**Terry:** 0:00

I think where the future is going to be is trying to integrate more of the parts of the human brain that are important during development to help humans integrate into the culture that they've been born into. That doesn't happen immediately. That requires long childhood and then adolescence. None of that is incorporated right now into these large language models, because they're just built from scratch and then put out into the world. They don't have an opportunity to live through a period where they're given a lot of feedback from society about what's good and what's bad and what's expected and that sort of thing. And this is you know, how would you expect a model that was only exposed to a lot of words out there to have absorbed any of the guidelines of how human beings behave and how we interact with each other? It's amazing that they are able to do as much as they have done, but there's just a lot more that needs to be put into those models.

**Craig:** 1:01

Hi, my name is Craig Smith and this is Eye on AI. In today's episode, we explore computational neuroscience and artificial intelligence with Terry Sanowski, president of the NeurIPS Foundation and a distinguished member of the Salk Institute for Biological Studies. We delve into the evolution of neural networks, the monumental impact of models like GPT-4, and the nuanced interplay between AI technologies and societal structures. Terry offers profound insights into the trajectory of AI development, the ethical considerations that come with it and the collective pursuit of lining AI with human-centric values. I hope you find the conversation as enlightening as I did.

**Craig:** 1:54

Ai might be the most important new computer technology ever. It's storming every industry and literally billions of dollars are being invested. So buckle up. The problem is that AI needs a lot of speed and processing power. So how do you compete without costs spiraling out of control? It's time to upgrade to the next generation of the cloud Oracle Cloud Infrastructure or OCI. Oci is a single platform for your infrastructure, database, application development and AI needs. Oci has four to eight times the bandwidth of other clouds, offers one consistent price instead of variable regional pricing and, of course, nobody does data better than Oracle. So now you can train your AI models at twice the speed and less than half the cost of other clouds. If you want to do more and spend less, like Uber 8x8, and Databricks Mosaic, take a free test drive of OCI at oraclecom slash ionai that's E-Y-E-O-N-A-I all run together. Oraclecom slash ionai that's oraclecom slash ionai.

**Terry:** 3:20

I'm here at the Neural Information Processing Systems 37th Annual Conference and I'm the president of the foundation that organizes it, so that's the most immediate job that I have. But I'm on the faculty of the Salk Institute for Biological Studies and also on the faculty at the University of California, san Diego, right across the street from each other, and my area is straddles computational neuroscience understanding how the brain computes and artificial intelligence, or what we used to call neural network models. The N in NeurIPS stands for neural right, so it's always been, at very beginning, an important inspiration for people who are trying to develop new approaches, computational approaches to solving very difficult real-world problems. And, as it turns out, of all the machine learning algorithms that have been developed over the last 37 years, the ones that began back in the 80s, the ones that were developed based on learning algorithms and neural network models, have been the most successful, and part of the reason has to do with scaling A lot of algorithms. They blow up as the difficulty of the problem, the number of parameters grows, they become intractable. But it turns out that the ones that we developed, which are based on a large number of simple units that are highly interconnected and then learning the strengths of the connections between them. It turns out that those algorithms have scaled beautifully between them. It turns out that those algorithms have scaled beautifully. Now the recent large that have been developed, like GPT-4, have trillions of parameters, trillions, and that couldn't have been done with a lot of other approaches that were developed, like Bayesian approaches or graphical models.

**Terry:** 5:24

There's a subset who pay a lot of attention to the principles of how biology has constructed our brain, and it's not like you have to become a neuroscientist. You can extract some very, very important general principles just by looking at the different structures of the brain. You know the models that we have today couldn't survive on their own without humans at every single stage, in terms of collecting the data, curating the data, training, testing and then putting in all the engineering guardrails and so forth. And you know it's kind of a very, very labor-intensive process to actually engineer one of these systems. It takes hundreds of engineers and then they put it into the real world. And this is what happened over the last year with ChatGPT paying attention to things that are very, very important, for example, for privacy and safety, reduce the bias, align the models so that they are compatible with humans, and those are all difficult things to do and those are engineering problems.

