SIGGRAPH Spotlight: Episode 84 - Award Winning Voxelized Destruction at Real-Time Live!

27:15

SPEAKERS

Angus Forbes, Tim McGraw

V **Voiceover** 00:00

Music.

V **Voiceover** 00:08

Welcome back to SIGGRAPH Spotlight today. SIGGRAPH 2024 Emerging Technologies,Chair Angus Forbes, welcomes SIGGRAPH 2024 Real-Time Live! Bes-in-Show and Audience Choice Award winner Tim McGraw, for an enriching conversation about his award winning demo and his passion for computer graphics. Angus, take it away.

A **Angus Forbes** 00:31

Hello and welcome to SIGGRAPH Spotlight. I'm Angus Forbes. I served as the Emerging Technologies Chair for SIGGRAPH 2024.

A **Angus Forbes** 00:39

My background is in graphics and visualization. I'm currently working at NVIDIA as part of their strategic researcher engagement team. Real-Time Live! is an amazing event that showcases cutting edge real-time technology demos from researchers and artists from academia and industry. It's presented each year live in front of the SIGGRAPH audience and the program is always an attendee favorite. Today I am thrilled to sit down with Professor Tim McGraw. Tim recently won both the Best-in-Show and Audience Choice Awards at SIGGRAPH 2024's Real-Time Live! program. His demo, “Mesh Mortal Combat: Real-Time Voxelized Soft-Body Destruction” presented real time simulations and rendering methods for soft body destruction

of voxelized meshes, and was especially notable both for its technical prowess and the macabre humor of the presentation in which unfortunate cartoon models met their increasingly improbable demise.

A Angus Forbes 01:33

Tim, welcome to SIGGRAPH Spotlight, and congratulations on your well earned awards from SIGGRAPH 2024. Before we start the conversation. Can you tell our listeners about yourself, who you are, what you're currently up to?

T Tim McGraw 01:44

Hi, I'm Tim McGraw. Good to talk to everyone here. I'm an associate professor at Purdue University. I research and teach in the areas of scientific visualization and computer graphics programming and related classes.

A Angus Forbes 02:02

Fantastic. Let's start by talking about your award winning submission at SIGGRAPH 2024 just start by giving us a high level overview of what Mesh Mortal Kombat is,

T Tim McGraw 02:13

What that is and where it came from, kind of the origins of it were a demo I wanted to show to class for a compute shaders class, and it evolved over two semesters of offering that class as one of the class projects that we do, position based dynamics, highly parallelizable. So can make good use of compute shaders. And the way that technique works is you can define all of these different sort of constraints between particles. And one of the places we start out with the distance constraints, kind of the easiest one, and you can build up chains of particles and make shapes and things like that. And it's always interested in seeing what other sorts of constraints we could come up with. And one of the challenging things, one of the things I wanted to do initially was come up with this perpendicularity constraint, to have keep three particles in a right angle without having to make a triangle out of it. That kind of extended can we make a square? You can make a square by putting the diagonal in there, I guess is, anyone with any kind of structural background knows make the four edges of the square. You put the diagonal a little become more stable, but kind of wanted to see if I could do just four particles make a square, eight particles make a cube. And kind of came out of that. The first semester I had just a deformable model I could build up out of voxels or out of started in 2d kind of generalized from 2d to 3d so I guess pixels to voxels, and then embedding the mesh and sort of initializing it from the mesh was the next place, and then being able to break some of the constraints, pull things apart. I always loved that SIGGRAPH. Over the past, I guess, five years, some of the techniques, like material point methods for had a lot of great demos with I remember, well, I think it was 2020, or so the sort of sandwich, the bread getting pulled apart. And can we do that in real time? How close to real time can we get on stuff like that? So that was the origins of that project.

A Angus Forbes 04:23

Fantastic. So was the innovation, fundamentally, that you simplified the mesh so that you could do these types of deformations in real time?

