**RedZone Podcast Episode #61: New Breakthroughs in Digital Manufacturing| 3D Printing| AI Creativity, Decision Making & Design Perception- with Hod Lipson, award-winning researcher, professor, and author**

Hod: This is why we look at the body and the brain, so to speak, of a robot. This is why I have [inaudible 00:00:05] and 3D printing and digital manufacturing, which is how you make future robots, and the AI, which is the brain, the mind. That's why I'm in both of these fields. Driverless cars is maybe the first autonomous robot that will interact on a daily basis.

[00:00:30]  
Bill:  
That's interesting. I love the metaphor and framing of words. I haven't been exposed to that, but the autonomous vehicle as a robot, but of course it would be a robot.

Hod: Absolutely.

Bill:

[00:01:00] I just had a conversation with a gentleman that was talking about the resilience of our networks. Literally from a warfare point of view, he was talking about our security of our satellite systems, and our GPS systems and such that encircle the planet. He's talking about it from a geo-political point of view and stability of infrastructure, and I didn't ask him this question, but he's firmly aware that in Pittsburgh they're rolling out autonomous vehicles now as we speak. What happens if we have autonomous vehicles and the satellite systems go down? Have you ever been posed with that question?

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Hod:

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When you design an autonomous system, you definitely have to make sure from a safety point of view, you are capable of handling situations where you work without any infrastructure at all. I think one of the things that has changed in the whole driverless vehicle community is that increasingly we see driverless cars as autonomous robots that basically deal with the same infrastructure humans do. What happens to a human when satellite GPS stops working? Nothing. You keep on driving. Maybe you're not sure if to turn left or turn right. That's not an issue at all. You keep on driving. The same thing will happen to the vehicle. There is nothing about immediate real time communication that's important for a driverless car at all. It's a non-issue.

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Bill:

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Our conversation might be wide and varied. But I know you'll be fine with that, but I got off the call with Kevin Kelly recently. We had a conversation and again, I love the planned words because I think sometimes these words turn into marketing terms for people, which can be misleading. He was saying that AI - machine learning is really practical use of AI. AI is still in the future, meaning AI is always in front of us when we take parts of AI that we understand and are practical, they become machine learning. Do you share that, or do you have a different opinion?

Hod:

[00:03:30] In some sense maybe he was referring to the fact that AI is a moving target. Whenever we talk about machines being intelligent, the moment they can do something, the AI that we were thinking of, once they can play chess, that's not a big deal any more. If they can predict the stock market, that's a trading systems, that's not AI. It's a moving target. We always want to see the next big thing that humans can do and machines can't as the target of AI. In essence, I would say machine learning is the ultimate AI. As I would say it the other way around, that finally we're there.

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[00:04:30] Actually, one of the things I'm passionate about, that I've been talking about quite a bit recently, is that I think AI has turned the corner in the last 2 or 3 years because of all this deep learning stuff where machine learning has finally reached a point where it can do things that have surprised even people who have been in AI for many years. It's a transition point where suddenly there's this incredible improvement in perception and even in creativity in generating things - all this ripple effect across AI. Things that people thought would never be solved are suddenly solved overnight. I think it's not business as usual. It's not something that's going to happen in the future. It's happening now and it's really a turning point.

[00:05:00]  
Bill:  
I'm really interested in the word "creativity" that you use. The AI that beat GO, the world champion GO in China, I guess that was one of the edge frontiers of AI as far as complexity. Does that game mean creativity to - or maybe you could just explain that a little bit further, what you mean about creativity in AI.

Hod:  
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[00:06:00] Creativity, generally speaking, I think we can look at 2 types of intelligence. One is analysis, and one is synthesis. Analysis means taking a lot of data and decide, make a decision, to buy or to sell a stock. To take a lot of weather data and decide is it going to be cold or warmer tomorrow. Take a lot of data in and decide whether somebody's going to click a link or not, or maybe if you're autonomous driving, you're taking in a lot of data from cameras, and you need to decide whether to stop or to accelerate, to turn or not to turn. These are all analytical AI instances, and we have become very good at these sort of things. The other type of intelligence is not decision-making, it's creativity. It's synthesis.