**Terry:** 7:07

But there is, like I say, a small group and, interestingly, a lot of them are a deep mind and they have focused on reinforcement learning, which is a very important part of our brains.

**Terry:** 7:22

Reinforcement learning is essential for aligning human beings, for example, through reward circuitry, and that's, I think, where the future is going to be is trying to integrate more of the parts of the human brain that are important, of the parts of the human brain that are important during development, to help humans integrate into the culture that they've been born into.

**Terry:** 7:52

Right, that doesn't happen immediately. That requires, you know, long childhood and then adolescence, and that none of that is incorporated right now into these large language models because they're just built from scratch and then put out into the world. They don't have an opportunity to live through a period where they're given a lot of feedback from society about what's good and what's bad and what's expected and that sort of thing. And this is you know, how would you expect a model that was only exposed to a lot of words out there a lot of them to have absorbed any of the guidelines of how human beings behave and how we interact with each other. It's amazing that they are able to do as much as they have done, but there's just a lot more that needs to be put into those models.

**Craig:** 8:52

Yeah, and I follow fairly closely the world model development research. Is that something that you're involved in which is taking data more directly?

**Terry:** 9:08

There are already a couple of really good companies out there that have robotic devices that are collecting vision and all sorts of sensory data, but also incorporating that into action. That into action and already we have with GPT-4, you can put in a video in the form of images, and I saw a really nice demo, which had to do with replicating the demo that Google introduced a few days ago when they were introducing Gemini. It turns out it was very heavily edited, embarrassingly, and he just decided well, I do GPT-4. I'll just go through the same demo in real time, just do it. He did it right. The same demo in real time, just do it, he did it Right. So so, in any case, yeah, there's.

**Terry:** 10:12

There's a lot of, I think, excitement right now because of the fact that it looks as if, as the models have gotten bigger, they've been able to solve more difficult problems, and that's true, for example, in vision, but now it's happening in natural language processing and we reached the point now where we have models that can do many things. That's what a foundation model is. It wasn't trained to do one thing, but it can actually very rapidly, one-shot learning, solve a lot of natural language processing problems. Just give it an example and ask it what you want it to do. But it might have lots of other capabilities that we just haven't asked it yet, right? So who knows? This is terra incognita. We don't know yet what the full range of capabilities is or, on the other flip side of it, some of the faults, some of the failure modes. You know, we do the best we can in terms of the ones that are obvious, but there are going to be unintended consequences that nobody can expect, and we'll just have to wait and see.

**Terry:** 11:27

One of the trends already that is apparent is that theory is coming online, where people now are beginning to analyze these large networks and try to understand a little bit about what happens during learning and also to try to understand the internal representations. And that's exciting because it might give us some insights, new insights that may help us understand not just how these transformers work, for example, but also how the human brain works, and we desperately need help with that, because the brain is a very highly evolved device that has orders of complexity beyond what we can right now create. But the other thing that is apparent and this has been going on now for quite a while, but when NeurIPS first began. 37 years ago, the Internet was just about to become public and be out there, and 37 years later it's changed every part of my life. Everything that we do now is oriented toward information flow through the internet and I don't think anybody really saw that coming, and I remember back then when people talked about internet time. So that's the speed with which things were changing and, if you think about it, these are massive changes in society in the way that companies sell products, amazon, the way that video is streamed, music it completely disrupted the music industry. Right now they're getting more money from streaming than they are from physical. I'm not sure what they sell now actually, but the world is changing now on an even faster pace.

**Terry:** 13:38

Ai time is not measured in years or decades. It's measured in months. In fact, it was really funny this brouhaha at OpenAI that was all over in a week. In fact, I was joking with some of the people in those companies and saying that you know Sam Altman came back from the dead in three days, but he didn't hold a record. Jesus got back in two days.

