Artificial Intelligence: Search Methods for Problem Solving
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Chapter – 08
A First Course in Artificial Intelligence
Lecture – 51
Game Playing
Popular Recreational Games

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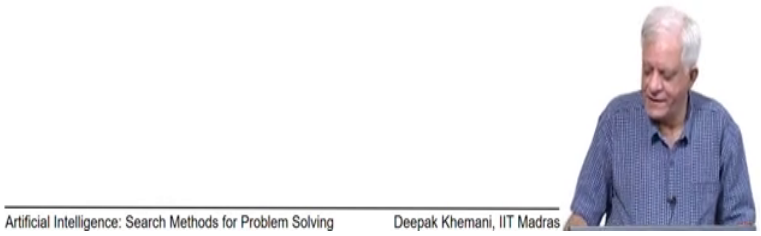

Welcome back. So, in the last session, we looked at game theory in general and we observed that game theory was concerned with rational choice in a multi agent scenario, where there are other players and how does an agent make choices in such a scenario. Now, many of the things that we talked about like corporate world or social situations and so on; they are slightly more complex to model. And we computer scientists have always been fascinated

with smaller games, which are recreational games; games like chess for example has been a fascination ever since computing began.

And the reason why we prefer games like chess is for first of all, they are extremely simple to implement; if you want to write a program to play chess, then you do not have to have a computer vision program, speech understanding program or you know collecting data and everything. You can in fact play chess simply by constructing a 8 by 8 array and place and you know putting pieces and you can even play it without any physical hardware.

So, I have known friends, who while going on a walk play mental chess. So, each of them has a model of the board in their head and they keep saying that this is my move and this is pawn to king 4 and pawn queen 4 and so on and so forth and they play a game without any infrastructure at all. So, it is easy to implement especially, because the moves are very digital in nature that you have to you know make some specific piece; you have to move a piece from one place to another.

At the same time, they are easy to evaluate; so the impact of your choices are available to you immediately after the game is over. So, you can figure out whether your strategy was good or not good. And at the same time as we will see, such games are complex enough to be able to retain the interest of people who are devising algorithms to solve those games. So, we will start with the game of chess; chess has been one of the most popular games in computer science.

Ever since computers began, people have been talking about programming chess; because you know for a long time chess was considered to be a hallmark of intelligent behavior. And people said that if you are a good chess player, you must be intelligent.

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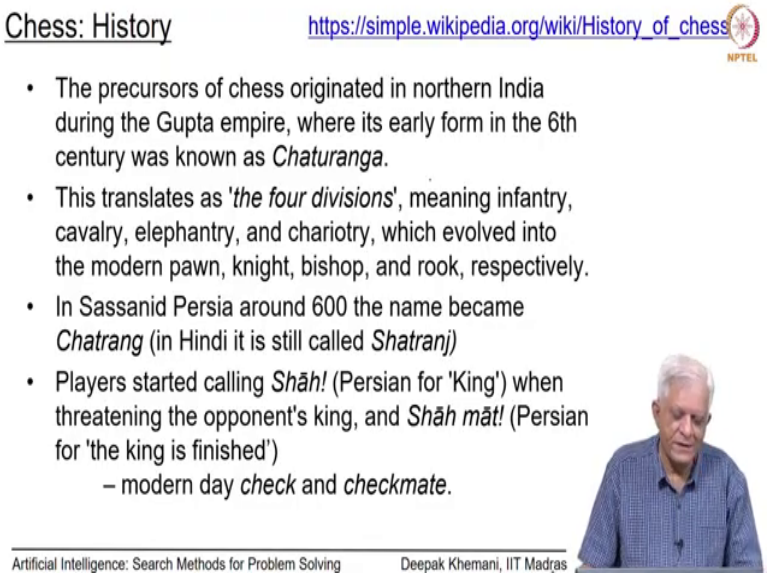

So, let us look at the history of chess to start with. It is an ancient game and the precursors of chess were in northern India during the Gupta empire in the 6th century and at that time the game was known as Chaturanga. Then it moved to other parts of the world. The word Chaturanga comes from four divisions; which meant that time infantry, cavalry, elephantry, and chariotry, which eventually evolved into the modern day pieces on chess which are pawns, knights, bishops, and rooks, essentially.

