You're listening to Imaginary Worlds, a show about how we create them and why we suspend our disbelief. I'm Eric Molinsky.

Way back in the 1990s, when I was studying animation, our instructors used to tell us to avoid animating realistic human being. What's the point? You can animate <u>anything</u> you want. And more importantly, you can't do it. No one can cross The Uncanny Valley.

In case you don't know what that means, The Uncanny Valley was first proposed in 1970 by a roboticist named Masahiro Mori. He predicted that in the future, when robots looks more and more like humans, they would repulse us until they look indistinguishable from real human beings. But the Uncanny Valley will be very difficult to cross because we are biologically wired to read human faces – if anything is slightly off we notice it right away because we have a primordial instinct to avoid people that appear diseased or psychotic.

Robotics didn't make the leaps people were predicting back then -- but computer animation? No one saw that coming. I remember how shocked people were by the digital dinosaurs in Jurassic Park, and those special effects are ancient by today's standards.

And speaking of Steven Spielberg:

CLIP: READY PLAYER ONE TRAILER

His new movie, Ready Player One, is coming out -- based on the novel by Ernest Cline. It takes place a future where the Internet has evolved into a virtual reality universe where everyone interacts with each other through their digital avatars. When I read the book, I imagined these avatars to be completely realistic, but when I watched the trailer, the avatars were so digital looking; it completely triggered the Uncanny Valley in me. In fact, the digital humans in current videos games are easier to watch than the digital humans in this virtual reality world, which is supposed to be set in the future.

Which made me to wonder – why are people trying so hard to cross the uncanny valley? Why is it still the holy grail of computer animation? Are we getting closer? What's holding us back? And what happens when we cross it?

Strap on your VR headsets, after the break.

> BREAK

This subject may seem really technical but it's personal for me because even though I left animation I've often wondered if I stayed, what would I have been working on? And how would my job would've evolve with technology.

I studied animation; we were still filming pencil-drawings with clunky video cameras. So I was curious how the uncanny valley is being taught in schools today.

I visited Terrence Masson (MASS-on), who runs the computer animation department at the School for Visual Arts in New York. When I showed up on a Friday afternoon, he was lecturing about a dozen students at their computer terminals.

TERRENCE: Here also a show here I have this example of why CGI characters so often look bad and why it pisses me off , it really does. (FADE DOWN) So I'm showing you a test by Activision in real time facial animation…

Terrance worked in the industry for decades. He was an animator on the Star Wars prequels. He's worked at major video game companies. He even helped Trey Parker and Matt Stone build the software for South Park.

TERENCE: Thanks everybody.
Thank you – clapping.

After the lecture, we sat in his office and he explained that the big breakthrough came about 10 years ago with something called "sub-surface scattering" – which can simulate all the inconsistent splotches, freckles, colors and hairs on the human skin. But digital effect can also simulate something much more important, and subtle:

TERRENCE: Everybody has done this including my five year old as a kid you put a flashlight behind your fingers and your fingers kind of glow red right because that the Light enters the skin it scatters it bounces around and then it reflects back out having picked up some of that color of blood. So to be able to do that in

C.G. was basically a huge necessary leap forward to accurately render flesh skin. And before that it just looked plastic.
So this is sort of the almost the internal light that a person has that's coming from inside of you?
TERRENCE: Yes.
As a living person as opposed to being a corpse that God that makes your skin luminescent?
TERRENCE: Yeah exactly right.
That's the thing that makes us look healthy.
TERRENCE: Yeah.

But that can exacerbate the Uncanny Valley. If digital humans look photorealistic, then our expectations are sky high when they start moving.

Terrence started ticking off the problems. No two people form their words in the same way. Everyone's mouth shapes are idiosyncratic. That requires a lot of extra work from animators, who are always crunched for time.

Also if a digital human is seen in a close-up or a medium shot, the animators will often only animate what we see on screen but when we move – every muscle in our bodies is interconnected, head to toe. But if the animator forget that:

TERRENCE: Otherwise it's just somebody on a stick you know it's a severed torso on a stick.

But the big problem are the eyes. His favorite term is "eye darts," which is when your eyes dart back and forth while you're thinking. Animators either forget to put those in, or they just move the eyes randomly.

TERRENCE: You can tell someone said well you're better or the eyes move so they'll just kind of look at something else in the room and then come back to the center position. Right. And without that kind of animated thought going on within the characters mind it just goes dead.

It's funny once he pointed this out, I started noticing this all he time when people were talking or speaking, just how their eyes dart around as their thinking. To demonstrate his point, Terrence showed his students footage of the most eye darty person that he could think of: Martin Scorsese.

Scorsese rarely makes eye contact with the interviewer, but he's super animated, especially his eyes.