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[00:07:00] Take a seed, an idea, or something very basic, and see if you can generate new ideas out of it. Can you write music, poetry, design an analog circuit, design a new robot. Paint a painting. These are all creative things where you generate something that didn't exist before. It's not going from a lot of data to a small decision. It's going from a small thing and creating a lot of stuff. It's very hard for people to do, and it's very hard for machines to do. I think it's the ultimate frontier of intelligence. It's creativity and curiosity. It's the one thing that people still pride themselves in. We humans think that creativity is still something unique to humans, and many think that machines can do a lot of things, but they can't be creative. I think that's been the ultimate challenge, and we're seeing even that ultimate challenge beginning to crack as machines become more intelligent.

Bill:  
[00:07:30] Where have you seen that happen, Hod? Do you have a couple of examples that you can share regarding synthesis?

Hod:

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[00:08:30] It's all over the place, and it's sort of hidden, but you can see everything from ... in our lab we've seen computers design things like analog circuits. I know a lot of people wouldn't think about designing analog circuits as creativity, but it's actually a very, very challenging task, and you have computers that can generate circuits that even the best designers can't. Computers can even get patents for their designs, so they're sort of clever. You're also seeing computers that can generate pictures and paintings of things that don't exist. They actually generate them from scratch. They can generate pictures of people, faces that they haven't seen, but they can generate them from scratch. They can generate designs for a hand bag that don't exist. They can generate art and engineering things that don't exist. We're seeing this all over the place, and I think it's a glimpse of the future.

Bill:

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[00:09:30] Just for our listeners, just to make sure that everybody's on the same sheet of music. If we're talking about the deep machine learning in AI, you mentioned the words analysis and synthesis, and so maybe you can explain the difference. I don't want to give you my words. How would you break this? If you were giving a 1 on 1 lecture in front of college freshmen, and they're trying to figure out where they're going to navigate moving forward in the future, as far as what path they're going to take. How would you break this down so they leave going, "Ah, I get it. I understand the differences here."

Hod:

[00:10:00] Let's look at different challenges that you have to face as an engineer. One challenge would be a challenge of analysis, where let's say you have a machine, or circuit, or computer program, and you need to understand how it works. You need to see if it's going to fail. You need to know if this machine is going to break when it's operated, or it's going to do what it's supposed to do. This is called analysis. We're very good at it.

[00:10:30] We have a lot of tools that can predict failure and can understand what is something going to do in the future prediction. This is the sort of number-crunching that we're very, very good at. Computers are good at it as well, and we can do a lot of this through machine learning. We can give them examples, and computers can predict where something is going to go, whether it's going to succeed or fail, whether it's going to go left or right, whether it's going to be hot or colder tomorrow. This is stuff that computers are very, very good at. It's called analysis.

[00:11:00] But the other thing that is very, very challenging for people and also for machines is the blank page. I give you a blank page, and I say, okay, design a new hand bag, design a new car, design a mechanism, design a robot. You have a 3-D printer, you have a bunch of components. Put them together to make something that works.

[00:11:30] Here's a Lego set. There's 1,000 pieces. Put them together in a way that will make a robot that will walk across the table. That's a challenge of synthesis, where you're starting with components, and you're figuring out how to assemble them together to make something. It's no different than taking a bunch of words and finding out how to assemble them together to make a poem or a story. How to take together a bunch of pixels and generate a picture. These are all synthesis challenges, and they're very hard for people to do. They're very hard for machines to do because we don't have any sort of systematic way of doing it.

[00:12:00] When we train people to be designers, we usually still do that by apprenticeship. You have the human do a lot of different designs and watch somebody else do a design, and hopefully they pick it up over time. But for many years, it's been thought that computers are very good at analysis, but they can never do this creative design on their own. But we're seeing in the last couple of years though, and especially in the last year I would say, that computers are getting better and better at designing things from scratch, starting from the blank page and generating stuff. That's amazing to see, it's also again a transformative moment for AI.