**Terry:** 14:21

Doesn't give a lot of time to explore some of the issues that having to do with you know now that the public is interacting with AI and that's the cause for concern. In some ways, the government really is missing, I think, its role. It hasn't played the role in AI that, for example, it did play in physics and some of the other, like nuclear energy and so forth, because things are moving so quickly. But right now all of the major models actually have been coming out of these big high-tech companies, because only they can afford to run 20,000 GPUs for two months, to run 20,000 GPUs for two months, which is what? And $100 million of computing that went into GPT-4, right. So there you go. It's academics are sidelined and it's partly because the government just hasn't.

**Terry:** 15:41

The funding agencies haven't really been able to shift their funding patterns. Every funding agency has its own clientele, faculty and so forth that they're trying to help with funding, and when something new and this big happens, they can't. They're not as nimble as these other companies that can hire some of the best new PhDs coming out. In fact, I heard a figure which kind of shocked me. It kind of shocked me. So do you know what the starting salary for a PhD right now in computer science who is joining OpenAI? A million dollars. Well, it's way above all the other companies actually, and in fact, they can't compete. But be that as it may, you know that's what it takes to get some technology to. You know, to and and, by the way, a lot of the people that are hiring are, like you know, ilya Sutskever, who was the, the chief scientist there.

**Terry:** 16:58

It was, it was into alignment. He, that was. His primary goal was alignment, and that's probably we what got him into trouble. But all of the companies are worried about that. So this is good, because academics have been worried about it for a long time. There wasn't a lot we could do about it, but now that's all changing. Government's been very slow to move in terms of responding to the very, very rapid changes that have occurred in the air over the last couple of years, and they're now beginning to um, try to create guidelines. Uh, in the us, and actually the, the new law that was just passed by the eu. It's really funny. Someone said the us innovates and the EU regulates. They've had a history of that, but some of the laws, some of their laws, are I shouldn't say laws, but some of the ways that they've couched the rules, of the ways that they've couched the rules like, for example, this is 105 pages of details like this, that thou shalt not use AI to screen job applications.

**Terry:** 18:20

I mean that is, you know, but it's wrongheaded in the sense that it shouldn't be micromanaging.

**Terry:** 18:29

It should be looking at the broader picture of excesses when are the excesses and come up with general principles, rather than try to say this particular application is bad. Right, the applications should be kind of, in fact, they're going to be the rules for each domain education, financial, you know entertainment, everything you know the Hollywood strike. You know entertainment and everything you know the Hollywood strike. Each industry is going to have a different set of criteria, that is, you know, for them, the things that are important for them, like writers and so forth, is going to be different from a doctor who is concerned with other issues, and so each one of these domains has to be looked at separately, and a lot of the decisions have to be made locally. It can't be made by the government. It's got to be made by the companies that are involved in making movies, the companies that are in the medical community that is involved in helping patients, and so forth. All of those have to learn how to adapt to the new technology, and that's going to take time. So it will unfold.

**Craig:** 19:53

And in terms of the compute being controlled by these big well-funded corporations, these big well-funded corporations, the US, there have been proposals to create a national resource that maybe wouldn't actually own compute but would provide credits for research institutions or people.

**Terry:** 20:23

Well, in fact, fei-fei Li at Stanford has been advocating this now for several years, and there is a bill wending its way through Congress I think it's in the Senate now which would provide that for academics which provide the sort of compute. What's happened, though, over the last couple of years, is that the amount of computing that is needed has risen, so it's not clear how they're going to do that with credits. It's just not enough computing available in the world. But, for example just to give you, one amazing thing is that NVIDIA makes these boards the H100, a100, h100. These are GPUs that are essential for training these networks, and you can't get them. I mean, everybody wants to get their hands on them, and, of course, now it's a trillion-dollar corporation, right? It actually, in just one year, went up by a factor of three. Now it's a trillion-dollar corporation, right? It actually, in just one year, went up by a factor of three. The cap, market cap, and it's hard to grow that fast in terms of the assembly lines or whatever it takes to actually build these boards and the chips and so forth. All of that is a big pipeline that takes months and years in order to be able to ramp up, and so that's what's happening right now is that the world is unprepared for either the scaling up, ramping up that needs to be done.

