Benefits of cybernetic models in philosophy

Ferenc ANDRÁS

ferenc@andrasek.hu

The Reasoner, Volume 18, Number 2, March 2024

Thought experiments versus cybernetic models

A common research method among philosophers is the usage of thought experiments. Take for example John Searle's 'Chinese Room' or Frank Jackson's 'Mary's Room' argument. David Lewis goes further by using neuron diagrams to represent causality in his counterfactual theories of causation. His method has since been further refined and developed (Erwig 2010). Interestingly, the usage of logical circuits or finite automaton to represent causal relations has not yet been considered. As an advantage, the latter can be visualised in cyberspace using spreadsheets and tested in practice. Furthermore, it is not only in the problem of causality that cybernetic models can fruitfully be used to provide a philosophical explanation, they can also be utilised to represent logical semantic problems. Let us consider an example for this.

Combinational and Sequential Logic Circuits

Many logic handbooks allude to the obvious connection between propositional logic and logic circuits. Truth functions in logic can be represented by logic circuits in which the high or low voltage levels of the circuits correspond to the true and false logic values, respectively. At the propositional logic level, the logical connectives of propositions can be simulated by logic circuits as follows: the true or false logical evaluation of atomic propositions corresponds to the high or low level of the circuit input and the truth value of compound propositions corresponds to the circuit output state. A high circuit output signifies that the compound sentence is evaluated as true, whereas a low output indicates that the compound sentence is false. It is well known that in the world of logic circuits, the AND connective in logic corresponds to the AND gate, the OR connective to the OR gate and the negation operation to the inverter. The output of a circuit equivalent to contradiction is always low and that of a circuit corresponding to tautology is always high irrespective of the input state. The remaining compound formulas correspond to logic circuits with a high output level for some inputs and low output level for other inputs. However, what logical circuit can model a circular sentence?

Indeed, every formula in propositional calculus can be modelled based on an equivalent logic circuit, specifically referred to as a combinational logic circuit. However, not all logic circuits are combinational logic circuits. The range of logic circuits is wider than that of the combinational logic circuits. It includes logic circuits whose input states do not determine unambiguously their output states, i.e. the output is not a function of the input. This is because the circuit has feedback. Circuits that contain feedback are called sequential logic circuits. Although every formula in propositional calculus can be modelled based on an equivalent combinational logic circuit, it remains unclear whether the converse theorem is valid. Can every sequential logic circuit be equivalent to a formula in propositional calculus? Does any formula at the propositional logic level correspond to sequential logic circuits?

Sequential logic circuits have memory owing to feedback mechanisms. (The operation of these circuits is mathematically isomorphic to that of a finite automaton. Examples of such circuits include flip-flops, registers, counters, clocks and memories.) The output state of sequential logic circuits is not a function of the input states but depends on previous input states. In contrast, the truth value of formulas in propositional calculus is a function of the evaluation of atomic formulas, without considering previous evaluations of these formulas. Therefore, the answer is negative; logical formulas cannot be simply matched with sequential logic circuits at the propositional logic level. However, logical relations between sentences may exist beyond propositional logic, corresponding to the operation of certain sequential logic circuits. What type of logic relationships can sequential circuits model? In the following text, I will provide a simple example of this.

Jean Buridan's paradox sentence

As an influential medieval French philosopher of his age, Jean (John) Buridan (c. 1295–1358) presented a puzzle with the following essence:

> Twelfth sophism: God exists and some conjunction is false (Buridan 2001).

Or in other words:

> God exists and none of the sentences in this pair is true.

What do you think about the truth value of these two sentences? Which of these two is true?

> $p :=$ God exists.
>
> $q :=$ Neither sentence p nor q is true.

'p' is true if God exists and false, otherwise. 'q' is true if neither p nor q is true.

Sentence q asserts a 'Not-OR' relation because 'neither p nor q' is equivalent to 'not (p or q)'. One component of the 'or' relation is an existential proposition, while the other is the 'or' relation itself. It is a peculiar sentence because it has a truth value, if it has any at all, which depends on itself. Therefore, it certainly cannot be translated into the classical first-order logic language.

Let us examine the logical possibilities. If p is true (i.e. God exists), then q is false because one of its components is true and the other is false. Consequently, the two together are false (i.e. q is false). The situation is not that simple if p is false (i.e. we deny God's existence). Suppose that q is true. This is possible only if both members are false. This is not, however, the case because the first member is false and the second member is true; hence, the result is false together and q cannot be true. Let us now assume the opposite that is, q is false. Both members of q ($q =$ not p and not q) are false because we denied God's existence. Consequently, q must be true, contrary to our assumption. Again, we are stuck in a contradiction. q can be neither true nor false. We alternately evaluate it as true or false. We are caught in a trap, from which the only way out is to assume that God exists.

Simulation of paradox applying logical circuits

Buridan's sentence has a constant truth value only if p is true, that is, we assume that God exists. In which case, q is false. This paradox cannot be expressed in the classical formal logic language, but can be presented using logical circuits.

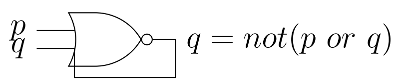

Figure 1: NOR gate

Logical circuits have either a high or low state. High and low levels correspond to true and false, respectively. The NOR (Not-OR) gate output is low if any of the inputs is high. In our case, the NOR gate has p sentences at one input and q sentences at the other input. The NOR gate output is also a q sentence. With this solution, the NOR gate output is fed back to one of its inputs. This feedback simulates the self-dependence of the truth value of Buridan's sentence. The logical circuit will work exactly considering that we have examined the logical possibilities.

The NOR gate output was connected to one of its inputs. This way, we can use the feedback to simulate the circularity of the truth value of a sentence q. The input p is high if God exists, but low if God does not exist. The output state of the automaton is fed back to the other input, thereby corresponding to the sentence 'neither one nor the other is true.' If the first input has a high level (i.e. God exists), then the NOR gate output has a low level (i.e. the sentence q is false). Conversely, its first input is low (i.e. God does not exist), the NOR gate output will alternate between low and high, such that sentence q will not have a constant truth value. The cybernetic model exactly simulates the logical paradox.

Conclusion

As mentioned, Buridan's sentence is a paradox. It cannot be translated into the classical formal logic language; however, the operation of the cybernetic model that simulates the paradox can be. Its operation is consistent, not paradoxical, which is the benefit of such models.

References

- Buridan, J. 2001. *Summulae de dialectica* (translated by Gyula Klima). c. 8, p. 980. Yale University Press.

- Erwig, M. and Walkingshaw, E. 2010. Causal Reasoning with Neuron Diagrams. *IEEE Int. Symp. on Visual Languages and Human-Centric Computing (VL/HCC)*:101–8. 10.1109/VLHCC.2010.23.