The game moved to westwards from India towards Persia, which is current day Iran and around 600 since AD came to be known as Chatrang. Now, in the speakers in India would recognize that you know we often refer to chess as Shatranj, which obviously is related to the word Chatrang. You might have seen the famous film by Satyajit Ray called Shatranj Ke

Khilari, which was based on a story written by Munsi Premchand. So, the word Shatranj is often been used in India for the game of chess still essentially.

In those days, people used to use the word Shah or which was kind of a check; the nowadays we say that you are giving check to the opponent. So, you are when you are as, whenever you are attacking opponents king; modern day chess the players obliges to say the word check. And you can imagine that this comes from the word Shah, which came from the Persian word for king, which is Shah essentially. And if you have managed to checkmate the opponent, then they used to say Shah mat; mat is a word that even in Hindi means defeat.

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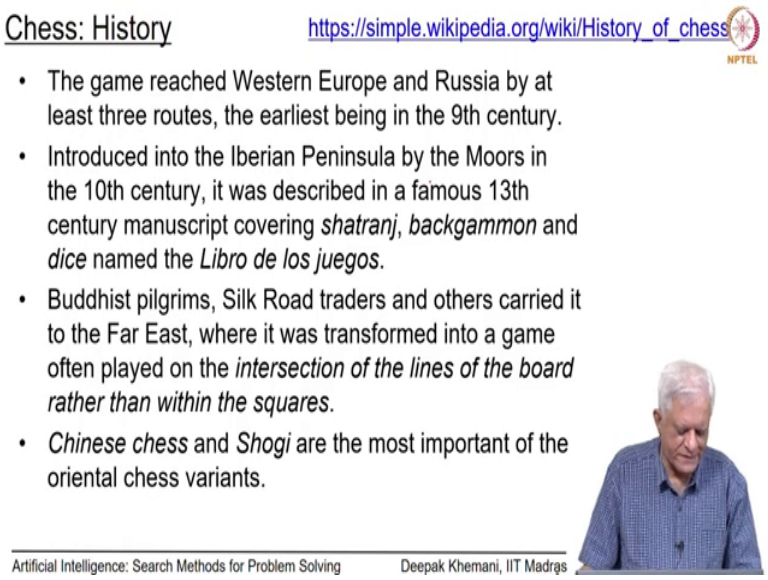

Then the game moved elsewhere from the middle east and went to Western Europe and Russia by at least three routes and the earliest being in the 9th century essentially. Introduced into the Iberian Peninsula which is the span, which is where Spain is by the Moors, who are

Islamic people in the 10th century. It was described in a famous 13th century manuscript covering shatrang, which is what we call as chess, backgammon which is a game which is played with dice and named Libro de los juegos if you understand Spanish, I do not.

Buddhist pilgrims along the Silk Road and others carried it to the Far East. So, you can see that the game went from here to Persia, from Persia to Europe, and Russia and then to Far East. And one change which happened was that through often played on the intersections of lines of the board, rather than within the squares essentially. So, Chinese chess which you might also know as Chinese checkers is a kind of a variation, and Shogi are the most important of these oriental chess variants. And we will also see the game of go as we go along, though its rules are very different from chess.

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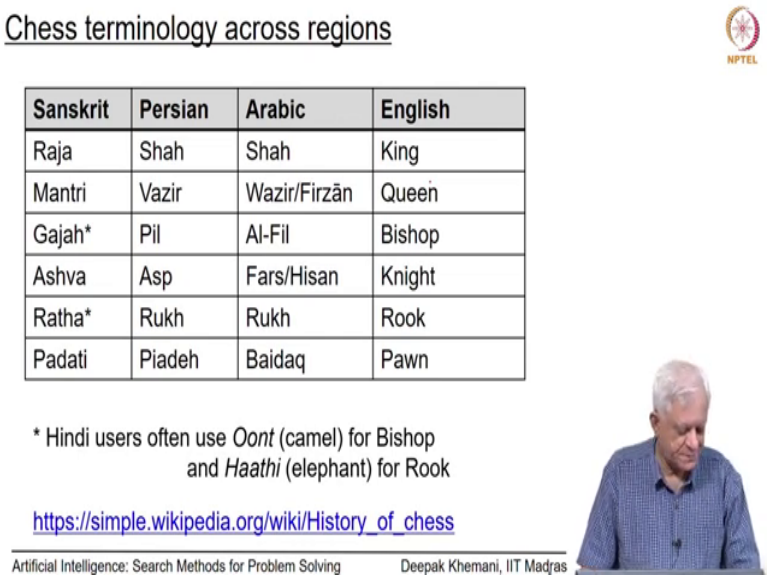