**Terry:** 22:00

And on the industrial side see, almost all of the computing that's going on is being done on digital processing chips of various sorts which are very, very energy inefficient and ultimately, that is not going to be feasible. You can't just scale that up because you know you'd use up all the energy in the world, right. If you think that it's going to be feasible, you can't just scale that up because you know you'd use up all the energy in the world, right. If you think that it's going to be used for so many different applications, right, it looks like it's heading in that direction. So what you need to do is develop a whole new technology for computing which is specifically designed for low energy, which is specifically designed for low energy and for this particular architecture that they've designed and built and we actually have that. It's called the brain. Nature was in that business long ago and has developed super low energy technology. I mean, your brain runs on 20 watts, right? I mean that's a very dim bulb, but it can run rings around all of the computing that we now have because it's so efficient.

**Terry:** 23:16

And so there is a whole field now, neuromorphic engineering, which was founded by Carver Mead about 30 years ago, analog digital processing, and that is really very low power because it's running silicon near threshold, where you're talking about microwatts rather than watts, and it shares some of the advantages actually of the computing we know for example, you don't need 64-bit precision when you are doing calculations that the brain, you know eight bits, five bits is sufficient. And also the other thing is that it's very fault-t, fault tolerant, in the sense that you know if you take out a few logical circuits in a computer, it'll crash right, because you know they're all of it's all deterministic. And but if you take out a few units in a neural network, you know it's it won't have a, it degrades it a little bit but it's not going to crash. And so again, you can take advantage of that when you're designing the hardware so that it doesn't have to be 100% exact and deterministic. In fact, the principles of computing in neural networks is probabilistic. So from the very beginning you take into account that it's not going to be perfect. Training is different from what's called inference, in other words using it on a particular task to give you an answer and what we've learned actually, this is a very interesting theoretical result is that you need a much larger network when you're training it than when you are using it for inference, and so this process of distillation is how you transfer the big network and download it into a smaller network. Yeah, and that's a very interesting theoretical. Why should that be? In other words, it has something to do with the amount of exploration that you can do in a much larger network. That allows you to come up with solutions that you couldn't if you started with a small network. But once you have the solution, it can be replicated in a smaller network and it can be distributed to the end.

**Terry:** 25:42

You know the users and edge devices, like you know your smartphone. So your smartphone will probably, within the next five years, be using, be talking to you already. In fact, you can talk to your phone and it'll translate for you, but it will be doing a lot, lot more because it can be your assistant and it will not just answering questions, but it will also be able to remember all of your needs and be able to help you navigate all of the complicated things that are going on in your life. And coming to a meeting like this and helping you sort out what you need to do next. Right, and this is something that'll help everybody Agency. That's a big hot. That's a hot topic right now.

**Terry:** 26:27

Right, in some ways, they already are grounded because of the fact that they know a lot about the world. In fact, there's a lot of questions they can answer that they couldn't have if they didn't know a little physics, right? And so in that trillions of words of text that is out there, there's a lot of physics stuff. It is a lot of descriptions of how things work in the world and so forth, and so, including how human beings work, social stuff, I mean. In fact, one of the strengths is ability to understand human intentions, of all things, and empathy. In fact, they could do a lot better than doctors when it comes to patient care.

**Terry:** 27:12

How could that be? So? Here's a speculation. It all comes from training set, in which the goal is to predict the next word in a sentence. Now, if you think about that for a while, right, and, by the way, they also now have what's called a context length of tens of thousands of words, like 30,000 words. That means they could take in huge amounts of text and take that into account when they are responding to your question. Right, that's like a book In order to get to the next word, they have to take into account all those other question. Right, that's like a book In order to get to the next word, they have to take into account all those other words. Right, they can somehow form associations and self-attention between all of the words and what the next one should be.

