**Modified**

So we are now going to cover the last topic in today's lecture. In this topic, I would like to talk about automatic negotiation or agent-based negotiation. And with multi-agent systems, when they negotiate, the aim is to reach an agreement between the agents you. So on this topic, I will talk about automatic negotiation and we talk about different types of negotiation, the elements of negotiation. Then we're looking into several advanced topics such as bilateral negotiation, the utility function, the concessions, the trade-offs, the negotiation tactics, and also learning and reasoning.

In negotiation, I mentioned about the automated negotiating agent competition, ANAC, and the genius environment. So now Beckham and Kodak. So Becca, Leo Hendrix Beckerland invented a type of photographic paper in 1891, and George Eastman Kodak company in 1888. He is the person who popularized the use of roll film and clearly being the owner of a company specializing in photography, the invention from Leo Henrik Becklen is something he is very interested in, and clearly he would like to purchase this invention from Becklen.

Now, when Eastman Kodak sent an invitation to Beckhalin to discuss the sale of his photographic manufacturing business, then Beckerland wanted to ask for $50,000, but he wasn't sure if he could even get $25,000. So he was willing to sell the business for $25,000. So that was in his mind before the negotiation, before the meeting. Nevertheless, Eastman spoke first and made an offer of $1 million to Becklen. And Becklen accepted the offer, clearly because it was in his mind thinking of at most $50,000, and he would even accept a deal at $25,000.

Further to the negotiation, he used the share of his profit for research and created plastic ecolite, which is a useful way to use the money. And so it didn't go to waste because more inventions have been developed. But the example tells us something. The first thing is that in negotiation, if you do not negotiate in the right way, then potentially you can lose a lot, or alternatively, you could win a lot.

And even though at first glance, it seemed like Eastman had lost a lot of money. But just imagine, just imagine that Eastman actually valued these inventions, the valuable ones from Becklen, at $5 million. And when he makes the offer of $1 million, he essentially just tried to squeeze the price down to pretend that it is not very valuable. Of course, no one knows if this is the case or not. But then let's just imagine that hypothetical scenario. And in the hypothetical scenario, let's just imagine that Becklen himself actually makes the first offer and asks for $4 million, then clearly it could be the case that they ended up settling for, let's say, $3 million or $3.5 million.

And so even though from this account it seems to show that Becklen got a great deal for himself, while Eastman lost significantly from the negotiations. But we don't know all the preferences of Eastman because we only know that he communicated later that he wanted to ask for $50,000 and was ready to settle for $25,000. And because of this, we can see that even for human negotiation, it is very important and can be affecting many of our life decisions.

So let's go back to negotiation. This is a core human activity. People form alliances, they reach agreements, they resolve conflicts in business and personal life with negotiation. Some examples with human negotiation include people negotiating for a job, like the salary; they negotiate to buy a house, they have at the marketplace; they negotiate assignment submissions, deadlines, and so on and so forth. It is an important topic of research in economics, AI, game theory, and social psychology. So many different disciplines are interested in this topic, not just multi-agent systems.

In the last two decades, the focus in this area of research has been on the automation of negotiation and also on building e-negotiation systems, which is what we are going to try to do in this unit. And for some of you who choose to do the first topic for the assignment project, then you are going to implement negotiation systems for buying a car with automated negotiation. There are a number of questions we would like to answer. The first one is, can we delegate negotiation to automated agents? Another one is, can software agents find better outcomes than humans? Can automation help reduce negotiation time and cost? Instead of having humans going back and forth to negotiate on something, if you can actually use automatic negotiation to reach an agreement without spending months negotiating back and forth, and maybe a lot of money to fly people from one place to another and then set up all these meetings, then clearly automatic negotiation would be a big benefit.

Using automatic negotiation, we can also avoid social confrontation because negotiation can sometimes be unpleasant. So even if negotiating to buy a TV, then some people are reluctant to go to negotiate for a better price. Also, another benefit of automatic negotiation is that it can possibly find better deals by exploring the outcome space, which you will see later in this lecture with integrative negotiation. Additionally, through automated negotiation, we can also learn from these negotiations and improve the negotiation skills for human negotiators.