[00:12:30]  
Bill:  
And so AI, the analysis piece, would that be more the machine learning, and then as you move towards the synthesis, that's AI, and then where would deep learning pick up from that point of view?

Hod:

[00:13:00] You've mentioned a couple of different terms. AI I would say is the top level umbrella of synthesis, analysis, any way you can exhibit intelligent behavior in a computer, in software, that's AI. Analysis, synthesis, deep learning, these are all sort of different types. Deep learning is a particular technique. It's a type of machine learning, and you can use machine learning and deep learning is one of those techniques to do both analysis and synthesis. Analysis and synthesis are 2 categories of applications. And driving ...

Bill:

[00:13:30] Deep learning would learn, right? Deep learning is essentially not just you giving someone a set of instructions, or giving the program, but it's actually self-learning? Am I on the right path?

Hod:

[00:14:00] Machine learning in general is this idea that in artificial intelligence historically, there's been these 2 paradigms. One is the critical algorithm approach, where some genius developer writes code that makes the computer play chess, or do something that appears to be intelligent. That's the algorithmic approach. It's based on rules and algorithms, if then, else, and logic. It's a very hard-coded way of doing AI. Search.

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[00:15:00] Then you have the second approach, which is machine learning, which says forget about programming the computer to do something. Just give it examples and it will figure it out on its own. For a long time there's been this duality in AI research. Even a hostile dichotomy between 2 schools of thought about we would reach this ultimate AI. Would it be by programming clever algorithms, or would it be by machine learning? I'd say the first 50 years of AI, the algorithmic approach, the logic, rule-based approach dominated. But in the last couple of years, in the last decade or 2, we've seen this transition to machine learning approaches that are actually finally surpassing what you can do with traditional programming, logic, rules-based AI. They're taking off, and you can use these machine learning approached to do everything from perception to creativity to decision-making. It's all based on machine learning. Deep learning is one particular algorithm in machine learning category, but there's lot of others.

[00:15:30]  
Bill:  
That makes sense. It's trying to dispel some of the marketing from the reality. That will help people a ton. You just got done talking about the 4 exponentials related to AI. Could you expand on those, or have we already covered some of those?

Hod:  
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[00:16:30] When people talk about why AI now? Why is AI turning the corner now. Why are investments in AI only going up. Why are we hearing about AI so much, and why are driverless cars suddenly becoming a reality, whereas they've been just hype for decades? The reason that AI is suddenly becoming possible because of compounding effect of 4 exponentials. The first exponential that everybody's familiar with is Moore's Law, right? Faster, cheaper, better computers. It's tempting to say, well, we have better AI because computers are faster, cheaper, and better. That's, I think, only part of the story. That's maybe the first exponential. But there are 3 other exponentials that are compounding that.

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[00:17:30] The second exponential is data. There's more and more data. There's an exponential growth in data. If you plot the amount of data being generated over the years, it is a staggering exponential. Much faster exponential than the exponential of Moore's Law. It's because we have more sensors. The sensors produce more data, it's easier to store data, it's easier to transmit data. Whatever the reason is, there's more and more data. The reason why data's important is because all these machine learning algorithms that we just talked about, the fuel that drives them is data. The more data they have, the better they get. One of the reasons why machine learning algorithms never took off in the 50's and 60's when people started thinking about that is because they didn't have data. There was no data back in the 60's and 70's. Now there are terabytes and petabytes of data streaming out of every possible sensor out there, and that is the fuel that drives this new AI, that didn't drive the old AI, because the old AI did not need data. The new AI's fueled by data, so that's the second exponential.

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[00:18:30] The third exponential is the algorithms. That's frequently overlooked, but the algorithms themselves are getting better. Even if Moore's law was flat, and data was flat, newer and newer algorithms keep coming out, and they are getting better and better in their performance. In fact, there are many algorithms in different areas, from perception to solving differential equations, that are actually having improved so much that their sort of co-efficient of improvement is again better than Moore's Law. Algorithms for solving differential equations, for example, which you might think, okay it's math, but really it's robotics, driverless cars, everything uses these algorithms, have improved much faster than Moore's Law.