So, here is some look at the terminology across different regions; on the left hand side you see words derived from Sanskrit, which for example. And on the right most you see the words, corresponding words in English which are used in modern day chess, and in between you can see the words in Persian and Arabic. So, for example, raja was called shah in Arabic and Persian, and king in English, mantri.

So, the Indian original chess which was you know model as a war game, the mantri was the advisor essentially. And in Persian, it was called vazir which is another name for mantra, and firzan also in Arabic. In the European word for some reason, they moved from advisor to queen; instead of minister, it became the queen. Then we have this piece called gajah, which in Persian is called pil and in English is called bishop. The word ashva which stands for a horse and asp in Persian and fars and hisan in Arabic and knight in Europe.

Because in Europe, the warriors or the elite warriors used to be called knights and they used to be on horseback. Then ratha, which was called rukh in Persian and became the rook in English. And padati which in Persian is called piadeh, which also we often use in Hindi nowadays, which eventually became the pawn in English. So, people playing chess in India would know that you know we often use the word Oont which is the Hindi word for camel for the bishop, and Haathi which is the word for elephant for the rook.

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Now, chess has fascinated us for centuries as we have seen. And in medieval Europe, Wolfgang Kempelen, he said to have constructed a chess playing machine which was called the Mechanical Turk in 1770 in order to impress the Empress of Austria Maria Theresa. It turned out that this was not a machine playing chess; but an illusion in which diminutive chess player was hidden inside this contraption that he took around the world. And but, he was a great success and; his so called Mechanical Turk defeated some well-known people like Benjamin Franklin and Napoleon Bonaparte.

So, as an interesting aside from here, you might be aware that nowadays when you are collecting data from the web or the internet or you are getting some jobs done on the internet that you found out jobs and you know; for example, if you have to translate words from one language to another, you might you know found them out on the internet and people do parts

of it and then they get paid for it. And that process of this mechanism is also known as the Mechanical Turk; this is kind of an ode to Kempelen.

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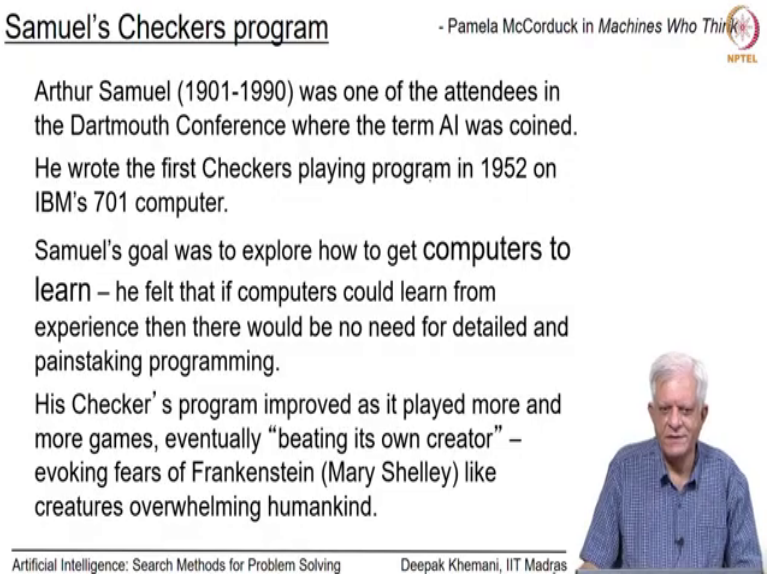

A small deviation from chess here, a simpler game of checkers was actually the first one in which we achieved success. And this was thanks to Arthur Samuel, who was one of the attendees in the Dartmouth Conference where the term AI was coined. He wrote the first Checkers playing program in 1952 on IBM's 701 computer. In fact, there is a curious story going around that, because the game of checkers is played on 32 squares of the chessboard; for example, they are always played on one colored squared, so either black or white as the case may be.