So automatic negotiation has been implemented, and in particular, at Windburn, we actually developed a tool called Smart Cloud Broker to allow intelligent agents to negotiate via a smart exchange. The negotiation can happen directly between humans via the smart exchange, or there can be intelligent agents acting on behalf of human negotiators in order to negotiate on their behalf and then reach an agreement on their behalf.

With automatic negotiation, it is a form of interaction between two or more parties to allow them to reach mutually acceptable agreements. In some matters of negotiation, the agents' interests are possibly conflicting, requiring them to resolve the differences. It could be that someone tries to sell an item and the other one wants to buy the item, but the seller wants a high price while the buyer wants a lower price, and so their interests are conflicting.

Automatic negotiation is a process of decision-making because once the agreement is reached, it is a decision between the parties to agree on doing what is specified in that agreement. If we use automated negotiation, then it means the negotiation where at least one of the participants is a software agent. That means that at least one of the participants will just execute the negotiation using the software without any human intervention. The software agents know about the process of the negotiation and then decide on what message to send to the other negotiators and when and under what conditions to reach an agreement.

The next thing that I would like to discuss is to look at different types of negotiation. So there are many ways to classify negotiation. The negotiation can be classified in the form of whether it is a one-on-one negotiation. For instance, a consumer negotiates with a provider, or it can be one-to-many negotiation. For example, when I want to buy a car and I go to different car dealers trying to buy it, I may negotiate with them. The negotiations with one dealer may actually affect the negotiation I'm having with another dealer. If I get an offer of $40,000 for a specific car from dealer A, when I talk to dealer B, I won't accept anything more expensive than $40,000.

So another way to classify negotiation is that you may have direct negotiations, so the agents directly negotiate with each other. Or you can also have mediated negotiation, where the negotiators can negotiate via a mediator. Also, there are some types of negotiations that depend on the number of issues involved in the agreement. If there is only one single issue, for instance when negotiating to buy a car, and then this is the car that we are negotiating and so there is only one issue. So, what's the price for the car? And then once we agree on the price and the buyer pays money, the seller just provides the car. Or it can involve multiple issues like car price, warranty, extra accessories, and servicing.

So for those of you who are looking into working on assignment topic number one for building an automated negotiation agent, these are some of the things that you would like to take into consideration. There are also other types of negotiations that fall into whether it is human against software negotiations or it is software against another software negotiations.

Then there is a very fundamental classification of negotiations that classify the negotiations into either distributed negotiations or integrative negotiations. We start with distributed negotiation because it's quite common and easy to understand. Distributed negotiation is zero-sum or win-lose. It's competitive and typically a single-issue negotiation. In this case, there is only one issue at hand, and because the interests of the agents are conflicting, when one agent gains on the issue, the other agent loses on the issue and vice versa. This is also called fixed-pie negotiation. The pie is fiscal and therefore, when an agent gets a bigger share, the other agents will get a smaller share.

And so you can see here, for instance, if the outcome is that agent one gets three-quarters and agent two gets one-quarter of the pie, on the other hand, if agent two's gain increases the size of the pie that he can get to two-thirds, then agent one's size will reduce from three-quarters to two-thirds only.

An example of distributed negotiation is the car sale. The car is as it is, so there's nothing for you to negotiate here but the price. The seller wants to sell at the highest possible price, while the buyer wants to pay the least amount possible. If the buyer gains by lowering the price, then the seller loses because he gets less money for the car. Conversely, if the seller gains by getting a higher price, the buyer loses because he has to pay a higher price for the car.

Opposite to distributive negotiation is integrative negotiations. Here we have situations where it can be win-win, and the aim is to maximize the cooperation between the agents, between the negotiators. The idea here is that the pie is not fixed but can potentially be enlarged. In both situations shown in the figures, player one gets two-thirds of the agreement, and player two gets only one-third. But because in the second case, we managed to enlarge the pie, both agents actually gain, both agents actually get better utility.