**Terry:** 27:56

And in order to be able to get better and better at it, it helps to have created an internal model of the meaning of all those words and, in addition, an internal model of how the complexity of the world is expressed in those words. In other words, these are very sophisticated internal models and, of course, that's what humans need to have too, when they're navigating the complexities of the world and first going to school and dealing with social interactions and ultimately, working in companies. All of that, all of that has to be internalized. You have to have an internal model of what's expected of you, of what you can say and what you can't say. I mean all those things you know that we're taught we call alignment. All that has to be internalized, and so that's where I think the future is going to be in helping, you know, create better internal models. And how do you do that? Well, a lot of it would be through physics, Right, about the properties of the world, and then a lot of it is going to be about reinforcement.

**Terry:** 29:04

Little kids have to be taught what's good and what's bad, right? Well, they have to be given examples and they have to be reprimanded, and that's something that has to go on during training. You can't wait till the end, because you'll end up with an adult brain that is completely unable to understand in some sense or to respond in a way that we expect other humans to respond. That's a problem. That's a solvable problem. I don't think that that's going to take that long to solve. I think it's just a matter of adding in a few more parts of the brain into the model and actually creating a much more sophisticated scheme for training that includes this developmental, sequential schooling, if you will, of the interactions that it has to learn along the way dealing with the world and with humans. You can't wait to the end to add that the guardrails are too late if you have a mature system that is already trained.

**Craig:** 30:11

Yeah, so the pure scaling of existing architectures is. Given the compute constraints, Do you think that's going to continue in the next year or will attention focus to some of these other?

**Terry:** 30:29

No, it's all going to go on in parallel. It's all going on right now and here at the meeting. Every single one of these issues is being debated and progress being made, in some cases more than others, but I, uh, uh, you know, I think we have, as a community, been aware of all these issues for a long, long time. Academics, uh, you know, but it's no longer an academic issue, right, because a lot of people in the public are using this, these, these, uh, devices now, which, uh, have been completely aligned, and but there, but? But.

**Terry:** 31:07

What's interesting, though, is humans are incredibly adaptable. You know, humans, for example, adapted to keyboards, yeah, and and it was always the humans had to adapt to the machine. Well, now the machine has to adapt to the humans, right, the other way around, and, you know, that may take a while. I don't think it'll take as long as it took for humans to adapt to keyboards and for other mechanical devices that have to be. You have to. Well, actually, another good example of that is music, right, being able to learn how to play violin or piano takes years and years and years, incredible amount of practice, practice, practice, and then, you know, to be able to compose requires yet still another complex process in which you now are creating, not just reproducing or translating. And all of that, you know, practice is part of the part of the brain called the basal ganglia, and right now, deep learning on its own is like the cortex, but without a basal ganglia you couldn't do all these things right. You couldn't learn how to play piano, you couldn't learn how to do mathematics, you couldn't learn anything that requires a sequence of actions to achieve a goal. So now, where are we in terms of the next step? Well, we should be incorporating a basal ganglia into these models, and actually that's already been done in AlphaGo. So AlphaGo learned how to play Go by playing itself, and it did that using two different learning systems. One of them was deep learning, which was good at developing models of the board, the positions on the board, but then it had to learn with the goals of how do you win the game and how do you make moves, and that is where reinforcement learning came in. And reinforcement learning the only reinforcement you get is at the end, whether you win or lost. Yeah, but somehow that was enough to help it figure out through a value function, that internal value function about the strength of game positions, but it then used that value function in order to be able to learn new moves, new positions that no human had ever thought of, which are actually better ones than humans were previously aware of. So that's fantastic.

**Terry:** 33:32

Here we have an AI that used a very sophisticated visual representation together with a very, very ancient Reinforcement learning. Is is every species in the world has reinforcement learning. It was thought to be very primitive because of that. Well, it was primitive in the sense that it was something that was evolved at the very beginning, but it doesn't mean it's primitive and it's not powerful. Obviously, all these species have to survive, and that's not easy, but reinforcement learning got them there right. So here we have reinforcement learning. That's not easy, but reinforcement learning got them there right. So here we have reinforcement learning, which helped the powerful cognitive processor be able to solve these complex problems.

