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Interview with Colin Garvey, Rensselaer Polytechnic Institute. *Artificial Intelligence and Systems Medicine Convergence*

Colin Garvey

Prof. Vural Özdemir (Editor-in-Chief, *OMICS: A Journal of Integrative Biology*): Colin, many thanks for agreeing to this interview for *OMICS* readership. Artificial intelligence (AI) and algorithms are becoming hot topics in systems medicine and emerging *OMICS* fields such as microbiome science. Therefore, please allow me to introduce the journal readership to you. *OMICS* is the first systems sciences and systems thinking journal with a legacy over two decades. Our approach to large-scale biology is interdisciplinary and integrative. With that, I mean an approach that is broadly focused on systems science technologies, interdisciplinary, and spans from ''cell to society.'' Let's start with a brief history of AI from 20th century. Have AI and its conception changed since the last century?

***Mr. Colin Garvey*:** An easy way to make sense of AI history is in terms of three paradigms, ''GOFAI'' (1950–60s), ''expert systems'' (late 1970–80s), and ''machine learning'' (2010–present). GOFAI, short for ''good old-fashioned artificial intelligence,'' employed symbolic logic to make ''thinking machines,'' which basically failed. But the basic insight that clever heuristics were more important than brute-force computation for intelligent behavior in machines lived on. Some say heuristic search, which is still used billions of times a day on the Internet, was the original AI problem.

Next, the expert systems paradigm still used symbolic logic but narrowed the focus from general intelligence to human expertise in specific domains, such as chemistry and medicine. Attempts to replicate experts' knowledge and decision-making processes led to the first major medical AI system, MYCIN, and eventually to more familiar software like TurboTax. But the expert systems paradigm has always been limited by the ''knowledge acquisition bottleneck''—it turns out that extracting expertise from living humans is hard, time-consuming work!

The current machine learning (ML) paradigm bypasses that bottleneck to extrapolate patterns or ''learn'' directly from data, usually through a training period of 100,000s of trial-and-error loops. This requires considerable computational power and memory, which is why the recent successes of ML algorithms in image and speech recognition, language translation, and games like *Go* and poker, owe as much to recent hardware innovations as clever programming. That said, ML doesn't seem to be taking AI any closer to the longtime dream of ''general intelligence.'' In many cases ML even makes AI *less intelligible* to humans. Most ML algorithms, once fully trained on a given dataset, become what you might call ''black box savants'': accurate 98% of the time, but totally incapable of explaining *why* they produce the answers they do. Defense Advanced Research Projects Agency (DARPA) recently launched the ''Explainable AI'' program specifically to address this problem.

Prof. Özdemir: AI and related tools are rapidly changing engineering, manufacturing, and industry practices. Yet, AI has not been firmly at the epicenter of medical research and life sciences compared to engineering, self-driving cars, or customer and retail services. AI might potentially be harnessed with a view to systems medicine, for example, to obtain and make sense of deep phenotypic data collected in the course of a day in community settings (instead of hospital settings) on individuals' health. What are the key prospects that AI offers for medical research?

***Mr. Garvey*:** With the proliferation of cheap computation and data storage, high-bandwidth wireless connections, and sensors in smartphones and wearables, the infrastructure for continuous monitoring of more life processes at finer scales now exists, and the data produced thereby offer great potential in the ML paradigm. Informed by a systems perspective of the organism-in-context, AI could help to facilitate a transformation in medicine, away from the treatment of symptoms by specialists to the intergenerational maintenance and enhancement of health at individual, community, and even population levels. Of course, the promise of gathering data across the entire phenotypic expression of the human organism raises a number of serious ethical questions—but this is an area where I think the medical community has greater expertise than the technologists. For this reason, systems medicine can and should inform the development of relevant AI technologies.

Prof. Özdemir: What about the AI prospects for clinical applications? Any linkages between AI and the quantified self movement?

***Mr. Garvey*:** One positive example I like is the electronic wristband developed by Rosalind Picard of MIT's Media Lab. It uses AI to predict epileptic seizures in the wearer by analyzing sensor data gathered via sensor contact with the skin, to prevent dangerous falls and other risks. But industry

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practices raise questions about the science behind these devices, since in-house research by AI developers and companies often remains unpublished. Today, the vast majority of human data now exists in the private sector—a contested space as far as ethical data governance practices are concerned. Medical professionals and other scientists can support the quantified self movement by demanding stringent patient data privacy protection in any trials they participate in involving AI systems.