Most of the time for integrative negotiation, it requires multiple issues. When you have multiple issues, then you can look at the interests of the agents. For instance, if one agent is more interested in getting a higher price, then he may make concessions on another issue of the negotiation. If we go back to the laptop example, the laptop comes with the standard two-year warranty, and because the seller's cost is already $1,900, he wants to make a profit by selling it at $2,000. The buyer only wants to pay $1,800 for the laptop.

Clearly, if we don't try to look at any other potential way to increase the pie, then there will be no agreement here because the difference in the price cannot be resolved. However, we can enlarge the pie by considering the five-year extended warranty. If the buyer values this five-year extended warranty at $400 and it only costs the seller $50, then the seller's cost increases from $1,900 to $1,950. On the other hand, because the buyer thinks that the five-year extended warranty would add value to the laptop, he values the laptop at $2,200. And because of that, both parties are quite happy to reach an agreement at $2,100. The buyer thinks that is quite a good deal because he values it at $2,200. And now he only needs to pay $2,100, while the seller having the cost of $1,950 and selling it at $2,100, meaning that he actually makes a profit of $150.

So, this matter of multi-issue negotiations and integrative negotiations relates to a concept in negotiation and economics in general called Pareto optimality. The Pareto optimal outcome is an outcome of the negotiation where no agent can increase its utility or its gain without reducing the other agent's utility. For instance, if we have a negotiation outcome for the laptop with the standard two-year warranty, then it cannot be Pareto optimal because there's a way to increase the utility by adding a three-year extended warranty to have a five-year extended warranty. And then both agents will gain by doing that. But because if we only look at the standard two-year warranty, then that's not a Pareto optimal outcome.

Now, if you look at all the possible agreements that are Pareto optimal, then they lie in the outcome space, and that lie is called the Pareto frontier. The idea is to try to get an outcome on the Pareto frontier because this is where all the utilities have been exploited and shared between the agents. So this is the optimal outcome for the negotiation. The good thing with integrative negotiation is that it enables negotiators to reach Pareto optimality. And in general, negotiating agents may not know the Pareto frontier because most of the time, they don't know the opponent's preferences. The seller may not know that the buyer values the extended warranty highly, and the buyer may not want to reveal this to get a better price.

So, because of that, sometimes the Pareto frontier cannot be reached. Getting to the Pareto frontier is an art in negotiation, and it is not simple.

**Summarise**

The lecture covered the concept of automatic negotiation and agent-based negotiation within multi-agent systems. It delved into diverse types of negotiation strategies, encompassing elements like bilateral negotiation, utility functions, concessions, trade-offs, negotiation tactics, and learning processes. The narrative was illustrated by the case of Eastman Kodak and Beckerland, underscoring the pivotal role of effective negotiation.

The lecture highlighted negotiation's pervasive role in everyday life, from job offers and property purchases to business dealings. The emergence of automated negotiation systems, such as ANAC, has opened up avenues for reducing negotiation time and costs while potentially achieving better outcomes. The integrative negotiation approach, seeking mutually beneficial solutions, was contrasted with distributive negotiation, which can lead to win-lose situations.

A crucial concept introduced was Pareto optimality, where no party can enhance their gains without detracting from others. However, achieving this state is complicated by the limited understanding of opponents' preferences. The lecture emphasized that mastering negotiation, particularly in the automated realm, involves navigating intricacies and honing the art of reaching optimal outcomes.

***Important***

**AUTOMATIC NEGOTIATION**

In this topic I would like to talk about automatic negotiation or agent based negotiation. In negotiation, if you are not negotiated in the right way, then potentially you can lose a lot, or alternatively, you could win a lot. It is an important topic of research in economics, AI, game theory and social psychology.

**TYPES OF NEGOTIATIONS IN THE REAL ESTATE MARKET**

The next thing that I would like to discuss is to look at different types of negotiation. There are many ways to classify negotiation. You may have direct negotiations so that the agents directly negotiate with each other. Or you can also have mediated negotiation so the negotiators can negotiate via a mediator.