**Terry:** 34:14

It's already happening in science. There's been a tremendous, tremendous just within the last 10 years advances occurring throughout science. At the level of molecular biology, we can now predict the three-dimensional structure of proteins from their amino acid sequences. We can design new chemical compounds. I just read today that, again, it was a group of DeepMind came up with predictions for new crystals. So crystal structures are repetitive structures and you know there's this I've forgotten how many we know, but like diamond is a good example or repetitive carbon atoms in a particular lattice. But now what they've done is been able to come up with a million, a million new compounds. Yes, I saw that. Yeah, so wow. I mean now they tested only a few of them, but it looks like about a 50 percent hit rate, right. In other words, that's amazing, because if you just did it by trial and error, you'd never make much progress. It's just too big of a space yeah, it's something.

**Craig:** 35:16

Well, just on that. On new materials, uh, which, you know, given the plastics, the plastics crisis is desperately needed. How quickly on something like that, do you think that'll be productized?

**Terry:** 35:33

Well, so there's a big difference between discovery and then creating a product that can be used in the world. And if you look at products in the past, like the first, laser was first designed, was first discovered back in the 50s, I think, but it took decades and decades to go from a room full of optical equipment to something that you could put on your desk, and then another few decades to go from that to a laser pointer that you could hold in your hand. Right.

**Craig:** 36:12

Yeah.

**Terry:** 36:13

So we're talking about many decades, and that's true of all technologies, Right? So don't expect even if you had a material that worked in some remarkable way today, don't expect that to be scaled up and commoditized, unless there's some really important need for it, in which case there would be a huge amount of money going into development, but that's still going to take decades.

**Craig:** 36:40

Yeah, just on the conference itself, it's growing and we were talking before we started about how certainly there are a lot of people here who are very young. It looks like they're mid-20s or late-20s, maybe even younger, and I've also noticed that there's, over the years that I've come, there's an increasing Chinese contingent. Do you track that at all? Not by nationality, necessarily, but it's just. That fascinates me, and we've spoken in the past about education, the education crisis in the US. Why aren't American high schools filling Nureps with? I mean, there's certainly a lot of Chinese Americans in America, but it just seems like the international contingent is growing.

**Terry:** 37:39

I don't know the numbers, I could probably find out, but you're right, just from informal observation. You're right that there are a lot more younger people and you know it's actually completely international. I mean it's not just Chinese students. I mean there are students from Korea, there are students from Indonesia and you know Africa Not as many, obviously but this has become a magnet. This meeting has become a magnet for people that want to be at the cutting edge of machine learning and then applications, ai applications and you say the companies. The companies also are sending their researchers here, so they also have a lot of foreign board H-1 visa employees that are coming.

**Terry:** 38:32

But this is reflected also in what's happening at colleges and I know that at UCSD there's a new data science institute that was just started three years ago and it went from zero to 40 faculty in three years 40 faculty. They started a graduate training program, a master's degree program and an undergraduate major Just think about that and it in fact was so successful that sometime in the fall it's going to transition from being an institute, which is kind of a standalone outside of a department, to a school. Now a school is actually above the department, like a school of medicine. Within medicine there are many subspecialties or a school of engineering, many different departments of engineering. So, by jumping it up to the level of the school, I think what that is signaling is that this is a technology that's going to have applications to all departments, all areas in science, engineering, humanities. Every department wants to hire people who can handle big data. So that's where the future is going and that's why, when they put a course on, you know they teach a lot of courses now in data science, so they have a course on deep learning.

**Terry:** 39:58

Do you know how many students show up? 600. 600. You know, we're not talking about classrooms with 50. Or you know, I thought, do you know how many students show up? 600. 600. We're not talking about classrooms with 50. Or you know, I thought you know, I have 100 students. You know that's a big class. No, no, I mean, these are. This is another order of magnitude beyond that. And, of course, they're all young and they're all going to go out and they want to get jobs and they're all going to be coming here.

**Craig:** 40:19

Yeah, do you worry about the education system, the primary-secondary education system in the US? And we talked I know you've been involved in using AI in education to improve education and I've been talking to teachers in the last month about this and there still seems to be tremendous resistance and and they're anyway. I'm just curious how you see education when, when.

