

Interface Theory of Perception

Author: Donald D. Hoffman
Speaker: Wenfan Jiang

An innovative theory of perception



Conventional theory: Faithful Depiction

Idea: The perception is veridical.

Goal: To recover, or estimate, accurately of the physical world.

People supporting this theory claim that human perception is a result of combining many probabilistic sources of information.

- **“Reconstruction”**: accurate and objective
- **“Construction”**: the properties and categories of one’s perceptual world

Conventional theory: Probability Theory

I - Image received from some sensors.

W - Properties in the real world.

$P(\mathbf{I})$ - Hyperparameter.

$P(\mathbf{W})$ - Assumptions that human vision makes about the world, also called *prior*.

$P(\mathbf{I} | \mathbf{W})$ - Assumptions that human vision makes about how the world maps to images, also called *likelihood*.

$P(\mathbf{W} | \mathbf{I})$ - The estimation that human vision computes about the properties of the world given the images, also called *posterior*.

Conventional theory: Bayes' Theorem

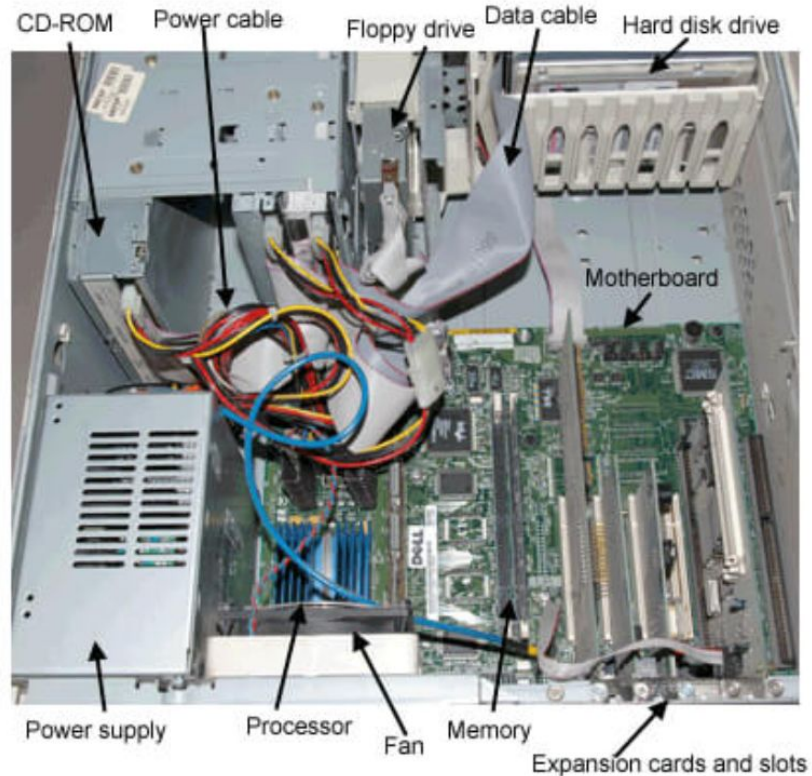
$$P(W | I) = P(I | W)P(W) / P(I)$$

When we measure priors and likelihoods in the world, our measurements are necessarily filtered through our posteriors. In other words, our measurements depends on our perception.

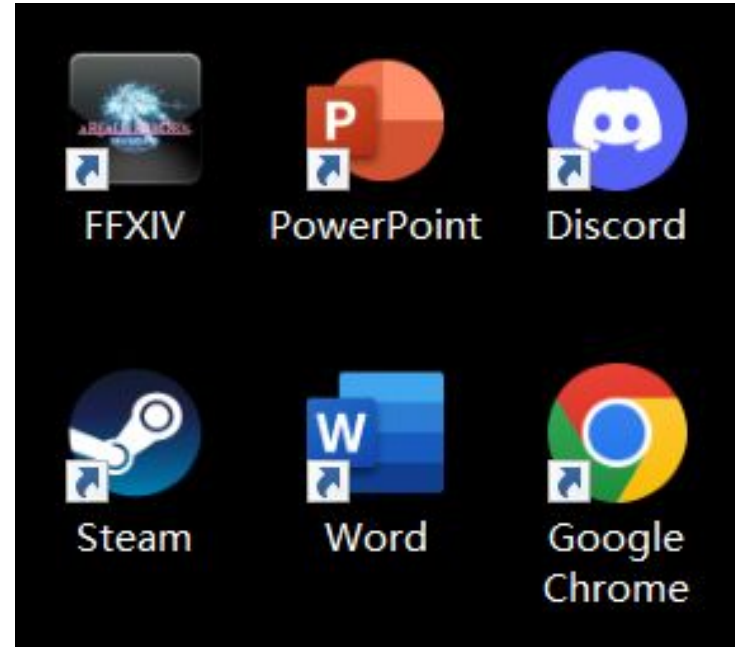
Interface Theory: Key Idea

1. Perceptions constitute a **species-specific user interface** that guides behavior in a niche.
2. Each perceptual category of an organism, to the extent that the category is shaped by **natural selection**, is a **satisficing solution** to adaptive problems.