**DISTRIBUTED NEGOTIATIONS AND INTEGRATIVE NEGATIONS**

There is a very fundamental classifications of negotiations that classify the negotiations into either distributed negotiations or integrative negotiations. Distributed negotiation is zero sum or win lose. Opposite to integrative negotiation is situations where it can be win win.

**MULTI-ISSUE NEGOTIATIONS AND PARETO OPTIMALITY**

Pareto optimal is an outcome of the negotiation where no agent can increase its utility or its gain without reducing the other agent's utility. Getting to the Pareto frontier is an art in negotiation, and it is not simple.

**Original**

So we are now going to cover the last topic in today's lecture. In this topic I would like to talk about automatic negotiation or agent based negotiation. And with multi agent systems, when they negotiate, the aim is to reach an agreement between the agents you. So on this topic, I will talk about automatic negotiation and we talk about different types of negotiation, the elements of negotiation. Then we're looking into several advanced topics such as bilateral negotiation, the utility function, the concessions, the trade offs, the negotiation tactics, and also learning and reasoning. In negotiation, I mentioned about the automated negotiating agent competition, ANAC, and the genius environment. So now Beckham and Kodak. So Becca, Leo Hendrix Beckerland invented a time of photographic paper in 1891, and George father isman Kodak company in 1888. He is the person who popularized the use of roth hime and clearly being the owner of a company specializing in photographic the invention from Leo Henrik Becklen is something he is very interested in, and clearly he would like to purchase this invention from Beccalan. Now, when Isman Kodak sent an invitation to Beckhalin to discuss the sale of his Vlog photosensitive manufacturing business, then Beckerland wanted to ask for $50,000, but he wasn't sure if he could even get 25,000. So he willing to sell the business for $25,000. So that was in his mind before the negotiation, before the meeting. Nevertheless, Isman spoke first and made an offer of $1 million to Becklen. And Beckland accepted the offer, clearly because it was in his mind thinking of at most $50,000, and he would even accept a deal at $25,000. Further to the negotiation, he used the share of his share of the profit for research and created plastic ecolite, which is a useful way to use the money. And so it didn't go wasted because more invention has been developed. But the example tell us something. The first thing is that in negotiation, if you are not negotiated in the right way, then potentially you can lose a lot, or alternatively, you could win a lot. And even though in the first look, it seemed like Eastman has lost a lot of money. But just imagine, just imagine that isman actually value these inventions, the villa ones from Beccalen, at $5 million. And when he makes the offer of $1 million, he essentially just tried to squeeze the price down to pretend that it is not very valuable. Of course, no one knows this is the case or not. But then let's just imagine that hypothetical scenario. And in the hypothetical scenario, let's just imagine that DeCalon himself actually make the first offer and ask for $4 million, then clearly it could be the case that they ended up settled for, let's say that $3 million or $3.5 million. And so even though from this account it seemed to show that Beccalenza got a great deal for himself, while Isthman lost significantly from the negotiations. But we don't know all the preferences of Theseman because we only know that they couldn't share later that he wanted to ask for $50,000 and ready to settle for $25,000. And because of this we can see that even for human negotiation is very important and can be affecting many of our life decisions. So let's go back to negotiation. This is a core human activity. People form alliances, they reach agreements, they resolve conflicts in business and personal life with negotiation. Some example with human negotiation include people negotiate for a job, so the salary, they negotiate to buy a house they have at the marketplace, they negotiate assignment submission, deadlines and so on and so forth. It is an important topic of research in economics, AI, game theory and social psychology. So many different disciplines interested in this topic, not just multi agent systems. In the last two decades the focus in this area of research has been on the automation of negotiation and also on building e negotiation systems, which is what we are going to try to do in this unit. And some of you who choose to do the first topic for the assignment project, then you are going to implement negotiation systems for buying car with automated negotiation. There are a number of questions we would like to answer. The first one is can we delegate negotiation to automated agents? Another one is can software agents find better outcomes than humans can automation list to reduce negotiation time and cost? So instead of having humans going back and forth to negotiate on something, if you can actually use automatic negotiation to actually reach the agreement without spending months to negotiate back and forth and maybe a lot of money to fly the people from one place to another and then setting up all these meetings and so on and so forth, then clearly automatic negotiation would be a big benefit there. Using