TERRENCE: When he talks about working with someone on set about a film or about something he's recalling from 50 years ago. You can watch his eyes and he's actually imagining what he's talking about in his mind and his eyes are darting around following those ideas and tracing color of what he's recalling. It brings it all alive.

We tend to think of the uncanny valley with movies – but there is a better imperative to get this right in video games. Almost every major game has realistic humans that you control, that you're supposed to build an emotional connection with.

And if you haven't played a video game since Atari – they've gotten a lot more complex. In fact the way a game would work – and I'm talking major big budget games -- is you'd control a character that would run, shoot, jump, punch, kick – video game stuff. When you reach your goal, you watch a "cinematic," which is a computer-animated movie that illustrates the next story beat. And that's where you'd see the characters up close, doing subtle acting, but it was always very uncanny valley-ish. So not only are animators trying to move out of that uncanny valley, but also they're trying to blend those two – so you don't put down your game controller when it's time to watch the cut scene. They all blend into each other so you feel like you're controlling a character in a movie.

Needless to say, that puts a lot of work on animators like Vladimir Mastilovic.

VLADIMIR: In movies, it's much easier.

He runs a game studio in Serbia called 3 Lateral. And he says the big difference in a movie is you see whatever the director wants you to see. In games, the player controls the camera.

VLADIMIR: You can't control you know from which angle the player will view the characters. Everything has to be rendered in real time rather than you know being rendered 10 hours per frame. So the challenge is orders of magnitude greater.

His company specializes in scanning real actors to create digital doubles. And he was part of a team that collaborated on a game called Hellblade: Senua's Sacrifice. Senua is the name of the main character.

She's an 8th century Celtic warrior who goes on an epic journey. But Senua is mentally ill. She thinks her psychosis are supernatural voices – in fact in the game, we see these voices manifest themselves as mythical characters or doppelgangers of her. It's a trippy game with a scary atmosphere and gritty attention to detail.

CLIP: SENUA

And unlike a movie, a game is recreated every time you play it. So if you have a character Senua who does a lot of complicated acting, your game console has to process all that memory power.

VLADIMIR: When it comes to the complexity of digital puppets. It's usually the high and intense emotions, which is also hardware intense. That's because that's where you need the most the biggest number of facial shapes and you know the code that runs the faces.

So in order to have hyper realistic humans doing believable acting, they also have to figure out ways to keep compressing the data.

VLADIMIR: So that's why we have these very elaborate level of detail systems which completely invisible to the player basically just shut off a lot of weight when it comes to the asset itself.

Digital humans are typically modeled after the performances of actors wearing motion capture suit, or MoCap for short. You've probably seen the behind-the-scenes footages where it looks like the actor is wearing black leotards with Ping-Pong balls all over their body and dots on their faces. And there's a rig on their heads with a camera mount that is directly back at their faces. That performance gets transferred on to the digital character, and Vladimir's company invented a technology that allows that transfer to happens instantly. He says they need to do this because otherwise the animators would never think to add things like:

VLADIMIR: The specific way of how the skin on the lips get stuck with the upper lip or the lower lip or how the eyelid unfolds against the skin that covers it or the

jiggle of the iris. So you know you would say that that amount of detail is crazy but for some reason we perceive all that. So I get a feeling that we will have to basically recreate all this phenomena until we can say that you know we created an appearance of digital human and I wouldn't say that we're close to doing so it would probably take another decade.

Another game studio doing hyper realistic humans is Naughty Dog in Santa Monica, CA. Naughty Dog's two big franchises are the Uncharted games, which are like Indiana Jones adventures, and The Last of Us, which is a zombie type adventure – but the designs of the zombies are really monstrous.

The main character of the first Last of Us game is a young girl named Ellie who survives the apocalypse with the help of an older mentor named Joel. And in the trailer for the sequel of the game – which isn't out yet – we see Ellie, now a teenager, more hardened than ever. She's in a room, there's blood on the floor, blood dripping down her face. We don't know what's going on but she's calmly playing the guitar. And the close up on her hands is incredibly realistic. And then we cut to her face, blood dripping down, and she says to Joel.

"I'm going to kill every last one of them"

That scene got the whole industry buzzing. And it's weird because I knew it was not a real person, it was a hyper realistic digital person, but she felt more real and alive than just about any video game character I've seen.

I talked with Marianne Hayden, who is an animator at the studio. And I asked her, why are digital humans looking so much better? She says it's became the motion capture has gotten so much better.

MARIANNE: You know the first couple of games of Uncharted. You can look at the motion capture data is kind of it looks jagged around the edges even though it's been touched by an animator. It's just much more precise now picking up a lot of the nuances that maybe we didn't see before.