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[00:19:30] These improving algorithms allow us to do things today that we couldn't do even if Moore's Law kept on going for a hundred years. We would never be able to do this. But because algorithms have improved, we can. So there's an exponential improvement in algorithm performance, and the sort of subtle thing about algorithm improvement is that it's difficult to compare algorithms. You can't say algorithm "x" is 10 times better than algorithm "y". It could be that algorithm "x" is 10 times better than "y" for a small problem, but a million times better than "y" for a big problem. They scale differently, and it's difficult to compare. But the algorithms of day can solve harder problems faster and better than the algorithms of a few years ago. That exponential curve is another thing that compounds the data and the faster ...

Bill:  
[00:20:00] Is that a robot? Would that be like a robotic arm being, like in the old days was maybe a slower, it was a slow-moving arm, but it would do the task. Is that because the underlying code, or you're calling the underlying algorithm of how it is now just flat out better and faster?

Hod:

[00:20:30] The algorithms of the way we approach solving problems is getting better. We talked about deep learning, for example. Deep learning is a new machine learning algorithm. That algorithm did not exist 3 years ago. So that algorithm allows us to do things - that new way of thinking about machine learning, the new code, allows us to do things we could never do with the old machine learning, even if Moore's Law went on for a thousand years. We couldn't do it. But these new algorithms keep coming out. The people invent, and they allow us to do things we couldn't do before, and that's an exponential growth in and of itself, regardless of the hardware, and regardless of the data. It's better and better algorithms.

Bill: That makes sense.

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Hod:

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That was the third exponential. The fourth one is the fact that these machines learn from each other. It's not enough that these algorithms are getting faster, there's more data and so forth, but they all learn from each other. In other words, if you have a driverless car for example, unlike a human driver that can have at most one lifetime of experience of driving, a driverless car can have 1,000 lifetimes of experience in a day because it can experience everything that every other driverless experienced that day. Within a few days, it has amassed a couple thousand lifetimes of experience of driving that no human driver can experience, and so these algorithms learn from each other. The more cars there are on the road, the faster they learn because they've experienced more and more things.

[00:22:00] That's another exponential that comes from the number of instances of the AI, and the fact that an AI can learn from another AI, and the fact that increasingly this is happening in the last couple of months, we have systems where one AI can challenge another AI in a sort of predator-prey kind of scenario, creating an arms race between the AIs that allows them to learn even faster. That's another exponential that's on top of the other 3 that makes things move even faster.

[00:22:30] There's all these reasons why these things sort of compound and they keep getting faster and better, and it's not just Moore's Law, it's all these other effects.

Bill:

[00:23:00] That's real interesting. Do you find now that human beings are helping to create these algorithms, or do you actually have the machines themselves that are synthesizing and essentially creating better code, not necessarily themselves, but because we have the machine that can help improve themselves?

Hod:

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[00:24:00] Yes, absolutely. Remember this idea of machines writing code is the old view of AI being based on code, on somebody writing clever algorithms. When you look at the new AI that's based on machine learning and it's based on data. It learns from data, so what you have is machines generating not code, but machines generating data in order to make the machine learning systems even better because they have now more and more data. Absolutely, you're already seeing machines, AI that can train another AI, but generating "fake" data, or synthetic data to make the other system better. That's already happening. That's an incredible improvement in performance, and that moment of singularity as it were, where machines can program machines, is already underway.

Bill:

[00:24:30] It seems that maybe the quality of the question, what's the multiplier here? Are you finding the students in your lab, or the quality of the question needs to be elevated if the machine are taking a lot of the thinking? What's the next frontier of how we approach problem solving?