And because of which, IBM chose their word length of their first machines to be 32 bit, so that you could easily represent a chessboard simply as a binary string; anyway that is a story

which is, which was going along. The interesting thing about Samuel's program was his goal was how can computers get to learn; which of cause is a modern day preoccupation with AI. In those days also he felt that computers could learn from experience; then there would be no need for detailed and painstaking programming. So, we are still trying to do a lot of that kind of a thing.

In this case, he was very successful and his checkers program improved as it played more and more games and eventually as you might say beating its own creator. Now, that is something which has been feared long in mostly in the western society. Thanks to the novel Frankenstein written by Mary Shelley, in which the artificial creature created by Dr Frankenstein actually overpowers him essentially. And modern day thinkers have often kind of raised such fears about AI and saying that AI will wipe out humanity; I mean there are people as eminent as professor Hawkins who have said such a thing.

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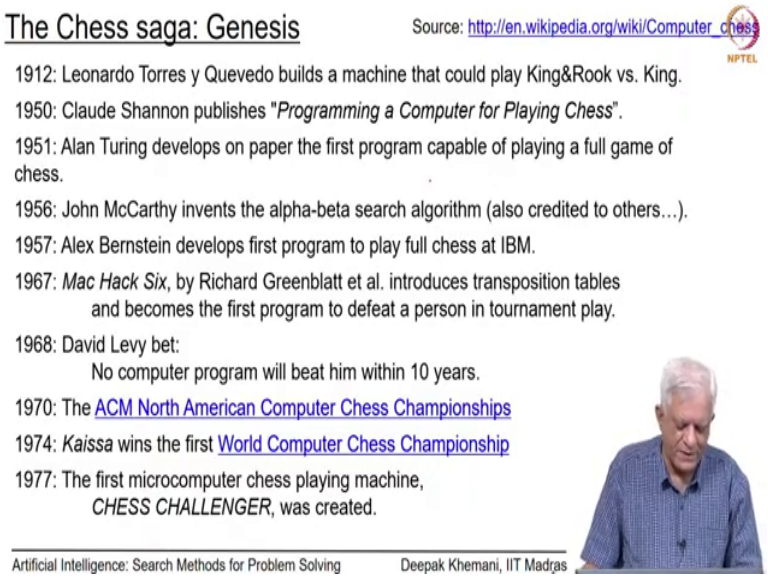

So, let us now quickly go over the chess programming saga. And in all began in 1912, when Torres wrote a program to play the King Rook verses King in game. Shannon, Claude Shannon, father of information theory published how to program a computer to play chess. Alan Turing wrote a program on paper; he did not implemented capable of playing a full game of chess. John McCarthy another luminary, in fact the person who coined the term artificial intelligence is the Dartmouth Conference; he invented the alpha beta algorithm that we will study later. But it is also credited to other people.

Alex Bernstein wrote the first chess playing program at IBM. Mac Hack Six by Greenblatt introduces new techniques like transportation tables, and became the first program to defeat the human being in tournament play. The British grandmaster David Levy he offered a bet in 1968, that no program will beat him within 10 years. In 1970, the North American computer chess championship started; so we started having tournaments for computer chess.

The Russian program, Kaissa wins the first computer world chess championship. And the first microcomputer; in those days remember computers were mainframe and huge filling rooms, but micro computers has started coming into the picture and or something that we call a desktop now. And the first micro computer processor chess challenger was created.

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Then progress happened as we moved along. In 77, a program called chess 4.6 is the first chess computer to be successful in a major test chess tournament. David Levy won his bet in 78; 10 years had passed and no program could be him, luckily for him. The Fredkin Prize was established 100,000 dollars; a lot of money in those days to beat a reigning world champion. Cray Blitz, now Cray was a supercomputer in those days. The Cray Blitz was the program which was running on the Cray machine, wins the Mississippi State Championship with a perfect score of 5-0.

