WEBVTT

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00:00:00.570 --> 00:00:02.399
Amy Walton: Well done amanda Okay, but you know.

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00:00:03.600 --> 00:00:04.529
Amy Walton: excellent track record.

3
00:00:06.720 --> 00:00:07.259
Okay.

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00:00:13.110 --> 00:00:14.219
Amy Walton: And Thank you everyone for.

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00:00:14.219 --> 00:00:19.170
Amy Walton: letting us know this is very, very helpful so i'll go ahead and.

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00:00:20.460 --> 00:00:21.990
Amy Walton: start all right.

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00:00:23.820 --> 00:00:31.980
Amy Walton: Well Thank you everyone for joining us today I want to welcome you to the size distinguished lecture, it is my great pleasure to introduce amanda.

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00:00:32.400 --> 00:00:44.070
Amy Walton: randalls she is the professor of biomedical sciences at Duke university and has already a master a long list of awards and publications.

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00:00:44.460 --> 00:00:54.570
Amy Walton: The things that I think we had nsf are most proud of is that she is one of our incredibly productive career awardees and during this time of pandemic she has done some.

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00:00:55.230 --> 00:01:08.790
Amy Walton: Very important work which she will be speaking on today so rather than taking time away from her talk, may I take a moment to say thank you and welcome Dr rambles it's over to you.

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00:01:09.570 --> 00:01:13.980
Amanda Randles: Thank you very much thank you so much for having me i'm really excited to talk to you all today.

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00:01:16.080 --> 00:01:26.490
Amanda Randles: So I wanted to all cover in the talk different ways of using personalized flow simulations and I

wanted to start with the idea of you know why should you actually care about personalized flow.

13
00:01:26.910 --> 00:01:35.130
Amanda Randles: And what I mean by personalized flow simulation is really creating patient specific models that are allowing us to improve diagnostics treatment.

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00:01:35.730 --> 00:01:44.280
Amanda Randles: Really planning the end the outcome and caring for specific patients on an individualized basis what i'm really passionate about is using.

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00:01:44.550 --> 00:01:57.060
Amanda Randles: large scale parallel computing cutting edge computing to kind of push forward what we can do for personalized medicine so i'll kind of cover today a couple different areas of how how we've been trying to focus on.

16
00:01:58.770 --> 00:02:04.950
Amanda Randles: And they asked me to start with a slide of giving you an overview of me in one slide introduction introducing my background.

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00:02:05.460 --> 00:02:11.490
Amanda Randles: So I kind of kind of put this tight this timeline together together to give you a sense of where you know.

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00:02:11.970 --> 00:02:21.930
Amanda Randles: Where where i've been both from a personal standpoint and from the research side so everything on the top is really associated with the career side, so in 2005 I graduated with.

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00:02:22.290 --> 00:02:27.090
Amanda Randles: My undergrad degree from Duke university I studied physics and computer science and I think this is.

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00:02:27.630 --> 00:02:37.080
Amanda Randles: This is a key part of developing, who I am as a researcher and where my research has come from as it's really everything i'll be showing you is embedded in the physics is coming from a physics first like.

21
00:02:37.560 --> 00:02:43.950
Amanda Randles: First principles simulations and i've always really been interested in this combination of the physics side of.

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00:02:44.280 --> 00:02:53.190
Amanda Randles: The physics side with pushing the computer science application and bring that into the bio bio medical application and bring that to biology bring that to medicine.

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00:02:53.730 --> 00:03:05.010
Amanda Randles: So after I graduated from Duke I actually worked at IBM for a few years as a full software engineer

on the bluejeans supercomputing team if you're if you're familiar with the bluejeans supercomputer.

24
00:03:05.520 --> 00:03:15.930
Amanda Randles: And that experience was my first exposure to parallel computing I really got to understand the power of using large scale computers how that can push push the science and allow you to answer.

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00:03:15.930 --> 00:03:17.730
Amanda Randles: Questions you couldn't otherwise answer.