Prof. Özdemir: Universal health insurance is not available in all countries. How might AI impact medical insurance practices?

***Mr. Garvey*:** I hope AI will help reduce costs and errors in medical care. Far more people die every year from mistakes in U.S. hospitals than on U.S. highways. But I worry AI will benefit private medical insurers more than it will aid patients. One highly problematic aspect of the data-driven ML paradigm we're in now is that little or no regulation exists to govern the ways your personal data can be gathered and used by private companies. Consequently, there is a real risk that insurers will gather and exploit detailed information about their clients in unprecedented ways. For example, you may tell your doctor that you sleep enough and don't smoke at your next company-mandated physical exam, but your insurance provider might come to a different conclusion from a data profile they have of you, which details regular late-night Internet activity, as monitored by your Internet Service Provider (ISP), frequent tobacco use, as detailed by your credit card history or online shopping records, and so on. Frank Pasquale's *Black Box Society* and Cathy O'neil's *Weapons of Math Destruction* detail a number of the disturbing ways in which Big Data can be exploited.

Prof. Özdemir: With the prospects of self-driving cars, taxis, and trucks, there have been debates and concerns that AI might supplant, rather than supplement, certain professions such as transportation and logistics sector or cashiers and customer service staff. What are your thoughts on the future of work and society? Will some jobs become obsolete as AI applications emerge? Some have suggested that the concept of Universal Basic Income might remedy these concerns for publics to be able to retrain for new jobs, as some jobs are phased out or become obsolete.

***Mr. Garvey*:** Estimates of AI's socioeconomic impact vary considerably, ranging from the widely cited and widely criticized Oxford study that claims 47% of U.S. jobs are at risk of automation over the next couple decades to more recent work that brings the number down to 9% across the Organisation for Economic Co-operation and Development (OECD) countries. But I think the considerable disagreement between experts suggests no one really knows what will happen. Nevertheless, investment in AI has never been higher, and businesses are rapidly adopting AI to cut labor costs wherever they can. This insider's perspective on possible job losses and displacement from the renown AI scientist Andrew Ng, former head of Google Brain, might be of interest to your readers (https://venturebeat.com/2017/07/25/ai-expert-worry-more-about-jobs-than-killer-robots/).

A systems perspective can help us anticipate some potential unintended consequences of rapid automation via AI technologies. For example, autonomous vehicles are always promoted on the grounds they are safer than human drivers and will prevent deaths on the highway, and to be sure, preventing some or all of the 35,000 deaths that occur on average on U.S. highways annually would improve public health. But the effect of putting the 3–5 million U.S. people who drive a vehicle of some kind as their primary mode of employment out of work within decade may result in much greater negative consequences for U.S. society overall, possibly exacerbating suicides and drug dependence, which in 2016 accounted for around 45,000 and 65,000 deaths respectively.

Prof. Özdemir: Indeed, in technology governance we have learned that every first order action has a second order reaction, and usually at an unanticipated dimension. Technology futures are always plural (i.e., futures, rather than a single deterministic future), and cannot be made future-proof, with a broad range of unintended consequences in society. Understanding technology futures as a linear extension of the past and in the form of a single proofed-future result in ''compressed foresight'' that does not serve well, and in fact, amplifies the uncertainties. How should we approach to AI futures in systems medicine and society and so as to avoid compressed foresight in particular?

***Mr. Garvey*:** Yes, futures are always plural. But as with many other emerging technologies, incumbent interests are working hard to establish control over the AI narrative and present it as *inevitable*. ''The machines are coming—are you ready, or not?'' For me, this is why AI manifests that ironic paradox of modern technology that the philosopher Hannah Arendt identified—it supposedly makes us more powerful, and yet we're somehow powerless to resist it! I think we can better cope with the futures of emerging technologies like AI by adopting a stance of ''thoughtful partisanship.'' AI is emerging, has yet to stabilize, and may still prove to be more hype than substance in many cases, so there is no way one can achieve an unbiased, objective view of it. So if we're bound to be biased, and normal science is inherently political, as scholars in social studies of science have observed for decades, the best we can do is represent our partisan interests transparently, rather than hiding them, while remaining thoughtful and reflective about how we do that.

