The State of Innovation and the Impact of AI
https://mindmatters.ai/podcast/ep284

Announcer:

Greetings and welcome to Mind Matters News. When technologies are new, we often see rapid improvements and impressive innovations. Over time however, the rate of innovation tends to slow as technologies mature. On the grand scheme of things, where do we seem to be today in terms of technology innovation? Where are modern innovations coming from and how will advancements in AI, like large language models, impact innovation? This week we're joined by Jeffrey Funk, author of the book, Technology Change and the Rise of New Industries to talk about the state of innovation. Now, here's your host, Robert J. Marks

Robert J. Marks:

Greetings. Welcome to Mind Matters News. I'm your fiscally solvent host, Robert J. Marks. How is artificial intelligence doing as a business? AI is hyped everywhere, but is it doing well in the marketplace or is it a bubble? The status of artificial intelligence should not be judged by click counts on the web or all these Chicken Littles who wave their hands for attention screaming that the sky is falling. Technology is ultimately judged by reduction to practice. Has the technology found use commercially? Has it found used industrially or possibly in the military?

Right now, it looks like AI is a bubble. How big a noise is it going to make when the bubble pops? That remains to be seen. Recently, Google's parent company stock dropped sharply when its AI chatbot, Bard, gave wrong factual answers. And I don't know why anybody is surprised with this, because anybody who uses large language models like ChatGPT knows not to trust the facts generated by the AI. These chatbots are not trained using meaning, but they are trained rather using syntax.

Nevertheless, ChatGPT, for anybody that's used it, is really impressive. It helped me to write a bunch of articles. I wrote something which was kind of clunky. I said, "That was clunky." I gave it to ChatGPT and I said, "Rewrite this for me." And it did a pretty good job. I had to edit it a little bit. GPT-3, or ChatGPT, has been used to pass MBA exams, and so it does some pretty interesting stuff. Our guest today to talk about technology companies in the marketplace is Jeffrey Funk. He is a consultant on business models and the economics of new technology. He has served in professor positions at the National University of Singapore, Hitotsubashi... We practiced this before we started to talk.

Jeffrey Funk:

Hitotsubashi University.

Robert J. Marks:

Hitotsubashi University. Oh, terrible Japanese. Also Kobe University and Pennsylvania State University. His book, published by Stanford University Press, a pretty prestigious publishing group is called Technology Change and The Rise of New Industries. Jeff keeps his fingers on the pulse of the impact of new technologies and he is a frequent contributor also to Mind Matters News. Jeff, welcome.

Jeffrey Funk:

Thank you. It's good to be here. So a little background on myself. I got my PhD back in 1984 from Carnegie Mellon, which was during the second wave of AI hype. So the first wave is 50s and 60s, and during the 80s, there was a lot of hype about expert systems. And I was part of that hype because I did my dissertation in the Faculty of Engineering on the economics of robots. So these expert systems were supposed to play a major role in reducing the cost of programming robots. And at the time, I believe robots were going to take over the world, and well, they've diffused somewhat slowly over the past 40 years. Remember, this is 1984, and a lot of the things that people get excited about now, I assume they would be available by 1990 because that's what my professors told me. And of course, I believed in my professors.

And instead it's been very slow, not only robots, but AI. We're now kind of on the third wave of hype; neural networks. So neural networks began to replace expert systems as the preferred method for AI as Moore's Law proceeded. So a lot of people look and they think, "Oh, all this ChatGPT, it's so new. It's all so new. Oh my gosh, it's so new and yet it's doing so well." It's not new. AI is not new. AI is 70 years old. ChatGPT and other generative AI models are based on neural networks, which have become economical through Moore's Law, through this incredible increase in computing power that has been going on since the 1950s. But it's slowed dramatically. If you look at the cost per transistor, it's not going down anymore. In a lot of cases, it's going up. And if you buy any kind of integrated circuits like video chips or something, you'll notice that they're a lot more expensive than they were a few years ago.

Robert J. Marks:

So can I ask you, is Moore's Law over? Is Moore's Law ended?

Jeffrey Funk:

Well, that's generally what the insiders say, and I can show you data on it, show the data on the rise in costs as we move to what they call these new nodes, these smaller feature sizes. So 10 nanometers, five nanometers, two nanometers. In fact, I just had a visit from a fellow I worked with in the semiconductor industry back in 1978. He's now at the University of Rochester, and I showed him the graph. He said, "Yeah, this is true. This is what goes on." So in general, people agree on this, people don't want to talk about it, right? So the AI proponents want to say, "Oh, no, no, no, we're in the early years." In reality, it's very mature, what they're using.

Robert J. Marks:

So yeah, the things you talk about in, gosh, since the middle of the 20th century are really true. I know Bernie Widrow at Stanford was using one of the first neural networks in the late 1950s in order to do things like recognized speech in order to do an inverted broom balancer. Just incredible stuff. But it's Moore's Law which has made all of these recent accomplishments possible.

Now, you were into expert systems. There is a difference between expert systems and so-called connectionist models, which the neural networks would fall under. Could you unpack that? They're a little bit different in their philosophy.

Jeffrey Funk:

Well, expert systems are a set of rules, whereas these neural networks is based on statistics, it's all about figuring out which word is most likely to follow another word for ChatGPT and other generative models. So they're very different. If you come up with a rule-based system, AI people found it got complex very fast because there's so many rules that are involved. And so the neural networks work better, but they required a lot of computing power. And so the cost of these neural networks goes up a

lot as we increase the size of these databases, sometimes they say the number of parameters, so it's the number of parameters in the model. So those are huge. We're talking about billions, hundreds of billions, now trillions coming up. So these are very huge. They're very computing intensive. So as we increase the size of these models, increase the amount of computing power, we increase the amount of cost. So they're going to get very expensive. So people talk about using these ChatGPT for search. Well, if you do that, then the cost of search goes up a lot.

Robert J. Marks:

I see. So what do you think about the technologies that exist today in the paper? In the paper you wrote, let's see, I don't have the name of it, but it was a paper you recently wrote, which was that this hype concerning artificial intelligence is kind of like it's in a bubble. It's in this peak of hyperbole. And with some of these things, we're starting to find out about some of the limitations of these large language models. And you and I are going to talk about that in a little bit. But you mentioned that many of these tech companies were really facing doom and gloom. Now, this was about a year ago, you mentioned, for example, that Lyft had fallen 70%, video conferencing, Zoom had dropped 70%, Meta, which is just a big catastrophe it sounds like, fell down 60%, Netflix fell down 60%. So how is AI doing today as a business?

Jeffrey Funk:

Well, it is hard to say what goes on inside Google and these other big companies, because they don't separate their accounts out for the AI business. But startups, there's no profitable AI startups. There is hardly even any pure play AI startups that have gone public. I think there's SoundHound and a couple, C3 AI. There's a few, they're all losing money. But then startups in general are losing money. 90% of the publicly traded unicorns in the US are losing money. 17 of them have losses greater than 3 billion.

I use this 3 billion figure because that is the amount of cumulative losses and cumulative losses are the losses that add up over time. That's the amount that Amazon had at the peak, right when it became profitable, 3 billion. So people say, "Oh, Amazon had big losses, so it's not a problem." But 17 have bigger than 3 billion and of course, Uber's up there about 40 billion. There's some foreign ones that are upwards of a hundred billion like Kuaishou, a Chinese AI company. So these AI companies, most of them are not public traded but we know some of the finances from it, particularly the Chinese one, they're losing big money. So AI as a business is not doing that well outside of the big tech companies. We don't know what's going inside them.

Robert J. Marks:

So why are venture... Well, first of all, could you define what a unicorn is for somebody that doesn't tiptoe around business very much? What's a unicorn?