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00:03:18.060 --> 00:03:25.560
Amanda Randles: And that really you know that first got me excited about what can we do with these large scale supercomputers and then also you know I decided, I wanted to.

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00:03:26.010 --> 00:03:34.560
Amanda Randles: switch focus from building the supercomputers and creating you know pushing them to be faster and switch over into the idea of how do we actually use them and can I can I work on the application side.

28
00:03:34.860 --> 00:03:47.520
Amanda Randles: So, with that in mind, I went back to graduate school, I went to Harvard my master's degree was in computer science, I received a PhD in applied physics and during my mask or during my PhD program with TIM tech cirrus.

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00:03:48.780 --> 00:03:57.900
Amanda Randles: We built a multi scale multi physics model called Harvey, which is what you'll hear about today and i'm still working on today to create patient specific blood flow models.

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00:03:58.710 --> 00:04:07.230
Amanda Randles: after finishing at Harvard I brought that to my postdoc where I worked part of the time as a Lawrence follow at livermore national lab one of the daily lives in California.

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00:04:07.710 --> 00:04:13.560
Amanda Randles: And then would spend part of my time and Franciscan me chorus lab at Dana farber cancer institute so i've really had.

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00:04:14.460 --> 00:04:20.010
Amanda Randles: kind of the best of both worlds of trying to learn how do we get you know how do we apply this computational models to real.

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00:04:20.430 --> 00:04:26.220
Amanda Randles: Biomedical problems learning more hands on about the cancer side of like you know how can we bring these flow models to cancer.

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00:04:26.580 --> 00:04:37.950

Amanda Randles: But then, working with some of the best computer scientists in the world at you know how do we scale on the biggest supercomputers there are and how do we really focus on pushing the bounds of the computer science side from my time at livermore national lab.

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00:04:39.780 --> 00:04:47.160
Amanda Randles: And then I came back to Duke opened my my lab and biomedical engineering and 2015 and since then.

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00:04:47.730 --> 00:04:54.990
Amanda Randles: we've really been growing and trying to you know grow our focus of looking at cardiovascular diseases we've we've looked at.

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00:04:55.740 --> 00:05:00.030
Amanda Randles: cerebral aneurisms we're trying to develop computational tools to really improve.

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00:05:00.600 --> 00:05:08.640
Amanda Randles: How we can diagnose disease, how we can treat disease and really focusing on improving clinical outcomes for patients, using computational methods.

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00:05:09.480 --> 00:05:13.320
Amanda Randles: I was very lucky in recently to receive the nsf career and kind of.

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00:05:13.890 --> 00:05:19.320
Amanda Randles: put these on it's like the big milestones in our lab as we're kind of growing, and I should put on shortly that we did just.

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00:05:19.560 --> 00:05:27.330
Amanda Randles: have our first graduate students finished in the last couple of months as well, so we're we're really rolling as a lot of and trying to like get it getting things out there which is really exciting.

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00:05:27.840 --> 00:05:35.790
Amanda Randles: But I did put on the bottom just kind of the personal side of you know, major major milestones going to see how how life has progressed, both from a career standpoint and the other.

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00:05:36.630 --> 00:05:44.100
Amanda Randles: I think the interesting piece was if you, you know as we're putting the work we've we now have the the three children that were three and under and everything during.

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00:05:44.460 --> 00:05:53.700
Amanda Randles: During pandemic, we had the infinite infinite twins while while we were working with us, so it kind of adds a an interesting an interesting side to all of our research in the context of what we're doing.

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00:05:55.320 --> 00:06:01.200

Amanda Randles: So jump into the research itself and the bulk of it i'll talk about today is creating.

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00:06:01.590 --> 00:06:08.520
Amanda Randles: Patient specific blood flow model, so I wanted to give kind of the context of what exactly I mean by that and then i'll come back at the end to talk about some.

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00:06:08.820 --> 00:06:14.760
Amanda Randles: Some of the ventilator work and how we were trying to participate and help with everything going on on the pen with the pandemic.