Hod:

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[00:25:30] In the short term, yes. It's can you pose the right question, do you have access to the data. It's not so much can you write the algorithms to solve the problem, but can you pose the question, and do you have the data to answer it. But in the long road term, as we see computers also venturing into the curious and creative realm of intelligence where they can also pose questions automatically, and they can also create new things, that begins to encroach on even that aspect. It's a moving target, but initially yes, it's about posing questions, and it's about having access to the data. What you're seeing the industry is while a lot of these algorithms are open source, what's not open source is the data. You'll see big companies open-sourcing their machine learning algorithms, but usually the data is very, very proprietary, so right now, the data, which is the fuel of all this new AI, is a new kind of asset the companies are keeping close. If you have the data right now, you hold all the cards.

Bill:

[00:26:00] Maybe you can explain a little bit about your lab. I'm curious about from a patents point of view, is there sort of an arms race to develop patentable algorithms, or is that even possible? I'm just curious about ... there's an arms race between AIs, but also it seems like there would be a lot of the research is trying to find practical use and application of these in the real world. How do you see that evolving?

Hod:

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[00:27:00] Patents for software are very, very difficult, and they're rarely granted. They're impossible to enforce because it's very difficult to know if somebody else is using your algorithm, and it's very easy to hide an [inaudible 00:26:34] algorithm. It's basically impossible to have patents around software almost at all. Maybe around user interfaces, or things like that. But the machine learning algorithms are virtually impossible to patent, and this is why you're seeing most of them being open-sourced. But what is easy to keep proprietary is data. This is the new asset. Our lab, the university lab, doesn't have a lot of data, and we tend to open-source and describe algorithms for academic reasons, but what you're seeing is that most companies are now holding on to their data.

Bill:  
[00:27:30] Basically what they'll do is extend an API out? You pay for access to the data, and then you can use your algorithm against that data? Is that how you're seeing it evolve?

Hod:

[00:28:00] There's a lot of different ways you could do it. You can have your own internal applications. You may have an API. You might allow people to use the data for end use, but not have access to the raw date. For example, you can see image view. On Google you can see lots of pictures of streets, but you don't have access to the entire data base, and you'll never get that. You can see snap shots of the data for different applications, but rarely do you have access to the entire data set. The entire data set is really the fuel that fuels a lot of these algorithms. The future is a lot based on data, access to data

Bill:  
[00:28:30] If you don't mind, if I could shift gears to talk about digital manufacturing, 3D printing world, and I'd love to get your perspective on that as it relates to ... where's this overlay with AI, robotics and 3D printing. How does one navigate that world right now? How are you approaching those and merging these disciplines right at this point?

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Hod:

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We're interested in 3D printing and digital manufacturing in general because it allows us to make the body of the robot, whereas the AI is the brain, and these things of course intersect in many ways. But I think more generally, you see 3D printing as another way were software enters another part of our life, which is manufacturing. Historically, every industry and every discipline, every aspect of our life that software enters into changes and starts to grow exponentially. The moment software touches something, it begins to grow. Software has changed music, it's changed photography, changed communication, we never looked back.

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[00:30:30] Manufacturing, dealing with physical things, has largely remained sort of immune to software. Yes, we have software guiding all kinds of manufacturing robots, but to a large extent, making things was sort of held back by tools and materials more than it has been by software. 3D printing really opens the door to manufacturing things by software, and it's the first time in history where we can make extraordinary complex things, but because it's entirely driven by software. This is where data and software meet - manufacturing in maybe the ultimate way. This is just the beginning because as these printers become more sophisticated, as they can work with more materials, as they can print with multiple materials at the same time, higher resolution, faster speeds, we're getting more and more into the stage where we can make things that we couldn't make before, and it's all enabled by software.

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Bill:  
I love this concept. I was watching one of your speeches where you talked about the complexity of design is moving towards, I don't know the word you said, but the democratization of complexity, where you can take something very complex that is in the software or the CAD design, and move it into a physical, tangible object, and that couldn't be done before.

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Hod:

[00:32:00]  
Right, the way I see it is complexity's free, is the term I used. I get a lot of heat for sayiing it because the manufacturing people in a quibble about it, but the long-term trend it is that making complex things is not more expensive than making simple things. If your 3D printer block, or your 3D print an ornate object with lots of details on it, it's all the same to the 3D printer in the same way that an inkjet printed doesn't care if you're printing a circle or you're printing the Mona Lisa. The printer doesn't care. The 3D printed doesn't care if you're printing a block, or you're printing an ornate 3D object. Adding complexity to your part does not increase the cost.