Jeffrey Funk:

A unicorn is a startup that's valued at 1 billion before it goes private. So there were unicorns 20, 30 years ago, but it became a popular term in 2013 when, I think her name is Aileen Lee pointed out that there were a lot of them now in 2013, and since then, they've become a lot more, not only in the US but globally. So I said, by my count, there's about 144 publicly traded, I should say ex-unicorns because they're no longer privately owned. They're publicly traded.

If you look globally, there's about 3.5 trillion in valuations for these privately held unicorns. That's in addition to the publicly traded unicorns. And if the publicly traded unicorns are losing money, then what do you think about the privately traded unicorns? They're probably losing money, right? That's just a very simple statistical trick, analysis that I've done. I've said, taken a sample of unicorns and I've looked

at the ones that are publicly traded. 90% are losing money. Well, most likely the privately traded ones are losing money. And when we look at data, I cited some data from Kuaishou and other Chinese, they're losing money.

We hear, for example, a lot of the news about Revolut, this fintech company. It's generally reported it's only one of two European fintech companies, of which there are many, that have been profitable for at least a year. But then it turns out that, well, they're not really profitable. The accountant who did the accounting says, "Well, there's a lot of weird things, a lot of irregularities. So we don't really know if it's profitable." And Revolut says, "Well, we had all this crypto income back in 2021, so we think we're profitable."

And of course, anybody's going to be suspicious about this, particularly when crypto dropped in 2022. So 2022 numbers, they're just talking about 2021, the 2022 numbers, they're definitely going to be losing money. So we look at this kind of data and we say, "Well, wait a minute. Let's not get too excited about all of these AI startups." We know all the others are losing money. Why are we thinking that AI is going to make big money?

Robert J. Marks:

So one of the things, you talked about the creative accounting. I think I read somewhere that DeepMind, which is owned, I believe by Google, was losing money hand over fist, and then maybe it was two years ago that they showed a profit, but if you look closer at the profit, all of their customers were Alphabet associated companies. Alphabet is the parent company for Google. So they were kind of selling to themselves in a way in order to make the books look better. That's the sort of thing you're referring to as far as this creative accounting that makes some of these things look better. Is that right?

Jeffrey Funk:

Well, that's part of the story, but that's not the worst ones. The ones with Revolut are worse because-

Robert J. Marks:

Okay, Revolut. Revolut, how do you spell that? Revolut? R-E-V-

Jeffrey Funk:

R-E-V-O-L-U-T.

Robert J. Marks:

Okay. Revolut.

Jeffrey Funk:

Yeah.

Robert J. Marks:

Okay. And that's a company where?

Jeffrey Funk:

In the UK.

Robert J. Marks:

UK, okay.

Jeffrey Funk:

But you're right, they're selling to themselves, right? We don't know what the transfer price was. It's all uncertain. What we do know is that Google said about five years ago that it had used AI to completely transform data centers and reduce the energy costs by 30%, and then later they rescinded that, retracted that statement. You have a lot of this stuff that people forget about, these kind of creative accounting, creative statements that people at Alphabet and Google have said, and that make me suspicious.

I'm sorry. I'm an old man. I'm 67. When I was young and when you were young, when somebody told a lie, we said, "Okay, I'm not going to believe this person much anymore." And that's what Google has been doing. They've been stretching the truth here and there, and yet, people are so willing today to jump on the hype and to forget about the old exaggeration. And I like to come back to some of the other exaggerations with AI in a moment, but the media forgets about it and jumps on this bandwagon of, "Oh my gosh, AI is going to put everybody out of work."

Robert J. Marks:

One of the things about the short-term memories, I think at least for me, some of the social media that we have out there is causing my memory to become shorter and shorter. So I'm wondering if all this social media is having these investors have short-term memories. Where does that go? We're also seeing this in politics where you don't remember lies for a year or two. It just kind of goes away with whatever the current news cycle is. So it's something similar, isn't it?

Jeffrey Funk:

Yes, it is. And I know, social media is very interesting. I get people all the time telling me when I give them something that happened a year ago, "Well, that's old news." Everything is changing so fast. This is part of this argument. Everything is changing so fast that none of that stuff in the past matters. And you wonder, well, what's changing? Productivity growth is slowing, VR, AR, blockchain, delivery drones, a long list of technologies that aren't diffusing. What's changing quickly? You want to ask, what is changing quickly that causes people to think that, "Oh my gosh, it doesn't matter what happened in the past. Everything is changing quickly. It's only a matter of what happened yesterday?"

Robert J. Marks:

What do you think about the introduction of blockchain and its use? It's very clear, I think, that nonfungible tokens went belly up. I don't know. Is blockchain making an impact outside of crypto?

Jeffrey Funk:

Well, when you look at the market size for blockchain, it's a few billion. It's not big. When you try to find a really successful application, there doesn't seem to be any. There was a report given to the UK Committee on Science and Technology that said they couldn't find a single successful application. There's been all these cancellations by mayors and IBM over the last couple of years. And basically the problem with blockchain is that it's too intensive. You're basically, if you want to have this complete transparency and have every transaction remembered and shown in some account, some screen, you have an enormous amount of computing power required. So in order to get around that, IBM and some

of these companies, well, they would say, "Okay, we're not going to show them all. We're not going to repeat them all. We're just going to be selective." So right away, this transparency in decentralization starts getting thrown away. And despite that, despite throwing away some of this transparency, they're quitting. They're quitting the blockchain.

Robert J. Marks:

So you think the blockchain is falling out of favor now?

Jeffrey Funk:

Well, there's a core group of people who support it. This is the thing. You pick any technology, and there's a core group of people who will keep publishing articles on it and they pay websites to publish it, or they have their own website, and they'll just keep pushing it out. They'll keep pushing it out and it never goes away. So even though the companies aren't implementing it, there'll be somebody in the background that keeps pushing out these articles so that we think that, "Oh my gosh, it's still going on," when it hasn't. This is something that's very different from 20, 30 years ago. 20, 30 years ago, there was a small number of news sites, right? A small number of television stations, major newspapers, television news stations. Now, it's infinite. And so if you want to keep the hype going with something, you can do it. All you need is money.

Robert J. Marks:

Doesn't it boil down to though, Jeff, that it is reduction to practice? And in order to assess the success of any technology, one has to do what you do, which is to look at the market and actually look at the profitability of these companies as accurately as you possibly can. And if there isn't the reduction to practice, if there isn't the profit, and there isn't the use of the technology in a widespread manner, then, well, after a while, you got to give up on a technology, I believe.

Jeffrey Funk:

Well, I agree 100%. So I have a very different approach from many people, a lot of the very optimistic forecasts about AI and robotics 10 years ago came from people looking at, well, is there a startup offering this product or service? Is there an academic paper describing this product or service? And so the rise of the robots and Eric Brynjolfsson's books and World Without Work, these kinds of books came from people looking for examples of something in an academic paper, maybe a patent, maybe a startup was offering. They never took it to the next step, which was, is it succeeding? Is the startup succeeding? Is the technology being used and there are happy customers? This is the way that people looked at it 40 years ago. And now the academics have this new kind of approach where they use a very quantitative approach and everything begets... There's a black box basically, because that's what's popular in academia, doing very empirical research because that's supposed to be objective.

And then what happens is that all the assumptions and everything get hidden inside there, but there's this fancy result that says, "Oh my gosh, robots and AI are going to take over the world." When in reality, if you look at the assumptions, they're wrong. Just because a paper was published doesn't mean something's going to happen in the next five or 10 years. If that was true, with the 3 million papers published in the world, our world would look completely different from it did five years ago, because there'd be so many new products and services coming out. But they're not. Productivity growth has been slowing. We look outside, we look in our houses, things aren't that different from what they were 10 years ago, 20 years ago, 30 years ago, right? Look in your house. Well, you see a better television, but outside of that, and computer, things aren't much different.