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00:06:15.750 --> 00:06:21.720
Amanda Randles: When we think about patient specific blood flow models, but I mean is taking image derived.

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00:06:22.530 --> 00:06:34.620
Amanda Randles: Blood flow simulations that we can use to determine know, should you or should you not send to the patient, which patients are likely going to have atherosclerosis develop, how do we really understand the blood flow patterns in three dimensions.

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00:06:35.340 --> 00:06:44.880
Amanda Randles: For specific patients will typically take data from MRI from CT scans sometimes by plane and geography or single pane and geography, with two.

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00:06:45.390 --> 00:06:53.730
Amanda Randles: to die injections, and will recreate the three dimensional topology of that patients vasculature so that's what you're seeing.

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00:06:54.060 --> 00:07:01.560
Amanda Randles: on the side of this on the side of the slide here we segment the data typically with commercial products like mimics for materialize.

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00:07:01.890 --> 00:07:13.290
Amanda Randles: Create that 3D mesh and then we apply a regular Cartesian grid to this mesh we identify which grid points are inside the message which are outside which are inlets wall nodes outlets.

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00:07:13.620 --> 00:07:15.810
Amanda Randles: And we solve the equations of fluid dynamics at.

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00:07:15.810 --> 00:07:21.750
Amanda Randles: Each of these grid points and ends up being incredibly computationally intense, so it needs large scale super computing.

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00:07:22.470 --> 00:07:28.920
Amanda Randles: And I won't get into it a lot in this talk, but i'd be happy to answer more questions later, but I wanted

to just throw out there, we have focused.

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00:07:29.340 --> 00:07:32.010
Amanda Randles: A significant effort and how do we actually validate these models we've.

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00:07:32.370 --> 00:07:37.380
Amanda Randles: had a lot of studies we're comparing against in vivo measurements but we've worked very closely with the freaks lab.

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00:07:37.680 --> 00:07:46.320
Amanda Randles: Where we 3D print these geometries we have a controlled environment where we run flow experiments and we replicate those flow experiments at different Rentals numbers different flow.

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00:07:46.650 --> 00:07:54.060
Amanda Randles: Different flow patterns and replicate those in the simulations and compare the velocity flow profiles from particle image blah symmetry.

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00:07:54.360 --> 00:08:00.810
Amanda Randles: With our simulation to really ensure that we are getting the correct flow properties out of this and always, I think, whenever you see.

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00:08:01.080 --> 00:08:06.930
Amanda Randles: A talk on the simulation side you always want to think about you know how is this validated Are we sure this is correct and how do we keep that in mind.

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00:08:07.410 --> 00:08:16.260
Amanda Randles: And we've put a concerted effort into that research, even though the experiments aren't necessarily in my research law we are, we are working on that we take that very seriously.

64
00:08:17.130 --> 00:08:30.540
Amanda Randles: The other part of this work is you know, we want to build these image image based models and we want to get them back into the clinic so they're actually usable so we think a lot about how are the doctors going to interact with the data, how do we improve.

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00:08:31.260 --> 00:08:42.450
Amanda Randles: intuitive interaction i'll touch a little bit on some of our work with virtual reality to ensure that we can get this you know, not just in a biomedical research lab but really getting it back into the clinic and the most effective manner.

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00:08:45.030 --> 00:08:54.630
Amanda Randles: The research we focus on kind of goes into these different areas where we really look at diagnostics, are trying to identify which patients should be treated, how can we not invasive Lee.

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00:08:55.440 --> 00:09:05.430
Amanda Randles: Find patients that need a Stan to or need need a shunt put in and that side of things we're also looking at virtual surgery and treatment planning, so the image, you see here.

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00:09:06.000 --> 00:09:12.990
Amanda Randles: Is from a pediatric cardiology project where we're trying to determine for patients that are just for babies that are just born that have.

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00:09:13.440 --> 00:09:21.570
Amanda Randles: Hypo plastic left heart syndrome do they you know what is the best way to handle the procedure if there are two different treatment options which one should is best for that patient.