T Tim McGraw 04:34

It's interesting, i'm actually going to present this at a conference in just a couple of days. I'm going to be talking about this again at ACM MiG, motion, interaction and games. And I'd say the contributions are, first of all to increase the parallelism. What we're modeling is actually not a full voxel grid, but it actually has a sponge type of structure, and you can kind see this in the demo a few times, where I'm showing sort of just a cube of these voxels, and I get rid of the particles, and you can kind of see just how the voxel or the particle centers are connected. If we had a complete voxel grid, each particle would be shared by eight different voxels, and so that limits the degree of parallelism. You can't have all eight of those voxels that influence a particle being processed in parallel, because they would all try to overwrite each other's results. You'd have to read write conflict. So with that sponge structure, we actually reduced it to each particle shared by four different constraints, a voxel and what I call the face constraints, which are the breakable constraints. So that was one, and the other contribution is being able to make use of the Graham Schmidt Ortho Normalization technique to constrain the particles. So there were other shape constraint techniques that rely on saving the previous transformation, saving a matrix. They have to keep this state warm start the polar decomposition, which is used to figure out the rigid body transformation of the shape relative to its rest pose, but we didn't need this anymore. We actually compute it just in terms of particle positions, using Graham Schmidt. And so turns out our voxels can actually be totally stateless. So I don't need to keep track of which particles influence each voxel, because I know each eight consecutive particles influence each voxel, and so I don't need that previous transformation matrix, and so that reduces our memory traffic, our memory throughput, and really helps speed things up.

A Angus Forbes 06:52

Yeah, very cool. I mean, the results speak for themselves. Just out of curiosity, what type of system did you run the demo on at Real-Time Live!

T Tim McGraw 06:59

This is my Lenovo laptop here that's got a pretty decent Corei9 processor in it, and NVIDIA 4070, it looks a lot better on a desktop GPU. I shall have to throttle it down. Anyone, I guess, who's done PBD is familiar with the fact that it's frame rate dependent, there's a lot of parameters to tune. So as you adjust one thing, you may have to adjust some other things. And you know, I was kind of tuned to this laptop, and actually I had to throttle things. I had to sleep my main thread every frame to kind of keep things working. And then on the backup machine was a desktop machine. If you're not familiar with real time live, you've got to come with backups of all your technology in case your sort of main device fails. And so that desktop machine was even faster. I had to throttle even more. So do some tuning when we're on site there doing rehearsal. I've started experimenting, looking at doing things in the headset on the

quest two. So with the Qualcomm system there, we're able to run on all types of different hardware. And of course, the complexity of the model may have to change a bit, but yeah, we're able to get some pretty good performance out of it.

A Angus Forbes 08:18

Yeah. I mean, it looked amazing at Real-Time Live! and the project obviously captured the tension of the jury. You won the Best-in-Show award as well as the Audience, and you took home the Audience Award as well. Kind of a high level question, what's the value of creating something that resonates both with research experts and enthusiasts? Follow up question, what advice do you have for others who want to target both audiences?

T Tim McGraw 08:42

I mean, a lot of the value was just the personal gratification that people came up to me tons over the entire rest of the conference the following three days, and I talked to someone at the conference the next morning. They're like, Oh, you're the guy everyone's talking about. Like, oh, man, I met so many people over that course, so many connections coming in on LinkedIn and on social media. So it was a lot of fun. I can't say that still a project I'm working on, so there's still sort of outcomes as far as that goes. All in all, it was a really, really gratifying experience, personally for me, sorry, what was the follow up again?

A Angus Forbes 09:24

I guess advice for people who want to participate at SIGGRAPH and participate at Real-Time Live! specifically, and I think the audience was struck not only by the technology and the ability of these meshes to be kind of ripped apart, but also your sense of humor. Your presentation was very natural, but I would say somewhat dark, but also very humorous at the same time. So I was just curious about that.