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[00:33:00] This is a marked difference from all of human history where adding complexity, or making a more complex object usually required more skill, more time, more investment, better tools. It came with cost. Now, adding complexity does not necessarily add cost. This is why the marginal cost of complexity is zero, and it's so intuitive that we'll take a couple generations to get used to it. But I still have students who come into the ... they're designing something for the 3D printer, and they don't realize that, oh, I can add this feature, I can round the corners, I can make this hollow. I can do all these things. It's not going to be more difficult to make. We still have students that design things with straight lines and flat surfaces, and sharp corners, even though they don't have to. That's where we are, and software and design tools have to catch up to that idea and allow people to design these more complex things, so that's where the AI comes in.

[00:33:30]  
Bill:  
Oh, I see. The AI ... a lot of the software you're developing in the lab to do this isn't necessarily commercially available. Is that the point you're making?

Hod:

[00:34:00] Right now we're at the point where you can make complex things, complexity's free, but design tools, people designing, our imagination and the available design tools cannot take advantage of this freedom. They still are at the point where it's easier to design a cube than it is to design an organic shape like a tree, even though it's the same to print it, it's easier to design simple things, and that's because software hasn't kept pace with these advantages of manufacturing. What's the solution? I think the solution is to bring in AI tools, especially these new creative AI tools that can design things for us.

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[00:35:00] Imagine a future where instead of having to design a part of your car, or for a bracket for a shelf, or whatever - part for a spaceship. Instead of designing it by pointing and clicking and thinking about it, you just walk up to the computer and say here's my 3D printer. I need a part that does this, this, and that. Design it for me, and the AI thinks about it and designs the optimal part, knowing full well that the complexity is free, and it designs this amazing thing, you print it, and there it goes. I think that's the future. We need to figure out how to do that, but that's the future of creative AI, and that's the only thing that will allow us humans to take advantage of this new-found freedom where complexity is free in the material world.

Bill: It's almost like we're going to need AIs as assistants to us almost as we move down this path.

Hod:  
[00:35:30] That's right. Initially it's going to be assistants, but eventually if it's good enough, it can do it on its own, and I think that's where it's heading.

Bill: If a company has, let's say, a parts manufacturing facility and they support refrigerators for the last 30 years, and someone calls in parts that are 10, 20, 30 years old, but they still want to maintain systems. Basically, they'll be able to take a design spec, move it to the printer, and be able to, on demand, print these?

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Hod:

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Right, there's a lot of advantages to 3D printing that have to do with things like that. What you just described is called digital inventories, and that's one of them. You can distribute things more easily, you can do design changes, you can prototype faster. You need less skill to manufacture. It's a mobile technology. It's less wasteful with some material. It has a smaller footprint per type of part that it can manufacture. There's a whole range of practical applications and reason why you want to use a 3D printer. But I would say the bottom line is the ability to customize and optimize parts. If you're only using a 3D printer to print parts that you designed two decades ago when manufacturing was slow and expensive, I think you're sort of missing the point. That's a retrofit rather than looking forward, but that is an application, absolutely.

Bill: The future thinking would be basically inventing different ways to disrupt supply chains or printing on demand from the cloud, or printing on demand from ... really the complete supply chain disruption is what could potentially happen with this.

Hod:  
[00:37:30] Right. The ultimate disruption is that you did not just print on demand, but you design on demand. In other words, if you need a new part for a particular application, the AI designs that part right there and then for the particular materials, the particular needs you have, and the particular circumstances, and it's optimized. It's customized for what you need right there and then. That's the future. That's where AI and 3D printing come together to really give us the optimal.