automatic negotiation we can also avoid social confrontation because negotiation sometimes can be unpleasant as well. So even if negotiate to buy a TV, then some people are reluctant to go to heavy Norman for instance, in order to negotiate the sticker price of $3,000 for a big screen TV. And then if they negotiate hard they can get it down to 2500. But then they may be reluctant to do that because they don't want to look stingy, they don't want to look like to squeeze in. Also another benefit of automatic negotiation is it can possibly find better deals by exploring the outcome space which you will see later in this lecture with integrative negotiation and also by automated negotiation we can also learn from these negotiations and improve the negotiation skills for human negotiator. So automatic negotiation has been implemented and in particular as Windburn we actually develop a tool called smart cloud broker to allow the intelligent agents to negotiate via smart exchange. And the negotiation can happen directly between humans via the smart exchange or there can be intelligent agents acting on behalf of human negotiators in order to negotiate on their behalf and then reach an agreement on their behalf. With automatic negotiation it is a form of interaction between two or more parties to allow them to reach mutually acceptable agreements. On some matter in negotiation the agent's interest are possibly conflicting, requiring them to resolve the differences. So it could be that someone tried to sell an item and the other one want to buy the item but the seller wants the high price while the buyer want the lower price and so their interests are conflicting. Automatic negotiation is a process of chawn decision making because once the agreement is reached is a chawn decision between the parties to agree on doing what specified in that agreement. If we use automated negotiation then we means the negotiation where at least one of the participants is a software agent. That means that at least one of the participants will just execute the negotiation using the software without any human intervention. So the software agents know about the process of the negotiation and then decide on what message to send to the other negotiators and when and under what condition to reach an agreement. The next thing that I would like to discuss is to look at different types of negotiation. So there are many ways to classify negotiation. So the negotiation can be classified in the form of whether it is a one on one negotiation. So for instance a consumer negotiate with a provider or it can be one too many negotiation. So one consumer try to negotiate with different providers. For instance, I want to buy a car and I go to different car dealers trying to buy it and then I may negotiate with them. And the negotiations with one dealers may actually affect the negotiation I'm having with another dealer. Because let's say that if I'm talking to dealer A and then I get an offer of $40,000 for a specific car, when I talk to another dealer B I'm not going to accept anything more expensive than $40,000. So if dealer B want to sell it to me for $40,500 for the same car, I will not accept it and I will insist in the price that I buy from him or her will be less than $40,000. So another way to classify negotiation is that you may have direct negotiations so that the agents directly negotiate with each other. Or you can also have mediated negotiation so the negotiators can negotiate via a mediator. And so they send the offer to the mediator, and then the mediator try to find a way to help them reach agreement. Also there are some type of negotiations that depending on the number of issues involved in the agreement. So if there is only one single issue, for instance when negotiate to buy a car and then this is the car that we are negotiating and so there is only one issue. So what's the price for the car. And then once we agree on the price and then the buyer pay money, the seller just pass the car, pass away with the car. Or it can be multiple issues because looking at the car but then the issues can be more than just price, it can be including price, the warranty for the car and then maybe some extra accessories that the dealer may fit into the car and some other issues like car price servicing as well. So for those of you who look into working on assignment topic number one for building automated negotiation agent then these are some of the things that you would like to take into consideration. There are also other types of negotiations where the classifications fall into whether it is a humans against software negotiations or it is software against another software negotiations. Then there is a very fundamental classifications of negotiations that classify the negotiations into either distributed negotiations or integrative negotiations. We start with distributed negotiation because it's quite common and easy to understand. Distributed negotiation is zero sum or win lose. It's competitive. It's typically a single issue negotiation and so there is only one issue at hand and then because the interest of the agents are conflicting. So when one agent gaining on the issue, the other agents losing on the issue and the other way around. This is also called fifth pie negotiation. And so the pie is fiscal and therefore the agents get the bigger share implies that the other agents will get the smaller