Interface Theory: Metaphor



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Interface Theory: Evidence

Australian jewel beetles used to look for desirable females (the bigger the better) but ended up mating with beer bottles 🍺



<https://youtu.be/7nStp4urqM>

Interface Theory: Summary

- There is an objective reality that can be explored in the normal scientific manner.
- Different species have different interfaces.
- No interface performs “reconstruction”.
- Each interface is tailored to guide adaptive behavior in the relevant niche.
- No specific model of objective reality, but the nature of objective reality is an open scientific problem.
- Vision doesn’t recover information about pre-existing physical objects in space-time.
- Evolution is central to understanding perception.
- Natural selection optimizes fitness, not veridicality.
- It is important to be aware of the case that conventional theory is misguided.

Interface Theory: Objection and Response 1

The examples of beetles require comparison between the perceptions of an organism and the objective reality that those perceptions get wrong, so they support that perceptual reconstruction of the objective world actually occurs.

Because the interface of human differs from that of other species, human can, in some cases, see flaws of others that they miss themselves.

Interface Theory: Objection and Response 2

Then why don't you try something dangerous because it is just a perceptual category of your interface, right :)?

Because we still take the interface seriously just like we don't carelessly drag a file icon to the trash bin, because the interface have shaped it to the point where we had better take its icons seriously or risk harm through evolution.

Interface Theory: Objection and Response 3

This claim makes the world unknowable and is inimical to science.

The interface theory doesn't determine a true theory of the objective world, but this in no way precludes us from creating theories and testing their implications.

For example, using probability theory, we can represent the world by a measurable space (W, Σ_W) , where W is a set and Σ_W is an algebra of measurable events. We can also represent the user interface by a measurable space (U, Σ_U) , and the relation between interface and world by a measurable function $f: W \rightarrow U$. The probabilities of events in the interface space would be distributions of the probabilities in the world space.

Discussion: Piazza @3 @4 @7 ...

Based on the interface theory, we see perceive the world in the current way because it's better for us to adapt that way, but the same might not be true for a computer and the applications we want to apply them to.

What should be the goals of a “computer perception” and how will these goals influence the implementation of it?

Discussion Summary: Piazza @3 @4 @7 ...

Some people believes that computer is better to have a different perception than human do, and it doesn't make sense to let computer have another "interface" again. Therefore, in the aspect of engineering, we may not want the computer to completely simulate the human perception. However, the professor has also mentioned that science and engineering are helping each other; when one has development, the other will also be improved. Therefore, even if in the aspect of engineering, we may not want the computer to learn about some interface-like perception, it is still good to learn about human perception, and we may get intuition for further development from it. Just like how we can develop sound-tracking navigation system from observing animals in a dark environment such as bats and owls, we may also find something useful from human perception once we know more about it.

Discussion Summary: Piazza @11 @12

This discussion thread has also been mentioned in class, which is about the “usefulness” of a certain type of perception (veridical or adaptive). We talked about how to determine if something is useful or not, and we ended up agreeing that it’s task-specific. Just like being mentioned in one of the comment in @11 and @12, intermediate representation uses this theory of non-accurate but effective perception, and computer can extract the most relevant information for a particular task rather than a single, general-purpose representation. Therefore, in these two threads, people tend to agree that computer can have a perception that is optimized for a specific task, and we may need better objective functions that can match it. This is also a flaw in the current cutting-edge state of art: ChatGPT. According to the reply from Rajiv Govindjee, “ChatGPT doesn’t truly optimize for the objectives we ‘care’ about.” Thus, further development can definitely be made.

Discussion Summary: Piazza @1 @10

There are also discussion about more examples that can support the interface theory. For example, the fish in the dark ocean appeared in the discussion of piazza, and in class, we have also talked about an evolution simulation done by Hoffman, where the species with more accurate and detailed perception was driven to extinction. Most people can understand and agree with the result of natural selection.

Discussion Summary

In the remaining posts from Piazza, people were also worried about if we can ever really detect whether the computer is interacting with the real world, because we are limited by our own perception too. Therefore, even with more developed sensation tool, we may not be able to tell the difference. On the other hand, there is a post that relates our current perception build-up to pre-trained model, and some people are more into the conventional view and Bayes Theorem.

In the class, we also discussed about “if there is really a real physical world”, and most of us think there is one, while some do not believe that. However, that might not influence much on our current life. The conclusion in the end was about “making sure what kind of usefulness and purposes we want”.