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00:09:21.810 --> 00:09:31.560
Amanda Randles: So we can mimic that surgery in silica allow you before you ever go into the operating room to try out different options for that specific patient see how it's changing the blood flow.

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00:09:31.920 --> 00:09:40.470
Amanda Randles: and improve the physician inform the physicians treatment planning, we also use this work for very you know more on the fundamental and maybe more on the nsf.

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00:09:41.700 --> 00:09:46.560
Amanda Randles: And NIH and nsf guidelines of trying to look at basic science and what are the underlying mechanistic.

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00:09:47.220 --> 00:09:58.860
Amanda Randles: rules that are causing cells to behave badly, you know what is driving cancer metastasis, what are the underlying mechanisms on that sense more of the cell cell interactions will i'll touch on a little bit at the end of the talk.

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00:09:59.970 --> 00:10:09.630
Amanda Randles: But trying to really understand, maybe not something that's ready for the Trans trying to translate to the clinic but understanding that underlying behavior that is driving disease progression disease localization.

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00:10:10.260 --> 00:10:22.620
Amanda Randles: And again we're always trying to figure out how do we do this in the largest scale possible, how do we make the best use of our supercomputers, how do we leverage these heterogeneous supercomputers and kind of pushing the forefront on the parallel computing side as well.

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00:10:24.780 --> 00:10:32.280
Amanda Randles: So, for the rest of the talk of kind of just touch on how the increase in compute capabilities has really improved our methods overall.

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00:10:32.970 --> 00:10:40.290
Amanda Randles: give you an a brief introduction of our method overview and then touch on a few different applications and yet to see how we're applying this in a few different areas.

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00:10:41.730 --> 00:10:48.120
Amanda Randles: kind of building on the you know from my perspective, and how compute power over time has really changed, even just like.

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00:10:49.230 --> 00:10:51.690
Amanda Randles: The simulations i've been able to do in my career.

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00:10:52.410 --> 00:11:08.370
Amanda Randles: Coming back to when I was at Duke university as an undergrad I really only worked with cereal cereal programming I worked on one processor I moved to IBM and 22 2005 and was able to finally work on on the bluejeans supercomputer which at the time, if you remember blue Jean l.

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00:11:09.750 --> 00:11:17.820
Amanda Randles: That kind of for the first time really top the top 500 list of the supercomputers I had about 65,000 processors and I was able to start working with that entire system.

82
00:11:18.420 --> 00:11:22.500
Amanda Randles: I was very lucky to be a part of the US extreme scaling workshop when I was.

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00:11:22.920 --> 00:11:31.470
Amanda Randles: first and second year graduate student, which allowed allowed us to go over and take take over the entire us supercomputer her about 300,000 processors.

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00:11:31.950 --> 00:11:36.870
Amanda Randles: And that's that's where those pictures are from you can see the arrows at me back in the in the beginning of graduate school.

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00:11:37.590 --> 00:11:43.380
Amanda Randles: But that was an exciting point where we were able to you and i'll show a picture in a moment, for the first time run flow simulations.

86
00:11:43.620 --> 00:11:53.160
Amanda Randles: And the full coronary artery tree on the scale of an entire heartbeat so having access to 300,000 processors really changed what we were able to what we were able to simulate.

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00:11:53.880 --> 00:12:02.160
Amanda Randles: In 2015 I moved over to the Lawrence livermore national lab and that's where we're able to access the coil, which is one of the biggest supercomputers at that time.

88
00:12:02.460 --> 00:12:10.650
Amanda Randles: And had about 1.6 million processors and with that capability, we moved from being able to model just a single like the corner arteries of the heart.

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00:12:10.920 --> 00:12:21.840
Amanda Randles: To looking at the full scale the arterial network of the entire on the stomach scale of the body, so the increase in compute powers really influencing this spatial scales were able to simulate.

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00:12:22.200 --> 00:12:28.110
Amanda Randles: and, hopefully, in the future we're looking towards it really extending those temporal scales as well we're part of the.

