

Language and Mind
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Module – 08
Lecture - 38
Language, Cognition and Computers

Today, we will look at Language, Cognition and Computers together. We talked about language and cognition and now, we want to bring in a discussion on computers to understand all three of them together. It adds a perspective to our understanding of how language works with human mind, what is possible, what is not possible, when such domains of knowledge are transferred to the discipline of computer science.

When we try to understand computers and functioning of computers in the domains of language within the perspective from language, there are certain things that are considered breakthroughs and there are certain things which are not possible so far. We will look at these questions as a whole.

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Questions

- What is the relationship between language and cognition?
- Do people who speak different languages think differently?
- What is the connection between language and computers?

So, the two questions which have been in the domain of language and cognition is very simple for us to understand; at least the two significant questions defining the area of cognitive science such as: What is the relationship between language and cognition, where in simple terms, cognition means understanding. Do people who speak different languages think differently?

How do people understand and how they think is also a question, which is relevant to our understanding, when we try to understand human understanding. In the study of these two questions, there comes a development, which is known as understanding of machines, very sophisticated machines, which are known as computers. We know and this set of information is available in a different domain of study called computer science, which is highly sophisticated and technical in their own ways.

And we understand these things; we understand the details of computers in that discipline. However, when it comes to language, there is an overlap between the two and we will try to understand the connection between language and computers and things that computers can do or cannot do in the domains of language. One of the primary goals of cognitive science as we discussed last time has been to come up with a unified theory of understanding.

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- Goal of Cognitive Science:
 - To come up with a theory that combines all kinds of learning including language.
 - Theories about language that came from psychology (language as behavior) were more unifiable in nature.
 - Unification did not happen because of the development of mentalist theory on language which focused on the primacy of functions/operations in human mind that are responsible for learning language.

That is, a theory which explains how all kinds of understanding works; that is, including language. Theories which came from psychology or understanding of language learning from a psychological perspective were easy and they looked unifiable in nature. A theory which talked about stimulus response; that is, the response in terms of learning, in terms of output, is connected with stimulus; that is input, and the role of human mind was not underlined in such a theory, was considered to be very simple for unifying it; that is,

language learning with other kinds of learning, like dancing and singing and swimming. Sounded very simple.

However, the development around 1955 in terms of understanding of how language learning works became a roadblock for such a unification. That was the time when a whole set of propositions came up and a new theory was proposed in the domain of language learning about language learning. This was known as innateness hypothesis or mentalist theory.

It focused primarily or on the primacy of functions and operations, where human mind was involved and with substantial evidence, which were responsible for language learning with the role of human mind in it. When such a proposal came up, it became increasingly difficult to unify the two types of learning; that is, language on one side and other things like swimming, dancing, singing, biking, riding, flying, etcetera.

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- Two existing patterns in Cognitive Science:
 - General purpose cognition
 - Singing, Dancing, Swimming, Writing, Flying
 - Special purpose cognition
 - Language is different from other learning abilities.

Therefore, we have seen that there are two patterns that exist in cognitive science, where we look at one as general purpose cognition, which solves issues about the other kinds of learning like singing, dancing, swimming, and so on; whereas language learning in the domain of cognitive science is known as special purpose cognition. Many cognitive scientists would still try for the simplicity of the goal of the discipline to unify the two things to come up with one theory.

This is a nice goal to pursue. However, challenges exist in terms of understanding of human language and learning of human language, learning of natural language. By human language we mean natural language. Then the question is, what are those difficulties and how can those difficulties be resolved and do we have a solution from other disciplines?

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ARTIFICIAL INTELLIGENCE

- Cognitive scientists have attempted to show that the Artificial Intelligence (AI) programs and computer algorithms can combine general problem solving and aspects of language acquisition and processing.

There was another set of development around the same time, which is known as artificial intelligence. In the simplest possible term, though it is hard to simplify the notion of artificial intelligence, I will try my best. In the simple possible terms, what artificial intelligence has to say is artificial intelligence is about computer programs, computer algorithm.

With the help of artificial language, computer scientists develop computer algorithm and with the use of such algorithm, they tried to come up with the model or they try to model 'learning'. And such a model works for many types of learnings and this attempt was made also for the purpose of modeling language learning. It was right here where difficulties were encountered and cognitive scientists came up with the idea that there are difficulties modeling natural language through the algorithms of artificial intelligence.

Artificial intelligence was also part of the discipline of computer science. Then, the role of computer science in modeling language... and for computer science, there were

challenges from the area of language learning. This also was taken up by cognitive scientists in collaborations with all other disciplines.

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AI and Connectionism

- AI talks about computational algorithms unifying all kinds of learning including language.
- Connectionism talks about development of neural network. Single neurons connected with complex network of neurons. This led to the understanding of complex parallel processing.

So, as we just discussed, artificial intelligence talks about all kinds of learning and unification of all kinds of learning through computer algorithms. There was another development, which is termed as 'Connectionism' in the domain of cognitive science and has input from the study of neurons in biology. The development was like, set of neurons being dedicated to different kinds of activities and each neuron being connected with complex network of neurons.

These are five tracts; and these neurons are connected with one another to transfer information and a set of neurons are dedicated to different activities. This led to the understanding of complex parallel processing. This also had implications for us to understand how and why human mind can do many things at a time. Now, all these things put together, if we try to understand the interface with computers and language, there is yet another discipline, which is known as computational linguistics and the goal of the computational linguistics is to help model or help... the goal of the computational linguistics is to help model natural languages using computer programs.