T Tim McGraw 09:48

Yeah, so first thing I would say, I when I was getting ready for this I, you know, I've seen a few when I'm there at the conference. I don't get to go every single year, but I've watched all of them now they're available on YouTube. I really wanted to start with a set piece. I didn't want to start just talking, describing things verbally. I didn't want to start, I think in Technical Papers, sometimes there's a temptation of people, they kind of want to build suspense and build up to anticipation. And you'll listen to all the technical details. And you know, 10 minutes in you, you kind of show your greatest result. But I think in the published papers, you have the teaser figure and that, like, puts your your great stuff right up front. And that's what I wanted, was the set piece right, right to start with the best result I had, which was the armadillo. And I wanted that just right there, right in the first minute. As far as the humor, you know, I realized that early on, it could have been pretty dark and violent. I wanted the presentation of it to be more comic violence, I guess. So I stayed away from any human type meshes things like that. I there's copyright issues I couldn't do, like Wiley Coyote or Itchy and Scratchy, but that's kind of

the vein I was I was thinking of things in, and I really thought, yeah, the humor would try to lighten things up a bit, because, yeah, could've seemed very dark and violent and kind of weird. And why is this guy doing that as far as applications.

A Angus Forbes 11:23

Yeah, I'm trying to remember what you had. You had a Armadillo and you had a teddy bear. What else did what other meshes did you have?

T Tim McGraw 11:29

Yeah, the gummy bear I had, like, sort of a cartoonish pig in the spot, the cow with the steaks, the ones that didn't make it. I had a skibbity toilet mesh. I wanted to have maybe some more pop culture reference things like that. One of the challenges is the technique is pretty sensitive to the input mesh like so do have to bit of do a bit of processing. It has to be water tight, and I have to actually pre process the mesh and pre compute all of these axis aligned plane intersections with the mesh and sort of output that as save. That is something I load at runtime, and it's interesting, those kind of old school classical graphics techniques. There's still work there to be done. I was not able to get all of the meshes I wanted to work to make them water tight and have this sort of Boolean pre slicing algorithm work out. So I've got blender scripts that kind of do all that for me. Some of them work. Some of them don't work as well. I would have loved to had some more things, like the more cartoony characters and pop culture stuff. As far as the copyright stuff goes to I wanted as the outro, was all ready for the sort of cheesy techno Mortal Kombat song to come on from the movie, from the old original Mortal Kombat movie. So I was going to kind of DJ to that as the outro, and along with the beat, kind of tear up the armadillo and the other characters. But I guess, as kind of mentioned earlier, one of the applications I'm looking at is I get the resolution up, is maybe a virtual dissection, and eventually maybe a surgical simulation, as we get the fidelity. But I don't think that would play as well, right? That would be another thing, I think might be a little dark for something like a Real-Time Live!, to have a very human dissection there and in real time.

A Angus Forbes 13:29

Oh, interesting. I guess I had assumed that the applications would be to games or interactive projects, but you're saying there might be applications to scientific visualization or surgery simulations?

T Tim McGraw 13:41

But I call it virtual dissection, a little lower fidelity for like, maybe general gross anatomy education, because that's something I think there's a little more funding for out there, right? It's going to be tough to ask NSF or someone to fund me to help make video game technology, but if there's some sort of educational outcome or some sort of social benefit.

A Angus Forbes 14:06

I was struck by what you said about there's still work to be done in quote, unquote, old school graphics your project, I thought was notable. I think it was one of the few that didn't use generative AI or emphasize AI or machine learning techniques as a main component of their project at real time, live and really throughout SIGGRAPH. Any thoughts about that old school quote, unquote graphics versus kind of generative graphics?

T Tim McGraw 14:30

Yeah, I guess the thing I would say is certainly, well, not generatively, but have been looking at relation to pins physics inspired neural networks. So as I look at the arrangement of the computation here, doing things on the regular voxel grid and doing sort of the physics update and computing these deltas to positions, it's got a lot of similarities to something like a ResNet with convolutional layers in there. And as we sort of break things up into partitions on the compute shader, we partition the problem up into these subsets that can be done in parallel, it becomes very much like the layers of a neural network. So I, in doing the implementation, really see the parallels there. So I do have a student taking a look into that, but, yeah, I do wonder if maybe part of the Audience Choice Award could have had something to do with maybe a little bit of AI fatigue or AI that's a very diverse audience, a lot of students, a lot of artists. There maybe some people wary of the AI, taking jobs, things like that. So, so there may have been a little bit of that in there, but I do think there is some room for the technology to sort of help in projects like this. And the parameter tuning. I've got a lot of hyper parameters I sort of manually tune in in the technique like this. And you know, if we could train a network to do that would be great also. So I think there's a lot of body use for it. But as far as its origins as a class demo, that's really where it came out. It was just sort of a low level compute shader programming where we don't really, we're not up at the PI torch lever level and the neural network architecture level, we're kind of down in the start out in the small scale, image processing, physics simulation type of stuff.

