Dr. Thomas Furness and Applications of Augmented Reality (https://mindmatters.ai/podcast/ep94)

Robert J. Marks:

What's the cutting edge of virtual reality technology today? That's the topic today on Mind Matters News.

Announcer:

Welcome to Mind Matters News, where artificial and natural intelligence meet head-on. Here's your host, Robert J. Marks.

Robert J. Marks:

Greetings. In the beginning of virtual reality, there was Dr. Tom Furness. He's our guest today on Mind Matters News. Dr. Furness has been dubbed the grandfather of virtual reality, and as we have been hearing, has been a continued pioneer in the development and application of virtual reality. So, Dr. Furness, welcome again. Dr. Furness, by the way, is a professor in the Department of Industrial & Systems Engineering in Seattle at the University of Washington. So, Dr. Furness, we have been talking about a number of fascinating things, but there's still some things that I'd like to talk to you about. Another one is ARToolworks. Now, AR stands for augmented reality. I believe that augmented reality was actually a term coined by Tom Caudell, when he was at Boeing. But what is the ARToolworks? What are you doing there?

Thomas Furness:

Okay, let me stop back a little bit. When we were beginning the work in virtual reality in the Air Force, we really didn't call it that. We called it visual coupling systems, and there was no differentiation between VR and AR. Now, the difference really is between the VRs generally, where you are completely immersed in a computer-generated environment. That's all you see is the computer generation of images. AR, on the other hand, is where you see the real world, the physical world, but you're able to superimpose on top of the physical world, images generated by the computer.

Thomas Furness:

Now, that can be done one of two ways. It can be done as a video-based virtual reality or augmented reality. And that's what the Pokemon GO was, where indeed, you were seeing a video scene of the outside world, but then you just had the Pokemon figures on top of that or embedded in it.

Robert J. Marks:

I remember, that was a really big thing. And there were pictures of people walking off cliffs and stuff while they were doing their Pokemon GO stuff.

Thomas Furness:

That's right.

Robert J. Marks:

Yeah.

Thomas Furness:

And then, there's another augmented reality, where it's this, basically an optical combining, so you actually see through, you see the outside world through a medium, through which you can... It's transparent, but at the same time, you see computer-generated information. So, you're actually not looking at a video of the real world, you're looking at the actual real world. That's the difference between the two augmented reality is the video-based and the direct view or the see-through of virtual or augmented reality. So, it turns out, the easier one to do... I mean, in the early days, we were with head-up displays, and most of our displays that we're using in the cockpit, our head-mounted displays, were actually see-through. You could see the outside world and then see the virtual information on top of the outside world, in daylight.

Thomas Furness:

But at night, what we would do is basically all you'd see is the virtual world. So, to us, it was really a spectrum, where we went through complete see-through to complete VR. And so, it was never, we never differentiated between the two. But as the technology evolved over a period of time, there was this notion of Tom Caudell. Indeed, a project that we did with Tom at Boeing was where we were looking at the wiring harnesses, how we could use augmented reality to help manufacture wiring harnesses for the large body aircraft.

Robert J. Marks:

So, this was the wiring sort of schematics for Boeing aircraft.

Thomas Furness:

Yes, very difficult to do this when you're, the traditional way of just putting wires on top of a blueprint. But with augmented reality, you would see a loom that contained these pegs, where you're going to stream the wires and you see one wire, virtual wire superimposed over that. And all you had to do is just take, look at that one wire and string it through this particular set of wiring looms to get there. It was a breakthrough, and that's what we called, we started calling this augmented reality, and as to differentiate it from where you didn't see the outside world, it was all computer-generated.

Thomas Furness:

So, what happened in the late 1990s, I had a graduate student, in conjunction with the HIT Lab New Zealand, Mark Billinghurst. He was a Ph.D. student in electrical engineering. And we were playing around with, how do we provide a way to interact with virtual images? Because what we were doing at the time was, we were trying to use these hand controllers to reach out and grab things. But we became interested in, how can we use objects as a means, tangible objects, as a means of doing this interaction? And we could use computer vision technology to actually track these tangible objects, and have them interact with the images.