Robert J. Marks:

Well, let me offer you a few other examples. You mentioned the TV, but now we have these incredible cell phones. We have GPS. We have Uber services. So there are some things which have made impact on how we live day to day, aren't there?

Jeffrey Funk:

No. No. I should have thrown in phones because yes, so anything associated with computing, anything associated with Moore's Law, mobile phones, computers, also with liquid crystal displays. So that was a great innovation. So that's impacted on televisions a lot. Even OLED, so organic-light emitting diodes. People make displays from those. They're a little thinner. They're more flexible. So you can have foldable phones. So that's one of the biggest innovations, I think, of the past five years. And I think you're going to see many people using foldable phones in 2030. So there are these innovations. It's just that not that many, right? Our refrigerator isn't that different. Our couches, our beds, our water heaters, a lot of stuff, it's very similar. Our houses are built the same way.

Robert J. Marks:

I've heard it said though, Jeff, let me push back a little bit that there are certain technologies that reach a point where further improvement is not necessary. One of the examples that I've heard is the common screw. You have the screw and it's been that way for the last few decades. You go with the Phillips screwdriver and you have one way screws and things like that. But basically that technology has remained exactly the same because it's reached the pinnacle of its use. There are no more innovations that one can use. So maybe some of our technology has reached that plateau where it shouldn't be improved. Maybe there is no improvement that could really make a big difference.

Jeffrey Funk:

Well, I agree, performance speaking, that a lot of technologies, they mature, they don't get any better, but cost reduction, think about houses getting cheaper, thinking about cars getting cheaper. Think about all of these things are important. Think about healthcare getting cheaper, think about education getting cheaper. So there's a lot of people in the world who don't have a lot of money. They depend on things getting cheaper. If things don't get cheaper, they don't have them. And a good mattress doesn't get cheaper. But I'll tell you, a good mattress is really important. It really impacts on your sleep. And yet most people don't have access to good mattresses. So we wish we had a technology that would make beds cheaper and so that people could sleep well at night.

Robert J. Marks:

Yeah. Well, we're going to talk in a subsequent podcast about education and the fact that education is not getting cheaper. And one of the reasons is you got to pay all these great high publishing professors, right? You got to pay them the big bucks.

Jeffrey Funk:

Yes, you do.

Robert J. Marks:

Yeah. So that's what happens there. One of the things you mentioned in your paper, and we're going to put a link to this on the podcast notes. It was called Web3: the Metaverse and the Lack of Useful

Innovation. This is kind of a new topic, but you pointed out, and I thought this was very interesting, that some of our new technology today is really not improving life across the spectrum, that if we looked at some of the older technology and technical innovations, it helped everybody. This would include, this is from your list, running water, electricity, mass production, the telephone, the automobile. I would even include cell phones. If you go to Haiti today, all of the people there, even though the average income I think is a dollar a day, most of the people there have cell phones. Even the cell phones have improved life across the board. But I think your point is that we don't see this help across the board for technology being developed today, right?

Jeffrey Funk:

Yeah, right. So mobile phones is a good example. And by the way, I was heavily involved with, I lived in Japan around 2000 when Japan had the first successful mobile internet services. So I was a big pusher of this and saying that there was a lot that the West should be thinking about because it took a long time for the West to have successful mobile internet services. Japan was the first, Korea was the second, around 2000, but it took a while for the rest of the world to catch up, and it took until the iPhone. But I was back in the 2002, 2003, 2000 talking about how this was needed. I remember Americans telling me, "No, no, no, no, that's just because they don't have a good PC internet, so they're going to use the mobile phone, but they'll soon quit that and move to the PC internet."

And I also, in 2004, gave a presentation arguing that the future was these apps, because with an app, you could download a lot of data at one time and then read it, read news, or do something for a long time before you had to download again. And I wasn't the only one. There were lots of people in Japan who saw these apps as the future. And so I was an optimist then. That's when I was very, very optimistic and people were telling me, "No, it's not going to happen." It happened. It happened.

But after the iPhone, well, you had the iPad, you had a few other things, OLEDs, displays, and folding phones. But not many. Not many. And I began to become pessimistic when I was teaching this course at National University of Singapore that dealt with the economics of the technology. So I covered all kinds of technologies, from superconductors to quantum computing, a whole set to more just general IT. And I began to see that, I'd update the slides each year, and I'd realized that there wasn't a lot of improvements in many of these technologies, wasn't a lot of progress. So I gradually, between 2012 and now, I began to become pessimistic. And so now I've become very pessimistic, but it started back 10 years ago.

Robert J. Marks:

So I'm wondering, you mentioned quantum computing. I know that there's people at the Hudson Institute, for example, that are Chicken Littles, are running around saying, "Oh my gosh, we have to be aware of quantum computing," and things of that sort. I remember quantum computing being discussed in academia, I don't know, 30 years ago. What's happened? Do you have any hope for the future of quantum computing? You hear these press releases that they have so many qubits, a hundred qubits or whatever, but I don't see them having the impact that everybody says that they're going to have. What's your feeling about quantum computing? Do you think there's going to be a breakthrough there?

Jeffrey Funk:

Well, I think I'm more optimistic about quantum computing than almost any other technology because there is progress-

Robert J. Marks:

Really? Okay.

Jeffrey Funk:

So you talk about the number of qubits. That's progress. That's progress in the number of qubits. I don't see the progress in all these other technologies. So I have a book that I'm finishing now that deals with big promises, small results. It deals with all kinds of technologies, all kinds of startups.

Robert J. Marks:

Is that the title of it, by the way, Jeff? Big Promises, Small Results?

Jeffrey Funk:

It's still undecided. That's the idea-

Robert J. Marks:

By the way, that's a great title. I was going to say, man, that resonated with me very nicely. But go ahead.

Jeffrey Funk:

So it covers a lot of technologies, all the technologies we've talked about today, but all the ones that are being discussed by the media today, and I don't see the progress in these technologies. That's what makes me pessimistic. It's not because I hate technology, because I don't see progress. When I was optimistic about mobile phones 20 years ago, I was optimistic because I saw progress in Moore's Law. So all of that progress helped the app store become possible because in order to download apps, you need lots of memory on phones. And so Moore's Law helped that memory become available. That's why I was optimistic.

So I'm optimistic about quantum computing because I see much more progress there than I see in other technologies, but it's going to take a while. The thing to remember about quantum computing is that most people say that it's mostly going to be used for science, to do science better. So it's in cases where you need a lot of computing power, much more computing power than we have available now with conventional computers. So it's going to be for science. So once it starts being used, it'll still be a lag before we see anything useful because it has to not only become useful to scientists, it has to enable the scientists to develop something, some new science, and then that new science to become new products and services. That's decades away. It's decades away.

Robert J. Marks:

Right. Back 30 years ago, they were talking about Grover's algorithm and Shor's algorithm for accelerating search and cracking encryption and things of that sort. So we've had these problems around for a long time, and it's going to be interesting to see what other algorithms they can actually come up with to use in quantum computing.

So yeah, I'm a little bit more pessimistic, but we will see and I do know that some of the quantum qubits that they're coming out with are... Last I talked to Eric Blair, he's a professor in our department that teaches a graduate course in quantum computing, he said that some of these new technologies with these qubits are using qubits that aren't entangled together. They're kind of used disjunctively instead of conjunctively, and that's kind of a trick to get the number of qubits upwards, but we'll see. So the jury is still out, so hopefully we'll be able to see some of these stuff in the future.

Where did today's technological advances come from? The universities? Private industry? The Department of Defense? And yes, innovation does come from the military. World War II gave us radar, analog computers used, for example, in the northern bomb site, and like it or not, thermonuclear energy. This continues. DARPA today, which has been called the US Military's Department of Mad Scientists because of their innovation, has initiated the idea of self-driving cars. They have initiated GPS that we all use and enjoy today, and they also started the internet. So we do get technological advances from universities, private industries, DOD, and we're going to talk about that today.

