Do We Have Common Philosophical Presuppositions?

I have always wondered if engineers who work in our discipline have any common philosophical beliefs and, if we do, what they are. To illustrate what I mean, consider the related field of mathematics. Many mathematicians hold a belief called *platonism*, roughly defined as follows [1]:

> Platonism about mathematics (or *mathematical platonism*) is the metaphysical view that there are abstract mathematical objects whose existence is independent of us and our language, thought, and practices. Just as electrons and planets exist independently of us, so do numbers and sets. And just as statements about electrons and planets are made true or false by the objects with which they are concerned and these objects' perfectly objective properties, so are statements about numbers and sets. Mathematical truths are therefore discovered, not invented.

Are control theorists and engineers anything like mathematicians, in that we believe in the actual existence of abstract mathematical objects? My hunch is that the answer is no, based on my own observations and conversations with numerous researchers and practitioners in our field and related ones. Instead, perhaps somewhat surprisingly, I found people in our field to be quite skeptical of the reality of even abstract mathematical objects in our own work, and often of scientific claims in general.

President Ed Chong visiting the Nanjing Chapter of the IEEE Control Systems Society in June 2017.

PHILOSOPHY OF SCIENCE

For the purpose of understanding the philosophical presuppositions in our field, I have grouped it together with allied fields into the rather broad disciplinary category I call *information sciences and systems*. This was the term used when I was a graduate student at Princeton to designate the fields of systems and control, communication, networks, and signal processing. These allied fields are sufficiently close in methodological approach to ours so that it seems reasonable to assume that our underlying philosophical beliefs are similar. In particular, in the area of information sciences and systems, our thinking and discourse often involve mathematical abstractions and calculations. Terms such as system, state, input/output, signal, information, frequency response, bandwidth, and objective function are commonly used even in informal technical conversations.

My basic conclusion about those in the field of information sciences and systems is that they are likely to hold a view called *instrumentalism*, defined as follows [2]:

> Instrumentalism, in the philosophy of science, [is] the view that the value of scientific concepts and theories is determined not by whether they are literally true or correspond to reality in some sense but by the extent to which they help to make accurate empirical predictions or to resolve conceptual problems. Instrumentalism is thus the view that scientific theories should be thought of primarily as tools for solving practical problems rather than as meaningful descriptions of the natural world.

Someone who rejects this view and, instead, believes that the deliverances of science are literally true is said to hold the view of scientific realism [3]; instrumentalism is therefore said to be a type of antirealism.

If you are unsure about whether you are a realist or an instrumentalist about the objects of your scientific and engineering work, ask yourself if you think your descriptions about the real world are actual facts or simply models that are useful for the purpose of practical ends, such as designing a stable controller. Is the transfer function of your system a real object or

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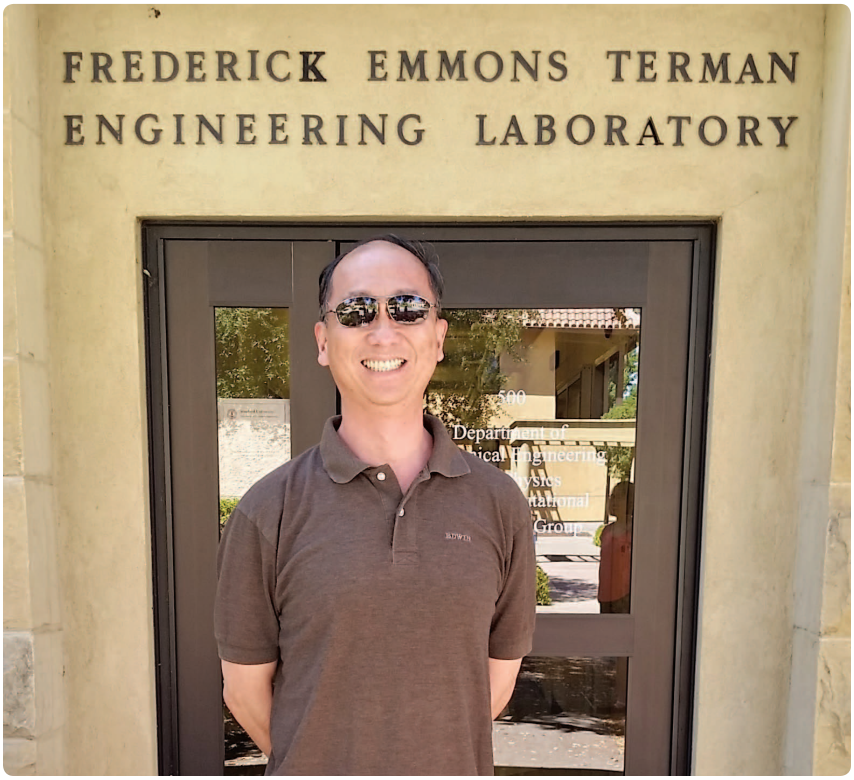
simply the label given to an abstract concept, useful for solving practical engineering problems? Even more generally, are scientific "laws" literally true, or are they just models that fit the observed data? My experience is that most engineers in our field are instrumentalists. What this means is that many of us admit that gravity and electrons might not actually be real, but they are nonetheless useful concepts.

Upon further reflection, perhaps this is not a surprising claim. For example, in linear systems theory, given an input–output specification, there is not a unique state-space representation for the system; instead, there is an entire infinite family of them, all of which give rise to the same input–output behavior. This means that the notion of a state in the system is representation dependent, at least in this context. So, why think that a scientific law is not also representation dependent? After all, isn't any scientific law simply some model representing the observed data? Yet few of us would deny that scientific laws and models are useful in engineering analysis and design.



Ed Chong at the Frederick Emmons Terman Engineering Laboratory, Stanford University.

OTHER PHILOSOPHICAL ISSUES

Our training in control theory and methods impinges on our philosophical understanding of the world. I have argued that our background seems to predispose us to an instrumental view of science. But there are other connections between our discipline and philosophy. The notion of observability in control theory, for example, is closely related to the study of epistemology in philosophy, which is concerned with knowledge and justified beliefs [4]. In fact, observability is, in a sense, a rigorous account of the epistemology of states in systems. Roughly speaking, if a system is unobservable, then there are states in the system that are indistinguishable, given only the output. In such a case, it is impossible, in principle, to "know" the state of the system if all we can access is the output of the system. Moreover, in this case, any belief that the state is any specific state is unjustified.

Control theory and thinking also have applications in the philosophy of religion. For example, I have done some work on the issue of divine foreknowledge, providence, and human freedom, issues that have puzzled philosophers of religion for a long time. It turns out that notions of state, feedback, and control have some role to play in understanding these issues. If you are interested, I'd be happy to explain what I have done.

PARTING REMARKS

This is my final "President's Message" column. I realize that probably the only people who will read my columns closely are future presidents trying to find out what their predecessors have to say in these messages. But if you are not a future president and are among those who have read my messages, then I say to you, "What were you thinking?" Seriously, though, I hope you found them at least enjoyable to read.

My term as your president in 2017 is almost over. This past year has been one of the most memorable of my 30-year career so far. In 2018, I will continue to serve on the IEEE Control Systems Society Executive Committee as past president. I am honored to have served you as president of our great Society.

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