I work in and around logic, artificial intelligence, and sustainable development (i.e., Green economics). And have significant creds in all three. For example, my first software company – Power Thinking Tools - developed a multidimensional database that was quite advanced in a number of ways and led to the company's unsolicited acquisition. I later had the privilege of writing the first text book on the topic; and am considered a world authority in this field which is a critical component in artificial intelligence. Most recently, under government-sponsored R&D contracts I've been developing new methods for understanding natural language combined with sensory-motor data. Before that I had published on the value of Wittgenstein's logic for the modeling of information. And recently had a paper selected as a finalist in a competition on the future of logic. In addition to being the World Bank's aggregation specialist for socio economic and environmental data I was also invited to Egypt as a part of an international expert group on the future of indicators for sustainable development.

As seemingly disjoint as these three areas may at first appear, they are, to me at least, intimately connected. Green Economics is the goal. Artificial intelligence is the technology required to achieve that goal. And logic is the foundation.

Green economics is all about finding objective ways to value, in some kind of unified fashion, the earth's physical environment, its ecosystems, human-produced tangible capital (such as buildings, roads and trains), human skills and knowledge (called human capital), and social capital (such as political institutions and even social media). Since almost all business and political decisions carry tradeoffs across different kinds of capital (e.g., one decision may be better for human capital but worse for the environment and vice versa), unified valuation methods are critical to support business and political decision making. Currently, the only established game in town is the classical economics definition of gross domestic product GDP and its derivatives. Media outlets clap when it goes up and boo when it goes down. Yet, most of us know that as a compass for human progress, GDP is brain dead - stranding humanity on a ship without a rudder. What GDP really measures is how much monetized activity took place; not what kind. But that monetized activity is 100% embedded in earth's ecosystem which is itself embedded in earth's physical environment of earth, fire water and sky. Get rid of people, and the earth and all nonhuman ecosystems will get along just fine. Get rid of earth's ecosystems or the physical environment and Poof, humanity disappears. We need ecosystems; they do not need us. The relationship is fundamentally asymmetric.

I was very fortunate to have been working at the World Bank as an aggregation specialist for the head of the Bank's socio economic and environmental data division: John O'Connor. There, I had the privilege of producing the Bank's environment model that supported the first earth summit in Rio in 1993 and their model of human well-being produced for the member countries on the eve of the Bank's 50th anniversary. John was the first person to figure out a method for providing unified valuations across all forms of capital which when originally published in 1995 got rave reviews from the likes of the Financial Times and the Economist for providing the first computationally tractable method for sustainable development.

The beauty of John's approach (parts of which have since burrowed their way into the fabric of international financial institutions such as Eurostat, the IMF, the World Bank) is that it leverages the part of classical economics that works really well – namely that the financial value of a good or service is equal

to its unit price times its quantity. And it places what makes Green Economics a challenge – the recognition of stuff that is not currently a part of our monetary accounting system (e.g., a liter of clean surface water) and the pricing of same (what is a liter of clean ground water worth), into an explicitly social context. People, individual people need to express their preferences. Those preferences need not be the same from place to place. So prices can vary dramatically from place to place. A liter of clean surface water will be much higher valued in Abu Dhabi where it is incredibly scarce than in Ontario where lakes abound.

The name given to this form of Green Economics is Wealth Accounting or Inclusive Wealth. To make it a reality requires a multi stakeholder information system to which private citizens, companies, universities, non-profits and governments can interact; expressing their preferences, their observations, and, their transactions.

I call the kind of information system that can ingest and produce the words, numbers, maps, sensor readings and so forth that we use to express and communicate information about our world, that can link people with the information they need and information to the people who should use it: a smart information grid.

Building a smart information grid is a technical challenge for artificial intelligence. It requires computational semantics which is the ability to computationally treat all kinds of statements and the ability to relate anything expressed in meaningful ways to anything else that may have been expressed. And it requires multi-source data fusion which is the ability on the basis of some kind of computational semantics to understand that for example that a time lapse video of a waterfall running dry and an environmental report may be describing the same phenomena or portion of reality. And it requires what's called natural language processing NLP or the ability to convert human utterances of whatever form into an internal semantic representation that can be reasoned over by a computer.