share. And so bigger shares mean that bigger individual gain of the pie and therefore the older agents will get smaller. So you can see here, for instance, if the outcome is that agent one get three quarters and agent two get one quarter of the pie, on the other hand, if the agent two gain increase the size of the pie that he can get to two third, then the agent one size will reduce from three quarters to two third only. So example such as Juice Castle. So the car is as it is, so there's nothing for you to negotiate here but the price. And so with the price the seller wants to sell at the highest possible price while the buyer wants to pay the least amount possible. And so if the buyer gain buy lower the price, then the seller lose because he get less money for the car. On the other hand, if the seller gains by getting higher price than the buyer lose because he had to pay higher price for the car. Opposite to distributive negotiation is integrative negotiations. Here we have the situations where it can be win win and the aim is to maximize the cooperation between the agents, between the negotiators. And the idea here is that the pie is not fixed but is potentially we can enlarge the pi. So if you look into these figures here, then you can see that in both situations, the player one gets two third of the agreement. Player two get only one third. And same here as well. So in the first case, one get two third and two get one third. In the second case, one also get two third and two get one third. But because here we managed to enlarge the pies, both agents actually gain, both agents actually get better utility. And most of the time for integrative negotiation, it require multiple issues. When you have multiple issues, then you can look at the interest of the agents. So for instance, if one agents are more interested in getting higher price, then he may make concession on another issue of the negotiation. So the example here is let's say that I go to buy a laptop. The laptop come with the standard two years warranty and because the seller cost is already $1,900, he wants to make some profit. So he's trying to sell it at $2,000. And the buyer only wants to pay $1,800 for the laptop, thinking that that is the fair price and he wouldn't want to increase that price. So clearly, if we don't try to look at any other potential way to increase the pie, then there will be no agreement here because the difference in the price cannot be resolved and then there will be no deal. However, we can enlarge the pie by considering the five year aesthetic warranty. If the buyer in this case value this five year aesthetic warranty at $400 and let's say that it only cost the seller $50. So from the standard two year warranty, laptops that cost the seller $1,900 now increase the five year warranty, then it cost the seller $1,950. On the other hand, because the buyers thinking that the five year standard warranty would have the value of $400 plus the original laptop value at $1,800, so he would value the laptop at $2,200. And because of that, both parties are quite happy to reach the agreement at $2,100. So buyer thinks that is quite a good deal because he value it at $2,200. And now he only need to pay $2,100 while the seller having the cost of $1,950 and selling it at $2,100, meaning that he actually makes the profit of $150. So pretty good for him. So this matter of multi issue negotiations and integrative negotiations related to a concept in negotiation and in economics in general called Pareto optimal. The Pareto optimal outcome is an outcome of the negotiation where no agent can increase its utility or its gain without reducing the other agent's utility. So for instance, if we have a negotiation outcome for the laptop with the standard two year warranty, then it cannot be Pareto optimal because there's a way to increase the utility by adding a three years aesthetic warranty to these two years to have a five year aesthetic warranty. And then most agents will gain by doing that. But because if we only look at the standard two year warranty, then that's not Pareto optimal outcome. Now, if you look at all the possible agreements that is Pareto optimal, then there is a lie in the outcome space, and that lie is called the Pareto frontier. And the idea is to try to get an outcome at the Pareto frontier because this where all the utilities have been exploited and shared between the agents. So this is the optimal outcome for the negotiation. The good thing with integrative negotiation is that it enables negotiators to reach Pareto optimality. And in general, negotiating agents may not know the Pareto frontier because most of the time, they don't know the opponent's preferences. So if the seller knows that the buyers value the aesthetic warranty very high, then clearly he's going to spar with that particular option and then trying to squeeze the most out of that, but clearly, because he doesn't know. And so it's always the case that he's trying to sell the standard two years warranty to the buyer. On the other hand, the buyer wouldn't want to tell the seller that I value the extended warranty at $400. So the buyer most of the time will pretend that he doesn't value much in order to try to squeeze the price down as much as possible as well. So because of that, sometimes the Pareto frontier cannot be reached. So getting to the Pareto frontier is an art in negotiation, and it is not simple.