A Angus Forbes 16:31

Very interesting. It sounds like you've been working on this project. I think you mentioned for a couple of years now. It sounds like you're adding additional features to it. My question for you is, what roadblocks did you encounter along the way of developing this project? How do you overcome them? I assume there are many iterations of this project to get to the level where it was award winning and real time live worthy. And I guess my follow up question is, what are the maybe you mentioned some of them right now about maybe exploring physics inspired neural networks or some other tools. How did you are there any stories about coming into a finding a roadblock, and finding a way to overcome it, and having resilience to keep working on the project? And research, as we know, is never done. So is there any problem you're working on now to try and to optimize the project?

T Tim McGraw 17:18

Yeah, so a little more background, maybe for people who haven't submitted to Real-Time Live!, you submit only a 90 second video, and you give an outline of your six minute talk and a few other things. And I saw that. Well, 90, 90 second video, I can, you know, I can do that. And so my 90 second video was probably 15 25 second shots. Every one of those was a different

version of the code was was over the course of a week or two where I'm polishing and pulling in other data and get another shot. Oh, that looks cool. I'll add that. And I kept working on the project itself. And then when it actually got accepted, then I had to go back, and I didn't check in the code every time I got a shot, and I overrode a lot of stuff, changed a lot of stuff. So I really when it got accepted. You know, what you see in the demo there at Real-Time Live!, is almost a total rewrite of the code to head to, to really different process of from just having to make some five second shots and stitch together a video to having to do six minutes live and sort of go from one technique one data set to the next to the next. So that really helped me do quite a bit of of cleanup, introduced some additional bugs, added some additional features. So there really was a good amount of development that happened after it was accepted, which I think people probably stressful on it here, but it really did evolve a lot. And also the rehearsal. So another part of Real-Time Live! is going and actually do a rehearsal. Do an on site rehearsal at the beginning of the conference, do an online rehearsal, sort of between when it gets accepted. This was in about June or so, so I had to kind of crunch and get that version ready for the rehearsal, and then crunch some more after rehearsal to get some new things in.

T Tim McGraw 19:30

But as far as sort of the newer things, I'm looking at the roadblock, of course, the resolution, right? It's a it's fairly low resolution. I think maybe deceptively low resolution. People looked at the surface mesh can be an arbitrary triangle mesh, but you know, the internals, I think all of the things we looked at in real time live, were voxelized to 32 by 32 voxels. Doesn't sound like a lot, but 32 times 32 times 32 times eight ends up being quite a lot of particles. So there's a lot of processing happening there. But to get that resolution up, we're looking at Adaptive grid techniques. So sort of refining the outer surface, refining the outer, sort of exposed parts of that model, and having much higher resolution. So in terms of breaking things down, we've got sort of what I call the voxels, and I've got the face constraints. So trying to generalize that face constraint, rather than just connecting two voxels of the same size to connect voxels that have different LOD levels. So can I connect, have this face constraint, join a voxel, you know, that's two by two by two, with another voxel that's one by one by one, and then I can then, at some point, have even more LOD levels. And sort of adaptively, as we break the model apart, the exposed parts you see are the higher resolution and the internals will be the lower resolution grid.

A Angus Forbes 21:06

Nice. Thank you. As a computer graphics researcher, as an expert, as an enthusiast, where does this drive and passion come from? What motivates you to work through all these roadblocks and iterate over and over again to get to better and better research.

