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Charlie Morrow: So it's nice that you could talk with us today. We've known each other for quite a few years here in Finland and I had the pleasure of being in your anechoic chamber, for example. And I knew about your work long before with your invention in software that's coursed through the world, and there's some interest in your background and your foreground. So maybe you could tell us a little bit about your first experience with immersive experiences and immersive sound.

Ville Pulkki: Oh, thanks Charlie. It's a great pleasure. I guess somehow I have been always interested in sound and music. Most music I was listening to when I was, I don't know, five or six, I had a record player and I played one [record] or maybe I had two.

Yeah, I had two. Yeah, my family was a bit annoyed of that. Children's songs all the time. And, from that time I also remember the first experience of directional hearing. We were out there in the field and there was an airplane and then somebody said: "Hey, do you notice that the plane is there?"

But you heard the sound from behind it. And it was like, wow, that's true. I could somehow perceive the direction of the sound source. That was the first place when and where I noticed it, I think. And then I've been also interested in silence. Like, when in Finland you ski in wintertime and you stop in the center of the woods and there is no wind or other sounds.

So it's completely silent and it's somehow a very powerful emotion you get there. But yeah, so I started to go more, I was always trying to make some music with whatever I had in my hand and also musical instruments. And at some point I started to go to piano classes and was singing in choirs and there was quite a lot of music in schools and later as a teenager, I was really thinking that I'm a classical pianist and that's my way to go. But I was also quite good in school and did okay in physics and mathematics, and in high school I started to like a lot this physics and I thought that, yeah, that's my thing. I wanted to be an engineer and or study physics or something. And then after high school, I was studying technical physics or engineering physics at university – or it was technically before – but at the same time I was still continuing my piano classes.

Then the music was so high and I was so excited that I made a decision that I would continue my music studies and I wanted to be a music engineer one day, never knowing what that might mean. Okay, I got the name of the film: All the World's Mornings is the name of that film.

Yeah, so I applied and I got into Sibel Academy to study musical education. So I was trained to be a music teacher for high school, although I never really took education or pedagogical classes there. But then, I had been in that school for three years and I needed some added income from somewhere.

And then somebody here on the Aalto university campus – I was here for some reason – someone said to me: Hey, Vil, there is a very cool project coming up involving Sibelius Academy and Aalto University. And I said, cool and they said they'd pay something like 2000 euros for it. And I was cool and I took that.

And then I ask, what do I need to do? And they said that Sibelius Academy had this 32-channel loud speaker set-up, or a concert hall with a lot of loudspeakers in the ceilings and walls. And Aalto University had 8 Channel D to a converter, which was really cool at that time.

The year was 1995. And then they said that they want to control the direction of perceived sound and I said, okay, I can do that without any knowledge of how to do it (laughter). And then I said, so what should I do? And they gave, gave me some papers on pay-wise panning where you have two loud figures and you pan the sound between those two and then, they said that, yeah, here is some background, do something.

And then I was kind of thinking of it for two months on how to solve this. And I first of this trip that, okay, if they're talking about pairs, so here it's treated, it must be triangles, then I was thinking about it for quite a long time, how to compute the gain factors for those loudspeakers in loudspeaker triplet.

And then I finally got this vector-based idea, which gave the direction for this vector-based amplitude panic. And it worked well. And I was happy that I had was educated in such a way that I realized that nobody else had ever done this before and it was really a golden egg in my hand. So I published it and gave the code away free to everybody.

So, then everybody started to use it. And Charlie also, it seems, yeah (laughter). Okay, and then I had to make a decision: do I continue with this special audio

endeavour or should I continue with my music? And then I thought this looks so good, this special audio [focus] that I wanted to continue there.

So then, I applied and got funding for my PhD studies at the university. And then I [focused] my PhD around this spec-based amplitude planning. And then after that, I became interested in sound and also building something by myself. I was interested in questions. So if somebody asks me a relevant question in my field, I never forget it.

It always stays somewhere in the back of my brain. And then one day maybe the answer pops up out of my brain. I don't know how it [happens], if there's some kind of green man behind some curtain or something. But whoever is sending me these messages, yeah, sometimes I get, that wow or aha effect.

Yeah, but yeah, you asked me about immersive sound. I don't know. I mean, I like sound, I like music. I like to invent. But it would not be true if I were to say that I'm really interested in immersive sound so that I really want to get immersive sound to highest possible level, just because it is *immersive* sound.

It's more that I'm interested in this work, the work of an inventor or a scientist. And then it just happened that my inventions are in the field of immersive sound. I dunno. What do you say?

Charlie Morrow: I think it's like that for everybody. I don't think that we start out with specific goals, particularly because these were new thoughts when you did your inventions, you could do them because there was uncharted territory.