**Terry:** 40:50

What is it they're resisting? What is it that you think that they're?

**Craig:** 40:53

I think two things. I think the, the, the. From what I hear, it's not actually the teachers, it's the administrations.

**Terry:** 41:04

There you go, they are. And this is something we discovered when we had a center, the Science of Learning Center, that was based at UCSD and involved a dozen institutions and 50 faculty Was that the problem with education is that there are barriers to get to the student Right, in other words, gates, gatekeepers at each of these barriers. There are, I think, on the order of 12,000 school districts in the US, and if you want to do something new, you've got to knock on 12,000 doors. You can't do that if you're an academic and even if you get through one of them, you have to run a gauntlet because you have teachers unions. You know you can't expect teachers to add something, or the principal, or you know the principal will say we don't have money to do something new. You know we were already. You know bare bones here, but you know I say OK, we'll do it for nothing. You get to the teachers unions and the teachers even if they wanted to do something new, they weren't. They wouldn't be allowed by the union because that's not in the contract, right?

**Terry:** 42:08

So there you go, and the only way that we were able to jump over the barriers was with a massive open online course, and this is now 10 years ago, when Barbara Oakley and I created a course called Learning how to Learn, and I've already discussed this with you. But do you know something? That course is now over 4 million people have taken the course online for nothing, free, and it still attracts, you know, literally hundreds of people a day. I mean, it's unbelievable. Around the world we're talking about 200 countries, ages 10 to 90. There's a great need and our course is just now, I think, showing how to get to the students, how to get to the people. Interestingly, we aimed it at high school students, but the group that is actually the one that has benefited the most has been 25 to 35. And by half of them are college educated, and these are people who are in the workforce. They probably have families and they have mortgages and they're trying to learn new skills because they want a better job Right, and they can't afford to go back to school.

**Craig:** 43:20

Yeah.

**Terry:** 43:20

So this is that's where MOO I think are really helping in continuing education, and I think we need to use technology more creatively for being able to get around these barriers. You know our educational system was designed at a time when there was a great need to train people to do manual tasks on assembly lines Right. And so you know it was. In fact, the school itself is an assembly line. You know they go from one teacher to the next, right, just like in the centerline. You know the car goes from one station to the next. They put on a window and they put on a headlight Right, and you know that's a very, very kind of antiquated way of thinking about humans and how humans learn about the world.

**Terry:** 44:11

People learn by doing active learning and sitting there passively and just having to absorb a lot of it's not really what the human brain was designed to do. I mean, you can do it. You can forcibly do it, but you can do it. You can first of all do it. But you know, here you have this class of kids, especially if they're adolescents. You know raging hormones. You know this is a tough job. Being a teacher is very difficult and I really respect the job that they've been given, but it can be done so much better with AI. Yeah, so much better, and that's what's going to happen eventually. But it will take more than just technology to get there.

**Craig:** 44:49

Yeah, yeah, that's right. And on your MOOC, what percentage of those are within the United States, the people that are?

**Terry:** 45:01

Ah, it's actually haven't checked recently, but it's been tracking at around half North America. But, like I say, it has reached almost every country in the world and we get, by the way, we get fan mail from them too. You know, from a housewife in India saying oh, thank you thank you, dr Sejnowski.

**Terry:** 45:27

You know you've made my life so much richer. And you know thiswife in india saying, oh, thank you. Thank you, dr sanofsky. You know you've made my life so much richer. And you know and this is really wonderful, I mean, I don't get that many much fan mail from all the students I've taught in class.

**Terry:** 45:35

so it's, it's, it's. It's still just. This is just the beginning. We're just going through this process and we're learning how to use tools, uh, like the Internet, in order to be able to, and people at the beginning thought that, oh, the MOOCs are going to replace the classroom. No, the classrooms are still there, but what it's done is provide an alternative. It's not like one or the other, why not both? And so for different purposes, and so there'll be other purposes that will be created. Once you have AI tutors out there, well, that will be another opportunity that would help a lot of other students.