Let's talk about where technology comes today. Some of the things which have gone bad and having read some of your works, boy, I agree with them. You mentioned that until, I believe the 1970s, most of the research was done in private companies like Bell Labs, RCA, and DuPont. And this was research that led to Nobel Prizes and real products and services, such as, for example, transistors, integrated circuits, plastics, radar. But since then, there's been a switch to university. The switch to universities, in my experience and according to your writing, has been spoiled a little bit because of Goodhart's Law. And you point out some of the problems with this. I'm wondering if you could unpack some of the challenges which have gone on in switching the innovations largely to universities.

Jeffrey Funk:

Well, Goodhart's Law deals with the fact that once you institute a measure, it stops being useful because everybody gains it. So we have decided that we're going to count the number of publications that professors have and more fancy techniques, like the H Index, which measures, so if you have an H Index of 20, you've published at least 20 papers with 20 citations. So this has just caused people to become obsessed with publishing papers in order to make themselves look good. So two months ago, Nature came out with an article, a paper saying that it found 9,000 people, 9,000 scientists, who published a paper, one paper every five days. Now think about that. Can you publish a paper every five days?

Robert J. Marks:

I can't even type that fast, Jeff.

Jeffrey Funk:

Well, obviously they're sending the same paper to a lot of journals, but this is what happens when you have this kind of measure and people are just hoping, well, you're not going to look at the papers at all. And of course, you don't. There's so many papers that no one looks at them all. And so many people have said that most papers are only read by the author, the reviewers, and nobody else.

Robert J. Marks:

I read somewhere; it was on the internet, so it has to be true. The median number of citations to the paper, to a paper that is published today, the median is zero. In other words, it follows up on your idea that nobody reads this except for the authors. And I think that sometimes even the co-authors don't read some of the papers.

Jeffrey Funk:

You're right.

Robert J. Marks:

And the impact, I think, on academia has been terrible because it's on a metric, and Goodhart's Law has totally destroyed it. I have a colleague in the physics department and his bio says that Dr. So-and-so, I won't mention his name, has published 115 papers. That is so, in my mind, so stupid. It's like a carpenter saying, "I have nailed 120 different nails into a piece of wood." It doesn't matter how many nails you've driven into a piece of wood, it's what you've built. And so the emphasis now is on the number of nails that you drive in. But you're right, as a professor, and that's how I've made my living my whole life, you were judged by the number of papers you publish. And there's an old joke in academia is that the dean can't read, but the dean can count. And so he doesn't care about the quality of the papers you publish, he doesn't care about what you've built. They frankly don't have the time or the expertise to do that. So they end up reverting to a paper count.

And you mentioned this, and I look at Goodhart's Law, there's a sequence. People try to overcome Goodhart's Law, but in doing so, they impose a different version of Goodhart's Law. Like for example, with publications, you can't count the number of publications. Okay. So now we're going to go by the impact factor of a journal, that measures the quality of the journal that you publish in. And that measure is really kind of stupid because it doesn't say anything directly about the quality of your paper. It just tells you about the company that you keep. An impact factor of a journal is high if those papers in that journal have been referenced a lot, so they figured out that wasn't good. So they went to the H Index. And the H Index is something that you mentioned, which is if you've published 20 papers that have 20 or more citations, you have an H Index of 20. And so the H Index is another measure that went against this impact factor.

But one of the problems here, and I did some research on this, in the web of science, it turns out that the number of publications in the last 10 years has doubled. And so what has happened to the citations? They have doubled. So a citation today isn't worth what it was 10 years ago.

Jeffrey Funk:

Well, in fact, it's more than doubled.

Robert J. Marks:

Oh, it has more than doubled? Okay.

Jeffrey Funk:

Because papers today have more references than papers did 20 years ago.

Robert J. Marks:

Yes.

Jeffrey Funk:

So they're going to get more citations, not only because there's more papers, but because every paper has more references, so it's citing more other work. So you're absolutely right.

Robert J. Marks:

And one of those things that makes the citations more available in Google Scholar, if you look up a paper and you go to that paper in Google Scholar, they have a little click there called cite, and you click on that button and it gives you the citation that you need to put at the end of your paper to cite that paper. So you don't even have to type out references anymore. You just go to Google Scholar and click and paste.

And I think a lot of people click and paste things because, well, they need to click and paste because they need to get more references.

In fact, there's something that's happened too in my area called citation coercion wherein, for example, I get back a review on the paper and they say, "Dr. Marks," I'll mention the journal. It's the IEEE Transactions on Systems Managed Cybernetics, and they says, "Dr. Marks, this looks to be a good paper, but we really don't know if this is good paper for our journal because you haven't cited any papers from our journal. So how do we know that our readership is going to be interested in your paper?" What they were doing very transparently is they were trying to get me to cite more papers in their journal to increase their journal's impact factor. And that's a big problem too and is mitigated by this, not mitigated, but it's accelerated by Goodhart's Law.

Jeffrey Funk:

Well, that's a particularly sad story because IEEE is one of the most respected engineering institutions in the world.

Robert J. Marks:

Yes.

Jeffrey Funk:

So if they are stooping this low, then what are all these other journals doing? They're stopping even lower.

Robert J. Marks:

Well, I have been a member of IEEE since I've been a student, and this was, I hope, an outlier. It hasn't happened a bunch of times, but I just hope it's an outlier. In one case, this was from the Journal of the Optical Society of America, I submitted a paper and they say, "Well, you should reference this." This is another thing they do. If you get a reviewed paper and somebody says, "This is a good paper, but you haven't referenced such and such." And what try to sneak in is they try to get you to reference their paper.

Jeffrey Funk:

Yeah, oh, absolutely.

Robert J. Marks:

And that happened, and I wrote back the editor, and because I'm at the point I need another publication like I need another toe. But I wrote back the editor and I says, "Look, this is totally inappropriate. I hope you bring this to the attention of whoever needs to know about such things that this was a totally inappropriate review." Trying to use their leverage over me of the acceptance of my paper in order to reference their paper. And this is all due to what you mentioned, which was Goodhart's Law.

Jeffrey Funk:

My impression is that's very common.

Robert J. Marks:

So the question is, what is the solution? We are now publishing more. We're publishing more and enjoying it less. I'm listening to these old radio plays and there's one for Chesterfield cigarettes, and it says, "Are you smoking now and enjoying it less?" That was their little sales line. So are you publishing more or enjoying it less? And the question is, what do we do?

It turns out, in a chapter by, I believe Frank Tipler, he pointed out that during Einstein's time, if you submitted a paper to one of their journals, it was probably refereed by, there was a chance of one in three that it was refereed by a current or future Noble Laureate winner. So you really had peer review back then, and boy, we certainly don't have it now. So the question is, I guess to you, Jeff, is we recognize this problem. It seems to be ubiquitous. How do we solve it? How do we get around this? How do we start getting more substance in the publications that come from universities? And these universities, by the way, are funded by US tax dollars in the United States. So how do we get better service out of it?

Jeffrey Funk:

Well, we have to change the metrics. Metrics is what drives people's behavior. And by the way, this problem is ubiquitous. It isn't just researchers. There's a great book about 20 years ago called The Tyranny of Metrics, and it doesn't talk about research at all, it just talks about organizations in general and how organizations have come up with all these metrics, most of them just ridiculous, very narrow metrics to measure the performance of people. People come up with them to measure organizations, they come up with them to measure organizational units within an organization. They come up with to measure individuals, and there's so many, right? And you can think of all the recent ones such as ESG and things like this. I mean we're just coming up with more and more and more and more metrics.

Robert J. Marks:

What is ESG?

Jeffrey Funk:

This environmental and social governance. So we're going to measure a company not by its profits, but by whether it is being environmentally and socially beneficial.