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00:12:28.560 --> 00:12:37.560
Amanda Randles: Early the early science program trying to figure out how do we, how do we leverage systems like the upcoming aurora pedal scale access or sorry access scale systems.

92
00:12:37.890 --> 00:12:51.090
Amanda Randles: How do we, how do we leverage that and really push forward, not just a spatial skills, but you know, can we move from simulating single heartbeats too many heartbeats along my heart beats over you know the course of a day the course of a week things like that.

93
00:12:53.130 --> 00:13:03.840
Amanda Randles: This is a video that it's getting a little bit old now but it gives you a good sense of what we're trying to model, and this is what we could complete this simulation is run on about 140,000 processors, it was on the argon system at the time.

94
00:13:04.260 --> 00:13:09.030
Amanda Randles: But it gives you the idea of why these kinds of models end up being so computationally complex.

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00:13:09.420 --> 00:13:18.960
Amanda Randles: As you're watching the video you'll see about 200 to 300 million different red blood cells interacting with each other interacting with the fluid with the walls there.

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00:13:19.920 --> 00:13:31.800
Amanda Randles: i'm sorry they're there they're being individually simulated, we need to capture those explicit models of the cells, the underlying fluid grid the the complexity of the geometry.

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00:13:32.160 --> 00:13:39.090
Amanda Randles: And this is the first time, we were really able to model corner a blood flow on the scale of the red blood cell for an entire heartbeat.

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00:13:39.450 --> 00:13:43.110
Amanda Randles: This required, I think it was probably like six to eight hours.

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00:13:43.500 --> 00:13:55.440
Amanda Randles: Of the entire super super computer at the time and it kind of just gives you a better visual of what I

mean by these 3D fluid simulations and why this is so important and why the computing component is such a big deal as part of this work.

100
00:13:57.000 --> 00:14:05.130
Amanda Randles: In 2015 we're able to push this using sequoia with about 1.5 1.6 million processors to the scale of the full body.

101
00:14:05.430 --> 00:14:14.970
Amanda Randles: In this case, this is just looking at the bulk fluid and then we can zoom in on different regions which you'll see in a second to look at the interactions of the formal red blood cells to foreign blood cancer cells.

102
00:14:15.240 --> 00:14:29.400
Amanda Randles: and trying to push the understanding of where these cancer cells going to move, and how are they interacting who were able to actually capture, for the first time three dimensional blood flow on that scale of the full body, because we're able to leverage these large supercomputers.

103
00:14:30.900 --> 00:14:37.050
Amanda Randles: I wanted to throw this word plot out just as a because I know the audience here is is very broad across across the nsf.

104
00:14:37.500 --> 00:14:44.580
Amanda Randles: And kind of just throwing out to that there's still many open computer science challenges are many open challenges in this area, and we really.

105
00:14:44.880 --> 00:14:54.930
Amanda Randles: are drawing from you know moving to cloud computing moving to domain like we need to improve domain to composition, we need to improve the integration of machine learning machine learning we've seen a lot of work with.

106
00:14:55.530 --> 00:15:02.580
Amanda Randles: The pins and the physics inspired neural networks we there, there are so many areas of open questions just in this.

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00:15:03.420 --> 00:15:05.850
Amanda Randles: Space of personalized blood flow simulations and.

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00:15:06.150 --> 00:15:16.860
Amanda Randles: And there are a lot of areas for collaboration with me but also just to get you all, you know kind of thinking of how could the work you're interested in really plan or i'll touch on a few things like virtual reality or use of accelerators but there.

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00:15:17.340 --> 00:15:23.940
Amanda Randles: were really you know we're pushing the bounds of we need, we need a lot of people to contribute to these problems, to make progress so.

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00:15:25.470 --> 00:15:33.420
Amanda Randles: i'll touch on this briefly to give you an idea of you know, the kinds of models we're looking at and just kind of give you the context of how to think about the models i'm talking about.