Thomas Furness:

Then, the idea came to mind, well, why don't we just put the images over the top of these objects? So, this became what we called, what we began to call video-based, augmented reality. And so, what would

happen is, let's say that you would have these special glasses that you'd wear. You put on these glasses and they have a television camera in the middle between the two eyes. And then what would happen is we'd display that image to the eyes. So basically, what you'd have is a video view of the world. Then, we'd take an object, for example, a piece of cardboard or a piece of paper that had a black square in the middle of this. And there would be a symbol in the middle of the black square. When the camera that we're wearing on our headset saw the black square, it started tracking it. And by looking at the edges of the black square, it could determine the pose or the orientation and position of that black square relative to the headset.

Thomas Furness:

Then, what we said is, "Okay, there's a symbol inside of that black square. That meant something." And so, we would recognize that symbol, a particular character, and that meant an object. We would extract that object from a library of three-dimensional objects, and we've superposed it in the black square. So now, it appeared that, that three-dimensional object was like super-glued to this card. And as you move the card around, it tracked perfectly. It was like it was really there, but it wasn't there. And this became the beginning of what we call the ARToolKit.

Robert J. Marks:

Oh.

Thomas Furness:

And so, what you can do is build them, build these objects. Objects can interact with each other. You can build a whole system. It's like Legos of this, that you see the real world, but you see these virtual objects in the real world, depending upon where you place these tangible markers, these tangible card markers. So, in the late '90s, I think it was actually '98 or '99, we had an exhibit at SIGGRAPH.

Robert J. Marks:

Yes.

Thomas Furness:

In the emerging technologies section of SIGGRAPH, where we demonstrated this. And we actually had a memory game. We had set out where you'd have two players who would be wearing these glasses and a big table. Then you have these cards that you would turn over. And let's say that you had turned over a card and you would see a spaceship, you see a flying saucer. Then, you'd turn over another card and you'd see a broom or something like that. And they didn't match. So, you turn those back over, and then you'd turn on... Then you go around playing this game, and then you turn over a card and there's the flying saucer, again. You turn over another card and there's an alien. Then you bring the two cards together. And the alien jumps into the flying saucer and it starts flying around the room.

Robert J. Marks:

I see. Okay.

Thomas Furness:

So, it's the memory game, only with a difference. And so, that's what we demonstrated at SIGGRAPH, and everybody just went ape over this.

Robert J. Marks:

Yes.

Thomas Furness:

This way of losing tangible markers as a means of manipulating computer-generated images, that appear to be there on those markers. We built a thing, teleconferencing where you can actually flip over the cards and call a person and they appear on top of this card, and you put them around your desk. So, you're interacting with these people in 3-D, around your desk, little miniatures of these people. We were also, we had one big card that we made in our lab. And when you walked in, if you had these glasses on, it's the Millennium Falcon. So, you see the real room, you see the real lab, but the Millennium Falcon is sitting there in the middle of it, and you could walk around it, the Star Wars Millennium Falcon. Anyhow, that got us started. So, we started this company, we built ARToolKit at the University of Washington. And then we released it, open-source, and we had 100,000 downloads.

Robert J. Marks:

So, is this still available for open-source?

Thomas Furness:

Yeah, it is.

Robert J. Marks:

Do you know the website off the top of your head?

Thomas Furness:

It was through Vuforia for a while. I don't what it is now, actually, what the latest one is. I'll have to let you know.

Robert J. Marks:

Okay, thanks.