Ken Thompson's hardware chess playing belay Belle earns a US masters title. So, people started developing special purpose hardware play chess. So, for example, if you have 64 processors; then you can imagine that you can speed up things quite a bit. A program called HiTech by Hans Berliner and Carl Ebeling wins a match against grandmaster Denker 3.5 - 0.5. So, it won three games and drew one game in a four game match. Deep Thought shares the first prize with Tony Miles, who was a grandmaster; ahead of the former world champion Mikhail Tal.

Deep Thought loses two exhibition games to Garry Kasparov, who was again the champion. Now, it is an interesting aside that the word, the name Deep Thought has been borrowed from the computer in the famous novel Hitchiker's Guide to the Galaxy by Douglas Adams, which if you have not read, I will strongly recommend. So, a lot of fun to reach read that novel.

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And then the chess machines started becoming better than us. In 1992 a microcomputer chess machine wins the 7th World Computer Chess champ, Computer Chess Championships in front of mainframes and supercomputers. ChessGenius, defeated a World Champion Garry Kasparov in a non blitz time limit. Deep Blue from IBM, who lost a six game match to Kasparov in 1996; but in 1997, it beat Kasparov and their creators were awarded the Fredkin Prize.

So, 1997 was a landmark year, in which a reigning world champion in that case Garry Kasparov was beaten by a program in a full match. 2002 Kramnik draws an 8 game match against Deep Fritz which was another variation. Hydra defeats Michael Adams in a 6 game match. The undisputed world champion Kramnik is defeated 4-2 by Deep Fritz. And subsequently chess machines became a tool in the effort of chess players themselves. And

chess players started consulting machines as backup devices that they could use to analyze positions and it is common practice nowadays.

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You must have heard about the game of Go and in particular the program called AlphaGo, which was created by this company called Deep Mind, which was a UK based company, which was eventually bought over by Google. Now, people consider Go. So, go as you can see in this picture here in the center is played on a 19 by 19 board. And as is common in the eastern part of the world; they place the coins on the intersections of the lines, rather than inside the squares essentially.

So, for example, many games like Reversi, Othello and Chess Checkers we place coins on the squares; but in Go you place them on the intersection. And there are two kinds of points black and white, which basically a game in which you want to capture territory. And because of the

size of the chessboard which is 19 by 19, people thought that it would be beyond the scope of computer programs to beat a world champion in Go; even though chess had been solved in that sense or tackled in that sense, not solved.

Solved would mean as we will see in a subsequent class, that you know what is outcome when both the players play perfectly or what is the value of the game or what is the payoff of the game. But we do not, of course it is a zero sum game; but do you know when both the players are playing perfectly with a, with side wins.

So, both in chess and in Go the game is not solved in that sense; but it is tackled in the sense that, in both the world champions have been beaten. And in the case of Go, it happened in 2016 very recently; when this program called AplhaGo beat the world champion Lee Sedol and it was a much publicized game. And there is a nice film on this which; if you can get your hands, you can get to see an account of the match which happened.

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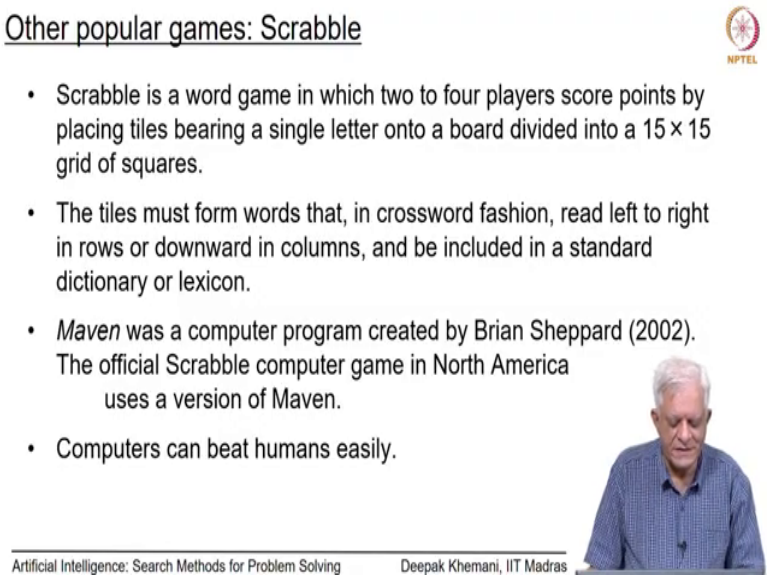

