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Understanding Logic, Knowledge Representation, and Critiques of Logic-Based AI

To be able to understand logic based AI, we first need to understand what logic truly is and how it works in relation to artificial intelligence. Logic is not something narrow or absolute. Logic is very broad, and it is not always about right or wrong. Different logics can lead to different conclusions, and sometimes one logic can even go against another. Because of this, logic cannot be easily generalized. This becomes important in AI, where systems rely on selected facts, assumptions, and forms of reasoning to derive knowledge. With this perspective, the following sections examine how knowledge is formed from experience, how it is represented, and why logic based AI has been both powerful and heavily criticized.

1. Concrete Domains, Ideal Experience K, and Derived Knowledge K*

Domain 1: Musical Instrument

Ideal Experience (K)
For the first domain, I choose musical instruments because it is simple to classify. The ideal experience K is the given assumptions about "is-a" relationships:

- ElectricGuitar → Guitar
- Guitar → StringInstrument
- StringInstrument → MusicalInstrument

These assumptions show the basic taxonomy. They are facts the system is given, which IL-1 can work with easily.

System Knowledge (K)*

From these assumptions, IL-1 uses the Rule of Deduction (transitivity) to derive new knowledge:

- ElectricGuitar → StringInstrument (from ElectricGuitar → Guitar and Guitar → StringInstrument)
- Guitar → MusicalInstrument (from Guitar → StringInstrument and StringInstrument → MusicalInstrument)
- ElectricGuitar → MusicalInstrument (from ElectricGuitar → StringInstrument and StringInstrument → MusicalInstrument)

So K* is the combination of the original assumptions and all the derived facts.

Meaning of a Term

In IL-1, the meaning of a term comes from its relations in K*, not from a dictionary. For example, "Guitar":

- Extension (what belongs below it): ElectricGuitar
- Intension (what it belongs to above it): StringInstrument, MusicalInstrument

The meaning is completely relational, based on the hierarchy of facts and derived knowledge.

Domain 2: Medical Pathology

Ideal Experience (K)

The second domain is medical pathology, using a strict taxonomic structure. Fever is a symptom, so it cannot be a category. Instead, the hierarchy focuses on disease:

- CommonCold → ViralInfection
- ViralInfection → InfectiousDisease
- InfectiousDisease → Pathology

These are the given assumptions for K.

System Knowledge (K)*

Using the same transitive deduction:

- CommonCold → InfectiousDisease (from CommonCold → ViralInfection and ViralInfection → InfectiousDisease)

- ViralInfection → Pathology (from ViralInfection → InfectiousDisease and InfectiousDisease → Pathology)
- CommonCold → Pathology (from CommonCold → InfectiousDisease and InfectiousDisease → Pathology)

K* includes all the assumptions and all derived facts.

Meaning of a Term

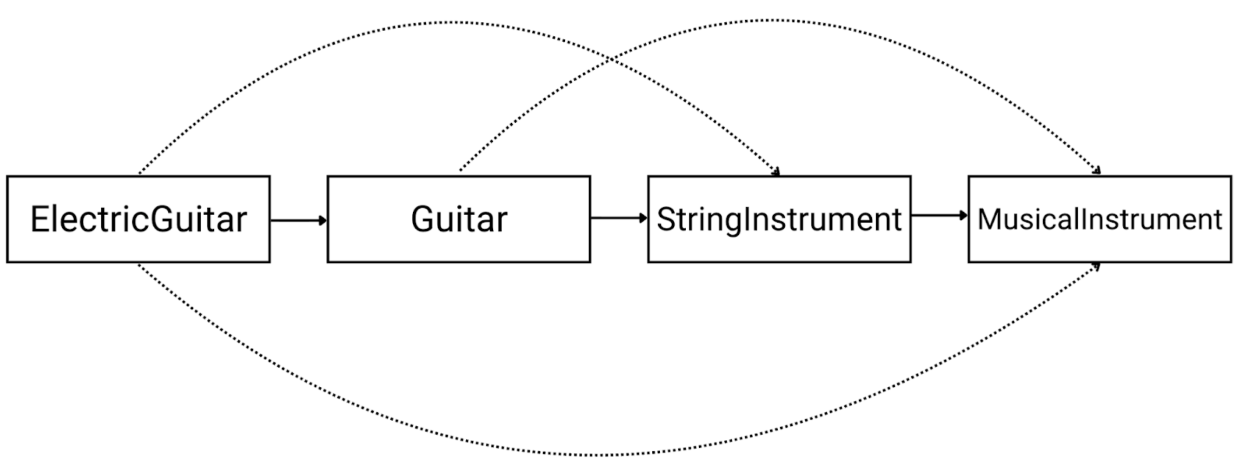
The meaning of "ViralInfection" comes from its relations in K*:

- Extension (what is below it): CommonCold
- Intension (what it belongs to above it): InfectiousDisease, Pathology

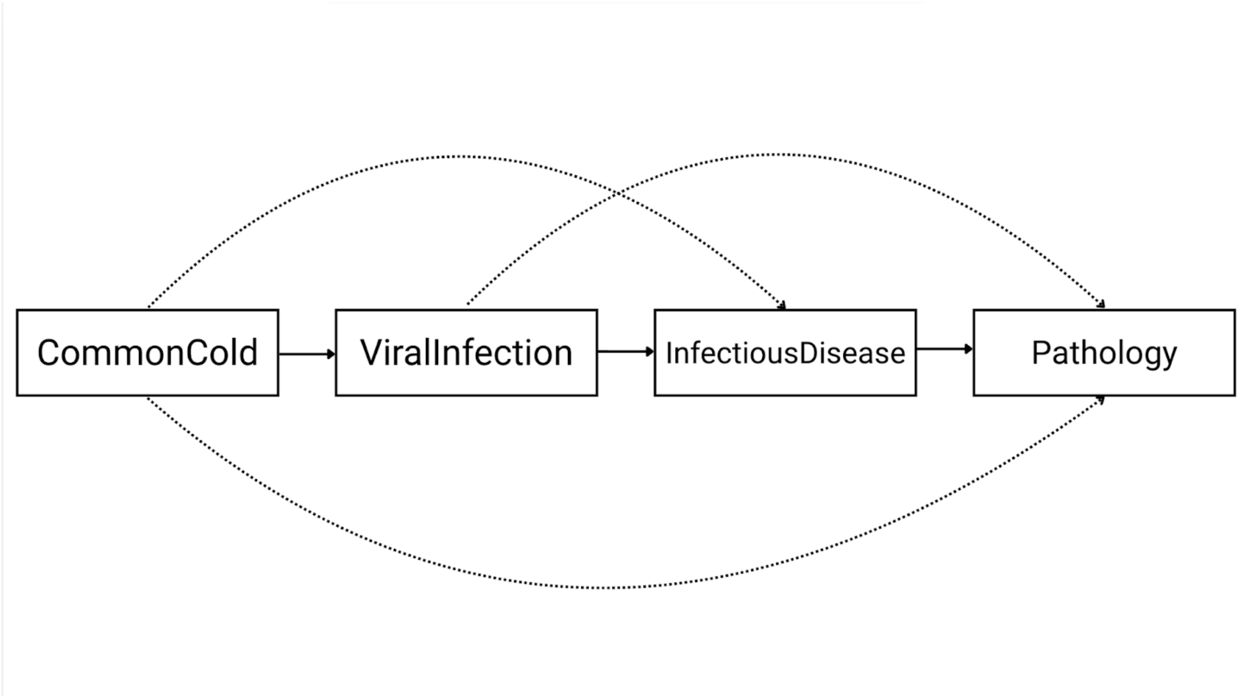
So again, the meaning comes from the experience-based structure, not absolute definitions.

2. Concept Graphs

Domain 1



Domain 2



Explanation of the Dotted Lines and Rule of Deduction

To understand why the graph has dotted lines, we need to understand how deduction works in Inheritance Logic (IL-1). The dotted lines are not random. They represent knowledge that is not directly given, but logically derived by the system.

In IL-1, there is a Rule of Deduction, also called transitivity. The rule is simple. If A belongs to B, and B belongs to C, then A also belongs to C. In other words, if an ElectricGuitar is a Guitar, and a Guitar is a StringInstrument, then an ElectricGuitar is also a StringInstrument.

This rule allows the system to generate new knowledge from existing knowledge. These new facts were not explicitly given in the original experience K, but they become part of the system's knowledge K*.

This is why there are multiple dotted lines in the graph. The system does not stop after finding just one connection. It computes what is called the transitive closure, meaning it finds all possible category relationships implied by the hierarchy.

For example, the system first derives the short jump. It learns that ElectricGuitar belongs to StringInstrument. Then it also derives the longer jump. It learns that ElectricGuitar belongs to MusicalInstrument. Each of these derived facts is important, so each one is shown as a separate dotted line in the graph.

These dotted lines show that the system has made implicit knowledge explicit. The system now "knows" every category the object belongs to, not just the immediate one. This is important for intelligence, because an intelligent system should understand all relevant generalizations, not only the closest one.

This also connects to the idea of control, or knowing when to stop thinking. One criticism of logic-based AI is that it thinks too much and never stops. In Classical Logic, a system might try to keep deducing forever, going from MusicalInstrument to Object, to Matter, to Universe, and so on.