Thomas Furness:

So, what happened was, we had all those downloads and we're thinking, "Hmm, maybe we ought to start a company." And so, what we did was, we started a company called ARToolworks, Inc. The idea, we were going to take the open-source thing and rewrite it, and support it, sort of like Unix and Linux and so forth. And so, we did that and started this company. It was the very first augmented reality company. It started in 2001, and existed until about 2015, when we sold it to DAQRI. And then, DAQRI worked on it for a while and DAQRI went belly up.

Robert J. Marks:

Oh, no.

Thomas Furness:

But you could still get it, I guess. But this has become the foundation for just so many other companies, that have taken this and built other approaches for doing this kind of thing, the same kind of thing. Matter of fact, there's one company that split off from my HIT Lab in New Zealand call Quiver.

Robert J. Marks:

Quiver.

Thomas Furness:

Then you can go online, QuiverVision, go online, QuiverVision, and you download these little, it looks like a coloring book. And what you do is you can print out this coloring book, and then you'd have your kids color those with crayons, and then you put, take your phone or VR device, and you look at that page that you've colored. And now it pops into life. This texture-mapped, the objects are textured-mapped by what you colored on that two dimensions onto a three-dimensional figure, and they do various things. They play games and things like that. And that's called QuiverVision.

Robert J. Marks:

That is so interesting. I got to ask you, I got to ask you now about your NSF project that we talked about offline. That sounds so incredible.

Thomas Furness:

Well, what happened in the early days, again, when I was working on virtual reality, we found that it was pretty amazing what was happening in the far periphery. That, indeed, we were taking in lots of information from the peripheral retina that we weren't necessarily seeing. So, when I did finally come to the university, we had a project that was funded by Eastman Kodak. Eastman Kodak was trying to build, and based upon, basically a plan that I gave them, what was called a world vision system. And a world vision system, and I sort of convinced them to do this, because, what Eastman Kodak is? I convinced them. I think I was trying to convince them. I gave them a keynote address at their awards ceremony, their annual award ceremony. And the theme of my talk was that Kodak is really, this is when Kodak still existed. That, actually, you guys are actually in the transportation business, and not in the image business. Why are you in the transportation business? Okay? Let's say, and I'm sorry for this story. It's going to be, take a little bit.

Robert J. Marks:

That's fine.

Thomas Furness:

So, here we have, let's say that we have this amazing Kodak technology, film technology. And so, let's say you're taking your family for a visit to the Grand Canyon. So, you're driving up to the Grand Canyon. You're up in the parking lot, park your car, you go outside, and to the rim of the Grand Canyon, you whip out your camera, it has Kodak film in it. Then, you take these photographs. And then, you go back home and turn in your roll of film to your drugstore. This is when film, when cameras still had film, and then you get your prints back. Then you look at the print, and you think, "Hmm, it's not the same as being there." Do you show it to your friends? And you tell them, "Well, you just sort of need to be there."

Thomas Furness:

I said, "That's the business you're in. What your business is, you're taking our eyes to another place in another time. The problem is, the vehicle you've built to take our eyes to another place and another time has really small windows."

Robert J. Marks:

Oh, yes.

Thomas Furness:

What you need to do is build a transportation system that lets you open the door, walk outside, and be there, and be there again and again and again, and take your friends so they can be there. And what you need is a world vision system. Then, what I did was, I outlined a whole program for them, to build a world vision system. I was doing this just for fun, just to give a talk. And I'd outline the world acquisition system, the world synthesis system, the world delivery system, the networking, all of that, in this talk.

Thomas Furness:

Well, after I finished, this executive vice president from Eastman Kodak comes up to me and says, "Have you written this down?" And I said, "Not really. I mean, I was just doing it for this talk." He said, "Would you mind putting together a concept paper for us on this world vision system?" And I said, "Oh, sure, I'll be happy to do that." So, I did, and sent it to them and they started a $20 million program. They awarded the University of Washington, the HIT Lab, the largest project that was ever done with a university.

Robert J. Marks:

Now, who was this? Who was this sponsoring organization again?

Thomas Furness:

Eastman Kodak.