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[00:38:30] It's sort of like a tree that grows in the field. It's optimized for its particular location. No tree looks alike. It's made "on demand". It's made right there and then on the spot, it's optimized for the lighting and soil conditions. It learns from its environment, and it's made for its particular environment. Contrast that with the parts that we make now that are designed far away, and they're all identical, based on this old manufacturing paradigm where manufacturing had to be done. It was slow and expensive, and had to amortized through mass production. But that's changing. It's such a big paradigm shift that it's difficult to do that overnight. There's a lot of inertia, but that's the new direction.

Bill:

[00:39:00] Food is also something you've mentioned before, as food potentially can be food on demand based on dietary needs or particular health goals that you'll be able to print food on demand. Is that one of the areas that is going to be impacted here?

Hod:

[00:39:30] That's right. The food printing is perhaps the killer app of your printing in my mind because again, it's the marriage of two big things that we do everyday, software and cooking. These are two big parts of our life today, but they've never really intersected in a big way. As I said before, the moment software touches something, it begins to grow exponentially. Software's never touched food, but the 3D printer that prints food, that you can dial the recipe and hit print, and it prints the food, puts all the ingredients together, cooks them, and makes something for you, that's a way to get software to touch cooking in a way that was not possible before.

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[00:40:30] There are great health benefits because you can tailor to your particular health and biometrics. There's also the ability to create novel foods that you can't make on your own, or you don't have the time or skill, and it's a new food space where people could share recipes or recipes could go viral, all these kinds of things. I'm excited to see how that unfolds. It's one of these frontiers of 3D printing that nobody's looking at. Of course AI can worm its way there as well and start creating recipes that it thinks we'll like that we can't invent ourselves. It's a new frontier and we'll see where it goes. Again, it's an example of software worming its way into an area where traditionally software has not existed, and when that happens, everything changes. If you think about it, most of us still cook like cavemen, with a frying pan over an open flame. Cooking hasn't changed from millennia, but it's about to take a big turning.

Bill:  
[00:41:00] Before we talk about your next book coming out, I was curious for the people listening if they wanted to really access talent and know-how within these different areas to help them solve problems with their businesses, where would you recommend they go to start to piece together the talent they're going to need to really reverse engineer, come up with new models for their businesses in these areas we're talking about?

Hod:

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[00:42:30] There's business questions, there's technical questions. But from a technology point of view, we're seeing kids coming out of all computer science, [inaudible 00:41:29] engineering, schools right now being very well-versed with these exponential technologies in ways that sometimes some of the more experienced people aren't. Because again, a lot of these things involve a fundamental paradigm shift that's difficult to keep up with. I'm seeing, when I talk about food printing, for example, younger people immediately get this idea that you print food like you download music, but older generations sometimes think it's a bad idea, and so you can see this generational transition. A lot of this is students coming out of universities. There are increasingly more and more on-line courses and so forth, to learn about this new machine, and techniques to learn about 3D printing, but the bottom line, this is moving so fast there's no single place where you can just go and learn everything. It's a moving target.

Bill: Is there a site that congregates for an E-lance or an Upwork, or a Gaggle or someplace that data scientists tend to congregate that people can go and try to tap into to build their own algorithms and to build their own maybe 3D printing capabilities, etc.?

Hod:  
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[00:43:30] There are certain websites where you can play around with this an recruit talent. Some of it is through competitions and crowd-sourcing like Gaggle allows you to create, to create competitions around data, and you can see who the winners are and recruit them. There are places where you can see, let's say, and 3D printing, designers compete over market share on Shapeways or Materialize. You can spot the best ones there, but again, it's difficult for me to point out a single place where you can do all that, but there's a lot of crowd-sourcing environments where you can post a challenge and pick the winners, and that's a good place to start.

BIll: That's great. You have a new book coming out in October. Are you allowed to talk about the premise of the book or anything of that nature before ... we're going to try to get this show published right as you're releasing. Any sort of a preview?

[00:44:00]  
Hod:

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Absolutely. Our new book is co-authored with Melba Curman. We wrote about driverless cars. It's not a technical book that necessarily goes into all the details of how driverless cars work, but it's more about what are the enabling technologies? Why now, why is it finally here despite years, decades, almost a century of attempts, and it also talks about the ripple effect this technology will have over our entire economy. Most people when they hear about driverless cars, okay, it's going to be a taxi without a driver. I hop in and it takes me somewhere. But really it's a whole tsunami of things that are going to happen. It's going to hit everything from real estate prices to new business models to e-commerce, to jobs. I mean, it's a whole economy, it's maybe the biggest I think technological revolution that's going to effect us in the short term. I think we have to start thinking about it and get prepared.