Let us quickly look at some other games, which are also popular games. We start with Scrabble; so you must be familiar with scrabble it is a word game in which you get seven letters from pile of letters and then you have to keep adding words to the board, somewhat like in a crossword like fashion and it is a very popular game. So, two or four players can play the game and they score points by placing tiles bearing a single letter on a board which is 15 by 15; but you cannot place a tile anywhere, you can only place it next to an existing word.

And then there are special rules like, you know on some squares you get a double letter score or triple letter score; on some squares if you place a word, you get a double word score or triple word score, in which means that you know double some of the value of each letter. So, each letter has a number associated with it and you want to maximize your score essentially.

So, the tiles must form words as I said in the crossword fashion, either read left to right or top to down and can be included in a standard dictionary or lexicon.

In fact, there are Scrabble dictionaries which are available. Now, which can help you solve disputes on whether a given combination of words is a acceptable word or not. The program called Maven written by Brian Sheppard in 2002. He reported this in his paper, was one of the first to beat humans at the game. You can imagine that, that computers are good at Scrabble; because they have access to a large vocabulary and they can try out the combinatorial combinations of trying out which words will give them maximum score and they can also do a little bit of look ahead.

So, it is not so surprising that, human beings can, computers can beat us easily in a game like Scrabble. But you can now play scrabble online against a machine and it is still a very popular game.

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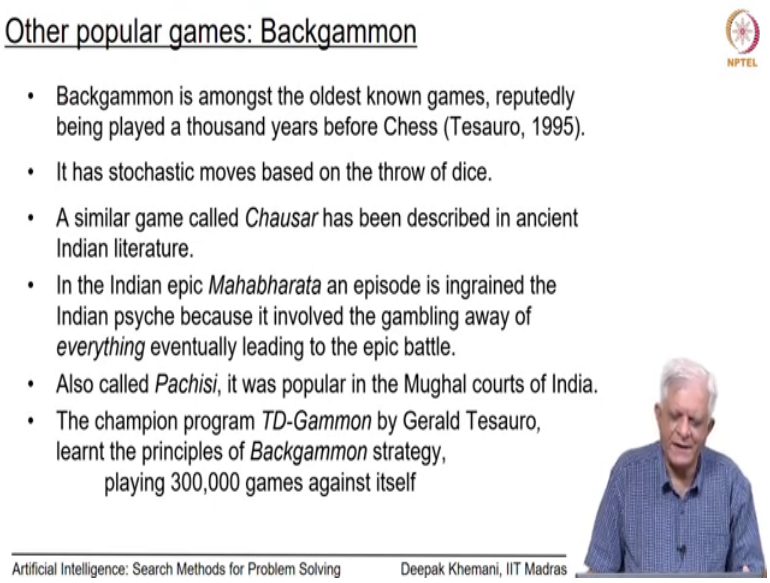

Another popular game has been Backgammon, which is introduced which introduces us to the notion of throwing dice; because that is an integral part of the game. Like you might have played the game of Ludo which is popular amongst children here or snakes and ladders. It is one of the oldest known games, repeatedly played much before chess was invented.

And it has this notion of stochastic moves, because you are throwing dice and you do not know what is the number that will show up and that will tell you how many moves your piece can make. A similar game called Chausar has been described in ancient Indian literature as well. So, for those of you who are familiar with the Mahabharata, you know that Yudhishthira lost a dice game and in the process he lost everything that he had including himself, which led to the eventually to the epic war.

It is also called Pachisi and it was popular in Mughal courts in India. And it is also a game where machines can beat humans comfortably, program called TD Gammon. So, TD's stands for temporal difference learning, it is a form of reinforcement learning program. And this program written by Tesauro, learned how to play backgammon by simply playing games against itself and employing this reinforcement learning strategy.