Robert J. Marks:

Oh, that was Eastman Kodak. I see, okay.

Thomas Furness:

So, we started working on it. And the first question that they wanted to ask us is, well, how good does it have to be, that to feel like you're there? So, we started doing research on this. Okay, that's how good does this picture have to be? And we started simulating various devices that would give you wide field of view, high resolution, things like that. But the problem is, how do you measure it? What is the dependent variable? Because so what we'd used up to this time is all subjective. You say, "Do you feel like you're there, on a scale from 1 to 10? Do you feel present? Do you feel immersed?" All this. And of course, this variability all over the place in this subjective assessment.

Thomas Furness:

We realized that we needed an objective assessment for this. So, we came up with this scheme of, let's measure postural stability. Let's measure how we can affect the balance of a person as a function of how big a picture is and whether it moves, and what is the resolution of it, things like that. Because this

is a direct connection to basically the central nervous system, through the postural stability mechanism, from our eyes.

Thomas Furness:

So, that's what we did. We built a posture platform. People would stand on it, they were in a harness, because we'd knock them off their feet. And we would display these different fields of view to them, up to 180 degrees. Sure enough, what happened is, as we increased field of view, the effect kept increasing, which meant that we had more and more presence with the wider field of view that we gave them. But our instrumentation was limited to 180-degree picture, because we're using a rear projection hemisphere. We're projecting all this for our studies. And I decided, we're going to have to eventually go back and extend the field of view because it's still going up. It hadn't asymptoted, in terms of the effect. I thought it would asymptote by that, based upon the work I'd done in the Air Force, but it didn't.

Thomas Furness:

So, here recently, I went back to visit this again. I'm really intrigued what's going on with the peripheral retina, especially since recent research shows that the retina extends way beyond that 180 degrees. And indeed, at the rim of the retina, in the area called the ora serrata, there is a rich ring of cone receptors, which gives us a highly detailed color vision, just right on the rim of the retina. So, why is it there? Because what happens is, the detectability, the limit of detectability is really around 100 degrees, all facets, which is 200 degrees. We were able to only go in our research with 180. But I was interested in what happened beyond that. This NSF grant was to help me explore that.

Thomas Furness:

So, we started doing the research to say, okay, what is the limit of detectability? And so, we extended the range out to where we'd go all the way out to 240 degrees field of view. And we found that pretty much around 101 degrees is where people stop seeing visual images. So, at 100 degrees centricity, which is one axis, you add that together to about 200 degrees is the limit of detectability. If you go beyond that, toward the rear, you don't see it anymore. Right?

Robert J. Marks:

Yes.

Thomas Furness:

And we've start from the rear and go front, that's when you start seeing it again. So, there's a little band there, of the limits of detectability. We said, "Okay, that's interesting. What if we display something beyond that?" The limit of detectability. Because the rim of the retina is way beyond that.

Robert J. Marks:

Really? Okay.

Thomas Furness:

Okay? So, what we did, we did these experiments, where we display different objects in the far periphery beyond this limit. And asked the subjects to identify what object we presented. They said, "But I can't see it." We said, "That's okay. Tell us what you think it is." And they get it right.

Robert J. Marks:

Seriously.

Thomas Furness:

Yes.

Robert J. Marks:

That's amazing.

Thomas Furness:

So, this is what is called perception without awareness. Now, it's obvious that this information is being processed in the brain somehow, but it's not in our consciousness. Now, it's probably processed in other ways, but we believe, and this is where we're continuing to do our work, that this may be a direct channel to some of the subconscious, and to the limbic system and to the emotional state, and actually help you establish where you are.

Robert J. Marks:

I'm not familiar with this system that you talked about.

Thomas Furness:

Limbic, limbic.

Robert J. Marks:

Limbic.