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Computational Linguistics

- Computational linguistics studies natural language. It studies languages such as English and Hindi, rather than computer languages, such as Fortran, C+, C++, or Java.

So, computational linguists study natural languages. This is one of the important things for us to understand in the domain of computational linguistics; the use of computer is for understanding and studying natural language. By natural languages again we mean Hindi, English, Tamil, Telugu, etcetera. And at this point, we can see natural languages are the ones that we speak, are the human languages, and there are machine languages like Fortran, C plus, C plus plus or Java. These are also known as artificial languages, because these languages are used to make machines communicate with one another.

So, to clarify this thing again, the computational linguistics refers to a discipline, which uses computers to understand, study, natural languages and not computer languages, not machine languages. That is also a part; that is also a type of language, which is studied in a different branch of computer science.

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Goals of Computational Linguistics

- Makes computers usable as tools in analyzing and processing natural language.
- Helps us understand, by analogy with computers, more about how people process natural language.

There were several goals which computational linguists came up with and they were of two types: one was technical in nature that they wanted to make computers usable as tools for analyzing the processing of natural language. That is, we need it to understand how natural language processing can be modeled. So, to make computers usable for such a purpose was one of the goals.

The other part of the goal was to help us understand, by analogy with computers, more about how people speak and how such a modeling can be developed. By now, there has been lots of advances in the discipline of computational linguistics.

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Some Breakthroughs

- Natural language interfaces to software
- Information Extraction and Data Mining
- Machine Translations

There are lots of breakthroughs in the field of computational linguistics. With the help of computers as tools and trying to understand natural languages, we have come up with so many things. We will list a few here for the purpose of understanding some of the breakthroughs in the field of computational linguistics.

Now, we understand the interface between natural language and software; that is one of the primary breakthroughs that came up long ago.

Information extraction and data mining is another breakthrough; examples are like, we can talk about one example, such as machines can help us understand, help us find some specific information from large set of data. This is one of the fields which is known as data mining and I am only giving you a simplistic understanding of information extraction and data mining, which is one of the breakthroughs in computer science.

Machine translation is yet another breakthrough. Through machine translations, what we have achieved is computerized response systems. We can talk to machines by understanding, how computational models work and how natural language processing can be modeled and translating it with...implementing such models with machines, we can help yet smarter machines come up with translations, automatic translations; and also, this includes translating electrical signals into natural languages.

There are some challenges, which it still needs to resolve and need to come up with. See, one of the major goals in understanding and developing machines like computers is to come up with a machine, which functions like human mind. With the development and understanding of neural network; that is, how neural tracts work in human mind in gathering and disseminating information and helps human mind process many things parallel... the goal that comes up and the goal that has been set up is to come up with a machine, which works like human mind.

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Some Challenges

- Developing a set of rules and procedures, e.g. to recognize the syntactic structure of sentences or to resolve the references of pronouns.
- Resolving ambiguity.
- Most ambiguities escape our notice because we are very good at resolving them using our knowledge of the world and of the context. But computer systems do not have much knowledge of the world and do not do a good job of making use of the context.

A lot has been achieved so far in the domain of study and the interactions between computers and language, but trying to come up with a machine, which is as sophisticated as human language, as human mind is yet a distant goal. So keeping that goal in mind, one of the challenges is for developing a set of rules and procedures; that is for example, to recognize syntactic structure of sentences or to resolve references.

Computer programs, computer models, yet have to be sophisticated enough for us. We still need to have computational models and develop them in a particular way, which will help us understand references of pronouns. This is one of the challenges in this domain.

Resolving ambiguity is yet another challenge in the computer science. See, most of the ambiguities escape our notice, because we are very good at resolving, resolving ambiguities with the help of knowledge of the whole world. This knowledge of the world is also known as context. So, with the help of our knowledge of the context, we resolve a

lot of ambiguities. However, machines have difficulty resolving such ambiguities. So, machines are yet to come to a point, where it can resolve such ambiguities in an easier way.

We will be discussing couple of examples of these ambiguities shortly, but just to give you one very brief example - if someone asks you a question, 'Let us go watch a movie' and the response is, 'I have a class in the morning', if you do the math, the answer is 'No, I cannot watch a movie tonight'. However, now the important point for us to see is, the answer 'No' which is implied is very easy for human mind to figure out. There is absolutely no ambiguity at this level in human mind when it figures out this response. However, it is difficult for machines to come up with this.

Now the conclusion is, machines have difficulty resolving such problems, because machines do not have the knowledge of context. Now, modeling of the context; that is the knowledge about the context and then, matching it with the set of syntactic structures and models for syntactic structures is the next step of challenge for computer science.

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Beginning and the Big Picture

- The brain is a kind of biological computer, and that an adequate answer to how people understand and generate language must be in terms formal and precise enough to be modeled by a computer.
- Computational system need to look at the functioning of language to make a machine which can remotely function like human mind.

What we know now is, the way human mind is looked at is, human mind is looked at as a biological computer and that is because it understands human mind is looked at as a biological computer. The fact that it is looked at as a biological computer has generated the curiosity that - can a computer be designed, which can perform the functions of this biological computer? Thank you.