

Time to think like a computer

For years, philosophers, linguists, and psychologists have puzzled over the relationship between human language and thought. Now, says **Robert Kowalski**, in the quest to create artificial intelligence in machines, researchers have come up with some unexpected answers

THE idea of machines that think and act as intelligently as humans can generate strong emotions. This may explain why one of the most important accomplishments in the field of artificial intelligence has gone largely unnoticed: that some of the advances in AI can be used by ordinary people to improve their own natural intelligence and communication skills.

Chief among these advances is a form of logic called computational logic. This builds and improves on traditional logic, and can be used both for the original purpose of logic – to improve the way we think – and, crucially, to improve the way we communicate in natural languages, such as English. Arguably, it is the missing link that connects language and thought.

According to one school of philosophy, our thoughts have a language-like structure that is independent of natural language: this is what students of language call the language of thought (LOT) hypothesis. According to the LOT hypothesis, it is because human thoughts already have a linguistic structure that the emergence of common, natural

languages was possible in the first place.

The LOT hypothesis contrasts with the mildly contrary view, that human thinking is actually conducted in natural language, and thus we could not think intelligently without it. It also contradicts the ultra-contrary view, that human thinking does not have a language-like structure at all, implying that our ability to communicate in natural language is nothing short of a miracle.

Research in AI lends little support to the first view, and some support to the second. But if we want to improve how we communicate in natural language, the AI version of the LOT hypothesis comes into its own, offering us a detailed analysis we can use as a guide.

Using this guide, we can then try to express ourselves in a form of natural language that is closer to the LOT. This will make it easier for others to understand our communications because they will require less effort to translate them into thoughts of their own. But to fully exploit the guide, we need to understand the nature of the LOT and the relationship between it and natural language.

One approach is to study natural language communications that are designed to be easy to understand. If they are indeed easy to understand, then their form should be close to that of the LOT. What better place to look than at communications designed to deal with emergencies, where it can be a matter of life or death that the reader understands the communication as intended, and with as little effort as possible.

Take a sign designed for London's



underground train system:

Press the alarm signal button to alert the driver.

The driver will stop if any part of the train is in a station.

If not, the train will continue to the next station, where help can more easily be given.

There is a 50 pound penalty for improper use.

What is most striking about the form of these sentences is that they all have the same underlying “logical conditional” form: *if conditions, then conclusion, or, alternatively and equivalently, conclusion, if conditions*. This conditional form is explicit in the second and third sentences, and it is implicit in the first and fourth sentences: if you press the alarm signal button then you will alert the driver; there is a £50 penalty if you press the alarm signal button improperly.

PROFILE

Robert Kowalski is Professor Emeritus at Imperial College London. The artificial intelligence language, Prolog, was based on some of his work in logic programming. This essay draws on Kowalski's latest book *Computational Logic and Human Thinking: How to be artificially intelligent*, published by Cambridge University Press



conclusion, and perhaps qualify it by concluding instead that if John has food, then John will eat. This kind of reasoning goes against the rules of traditional logic, but conforms to what AI researchers call “default reasoning”, that is, drawing a conclusion in the absence of evidence to the contrary, and then gracefully withdrawing the conclusion if there is reason to believe otherwise.

But suppose that I am performing a psychological experiment, and instead of stating the exception, I state that *if John has food then John will eat*. Do you then conclude that I really mean that John will literally eat all

“Reasoning using rules and exceptions is an important feature of our everyday life”

the food in the house, no matter whether he is hungry or not? Or am I trying to draw your attention to the exception, without stating it explicitly? What should you do? Take me at my word or try to work out what was in my head?

As far as I know, no one has carried out this experiment, but psychologists have carried out similar experiments. Here is the most famous. Suppose I tell you that *if Mary has an essay to write, then she will study late in the library* [And] *Mary has an essay to write*, what do you conclude? That Mary will study late in the library, of course.

Now suppose I say: *If the library is open, then Mary will study late in the library*. What do you conclude? That Mary will literally study late in the library whenever it is open, no matter whether she has a reason to study or not? Or do you ignore what I actually said, and assume I meant to draw your attention to the obvious exception: *if the library is not open, then she will not study late in the library*.

Taking me literally means standing by your earlier conclusion. But if you try to figure out what was in my head, you will probably want to withdraw or modify it. Not surprisingly, many – perhaps most – psychologists end up concluding that ordinary people do not use the rules of logic in everyday life.

There is an alternative way of seeing this: that there is a language of thought, and that it has a more logical form than ordinary natural language. This view has an added bonus: it tells us that, if you want to express yourself more clearly and more effectively in natural language, then you should express yourself in a form that is closer to computational logic – and therefore closer to the language of thought. Dry legalese never looked so good! n

A thought experiment about food shows how language can mislead us over intentions

the use of conditional form to represent rules and exceptions. Take this clause:

40.-(2) *The Secretary of State may by order deprive a person of a citizenship status if the Secretary of State is satisfied that deprivation is conducive to the public good.*

40.-(4) *The Secretary of State may not make an order under subsection (2) if he is satisfied that the order would make a person stateless.*

Reasoning with such rules and exceptions is not well catered for in traditional logic, but it is an important feature of everyday reasoning. If I tell you that *if John is hungry then John will eat* [And] *John is hungry*, what do you conclude? That John will eat, no doubt. But if I draw your attention to the exception that *if John does not have food then John will not eat*, then you might be tempted to withdraw your

We can also find evidence for the logical form of The LOT in communications that may be hard to understand because of the complex nature of the thoughts they convey, but which are designed to minimise any additional complexity due to the inadequacies or ambiguities of natural language.

A good place to look is in well-written legal documents. Consider the very first sentence of the British Nationality Act 1981:

1.-(1) *A person born in the United Kingdom after commencement shall be a British citizen if at the time of the birth his father or mother is – (a) a British citizen; or (b) settled in the United Kingdom.*

Here the conditional form is explicit, but with some of the conditions, *born in the United Kingdom after commencement*, inserted, for succinctness, into the middle of the conclusion.

The British Nationality Act also illustrates

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