Uh, same for me, and I think this is what became interesting for me. I became interested in VAP as I had started out as, amongst other things, an outdoor composer of outdoor experiences. I left the concert hall and decided I'd rather perform with musical instruments in open spaces [that was] free to the public.

I wanted people to come to hear experiments in music and sound and language that they might not hear otherwise, so they should come for free. So that's what we were doing in New York and it's in that context. What to do in a park, what to do with sound that can be heard a kilometer [away].

The circumstances led to the observations, but it was first experience and then giving it the name. Yeah. Would you like to talk about the work that you're doing now, though? Cause I think I was amazed by your headset.

Ville Pulkki: Yeah, yeah, okay. So, after this PhD, I had a few topics that I have been working on like this let's say ambi[sonic] recordings and using some knowledge of human hearing to enhance them, which then, bypasses some of the artifacts that exist in first order **amons**, and that's actually quite a big part of my work [involving] directional audio coding or what has been coming out of first order and higher orders, also for impulse responses. But then also it's kind of diverging to be informing – and we've used some of the same principles how in how to make the beam pattern of a microphone array to be as narrow as possible.

And then also, at some point, there were some studies with lasers and because when you measure impulse responses of more spaces then loudspeakers are problematic because they're quite bulky and big, and they have a directional pattern. But if you take a high-power pulsed ultraviolet laser, then you can explode the air and you get the small spark there, which produces something like 170 decibels, which is quite loud.

Charlie Morrow: I'm looking at a chart behind me and we can see exactly how loud that sound is.

Ville Pulkki: But it's a nice way to measure impulse responses, but it's a bit, dangerous. You can light fires and if it comes [near] your eye, you will lose your sight, which is a problem.

But that's still on. Hopefully we can continue the work to develop it to a safe version of it. And then I studied also psychoacoustics, like how good we are in hearing the directions of different broadband sources and some modeling of human hearing; how do our hearing devices work in the brain?

But lately at some point, I got this idea of super hearing, spatial super hearing that … you know that when bats are yelling a lot, they are actually very loud. Some bats can produce something like 120 decibels of sound, which is something that we are glad we don't hear because it's so loud.

But sometimes it would be nice to hear the kind of sources we have around us and where they are. So, they exist, these devices, they're kind of modulators that they bring the sound to an audible range and then they play the sound back with a small loudspeaker. So then you'll hear the bad sound from your [source]. But then you don't know where the bad is. But we can kind of pinpoint this knowledge of how to modulate the sounds to an audible range [using] this knowledge of this spatial audio reproduction, this direction, audio coding knowledge. And now we have a headphone device where we have six microphones on a cube, a small cube, like a dice or a die.

And then we kind of measure in one millisecond windows, where the sound is coming from, and then we bring the singing or sound signal to an audible range. And then make it audible via some processing to that direction where we analyzed it to come from. And it's a quite nice effect because we really can then hear that there are bats in that tree …

There is a small light leak here. Or you can find that power supply in your closet that makes some ultrasound noise. So, it means that there's some vibrations inside that power adapter and it might break in one place. But yeah, we are going to continue this work to [help the] blind, [making] helping devices for blind people and maybe divers.

We are going to try if we can hear the wifi stations around us and localize them by hearing. Yep, I kind of like to make this kind of a bit of esoteric project.

Charlie Morrow: Well, it's wonderful that you follow your bent. I mean, there's a saying in the pop music business that when you're having a good time, you don't even notice that have recorded that tape that's going to sell millions of records.

And it seemed to me it's the same with any kind of invention. Often you don't have any idea what the value is because you're just so deeply engrossed in making it with your hands.

Ville Pulkki: Yeah. And then it's very valuable if somebody comes to you and says that, hey, we could use this here and there, and then it's great to me also to find that somebody is interested in my technology, who is willing to take it and use it somewhere.

Because I mean, the scientific publications are nice because they describe what we have been doing, and that's of course something we have to do. But they are worthless if they don't ever lead anywhere or if they don't lead to any influence in society, among people or industries or something.

Charlie Morrow: I think it would be very nice now to play a few examples of the sound. And so at this point i we'll have some hearing examples.

Ville Pulkki: There is in this example we were actually walking next to a streetlight in Espo, Finland. And there were bats flying around that streetlight catching insects that were attracted to the light. And you can hear that they are moving. They sound like birds and they kind of go around and you hear that they're moving.

Yeah, the bats are flying around quite fast. You can hear that they are flying around quite fast, but they are so fast that it's hard to say where they are actually, because our hearing is a bit sluggish, especially these items, those mechanisms that are related to interval time differences, decoding or encoding, they [react] a bit sluggishly than the actual direction of the source.