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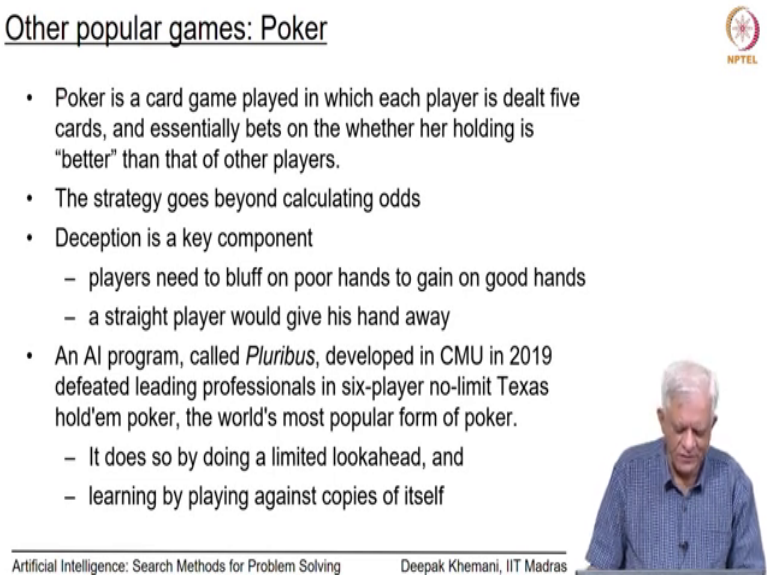

Another popular game is poker. So, poker is played, it is a card game in which each player is dealt out five cards and essentially each player has to bet on whether her holding is better than that of the others. It is a very popular game especially in the US, the strategy goes beyond calculating odds; it is not just that you calculate how likely you cards are to be better than the other players, because that could be not so much fun.

But deception is a key component of the strategy that, players need to bluff on poor hands; because if you just bit the value of cards, which means if you have very good cards and you keep betting, then if you stop betting, people would know that you do not have good cards and so on essentially. Or if you keep betting, they would know that you have good cards and you know they would take appropriate action.

So, a key component of poker is to deceive a bluff opponents and to be able to read other peoples deception; because a straight player would simply give his hand away and would not really gain. Now, an AI program called Pluribus was written in this year 2019 in CMU along with in collaboration with Facebook and it defeated a team six options six player no limit Texas hold'em game, which is the world's most popular form of poker. It does so by doing a limited amount of lookahead, and learning by playing against copies of itself.

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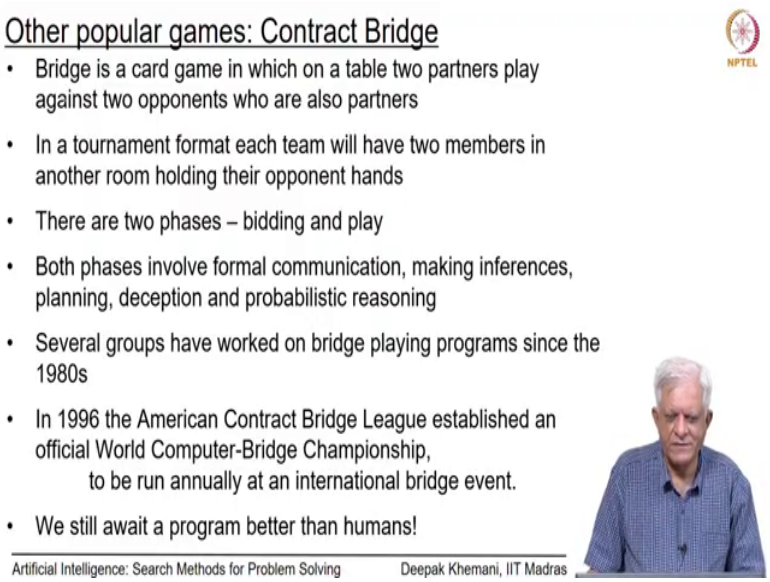

The last game that we will look at is contract bridge, which is card game in which on a table there are four players, two of them are partners and other two are their opponents. In a tournament form format corresponding to each table, there would be a table in another room. So, it would be a team of four members playing against another team of four members. The game has two phases; in the first phase, each side bids for a contract and that is why it is called a contract bridge.