In artificial intelligence, our team's basic idea is to link/associate all kinds of information (e.g., maps, database records, sensor readings and natural language) with composites of our system's semantic elements like space, time, objects, persons, relevant attributes and events. And we reason/query over these semantic composites which we represent as in-memory graphs in a computer.

Although we include a standard NLP pipeline and can make use of linguistic knowledge such as parts of speech, we map natural language directly to compositions of our semantic elements. This avoids the impedance mismatch between linguistic structures and semantic structures that has long been a problem in NLP. If you speak two languages, this is easy to understand. Say your mother tongue is English. Before you learned a second language, it was hard to differentiate your minds internal meaning elements, the elements out of which your mind creates arbitrarily complex understandings, and the English language representation of same. But once you learned a second language, say French, and became fluent in the sense that you could understand French without translating into English, then you understood that there was some kind of semantic representations used by your mind that were the same regardless of whether the words used to communicate them were English or French. The surface words lost their preeminence;

becoming subordinate to the minds internal (not necessarily private) language In this sense, we believe our approach to AI is very natural.

In fact, the basic meaning elements we use are themselves derivative of a generalized sensory-motor agent, something we have also had the privilege of working on.. In other words, any tangible agent that has sensors whether feelers or eyes or ears or a nose, etc.. and that has motor devices…..arms, legs etc… produces information about what we typically call space, time, objects processes and so on. So the grounding concepts are not simply assumed; rather they can be shown to be common to all acts of sensory motor interaction with the world. In this sense, our approach is different from the traditional "ontological" approaches that try to place different portions of reality into different buckets. Rather we have one multi-dimensional bucket that can stretch, split, combine etc.. We are delighted in this area to be working with one of the world's most recognized ontologists Barry Smith (whose upper ontology is a defacto standard in the US government) on extending traditional ontologies to accommodate this multi-dimensional approach.

Following this thread leads to a very different conception of the mind-body boundary. Instead of equating mind with brain, and body with everything else, our conception treats mind as a process that recursively builds on itself. One can speak for example of non-representational mind..such as what's exhibited by an amoeba, or uninterpreted representational mind as what's exhibited by simple insects, or interpreted representational mind as what's exhibited by mammals. The key thing is that each successive layer of mind is inextricably embedded in the next simplest layer. So for example, any real world phenomena get picked up first in a non-representational way (pressure, heat etc..) and are then converted into a representational form (electric signal) which may be drive a subsequent interpretation before triggering a response that gets translated into a non-representational motor action.

The way that the basic meaning elements combine, what's called 'grammar', for example, the fact that "2 + 7 = 9" would be grammatically recognized as a sensical statement whereas "+ 2 +" would be grammatically considered nonsense is fundamental. Some grammar must govern how meaning elements are combined to form complexes. The thing is, that grammar does not come from AI. It is prior. And that's because the grammar comes from logic.

And this is where Ludwig comes in. Unlike the logicans of his day, most notably Frege and Russell, Ludwig believed that all thought had a grammar and that Logic provided the most general and therefore the most invariant form of grammar. What was logically ungrammatical could not possibly have any meaning. Whereas Russell, Frege and modern classical logicians treat well formed sentences as necessarily meaningful, in line with Wittgenstein's views, we treat well formed sentences as only potentially meaningful. Whether they are in fact meaningful (to use logicians terms -whether a well formed formula is or is not a proposition) may depend on whether certain information exists or whether certain other facts are true. Ludwig was in this sense the 20th century's pre-eminent non classical logician. He did not conflate grammatical sense with empirical testability. He acknowledged that pure logic and mathematics could say nothing about the empirical world. That all empirical knowledge was probabilistic. And that all semantic computations were but specializations of an underlying logical grammar. And most importantly,

that logical elements did not refer to anything in the world but rather referred to functional roles in the process of computing with meaning elements.

Ludwig's only published work was the Tractatus. We therefore are using a tractarian logic to build an AI-based smart information grid for sustainable development.