Robert J. Marks:

I don't know if I'd invest in a company which had that as their metric, but people do that, don't they?

Jeffrey Funk:

Yeah, they do. It's just constant, these metrics, and the idea there is that humans are so stupid, we can't think, unless we've got a number there, we're too stupid. Well, there are people, humans like this, but most of us, we grew up in an age when common sense and being able to put together an argument was valued. That's kind of fallen out of value. We have a whole educational system that's very superficial, that doesn't require students to do in-depth thinking, and that's the way our organizations are run. And so that's the way our universities are run. So this tyranny of metrics, it's everywhere.

When we need to step back and say, "Wait a minute. Okay, you're doing research." You know what? We're only going to really know whether you're doing good research in 10 years or 20 years. So the first thing we're going to do is stop paying people a lot who get lots of publications. Because you know what? We don't really know if they're that good. We don't know. We need to keep a we-don't-know attitude

towards things and think that, okay, there's these ideas out there, some are going to win, but we're not sure which ones.

The second thing is that we have to be able to talk about an idea. We have to talk about the idea of the paper. We have to talk about the ideas that professors are producing, whether they're useful. And we need people who can do that. So now we're talking about a completely different person than the kind of person who likes the tyranny of metrics, or I should say who likes metrics. This is going back to a different world. You think back to Bell Labs, RCA, the old IBM. You think back to them, there was no bureaucracy. I mean there was much smaller bureaucracy than we see now.

So today, researchers, professors, they're producing papers, many with 100 authors, for these hyper specialized journals. They're producing grants, they're writing letters of recommendation. They have a big lab they run with lots and lots of PhD students, lots and lots of postdocs. They're administrators, they're not scientists. Now, think back to Bell Labs in the 1950s, where was the administrators? It was much different. What they were doing was they were talking. They were talking about the ideas. They weren't just producing all this paper and saying, "Oh, we got so much paper. It's so great." They were talking about ideas. That's what we need to go back to. We need to get back to the idea states to talk about an idea, okay, you've got this idea. You say that science is wrong. Here's your evidence why you say it's wrong and your idea is going to help us develop these kinds of products or these kinds of processes or change the way we do medical practice.

That's the state we want to have. We want to have all these smart people talking about ideas again, not about how to publish a paper and how to game the system and how to get the right reviewer and how to cite the right paper so that we'll look right and we'll look good to reviewers.

Robert J. Marks:

And unfortunately, it's been that way for a long time. Frank Tipler, for example, was up for tenure. He was a physics professor and it looked like he wasn't going to get tenure. Now, why wasn't he going to get tenure? Well, it wasn't because his ideas were bad. He was well published. He really thought of some good ideas, but he wasn't going to get tenure because he hadn't attracted any money. Then all of a sudden, a grant came in and everybody got excited and Tipler got tenure. I tell you, that's the way it is with academia today in the STEM field, if you come in and you get a National Science Foundation, a Young Investigator Award from the National Science Foundation, you are guaranteed tenure. It has nothing to do with your productivity, has nothing to do with your ideas, it's just that you've attracted money.

And you're right, it has changed. I love the story about Dwight Eisenhower when he was president of Columbia University, it was after World War II and before his presidency, and he went to the faculty and he says, "It's great to be here among all the employees of Columbia University." And one of the professors interrupted him and he says, "I'm sorry, General Eisenhower, or President Eisenhower, whatever they called him. He says, "We are not the employees of the university. We are the university." That certainly is not the case anymore. Professors are employees of their university and they're pressured to publish and they're pressured to do things which, in the end, have currency in academia but don't have currency outside. So it's a very sad situation.

Let me offer this. This is one of the suggestions that Tipler gave in the United States. Right now, we have funding in the United States. Now you're in Singapore. This is modern technology, ladies and gentlemen. I am talking to Jeffrey Funk and he's in Singapore right now, I'm in Waco, Texas. But in the United States, if you get funding from the government, from the National Science Foundation, National Institutes of Health, the Department of Energy, et cetera, you get tenure.

One of Tipler's suggestions was to disseminate this to individual states. In other words, make the funding a little bit more local in order to get a better handle on the way that the funds were expended. I don't know if this would work, but it seemed like one solution that could possibly work. Because right now, and you mentioned this in your article, that all of this Goodhart's Law effect has really stifled creativity. In order to get money from the National Science Foundation, you have to go in and you have to tap into one of the areas that they have identified. So there is very little room for creativity there. And you mentioned this in your work, in your paper, and I thought that was just spot on.

Jeffrey Funk:

Well, this localness of universities is a very important point because 200 years ago, universities supported their local economy. So if you had agricultural professors in Minnesota, they were expected to work with farmers and help farmers introduce new types of wheat. So they were measured by working with those farmers, and they may never publish a paper, who cares? They were helping farmers understand something complicated, such as new strains of wheat, how to implement them. That's all gone away. No one now works with the local people, whether it's a local city or a local rural area, it's all global now. Almost every university hires now by the same criteria; have you published in these papers? They don't care whether you can work with local industry. They don't care whether you have expertise in the local technology so you can help students find jobs with local companies. They don't care about that. It's all this incredibly, just this H Index or something like that that's being used to measure everyone.

Robert J. Marks:

So you have taught in Japan and I have had some colleagues in Japan, some professor colleagues, and I've also visited Germany and some of the colleagues they have there. In both Germany and Japan, there is a greater connection to industry is my experience. Was that your experience in Japan?

Jeffrey Funk:

No, I agree. They've fought against this. So it's been American led, this global, the way to do things. So there's a lot of countries that have said, "Okay, we got to be like America and we're going to measure our universities, not by whether they contribute to societies, but how well they stack up against American universities." And oh my gosh, in Singapore, we have these universities. They're as good as those American and UK universities. Wow, they must be doing great. No mention of whether or not anything is coming out of those universities that helps the local industry.

But you're right, Germany and Japan have fought, are fighting against this, and I hope they continue to fight because this is the way that, I haven't mentioned the free market, but this is the way the free market works. Different countries try different things and some things work better than others. And I think that Germany and Japan are right to emphasize professors working with local industry, trying to produce something that's useful for the people of the country.

Robert J. Marks:

And do you know why the United States, in my opinion, why the universities don't appeal to local companies? They don't get big bucks. Smaller industry or companies, private enterprises do not have the money to give to universities to the degree that the National Science Foundation, the National Institutes of Health give to the universities. They would be in the tens of thousands of dollars where NSF and NIH can go up into the hundreds of thousands possibly. So that's unfortunately one of the reasons that that is not pursued very much. Yeah, very sad situation.

So, yeah, hopefully something can happen here. And it's kind of like the universities live in their own little world where they have their own currency and that currency is, how much money do you bring in? How many papers do you publish? And nobody outside of their world carries very much. We were visited at Baylor by General Murray, who's a four star general that was Head of the Army Futures Command. And God bless him, he came in, and I love DOD and I love working with the Department of Defense of the United States, and he came in and the first thing he said, "I don't want to see your stupid papers. I want to see what you have in the lab that I can take to the war fighter. I want to see what I can reduce to practice. I don't want to see all these vacuous papers that don't really say very much."

And so I think that the military understands what they need to avoid in universities. There was likewise with the journal, not the journal, but the Joint Artificial Intelligence Command, which was a multi-discipline command over all of the armed forces where they did something similar. They said, "We want things which can be reduced to practice." And I'm an engineer, and so that needs to be done. But that does not address the question, what do you do to these pure mathematicians and these theoretical physicists who are studying string theory that they can't be reduced to practice? Do we throw them under the bus or how do we support them?