And in the second phase, they have to fulfill the contract; which means, they have to make a certain number of hands or tricks as they are called in the game. Both phases involve formal communication; because there is incomplete information, players are trying to communicate with each other and they do so by making public announcements.

Then they have to make inferences from what they are seeing, which cards opponents are playing, which bids opponents are making and so on. They have to plan and interestingly deception is part of the game; because wherever there is communication and inferences, there can be deception. And obviously because it is an incomplete information game, a significant amount of probabilistic reasoning has to be done.

Now, several groups have worked on the game of bridge since the 1980s and we have many programs which are doing fairly well. But it is a game which is still a challenge for computer scientists; because we still do not have programs which can beat human beings and it is something that many people are working on.

Like in chess, a computer bridge tournament was started and we have world bridge championships every year. And they kind of happen at the venue of major bridge tournament and there have been many programs which have been participating in this and one of the programs which has been doing very well is a program called jack, which comes from Netherlands.

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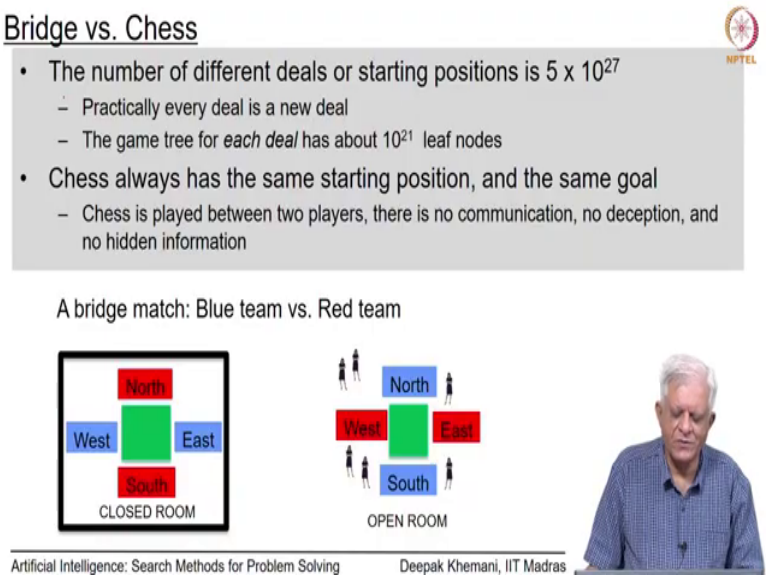

But having said that, it is still an open problem; because we still do not have programs which are better than humans. So, let us just do a very quick comparison between bridge and chess. In chess, you always start at the same starting position. So, the starting position is always the same and the goal is also always the same, which is to capture the opponents king.

Is played between two players; there is no communication, no possibility of deception, no hidden information. Bridge on the other hand has 10 rise to 27 different starting positions possible, so that every deal is practically a new deal. And the goal is also set as part of the game, to bid a contract and make it and the contract can be different in every game, because this cards dealt out are different.

And having given a deal, the game tree itself has a large number of nodes, which is about 10 rise to 21. So, as I said in a bridge match, it is four players playing against four other players.

So, you can imagine at the bottom of the slide that, there is a blue team which is playing against a red team one. One table is inside what is called as a closed room from where information does not go out and in the other table is in what is called an open room, where people can watch the game.

And you can see that the two players in the two, the two players in the corresponding position; for example, west and east are from the blue team in one room, and from the red team in the other room. Which means that they are will be holding the same cards; whatever cards are played in one room are then sent over to the other room. So, that you cannot say that you won a match, because you got good cards; but you can only say that you won a match, because you played better with those same cards.

So, in that sense we try to eliminate this element of gambling which say that, if you get good cards that you will win and so on; in bridge that is not the case, because both teams get to play with the same set of cards. It is a game worthy of attention, because it is still something in which we have not been able to beat human beings.

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So, in the next video or next session, we will focus on a smaller set of games which are called board games; and we will see how they are modeled as game trees and then how they are solved essentially? So, see you the next time.