Okay, and in this demo there was a bicycle innertube in which we made a very small leak. And you can hear it on the recording, you can hear this sound coming from left to right because I was moving the bicycle innertube in front of the camera. So, in this demo there was bicycle innertube [with] a very small hole and I was moving it left and right in front of the hearing device.

So you heard this sound going left and right and there's one demo, which is about the listening test and it's quite boring.

Charlie Morrow: Well, we were talking about emotion before and I thought it was very honest of you to say that a lot of the discussions about emotion have been based on different principles. The first one you recalled was from Audio Engineering Society paper, back in the, I think, 1990s.

Ville Pulkki: This actually was quite recent, like in the last five years. There was somebody showing in a New York convention something that actually also came out in the journal later, but they were going through different definitions of immersion and what does it mean and they like the idea that immersion

happens if something is mediated [regarding] you and you don't realize that it is not real.

So it's kind of a perfect illusion that you really think that something is real. And then immersion can happen, for example, if somebody sees a video of a fire for the first time and then the viewer blushes because he sees the fire, which causes this kind of physiological reaction, which can be said [to be]total immersion because the viewer thought that it was a real fire and had this effect of [feeling an increased] temperature in the skin. But it might not happen when you show the fire video again – it doesn't have the same effect. But, then this relates to some scientific definitions and then we can talk about immersiveness if something is a bit immersive. But, in a way, I kind of like the idea that the better you reproduce everything, all these aspects that humans are sensitive to the better is the, let's say, level of immersion and then you are closer to that original scene. But, of course, you have to compare this, the quality of reproduction. And you should then always have the listener in the original place and in the reproduced place. And then somehow you should be able to compare those perceptions because in audio it is practically impossible to reproduce the sound fields as they are just because of various limitations.

There are the microphones and loudspeakers. And [you have various] shortcomings in the technologies. And then finally, it doesn't sound the same, but it's very hard to say how [exactly] it is different and what is causing this. Hmm. I don't know if we are close to the immersion anymore, but it's kind of a subjective term. I like it because it's describing the perception of the listener and in a way, it's the ultimate goal of spatial audio reproduction.

Charlie Morrow: You've made a point though that really interested me since you're a music lover, music maker, performer and you've said in fact you enjoy performing more than you do being in the audience.

And you said when the rhythm and the melody and the harmonies all come together, there's something really special and you said that it's a kind of immersion. I wonder if you could talk a little bit about when the music works.

Ville Pulkki: Yeah, I mean, there's so many levels in audio reproduction and already before photographs and anything, music was reproduced as some kind of clockwork that the melody was sent as a kind of thing you could play in a clockwork or in these mechanical pianos. You had those pianos and then it

became a revolution because you could [transport] audible music from one place to another and what you were reproducing was some kind of melody, some kind of harmony, some kind of rhythm. They didn't have too much of a voice yet, but still, it was an industry with somebody producing them and getting money out of that.

Nowadays you have so many ways to do it, but anyways, then you were going to photographs and gramophones and you've also got the voice and real instruments and strings and horns and everything reproduced, that's always better and better. But still, I mean, when you can deliver music, you didn't need so much. And then, of course, you could think that finally the people who are the composers, they could have been actually designing their music in a way that it fits these clockworks, that they can bring a very nice piece of music to the people using this media that they have. Yes, I really enjoy playing piano, singing. I enjoy performing; I perform in musicals by singing, acting, and dancing. Maybe it's similar that I really love to build my measurement devices and my summer houses and what not. It's the same thing as enjoying music and the best is I enjoy it when I make it myself and I'm playing … my piano. That's just so enjoyable. Of course, good music from audio or whatever, headphones or loudspeakers can be also very good. But I would say that I enjoy it more when I play it myself.

Charlie Morrow: It's interesting to hear you say that. One of the writers who's involved in this immersion project of mine; I interviewed the poet Jerome Rothenberg, who's been my mentor over the years. He's older than me, and he said one of the most immersive experiences is the lone poet or lone musician all by themselves, just creating in the moment.

Ville Pulkki: Mm-hmm. You're kind of inside that music. Yes. I also compose a bit and you can check my YouTube page of my compositions and it all kind of springs together that making music yourself and bringing it to an audience. But when you're a composer, it's quite a long road when you're typing some notes with your software and then finally somebody is playing it somewhere or singing it and, I mean, I don't necessarily need that. I'm performing it myself, but it also feels so great that when my peace is played somewhere and if I happen to be in the same place. Of course. That's excellent.

Charlie Morrow: Well, thank you for being in this place and having this conversation, which we've recorded and very much appreciate.

Ville Pulkki: Thank you Charlie and thank you for listening to this.