T Tim McGraw 21:23

I guess the fundamental motivation, just like making images, like to make a picture, like to create something. But I think in terms of the drive and the motivation, I feel an irritation and a discomfort when things don't work. It's difficult to walk away when the project isn't compiling, or, you know, the latest thing and trying to do isn't working. I think, yeah, it's that feeling of unease I get and I've got to come back. I've got to fix it. I've got to make it work. Say, Yes, a

good amount of it is debugging, in terms of the general technique, you know, it's easy to describe in a couple of pages in a paper, but the underlying implementation is sometimes a lot trickier to get actually working. So I think that is one thing, but another thing. And I think in terms of advice to other people, or to students, people looking to get into industry or something, I tend to practice the craft, and then encourage students to do the same. If you want to go into some field, you want to work in, got a lot of students here want to go into the game industry. Well, build that portfolio, practice your craft. Don't just do class projects. Have your own thing, build up that demo reel on that portfolio, and make a project that's your own and that you can talk about, and that helps reflect sort of your vision and your style. I guess I've thought of it as my creative outlet. I've dabbled in other sort of hobbies, you know, in electronic music in the past, and dabbled in photography. And I think it all kind of having some other related hobbies also kind of helps, I think, for people who are working, I wouldn't say, Sit there crunch time and in the studio and then go home and write some more code. But in those situations, I think maybe having a related hobby can kind of help and give you some feedback and some influence into your work.

A Angus Forbes 23:31

So when was your first SIGGRAPH? How long you've been going to SIGGRAPH for?

T Tim McGraw 23:35

Oh man, I never went as a student, and my first SIGGRAPH would have been in Boston i think 2007 was my first SIGGRAPH. I've been to Vancouver a couple times. I've been to LA a couple of times, and Denver. Voice, that's maybe six or seven, something like that.

A Angus Forbes 23:57

Was this your first submission to Real-Time Live!

T Tim McGraw 23:59

This was my first submission to real time live, yeah, but I will say about the conference, it is, I think, for all of us, like a holiday. It's the second best time of the year, if you're, I guess, if you're into Christmas, right? It's, it is that Christmas day feeling of getting there and looking at the program, figuring out everything you're going to do, it is really a thrill to get to go there, especially as part of work, right? As we can use this as some professional development also. So it's, it really is great experience.

A Angus Forbes 24:32

Yeah, it's a fantastic conference. Well, I guess we can wrap things up. I'm curious one you mentioned that you're presenting this work in kind of a more technical venue as a paper, is that right? Can you say a little bit abouwhat conference that is?

T Tim McGraw 24:44

Yeah, motion interaction and games. That is another SIGGRAPH conference, actually, ACM SIGGRAPH conference on motion interaction and games. So Arlington, Virginia, not sure when this podcast will be out, but maybe I'll see you there. Maybe I've already seen you there. If you're listening.

A Angus Forbes 25:00

Nice and final question, anything you're working on that you want to talk about or mention to your audience here,

T Tim McGraw 25:06

I am still working on this. I've got master students working on all types of things, but at the point in the year that they're sort of finishing up proposals on those so maybe I'll just, I'll cryptically say stay tuned and see what comes out. And hoping to get something submitted to one of the venues, maybe not Real-Time Live! again, maybe one of the other so many great places to look at submitting things, Immersive Pavilion, Technical Papers and short Courses. So those submissions are opening up here soon. So we'll take stock of what all the students have gotten done here over the break and look in January and see what we're what looks ready.

A Angus Forbes 25:52

Right on. Well, Tim, thank you so much for taking the time to join us today and to celebrate your award winning work with us from Real-Time Live! for those of us in the audience who haven't yet had the pleasure of viewing Real-Time Live!, you can check out the full show on the ACM SIGGRAPH YouTube channel. We'll provide a link in the notes to this podcast. And thank you to the audience for joining us for this episode of SIGGRAPH spotlight. If you want to submit your latest demo or your latest innovation to SIGGRAPH 2025 please make sure to visit s2025.siggraph.org, to view the program Submission Details and deadlines, which again, begin in January, I think, real time lives deadlines a little bit later, and save the date to join us in Vancouver from August 10 through the 14th next year for SIGGRAPH 2025 Thank you, Tim.

T Tim McGraw 26:44

Thank you. Bye, everyone.

V Voiceover 26:49

Thank you, Angus and Tim for a wonderful episode of SIGGRAPH Spotlight. If you want to submit your latest demo or innovation to SIGGRAPH 2025 make sure to visit s2025.siggraph.org. And save the date to join us in Vancouver from August 10 through 14th 2025.