Thomas Furness:

Limbic system. This is sort of the emotional side of people. And this is, we're particularly interested in that because that's where stress comes in, and perhaps pain, things like that. So, it's conceivable that we can build devices that are inconspicuous display devices that only display information to the far peripheral retina, that you don't realize that are even there, that can help heal you.

Robert J. Marks:

That's incredible, Tom.

Thomas Furness:

Yeah. So, that's what we're continuing to do, in what we call the Ben Lab, which Benjamin Hall at the University, and with an NSF sponsorship.

Robert J. Marks:

That is really amazing stuff. And you're going to be doing experiments in this, I guess?

Thomas Furness:

We are.

Robert J. Marks:

And psychologists.

Thomas Furness:

Oh, yeah. Yeah.

Robert J. Marks:

Goodness. That's incredible. Well, let me ask you one final question about, what do you think the future of VR is going to be like? We see stuff in movies, like in The Matrix, where there's total immersion. You have no idea you're in a virtual reality world. I don't see that ever happening, but Elon Musk just came out with something where he sticks wires in your brain. I've decided that he's not going to stick any wires in my brain because I think it's kind of wacko stuff. But what do you see the future of the technical reach of virtual reality, in so far as total immersion?

Thomas Furness:

Well, I believe that indeed, we aren't going to stick wires in the brain, but they're already there. We're born with them. It's called the optic nerve.

Robert J. Marks:

Aha.

Thomas Furness:

We have the most amazing optical coupling to the brain that you can imagine. We also have an amazing coupling of a chemical sensor to the brain, which is already there, which is olfactory bulb. We have the same, we have gazillions of sensors in our skin, the largest organ of the body. It's already there, the interface is there. So, what we need to do is just figure out a way to stimulate those sensory end organs, that provide us this picture. We don't have to put wires into the brain. Well, it's already there. So, what we need to do is just figure out a way to do the optical coupling. And that's what we're talking about with these virtual visual displays, virtual acoustic displays, and virtual olfactory, and whatever, the different senses. So, I think that what will happen, is we will realize that that is a way to go.

Thomas Furness:

Now, let me back off a little bit. It's easy to get intoxicated by all this stuff. It's easy to get intoxicated about virtual reality, because you've had the experience, you put the headset on. And by the way, that's a sacred moment, the first time you put a headset on a person, and they experience VR for the first time. It's sort of a holy moment, because they'll never be the same after that.

Robert J. Marks:

It's like remembering where you were when Kennedy was shot or when the space shuttle exploded, and all of those other things.

Thomas Furness:

That's right.

Robert J. Marks:

Yeah.

Thomas Furness:

And that's what we've found over the years and especially all the educational projects we've done. I've done 10 different projects with kids in education, using VR. It's amazing. What we found is, kids that were failing caught up with the smart kids. And we test them a year later, and they were better. It all has to do with awakening of the spatial memory. And that's what VR does. Once you've been in a virtual world, you never forget it. It's just like you were talking about. And so, it's a very powerful meeting. We're playing with fire, and we're unleashing enormous power, in terms of the ability to influence people. Because we're putting these images in their head that will never go away. And we're doing that by putting them in a place. We're putting places in people by putting people in places. So, we have to be responsible for that. And that's one of the reasons why I did the Virtual World Society. This is because we need to not go to the default of building games of violence that people will play in VR. We need to be using VR for education.

Robert J. Marks:

Tell us about this society. It is a society that you founded, right?

Thomas Furness:

Yes.

Robert J. Marks:

And this is its mission?

Thomas Furness:

Yes, the Virtual World Society mission is really to do three things. One is to unlock intelligence, link minds, and lift hearts. And it's all for humanitarian applications of virtual reality, in education, in medicine, in design, to lift mankind. Whereas, the default of industry is to tear us down, by practicing killing people. And if you kill a person in VR, it's different than killing a person on a computer screen, because you're up close and personal. When you blow out their brains, it's different. And what happens as a result of that is you either have nightmares or you get numb. So, what I'm trying to do in the Virtual World Society is all these projects that show the positive aspects of what we can do with virtual reality, in education, building what we call a learning living room. This is where we have thousands of families around the world, who are basically Theo laboratories that are using VR for educating their families, as well as coupling with the other families that are doing this.