Now Marianne went to the same animation school that I went to – CalArts. And in our program really stressed creative freedom. I asked whether she feels less freedom working with motion capture.

She says, no. The actors never look exactly like the characters, so there's a lot of tweaking. They also have to caricature te movements to make them feel more real – and they add stuff all the time. In fact, sometimes they stitch together different performances the actors gave to create an original acting moment invented by the animators.

MARIANNE: Some people feel like we're loosing animation when we have the motion capture and I just think it's a base to start out as an animator with the eye of an artist take it one step further.

But what amazes me about characters in the Naughty Dog games are the eyes. Like in this scene between the main character of the Uncharted video games, Drake, and his wife Elena. I've seen previous versions of Drake and Emily, which are plastic looking, but in the fourth Uncharted game, they look not just hyper real, but their acting on the eyes is so subtle. Like here, they're having a difficult conversation, their shifting his weight and they have trouble making eye contact. In fact it was only after watching the animation scene that I realized people do this all the time in real life, like even if they're focused on something, they're doing tiny eye darts, registering micro-things.

MARIANNE: But there still needs to be an extra layer of love put into the movement. And it's not just the eyes moving because when the eyes move your eyebrows move and like your cheeks move and your nose moves. Sometimes if you're smiling and looking around like your whole face is alive. And if part of that isn't captured in the data then we have to go back and add that and I think that part's getting it as perfect as it can be from taking that original performance and then amplifying it so that it crosses the uncanny valley. That's the tricky part. That's what our job is.

And, of course, telling a good story.

MARIANNE: I think the more immersed you are hopefully the less you pay attention to the fact that these aren't really real people but they feel like they're real because you're emotionally invested and viscerally invested. If it looks really great it plays really great and you're enjoying it. Then I think you're not in that valley anymore.

But a game studio is still limited by the processing power of the game consoles. You know who isn't limited by very much? Industrial Light and Magic.

CLIP: ROGUE ONE.

In 2016, they took on a big leap into uncanny valley with the movie Rogue One. If you haven't seen Rogue One – spoilers ahead.

The movie takes place right before the original Star Wars: A New Hope. It was about how the rebels who stole the plans to blow up the Death Star. And the filmmakers wanted to bring back characters from the 1977 film.

Darth Vader was easy. They got James Earl Jones to do the voice, and they put a new guy in the costume. But they also need Darth Vader's right hand man, Grand Moff Tarkin. The actor who played him, Peter Cushing, died in 1994. So they brought an actor in named Guy Henry to play Tarkin in a motion capture suit. Then they animated a digital version of Peter Cushing on top of Guy Henry's performance. And to make things even more challenging, their digital Tarkin was sharing the screen with fresh and blood actors.

HAL: You know I think we had shots of Tarkin in rogue that were great and totally convincing and then there were others that that were less so.

Hal Hartley was the animation supervisor on that character. He mentioned all the same issues of eye darts that feel motivated, mouth shapes that feel specific to Peter Cushing, animating the full body even if it's not in the shot. But they had another problem. We've only seen Tarkin was in the original Star Wars, which had a harsh 1970s style of lighting. The lighting in Rogue One was more subtle.

HAL: And so we would put our CG Tarkin into the shots and that lighting rig one lighting and we know we'd work on it. We were kind of we were kind of we'd feel like we were so close but it just doesn't. It feels like Peter Cushing's cousin or something we know what's the problem and so we did an experiment where we took the same animation same texture same model that we've been working with and all we change is the lighting and we lit it like one of these shots we've been staring at from 1977 and boom it was an instant improvement and likeness was like oh that's Tarkin, that looks great. That's Peter Cushing. But the problem was

when you light him that way and he doesn't match with anything else and it looks pasted on.

They managed to find a balance between the two styles of lighting. But:

HAL: The other thing that's difficult about digital humans is the sort of swamp of opinions that you. Find yourself there because you know you assemble the best team you possibly can and you are all together every day reviewing the work and looking at it but would find often happening as you know you're all in there looking at it and somebody goes you know what it is foreheads do high and then somebody else goes, no it's the forehead. Fine we checked. You know what it is I think the nose is just not quite long enough or whatever you know. And it is amazing that the nose is fine it's easy to look at the cheeks the X and the X where. And you know it was rare that everyone would walk in and there'd be this consensus exactly what the issue was. And I'm talking about when you're way down the process and you're in that last two percent are really hard to define. Hard to crystallize things where there's something bugging everybody in the room or most of you in the room but nobody can quite agree on what it is. And that's where you start to even lose if you're not careful you start to lose your own certainty about your own opinions. You start to second guess your own opinions and that's when it gets really hard to get that to get over that last bit and get over the goal line with the uncanny valley and all that because identifying what that those final little percent of believability are and realism is just the hardest thing!