Jeffrey Funk:

Well, I think you need multiple measures, measures that are different for each person, for each discipline. I don't think you should have one measure. I realize what's driving it, right? We got to be fair. We got to decide which department is doing better than the others and things like this. But even in physics, you're asking, well, have you really changed the models of physics? It's not just whether or not products and service come up, but have you really changed our model of physics? Does your work change it? Because that's ultimately related, in most disciplines, to products and processes. If you're able to come up with a different model of science, a different model of whatever specialty you're looking at, you can think of, you can envision products and services being based on that new model.

So I don't think it's too hard. It takes work. It takes more work than just counting. And we live in a world where everything has to be simplified down to some counting. Again, it's the tyranny of metrics, the tyranny of superficiality, of simplicity, of bureaucrats who can't think of new ideas, who can't talk about ideas, who can only talk about numbers. And it's the old bean counters. It's just that now the bean counters aren't just in accounting. We've let the bean counters into every aspect of our life, including all this research. They reduce science, this wonderful science, all the wonders of science. I'm sure you're like me. You grew up on being so excited about science. I mean I was 13 when we went to the moon. This was so exciting. And the bean counters have reduced this to, how many papers did you publish?

Robert J. Marks:

Yeah. It's very frustrating. One of the things you mentioned in your article concerning the consequences of Goodhart's Law is the proliferation of journals, the number of journals published by the Association of Computing Machinery, you said, has reached 59. They publish 59 journals. The American Chemical Society has 39, the Society of Mechanical Engineers, 35 different journals. And for the IEEE, which we've mentioned, IEEE stands for Institute of Electrical and Electronics Engineers, it's the largest professional society in the world. I think it has 400,000 members or so. The number is over 200 journals and magazines that they publish in technology. And what this has led to, you pointed out... Oh, and Nature, by the way, Nature has reached 157 journals. 50 years ago, they had one journal, according to your paper, which I found just terribly jaw dropping.

One of the things that this has led to is hyper-specialization. There is no cross-fertilization and I can't tell you the number of times I have submitted a paper to a journal and had it returned to me without review

because it says, the paper you submitted is a square peg and we only have round holes. Your paper does not fit within the little silo of our specialization. And so this hyper-specialization is turning against cross-fertilization and innovation, and it's really a sad thing. So that needs to be addressed also. So, I don't know.

Well, we have ripped apart the Goodhart's Law and the American university and the way they've done business. I would like to put in a good pitch for the Department of Defense. We're funded with the Department of Defense. Most of these funding agencies, they're just interested in giving you money. They give you money, and they says, "File a report at the end of year, pro forma, maybe somebody will look at it, maybe somebody won't." And the Department of Defense doesn't do that. With the Department of Defense, you get a contract and they meet with you weekly to make sure you stay on track for your deliverables. And so they also have their bureaucratic problems, of course, but I'm really impressed with the Department of Defense, at least in their funding operations for development of military weapons, at least that they keep you on track and they care. So that's one of the good points.

Okay. Any final thoughts here, Jeff?

Jeffrey Funk:

Well, I think we need to get back to the products. We need to measure people differently and we need to encourage corporations to get back into the business of basic and applied research. They've been getting out of the business, and that's unfortunate. We need to get them back into the business. We need to give them incentives to do this. We need to get them to create alliances among firms in the same industry to do basic and applied research in some specific area. So we need to do that. We need to have a lot of research moved from universities to companies. We have to do it in a way that enables this basic and applied research to be done and for something to come out based on it.

Robert J. Marks:

There is an old saying that only rich countries can afford poets. And so in a way that's probably true of some of these large corporations, I do know that places like Amazon and Google make some of their AI software available for free to anybody that wants to use it, TensorFlow, for example. And I think that that's good. So they're doing a lot of interesting work there. Just making available ChatGPT to the public is a big deal, and it has to be a rich country that does this. So, yeah, hopefully these things will happen.

Large language models are everywhere. These include Google's Bard and Lambda. The most visible large language models is OpenAI's GPT-3. GPT-3 has a little brother, ChatGPT, and ChatGPT is available for everybody to play with. And I say it's a little brother because GPT-3 has 175 billion parameters and ChatGPT has only about one and a half billion parameters.

What's a parameter, by the way? You can think of these chatbots as a big piece of technology with little knobs that can be tuned. So you can turn one knob up and another knob down and for GPT-3, there's 175 billion of those knobs and you can turn them up or down and you have to place them just right to get GPT-3 to work. So GPT-3 has 175 billion parameters, ChatGPT only has one and a half billion parameters. Also, to train these large language models, you need to have training data, and you get this training data from English text. Lambda is trained on over one and a half trillion tokens. You can think of a token as a word. This is probably including most everything ever written in the English language. One and a half trillion is a big number. If you think about one and a half trillion seconds, that turns out to take 48,000 years to count. So one and a half trillion seconds is 48,000 years. So that's a lot of tokens, a lot of words.

Now, GPT-3 has been, at least they're claiming to have sold their technology to different companies that are using GPT-3. Jasper is an AI platform that allows businesses to quickly create tailored content, like

blog posts and marketing copies and AI generated images. Another company that has bought ChatGPT is Writesonic, they generate, according to their press releases, content for social media and websites. And then there's another company called Auto Bot Builder where they build advanced chatbots tailored to the needs of enterprises.

Our guest today has some firm convictions about GPT, ChatGPT and GPT-3, how it's broken and how we might be able to put some band-aids on it. Jeff, you're in Singapore, and this is incredible because I'm sitting in Waco, Texas, you're in Singapore, and we're talking to each other. I visited Singapore and I love the country. It's clean, it's well run, its official language is English, is that right?

Jeffrey Funk:

Yes, that's correct.

Robert J. Marks:

But they had some really strange laws like when I was there, I think chewing gum was against the law. Is that still true?

Jeffrey Funk:

Well, not entirely, but mostly. Yeah, they don't sell gum here, so you can bring it in from overseas. And so my wife recently, or somebody, a friend brought some in for us, and so our son gets to enjoy some of it for a while.

Robert J. Marks:

That just cracked me up that they... And I understand there was a fine if you didn't flush a public toilet there. They have some very interesting laws, but I like the idea that for people that were convicted of selling drugs were executed, rapists were executed, and murderers were executed. So that really prohibits repeat offenders.

So let's talk about GPT. Is it going to break out of the AI bubble and make OpenAI any money? What's your prophecy here?

Jeffrey Funk:

Well, I think it's important to look at this ChatGPT in the context of the history of AI. So we're really on the third big wave of hype for AI. First was in the 50s and 60s and then the 80s while I was doing my PhD work at Carnegie Mellon, expert systems were big. That was replaced by the current wave of AI hype that comes from the neural networks. So neural networks became preferred over expert systems as Moore's Law proceeded and the cost of computing went down and you could use these huge neural networks to train models on huge amounts of data. And now within the third wave of hype, I'd say that you could break it down to multiple waves.

So a lot of the third wave of hype began with Jeopardy and these games Go and chess and the victories of IBM Watson in those games, causing IBM Watson to be used in healthcare. And a lot of people claimed that it was going to put doctors out of work. Well, it didn't. It failed pretty miserably. Then there was Geoffrey Hinton saying in 2016 that nobody should study radiology anymore because they were all going to be put out of business. Well, there's actually a bigger demand for radiologists now than there was in 2016. There was self-driving vehicles, which didn't do well. There have been predictive policing, image recognition for police, there's home flipping, there's Carvana, and there's all these examples that have failed. They're all part of this current wave.

And so ChatGPT is the most recent one. And so people say, "Well, but it's so new, so new, and therefore it's going to get so much better." Well, neural networks, this is 50, 70 years old. Even when we look at this chat technology, this generative AI, we're talking about very old. I mean chatbots have been available on websites for a long time. And as you mentioned, we're now talking about models that have how many parameters? 100 billion parameters, is that it?

Robert J. Marks:

Let's see. Yeah, no, yeah, 175 billion parameters for GPT-3.

