that it is only a local plateau, I will keep moving on sideways and I will get some point, I will hit a point from where I can start moving up again. So, start up with the hope that I will be in in the left side of this figure, I keep moving I rest on the shoulder and I keep moving on the shoulder, and at some point I reach these corner points and start moving up again. This is called sideways move.

And for 8 queens, ok now the question is how much sideways move to be allowed, to be allowed? An infinite sideways move or do we allow a little bit of sideways right? So next we place a limit on the number of possible sideways move to avoid infinite loops. Let us say we impose a limit of hundred on 8 queens. So, remember, without sideways move 8 queens have succeeded 14% of the time which sideways move 8 queens 94% of the time.

With just this one small change, greater than to, greater than equal to, we have an a maximum limit of 100 for that we have converted our problem into 14% successful to 94% successful. Little bit of catch, the catch is now it does not take 4 and 3 steps now it takes 64 and 21, 21 and 64 steps for success. So, 21 steps are for success and 64 steps for failure. Today in the next class we will be looking at many, many different algorithms in this fold.

And in fact, Local Search is sort of a very intuitive and you can start making your own algorithm and mostly like somebody has just made it and if there are some problem where it is helpful. So just think about it that way. Let us talk.