Bill: How do you think it will effect automobile dealers? I know it's a small segment, but do you think the new models are going to ... since Tesla's going direct to consumers, is that what you think might happen?

Hod:  
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[00:46:00] No, I think the dealer and ownership is independent of the driverless car. You can see e-commerce model how people will buy cars and so forth may change, but in general, we'll see a lot more cars, I think a lot more miles driven because cars are going to be so easy to use. Traffic is going to improve. You can shift things without even being in the car, so we'll see a lot more miles driven per person, per capita, and so there'll be overall, more cars on the road. I think generally speaking, it's good news for everybody who's involved in cars, automotive manufacturers, software designers, anybody that sells cars is going to benefit. If these are going directly to consumers is orthogonal issue that could happen regardless of autonomous or not.

Bill:

[00:46:30] This has been fascinating discussion, Hod. I do appreciate you very much for your time. Is there any last thought that you want to leave with my audience, or anything that we didn't cover that you just want to make sure you leave people with, regarding any of the topics or outside?

Hod:

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[00:47:30] I think one thing to remember about this AI revolution is that it's a double-edged sword, and a lot of people think about, and I don't want it to come across as if it's an entire utopia. A lot of it has to do with how we use this powerful technology. For example, if you take driverless cars, millions of lives are going to be saved. 28,000 people a week die from car accidents, so incredible benefits, new opportunities for the environment, for commerce. But then we'll have jobs lost, for example. With new AI techniques, there's opportunities also for better health care, for better education, but also for surveillance, new kinds of weapons. There's a double-edged sword. One thing I think we have to keep remembering is that while this technology moves forward, and I'm definitely a tech-neo Utopian. I think the good far outweighs the evil, but we do have to recognize this is a very powerful technology and we should all remain engaged in the way it's being used in the plight.

[00:48:00]  
Bill:  
Is there a way to have AIs ... you mentioned competing with them out there. Can you have an ethics and governance AI that oversees in the [inaudible 00:48:06] action AI? Is that a possibility? What do you think about that?

Hod:

[00:48:30] Yeah, I think that's one approach. You can definitely have, I can imagine, civil rights drones watching over military drones, and checking that they're not doing anything that they're not supposed to, absolutely. That's probably the way it's going to go. It's not going to be anything abstract. It's actually going to be drones monitoring drones, and AI that keeps trying to look for things on the web to check that the censorship AI on the other side isn't banning anything. Absolutely. It's going to be an arms race in AI as well.

Bill:  
[00:49:00] How interesting. This has been blast, Hod. Thank you very much for sharing your thoughts and your wisdom with my audience. Where can people learn more about you? When you go to publish the book, obviously it's going to be available on Amazon. Is there any sites that you want people to frequent to learn about your new research and new material that you're sharing?

Hod:  
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[00:50:00] Our two books, Driverless, Intelligent Cars and the Road Ahead, covers a lot of these autonomous driving, but also the bigger AI trends, the exponentials that I talked about, so that's a good place to start. The book on 3D printing, called Fabricated, the New World of 3D Printing, covers a lot of these trends in 3D printing, the challenges with software, the design challenge, and food printing, and all these different ideas, so these are two places where we describe a lot of these long-term trends of technologies. But besides that, I think, as I said, it's a moving target. It's difficult to pinpoint a particular place where you find more information.

Bill: I will link up all these on the show notes so that people can access to the book. Both books, I'm staring at the Fabricated one right now, which I enjoyed, and I'll make sure all the listeners have the opportunity to go and purchase that.

Hod: Awesome.

Bill: I appreciate your time. Thank you, Hod.

Hod: Thank you.

Bill: Okay, bye-bye.

Hod: Bye-bye.