**Craig:** 46:12

Yeah, let me ask you, though, the other big thing that happened this year I mean, it was so much has happened that it seems like more than a year, but were these letters, starting with the Future of Life Institute letter, calling for a pause? I saw Max Tegmark here yesterday. I'm not sure if he's speaking, but it got a lot of press. It upset a lot of press. It upset a lot of people. There's a pretty acrimonious debate continuing, but it didn't pause anything, and I'm wondering where you stand on that debate, whether you're worried about the speed that things are progressing, whether or not it's possible to slow it down.

**Terry:** 47:08

Yeah, so you're right, there seems to be two approaches. There's those who say look, there's this existential danger, we should pause and reassess and be more careful, more careful. And this other group that says let's just barrel ahead. I mean, you know, and I think they're both right in the following sense we, we won't really understand the strengths and weaknesses of the technology unless we develop it. You can't predict, we just can't predict the impact up. We don't have imagined the impact of the Internet until you actually make it. And then you see how it's used in ways that nobody could have imagined right. And so there you go. So you've got to do that.

**Terry:** 47:53

But at the same time you know you can worry about worst-case scenarios. You know not that it may have very low probability, but unless you have planned ahead, if it finally arrives and if you're not prepared for it, you're in trouble. So you know we're creating this technology, we should be able to understand how to control it. And so I think that it's good that a few people like my good friend Jeff Hinton are concerned, because he's very, very smart, and so he'll figure out what needs to be done to avoid a catastrophe or a cataclysmic catastrophe. But in the meantime, full speed ahead.

**Terry:** 48:36

Come on, let's get on with it, because, you know, never in the past has any technology been stopped because academics think it might be dangerous, even the atomic bomb. You know openheimer you've seen the movie, okay, well, he had second thoughts, but he was, he was the father of the atomic bomb and you know he actually said, uh, that when something is technically that sweet, you know you can't not do it Right. Right, it's kind of like wow, you know, how can you? It's just amazing if you could, if it worked. And it was amazing, yeah, yeah. So, but the consequences are always difficult to predict.

**Craig:** 49:16

Yeah, so at least it shifted a lot of people into safety research.

**Terry:** 49:22

Yeah, that's right, that's, and people are already well, I would say that not a lot of people, I mean. I think that there's that's going to be a very important specialization, along with others that are going to be needed, for, you know, truthfulness and privacy and all of these things are very important, but it's not like you have to be regulating it from the get-go. In other words, let's just see where the failure modes are and which ones are going to be, I shouldn't say acceptable. But let me give you the example of automobiles, automobiles, transportation on demand, so forth.

**Terry:** 50:07

Do you know how many people die every year when it crashes? And you know it's like 25,000 or more people die every year on the roads in the US, right, I mean, that's a tremendous amount of bad consequences, right, and you know we put airbags in, we try to come up with ways to ameliorate it, but there's still. But people are willing to accept some risks for the benefits, right, and that's what we have to do. We have to know what are the risks for AI and what are the benefits. Unless you know both, you can't make a good compromise.

**Craig:** 50:43

AI might be the most important new computer technology ever. It's storming every industry and literally billions of dollars are being invested, so buckle up. The problem is that AI needs a lot of speed and processing power. So how do you compete without costs spiraling out of control? It's time to upgrade to the next generation of the cloud Oracle Cloud Infrastructure, or OCI. Oci is a single platform for your infrastructure, database application development and AI needs. Oci has four to eight times the bandwidth of other clouds, offers one consistent price instead of variable regional pricing. And, of course, nobody does data better than Oracle. So now you can train your AI models at twice the speed and less than half the cost of other clouds. If you want to do more and spend less, like Uber 8x8, and Databricks Mosaic, take a free test drive of OCI at oraclecom slash ionai that's E-Y-E-O-N-A-I all run together. Oraclecom slash ionai that's oraclecom slash ionphen O-N dot A-I. And remember the singularity may not be near, but AI is fast changing our world, so pay attention.