Now I have nothing but reverence for the skills of Hal and his crew – they're some of the best digital animators in the world. So I hate to admit this but Tarkin didn't work for me. He looked great, but I could feel the decisions the animators made, like I could see when they decided his eyebrows should crinkle, or when he decide now he should blink and turn his head.

And Hal did get that kind of feedback from some of his colleagues in the industry, and he got a lot of praise as well.

HAL: But amongst general populace moviegoers like I've given a bunch of talk since the movie came out and some of them have been to completely non industry people and I would say the vast majority of those folks I've had tons of them come up to me and say oh, I thought you recasting or something so that tells me we got most of the way there.

But if Grand Moff Tarkin was hard to animate, recreating the young Princess Leia was even harder.

HAL: The architecture of Tarkin's face as her cannot describe it kind of just gave us more to work with. Whereas her face is just -- especially of that age of 18 or 19 I think -- and it's just this perfect form with like flawless skin and as soon as you started moving things and lighting it just like any for anything that was even the tiniest bit off was glaring.

CLIP: ROGUE ONE.

They had a young actress do a motion capture performance, but Hal wishes they could've scheduled time with Carrie Fisher. In the end, the producer Kathleen Kennedy did to show the footage to Carrie Fisher, shortly before Carrie Fisher died – which made Hal very nervous. Finally word came back:

HAL: She loved it. That really made us all feel good. I was like thing we were biting her nails about the most to be frank. I mean we knew it had to be the capper on the film and that was enough pressure. But honestly the thing we cared about the most was Carrie going to feel about it.

I asked Hal if any digital humans had blown him away. And – sorry but this is a spoiler for Blade Runner 2049 – so if you haven't seen it, skip ahead a minute.

Hal said he was blown away by Rachel in Blade Runner 2049. She was a character from the original film, and they wanted to animate a new scene with her, looking as she did in 1982. But in this case, the animators were able to bring back the original actress, Sean Young, to do a motion capture performance.

CLIP: BLADE RUNNER 2049

This has been before. Jeff Bridges, Robert Downey Jr, Kurt Russell and Michael Douglas have all played younger versions of themselves. And they were cool effects, but you could always tell they were digital effects. I asked Hal – in his professional opinion -- what did they do differently in recreating young Rachel? Even he couldn't put his finger on it.

HAL: It was the absence of you know she comes on screen and you go oh that's cool but it was the absence of the but it was just like wow it's her that's amazing.

This whole experience has left him feeling kind of frustrated.

HAL: You kind of get to a point of what's the point?

And he says his company ILM gets contacted all the time to bring back dead celebrities.

HAL: I'm very squeamish about that I mean people have asked me and some of the talks I've given some pretty pointed questions about the morality of even you know what we did with Tarkin and with Tarkin I felt really assured because he only did stuff he did in New Hope, which is stand on the Death Star and bark at people about firing the Death Star laser. On the other hand if someone came in and said you know we want to how are you going to do a TV commercial and we want to put Jimmy Stewart in it. I have to bet I have to just decline.

But recreating celebrities isn't just for the pros anymore. There's a new app called Deep Fake where you can try this at home. And a bunch of people used the app to reanimate that scene of Princess Leia from Rogue One.

And there were all these articles that said, look! This just as good as the pros at ILM! And I looked at it, and it's not even in the same league.

But Deep Fake is being used to create fake sex tapes of celebrities. And what's even more disturbing it's being used to create digital versions of politicians saying things they never said. That's a whole new scary level of "fake news."

But Terrence Masson is still optimistic about where this technology is going, and how it could be used.

TERRENCE: Eventually will become so much automatic and so cheap. That's going to be the endgame is that it will be available in real time Augmented Reality and Virtual Reality and photorealistic and hyper real ready well ready the world. *The world of Ready Player One.*
TERRENCE: Yeah yeah but really cheap and just everywhere and yeah everywhere and everything.

When I studied animation, our teachers would often use a phrase called The Illusion of Life. It came from by these two Disney animators, Frank Thomas and Ollie Johnston, who said when you animate your first character, even if it's just a bouncing ball, you will become so amazed by the illusion of life -- you'll be hooked on animation forever. And I remember that feeling and thinking, I want to do this forever. I didn't, I left the industry, but talking with these animators reminded me how much I miss that delighting in knowing, after a lot of hard work, I had created the illusion of life.

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And the desire to create life is part of what makes us human – and not just for the survival of the species. Whether we think this technology is good or scary, we will never stop wanting to create the illusion of life -- even if the life we create is only good at conniving us that it's human.

That's it for this week, thank you for listening. Special thanks to Terrence Masson, Vladimir Mastilovic, Hal Hickel and all the other experts I talked with that I didn't have room to include.

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