Jeffrey Funk:

This is a mature technology. Moore's Law has slowed dramatically. It is now the cost per transistor is not going up. And yet all these neural networks, the economics of them were driven by Moore's Law and the dramatic reductions in the cost of competing. Now, it's reversed itself. Now it's going down. It's going up or at least not going down. So it's not the early years. So this is the thing we have to... The first thing to remember is you put this in the historical context, you realize we're looking at the later stages, the mature stages of this technology.

Robert J. Marks:

That's a little bit scary. I mean usually in the training of these large language models, there's two stages. Number one is just the raw training with all of the parameters, all of the words. And then there's the fine tuning. And both Google's Lambda and ChatGPT have been doing it. GPT-3 too has been doing it. And so if you go onto the ChatGPT website, it says that some of your responses, if you give a thumbs up or thumbs down, might be used to train GPT-3 to be more accurate in the future. And the challenge with that, of course, is that this is putting little band-aids on a place where there's potentially thousands or billions of cuts. And I don't think that one is going to make a coherent ChatGPT just by correcting little errors here and there. So it's frustrating. So what do you think some of the limitations of GPT-3 are or large language models in general?

Jeffrey Funk:

Well, I think that people have been pointing out these problems, and some of the leaders include Gary Marcus who blogs every day about this, there is our mutual friend Gary Smith, who publishes a lot of articles on this and his conversations with ChatGPT. So there's a bunch of people that are showing that there are problems. And it's interesting that this is not appreciated by the ChatGPT proponents who just say, "Well, you intentionally attempted to make it say something stupid." And there's some truth to that, but that's what you do with a new technology. You try it out in ways so that the developers can fix these problems.

But then that becomes the question. The question is whether they can fix these problems with a bigger data set. The data sets are already big. You have to remember that, if we make these parameters bigger, these data sets bigger, we increase the costs of it. Costs are going up. So the question is, will the improvements in accuracy outweigh the increases in costs?

Robert J. Marks:

Yeah, certainly you get to a point of diminished returns and I think that's where they are now with this fine tuning. You're going to get some improvement, but really it's diminished returns. Most of the stuff has already been done with the first phase of the training.

Jeffrey Funk:

And the other thing is that what goes on in the background is that when you have a conversation with ChatGPT and you are able to cause it to say something stupid or ask it a question that it doesn't know, there's these people in the background, usually locate people in Africa, who are fixing this, who are making it answer correctly, "Oh, it didn't know the president of the United States, so we'll put that rule in there," right? That's an expert system. We're going to put that rule in there.

Robert J. Marks:

Yes.

Jeffrey Funk:

This clearly cannot solve all these problems. This is very expensive to do all this manually.

Robert J. Marks:

And to just do one at a time is going to take forever. So I think that most new technology goes through what I call a hype curve, which is, first of all, there's a bubble where the hype curve goes up and everybody is thinking of great things about it. People start noticing the limitations, so it goes down to the depth of cynicism and then it comes out to be the asymptote of reality. I think that most new technologies introduced go through this hype curve. And so I think we're starting to find out some of the limitations to these large language models.

And I think the big one is the fact that they are trained on syntax rather than semantics. In other words, they're trained totally on the interrelationship among the words that are being used. It's kind of like when you try to do a text on your telephone and it suggests the next word, the next two words, large language models are like that on steroids. They're able to generate all of these things based on these statistical models, but they have no understanding of what they're doing. And as a result of that, they do make stupid comments and they don't get things right. They have a problem telling the truth because sometimes they don't understand the truth because they just understand the syntax versus the meaning of what they're doing.

So what are some of the other limitations? One of them Gary Smith just mentioned was the idea that these large language models don't have the ability to think critically. Did you read his column on that? I thought that that was very insightful.

Jeffrey Funk:

Yeah. Yeah. I follow what Gary writes very closely. Some of the things he writes are done with me. But yeah, he's had these insights for a long time. He's one of these common sense data analysis guys who's been doing this, he's 70 something, 75 or so. He's been doing this his whole life, looking at how people misinterpret data. And it's unfortunate that data scientists aren't trained better in this way. Data scientists, and in general, it's mathematicians and scientists, we're trained more in the mechanics of science and math and data science than in the interpretation, the overall looking at data and interpreting it. Which is really the more important thing. You have to decide how to interpret data, but also what data you're going to collect. And data scientists don't seem to be very good at this. And so there are these problems, this inability, the model has been created just on statistics. It can't think critically. So it'll be hard for it to do some of the things that the very big proponents of AI claim it's going to do.

Robert J. Marks:

So do you think that these large language models can be creative at all?

Jeffrey Funk:

Well, I don't think they can be creative, but I think they can offer value. I think that... Think about coding. I'm not a coder, but my understanding of coding is that there's a lot of libraries that solve problems that coders can use. So what we've seen over the last 50 years is coders move to higher levels. I mean I took a class in programming a IBM local processor, or what we call machine language, 40 years ago when I was a Master's student in engineer. Nobody programs to that level anymore. You're programming at an even higher level. And so as part of that move, you can envision some generative AI being used to help people find solutions, find existing solutions, and then put those solutions together into bigger solutions.

So I think there's a possibility, there's a place here generated by it. You have to realize it's already gone. These libraries already exist. It's not this huge change. It's going to be some improvement on that, and that's what it needs to focus on, all these libraries and how that they can be used a little easier, how old solutions can be found and then combined with other solutions.

Robert J. Marks:

Okay. Yeah, ChatGPT is really fascinating. It's something that I have used and where I've used it, it's been very helpful. I was writing a column for Mind Matters News and I wrote this paragraph and I went back and I read it and I said, "Oh my gosh, that really sounds clunky." In other words, the syntax wasn't right, it just didn't flow. So I went to ChatGPT, I said, "Rewrite the following more coherently." And it gave me a beautiful result and I was able to take that and tune it, and I actually used it. And I don't think there's any problem of doing that.

I've encouraged my research group here. The students that I work with, who are notoriously terrible writers, I mean they're engineers. They usually get Cs and Ds in English. And I encourage them to use ChatGPT, not to write original stuff, but rather to take their prose and make it into a more coherent presentation. So I think at least that's one of the places where these large language models are going to be very, very useful, but they're going to be useful as a tool. And I think that that's one of the things we have to keep in mind for all of the artificial intelligence is that each case, it's a tool. It can be used for good, it can be used for bad, and we have to make up our minds which one we're going to use it for. It's just like fire.

Jeffrey Funk:

I was going to say, it's an augmentation tool.

Robert J. Marks:

It is an augmentation.

Jeffrey Funk:

AI was sold in the beginning by people like Brynjolfsson who say it's going take away all these jobs. So a lot of these social science academics that these studies have said, "Oh, it's going to put everyone out work." No, it's going to make people slightly more productive this year, and slightly more the next year, and slightly more the next. That's the way agricultural equipment works. It took decades, many, many decades to put people out of work. Same thing with machine tools or manufacturing technology. It takes decades. It's an augmentation tool, right? It was sold wrong. AI was sold wrong. IBM Watson was wrong.

It was sold as too big of a thing. Geoffrey Hinton saying it's going to replace our radiologists, it was sold as too big a thing. There are ways that you can use AI to augment radiologists to make them a little more productive. And that's what we need to focus all this on is augmentation and how to make people a little more productive.

These big pronouncements about how it's going to put people out of work are crazy. And you see a lot, it's not just the media, but it's a lot of these investment companies. And why do they do this? Because that's the way that you make money. You make money by hyping up a technology company, people put in money into the VC to invest in the company, then it goes public, does an IPO, people make a lot of money. Nobody wants to wait 30 years until the technology has improved, it makes people's lives better over the next 30 years. They want to make it right now. They want to make their billions right now.