The medical community has at times been regarded by the computing community as relatively reluctant to adopt new technologies. But instead of a failure to keep up with the times, this reflexive trepidation toward early adoption can actually be a valuable asset in shaping AI for the better. Medical professionals and others in the systems sciences have considerable social power and scientific authority, and they can bring that to bear in shaping AI future trajectories. As thoughtful and transparent partisans, I think they ought to avoid hasty adoption, and in the meantime clearly articulate their needs and concerns in response to the promise of AI. Failing to do so would be to give in to what the political philosopher Langdon Winner called ''reverse adaptation.'' The interaction between technology and society is bidirectional and co-productive: technology can and should adapt to social and local community needs.

Prof. Özdemir: It has become challenging to make sense of exponentially growing published literature. Could AI help the readers, scientists, authors make sense of the Big Data in scientific publishing?

***Mr. Garvey*:** Scientific knowledge is growing exponentially faster than humans can absorb it. AI could help us make sure that we're not missing out on the vast majority of new knowledge. To that end, IBM's Watson, a hybrid expert system, is said to read, understand, and summarize scientific

literature in certain areas. There is disagreement about how successful it has been, but machine translation between languages has clearly improved. ML techniques on large datasets have transformed natural language processing, with AI tools like Google Translate now in regular use. As a speaker of English and Japanese languages, I can attest they all still stumble on Japanese to English though!

Prof. Özdemir: Do you think one day Big Data will be placed under the overarching and broader field of AI? Will Big Data be subsumed or reframed under the AI field?

***Mr. Garvey*:** Although from a technical perspective Big Data and the ML paradigm of AI appear to be converging, since both fields basically just apply algorithms to datasets to extrapolate patterns, there are social reasons one will probably never subsume the other. AI and Big Data are still the products of human communities, with differing institutions, cultures, and practices. And neither is immune from the effects of public perception. AI in particular has been a rollercoaster of hype and disillusionment over the last 60 years.

Prof. Özdemir: What about the opportunity costs of AI? This is not always discussed especially when compressed foresight shapes technology policy.

***Mr. Garvey*:** The proliferation of black-boxed ML algorithms in the sciences could fuel a return of science based on spurious correlations rather than understood pathways of causation—a kind of ''digital phrenology'' if you will. For example, a recent study on automated inference of criminality using facial images ignited controversy—these researchers trained neural networks to identify ''likely criminals'' from their facial features alone! Access to powerful computers, cutting-edge algorithms, and databases of genetic and phenotypic data could open a Pandora's Box of questionable studies if governance and epistemic norms are not rigorously and transparently articulated and guarded.

Prof. Özdemir: Any final thoughts you wish to add?

***Mr. Garvey*:** Sure, I'll leave you with the main questions that drive my current research. Who is being put at risk by AI? And what can be done to mitigate those risks? I hope that mapping out a multidimensional spectrum of AI risks can help ''decompress foresight'' on AI technology futures and raise broader awareness that almost everyone is a stakeholder in AI futures. It is time for broad, public deliberations about the role we want this technology to play in society.

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Abbreviations Used

AI = artificial intelligence
ML = machine learning

Professional Biography: Colin Garvey

Colin Garvey is an interdisciplinary scholar in social studies of science and technology, with a focus on innovations driven by artificial intelligence. A graduate of Vassar College in upstate New York, he had extensive training in liberal arts, science, and social analysis. After years of experience in Japanese literature, he has taken on a PhD dissertation entitled *Risk Governance in Artificial Intelligence* in the Science and Technology Studies Department at Rensselaer Polytechnic Institute in Troy, New York. In addition to being an academic-in-training on the societal context of emerging technologies and knowledge-based innovation, Colin is also a Zen buddhist monk, formally ordained in the Japanese Soto tradition, and a freelance translator of Japanese academic books and scientific papers. A systems thinker, his interests include, among others, democratic theory, and the reflexive and active steering of technological trajectories toward sustainable human and ecological futures. With artificial intelligence having broad relevance in diverse sectors of engineering, industry, life sciences, and systems medicine, Colin is a frequent presenter in conferences and scholarly forums on critical studies of knowledge co-production, responsible innovation, history of science, and social studies of science. He travels to and visits Japan frequently.