In Dr. Wang's reasoning system, logic is combined with control. The system stops once it has done enough useful thinking given its limited resources. In the graph, this is shown by the fact that the dotted lines stop at the meaningful top-level categories. The system derives the necessary knowledge in K* and then stops, instead of entering an infinite loop.

3. Criticisms of Logic-Based AI

Is the target logic in general or only specific types of logic?

To really understand this criticism, we first need to understand what logic actually is, or more correctly, what logic are. Logic is not just one thing. Once we understand this, it becomes clear that logic is very broad. Sometimes logic is about right or wrong, true or false. But sometimes it is not even about that. Some logic systems allow uncertainty, some allow contradiction, and some even go against each other while still being valid in their own way.

Because of this, it does not make sense to generalize logic as one rigid tool. When people say "logic-based AI failed," most of the time they are not talking about all logic. They are talking about Classical Logic, even if they do not realize it.

Logic is "too brittle"

One common criticism is that logic-based AI is too brittle for the real world. The idea is that if the system sees one exception, everything breaks. This criticism is actually true, but only for Classical Logic.

In Classical Logic, everything must be absolutely true or false. If a system believes "birds fly" and then sees a penguin that does not fly, the system now has a contradiction. In Classical

Logic, contradictions are deadly. From one contradiction, the system can conclude anything, so it basically collapses.

But this does not apply to logic in general. It only applies to logic that assumes perfect truth. In Non-Axiomatic Logic, like the one Dr. Wang describes, statements are not treated as universal laws. They are based on experience and confidence. So when the system sees a penguin, it does not break. It just learns that "birds fly" is mostly true but not always. The system keeps working.

So here, the criticism is clearly aimed at Classical Logic, not all logic.

Logic "cannot learn"

Another criticism is that logic cannot learn because logic is monotonic. This means once something is proven true, it stays true forever. Learning, however, requires changing your mind.

Again, this criticism is correct, but only for monotonic logic. Classical Logic cannot easily remove or weaken beliefs once they are proven. This makes learning almost impossible.

Non-Axiomatic Logic is different. It is non-monotonic. Beliefs can change over time. A belief that was strong before can become weaker later when new experience arrives. This is actually closer to how humans learn. We do not instantly delete old beliefs, we slowly lose confidence in them.

So saying logic cannot learn is really saying Classical Logic cannot learn. It is not a problem with logic as a whole.

Logic is "too slow"

There is also the criticism that logic is too slow and leads to paralysis by analysis. The argument is that logic systems try to reason through everything before acting, and in the real world, you do not have that time.

This criticism is partly fair, but again, it depends on how logic is used. Logic itself is just inference rules. The real problem is reasoning without control. Early logic-based systems tried to deduce all consequences, which is not realistic.

Non-Axiomatic Logic solves this by limiting resources. The system does not try to think about everything. It only focuses on what is most important right now. It can act even when its reasoning is incomplete. This makes logic usable in real time.

So this criticism targets systems that separate reasoning from control, not logic itself.

Broader criticisms

There are also broader critiques that go beyond formal logic. One is the symbol grounding problem. The idea is that symbols in logic systems do not mean anything because they only refer to other symbols. The system does not really know what a “cat” is.

This criticism is valid for symbolic systems that have no experience with the world. If symbols are never grounded in experience, then logic becomes empty. Non-Axiomatic Logic tries to fix this by defining meaning through experience, not dictionary definitions.

Another criticism comes from Hubert Dreyfus, who argued that humans do not think by following rules. We rely on intuition and skill. Logic cannot capture this kind of intelligence.

This is a strong criticism of rule-only systems. But it does not mean logic is useless. It means logic alone is not enough. In NAL, intuition can be modeled as beliefs with very high confidence, allowing fast decisions without deep reasoning every time.

Finally, people argue that neural networks work better than logic, so logic is unnecessary. This is true for tasks like vision and speech. But neural networks are black boxes. They cannot explain why they make decisions. For AGI, explanation and reasoning still matter. Logic is still needed.

Final conclusion

When people say logic-based AI failed, they are usually attacking a very specific kind of logic. They are not attacking logic in general. Classical Logic assumes perfect truth, no uncertainty, and unlimited resources. These assumptions do not match the real world, so systems built on them failed.

Logic itself is not the problem. Logic is broad, flexible, and sometimes even conflicting between systems. Non-Axiomatic Logic shows that reasoning can handle uncertainty, revise beliefs, and work with limited resources. The real failure was treating one narrow logic as if it represented intelligence itself.

In the end, logic did not fail. A specific logic failed, and people confused that with all logic.