Robert J. Marks:

You're right. I can see that breaking down social barriers.

Thomas Furness:

Yes. And it's amazing on generating empathy. I mean, when you go... And New York Times has done this, when they... If you're a subscriber of the New York Times, you received in the mail this Google cardboard, and you basically assemble this and put your phone in it, your smartphone, and then you could download of these different experiences. One of them was a food drop in Africa. And here you are, standing on this field, with all these other people from a village, waiting for the C-130 to fly over

and drop food. Wow. That changes your life. You'll always remember it. You'll see the faces of those people, what happened when they rushed to the packages, and you're there in the middle of it. And this is transformative in terms of generating empathy, and what is going to be the future of news, and because you're going to be there.

Thomas Furness:

So, I think that, again, the Virtual World Society, we're just a fledgling society. We have about 1200 members now, but these people are really keen on doing humanitarian things. They want to build these worlds that educate and lift. And I mean, we're doing work with the Make-A-Wish Foundation. We're doing things for helping communities who have a problem of social unrest, with people who are isolated because they have dementia, or because they're locked into a nursing home, or in a hospital. And so, this is the area where there's a huge market for VR. I'm trying to point the way to industry to say, "Hey, guys, there's a whole market out here. We don't have to default to games of violence."

Robert J. Marks:

Where would you go to find out more about the Virtual World Society, and can anybody join?

Thomas Furness:

You bet. And you can join for free. So, you just go online to www.Virtual World Society, one word, .org and their amazing newsletter about what we're doing, and the community. We've built a platform called, we make reality for kids who want, or people who want to be involved in building these worlds and so forth.

Robert J. Marks:

Excellent. We'll put a link to that on the podcast notes. So, I guess virtual reality is like any technical tool. It's not good or bad, it's how you use it.

Thomas Furness:

Absolutely. And that's why we need, as a civilization, to be responsible for these tools. It's not going to replace what's out there now. I mean, it's just going to be just like television didn't replace radio. And so, it is just another tool in our arsenal to help us grow and progress and make the world a better place.

Robert J. Marks:

Dr. Thomas Furness, what a wonderful note to end on. You've led a full and rewarding career in virtual reality, being one of the big pioneers and also leading innovations in it. And you got to have a good feeling about living a life like that. Congratulations, sir. It's really, really good stuff.

Thomas Furness:

Thank you. I'm a lucky guy.

Robert J. Marks:

Yes. Yes. When you're able to use the gifts that God has given you for the good of mankind, it's a good life. And also, Dr. Furness and I, we share something in common. Our wives won't let us retire. Right?

Thomas Furness:

That's right.

Robert J. Marks:

Yeah. You were in a trial retirement and your wife said, "Nope, you can't do that." So, you got to keep on working. I was talking to a friend of mine at church, and he said, "Nowhere in the Bible did they mention that people retire."

Thomas Furness:

That's right.

Robert J. Marks:

And I told my son, of course. I told my son that. He was happy to hear that. But I did say that it does talk about kids taking care of their parents when they get old. So, maybe, maybe that will kick in somewhere.

Thomas Furness:

Well, it's better to wear out than to rust out, right?

Robert J. Marks:

Exactly. Exactly. We've been talking to Dr. Tom Furness at the University of Washington. He's a professor there, an innovator in virtual reality and augmented reality, and is sometimes dubbed the grandfather of virtual reality. And Tom, it's been a delight to talk to you.

Thomas Furness:

Same here. Thank you, Bob.

Robert J. Marks:

Okay. So, 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 mind matters dot AI. Mind Matters News is directed and edited by Austin Egbert. The opinions expressed on this program are solely those of the speakers.