Robert J. Marks:

Yes, I believe that technology does change things. The industrial revolution got people off the farm and into the cities. And I think AI, for example, has replaced occupations like toll booth operators. I see very few of those these days. Travel agents is another example. You just go to the web and you book your own flights now. You don't have to go through a third party that specializes in that, but in any occupation where it's required that you understand that you're creative, that you do apply critical thinking, AI is not going to replace those. And so that's, I think, the good news is. One of the things I have a concern about, and I don't know your politics, Jeff, but one of the things that AI is doing now, especially GPT, is it's training its responses to be, if you will, woke.

I asked it, for example, to write a positive poem about Donald Trump. It says, no, we don't do that because we don't write poems that are negative. And then I said, "Well, write a negative poem about Donald Trump." And I got a very nice four stanza poem that said Donald Trump with a face like a moldy orange, I think is the way that it started out. All of a sudden I knew that this wasn't very smart because they were trying to rhyme each of the verses, and orange I think is one of the few words in the English language that has nothing that rhymes with it. But nevertheless, it was something which was used on Twitter and it borrowed it from Twitter. And so it's doing things on the political left, unfortunately.

Now one does have to go and one does have to trim out negative bias. You don't want people saying negative things. You don't want racial slurs, for example. You don't want profanity. But unfortunately, you get to a point where one person's truth is another person's lie. And I think that ChatGPT is being groomed to go this way. So it's being groomed to go the way that the old Twitter was groomed.

Another thing it can't do, I don't know. What else can't it do? It can't write a belletristic novel. I found out it couldn't do simple math because it learns on syntax as opposed to semantics. I'm sure that it had a bunch of pages it went to that told you how to multiply numbers, but it didn't learn from that. It just learned from the syntax and from the syntax, you can't solve problems. What is 1111 times two. I asked the GPT-3 program to do that, and it responded 22. It didn't know how to do that specific problem because it had never seen it before. And the irony is I went to Alexa and I ask it the same thing. And with Alexa and Google, they switch immediately to a math mode and it gave me exactly the correct answer. So, yeah, we're going to see lots of interesting results. What do you think the implications are going to be when ChatGPT is able to pass exams like MBA exams and bar exams? That's a little chilling to me.

Jeffrey Funk:

Well, that's what we were talking about earlier. I don't think that's going to happen. It's not going to get to that level, at least for decades because you can't really keep increasing the number of parameters without the costs skyrocketing. And we already saw this happen with image recognition where people

found that if you tried to go from 90% to 99%, 99% to 99.9%, and 99.9% to 99.99%, you had exponential increases in computing power, costs, and other things.

And so the same thing is going to happen with this ChatGPT technology. Already people are saying that it's going to cost 20 times more to do search with current ChatGPT technology than the conventional search. So these costs keep going up and they become a problem. So I don't think that you're going to see it becoming good enough to do these exams at a high enough level, at least for decades. They're going to need a different approach. And this is Gary Marcus's argument also, that you need a different approach, and even Yann LeCun, who's a Turing Award winner, like Geoffrey Hinton, he even says, "In order for ChatGPT to become really, really useful, we're going to have to come up with a new approach." So a hybrid approach with rules. So it's going to take that different approach, I think, in order to achieve the type of things that you're talking about.

Robert J. Marks:

Well, I think you mentioned something, you were first involved in expert systems and now the connectionist neural network is coming along, and I think it's interesting that you pointed out that now the two have kind of merged. I remember historically that the founders of expert systems, Papert and Minsky, were really against neural networks and they wrote a book called Perceptrons, which basically killed the second movement of artificial intelligence. But now we've found out that they can be complimentary to each other. They don't have to be mutually exclusive like people used to think. So, it's very interesting.

Another thing that it can't do, I found out, is it can't do self-reference. I was sent this by one of the readers of Mind Matters News and he asked GPT-3, I thought this was very funny. It says, "Gary's mom has three kids; Snap, Crackle, and..." And he left the end open to the GPT-3. And of course, Snap, Crackle, and, GPT put in Pop because that's what you get with the commercials with the cereals. But if you look at the context and you look at the self-reference of the phrase, it says, "Gary's mom had three kids." Gary's mom had three kids, Snap, Crackle, and Gary. So it doesn't have the ability to look, do self-reference.

You can ask it, and I've done this and it doesn't get it, does this question contain 10 words? And no, it doesn't get it. It can't go in and it can't count those words. It has no concept of self-reference. So yeah, we're starting to find out all of these different limitations of these languages, which I agree with you, I don't think are going to be cured by additional training or fine tuning. And we're going to live with them. We're going to find the ChatGPT is going to do great and wonderful things that we can use it for. I was recently on a Give and Take with Max Tegmark, who is a guy from MIT who thinks, well, this ChatGPT has the capability of becoming sentient. Have you heard those arguments, by the way?

Jeffrey Funk:

Of course. Yeah.

Robert J. Marks:

And what's your reaction to those things?

Jeffrey Funk:

Oh, it's crazy. It's people who are very easily convinced by this type of argument. I mean I'm the kind of person, I've always been. I said, you can't tell whether something works well just by using it once. I mean I worked in semiconductors for the military back in late 70s, and we had to lifecycle test things because, so what if it worked for 10 minutes? It had to work for 30 years if it was going in a satellite. So it takes a

long time to figure out before something works well, you can't just have a conversation, say, "Oh, it works. Oh, I drove a few self-driving cars. They work." No, if you want it to work at 99.9999% of the time, you got to test it a lot. And that takes a long time. That's what this whole lifecycle testing was in the military was to increase the temperature to simulate 30 years in an hour.

Robert J. Marks:

Oh, yes. In fact, my first job after I got my Master's degree, I worked for the government, the United States Navy as a reliability engineer. And we used to go in and we used to do all stuff to this equipment that the military was going to buy. We'd put it in big chambers and run it down to 50 degrees below zero. We'd take it out and kick it around the room and then turn it on and see if it worked. And all of this was supposedly accelerated testing. And you got to think about that and the validity of doing that, and that's probably not the most accurate way to determine the reliability of stuff. You got to use it and I think you're exactly right.

Jeffrey Funk:

So that's what all these people, testers, that's what Gary Smith and Gary Marcus and others are doing. They're trying to give a sense of these problems. And a lot of the AI people, they get angry. I mean I see them on LinkedIn, these VCs who are promoting it, they get angry, say, "What's the use of all this?" Finding the negative things, because that's what you do with the new technology, you life cycle test it early on to try to figure out what are the problems so that we can solve them now? Not so that we wait until all of our systems are using AI and then we see that there's these big problems. No. Test them. We try to lifecycle test them now before they become part of big systems.

Robert J. Marks:

Well, as an engineer, we have different types of... Well, I don't want to say we have different types of ethics. There is something called design ethics. Design ethics make sure that when you design something, that it does what it was meant to be designed to do and nothing else. And that takes, first of all, domain expertise and the creation of the technology. It also takes domain expertise in the testing of the technology, and that's what needs to happen to all of these large language models and all of this AI is they need to be tested and to make sure that they do what they claim to be doing and do nothing else. So we need to understand all of that.

Okay. Jeff, any final words?

Jeffrey Funk:

I think I've said enough.

Robert J. Marks:

You think you've said enough. Well, we've talked for a while. By the way, this is the third podcast, so Jeff and I have been talking for an hour and a half and I am sure that that's very, very tiring. I know it is for me. So thank you, Jeff.

We have been talking to Jeffrey Funk and this has just been a delightful time together. Jeffrey is a consultant on business models and economics of new technologies. And thank you, the listener, for joining us on Mind Matters News and until next time, be of good cheer.

Announcer:

This has been Mind Matters News with your host, Robert J. Marks. Explore more at mindmatters.ai. That's mindmatters.ai. Mind Matters News is directed and edited by Austin Egbert. The opinions expressed on this program are solely those of the speakers.