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00:15:33.960 --> 00:15:42.990
Amanda Randles: The big part I want, I want to convey here is we're using a lot of sportsman, which is an alternative, not your stokes if you're familiar with fluid dynamics you typically will see.

112
00:15:43.560 --> 00:15:52.140
Amanda Randles: Not her stokes equations being solved we're using a similar approach that will recover and have your stokes but it uses a democratized view of the system.

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00:15:52.530 --> 00:15:58.410
Amanda Randles: So we are using it's all based on a lot of us, so you can kind of think this from you know the computer science side of like.

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00:15:58.830 --> 00:16:03.240
Amanda Randles: The underlying component is a stencil and we're using a 3D stencil.

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00:16:03.840 --> 00:16:16.170
Amanda Randles: to calculate the flow dynamics the advantages that are worth pointing out here is we're viewing the fluid is if it's essentially a bunch of particles in each time stuff that can move along the lattice that you see on the top the top corner.

116
00:16:16.650 --> 00:16:26.700
Amanda Randles: And each time stuff they can only move one lattice away and we're getting both properties like shear stress velocity pressure from the movement of these particles.

117
00:16:27.150 --> 00:16:32.850
Amanda Randles: That ends up, meaning that we don't have a global pusan solver we don't have any need for global communication.

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00:16:33.090 --> 00:16:38.490
Amanda Randles: All of your all of the data that you need for collect calculating velocity pressure these key quantities.

119
00:16:38.760 --> 00:16:49.590
Amanda Randles: are available locally and everything is based on nearest neighbor communication, which is really you know lends itself extremely well for the parallel computing and one of the main advantages of using this method.

120
00:16:51.300 --> 00:16:54.630
Amanda Randles: So the next question is how do we actually make these models tractable.

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00:16:54.960 --> 00:16:59.820
Amanda Randles: And we'll start out very basically just to give you the right kind of picture in your head as we start thinking about this.

122
00:17:00.090 --> 00:17:09.270
Amanda Randles: We use conventional demand to composition, in the sense that it is spatially broken down, we will split up different parts of the arteries, and each processor is handling that that domain.

123
00:17:10.620 --> 00:17:14.640
Amanda Randles: it's actually a little bit more complicated than that we're we're using your regular domain to composition.

124
00:17:15.720 --> 00:17:21.300
Amanda Randles: where you can kind of imagine if each color here is representing what's being sent to a different different processor.

125
00:17:21.600 --> 00:17:30.720
Amanda Randles: it's not necessarily this you know this easy let's just go across the sea space and say every 10 microns we're going to split it up, we do we're now we're relying on the code called medis.

126
00:17:31.170 --> 00:17:39.210
Amanda Randles: To do more on your regular domain competition, this is kind of the visual I want you to have in your head of how we're splitting this up across across processors across nodes and how.

127
00:17:39.600 --> 00:17:47.700
Amanda Randles: How we're kind of attacking this problem from a first dance, the next step, and one of the key pieces to getting to this first 3D arterial.

128
00:17:48.120 --> 00:17:56.250
Amanda Randles: systemic scale was switching from a direct addressing scheme to something like an inter addressing scheme What I mean is, if you look at this.

129
00:17:56.580 --> 00:18:01.710
Amanda Randles: This picture on the right, and you see the geometry imagine putting a bounding box around the entire geometry.

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00:18:02.160 --> 00:18:07.740
Amanda Randles: This is actually a very, very sparse geometry, where we only have fluid in a very small portion.

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00:18:08.130 --> 00:18:13.050
Amanda Randles: Of that, overall, bounding box, so you don't want to keep the entire bounding box and memory that would be.

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00:18:13.470 --> 00:18:20.940
Amanda Randles: Here we're showing an example of at a nine micron resolution that would be a 90 petabyte you would need 90 petabytes of data of memory, to actually keep all that in memory.

133
00:18:21.750 --> 00:18:25.710
Amanda Randles: The current biggest supercomputers in the world don't even don't even have this amount of memory.

134
00:18:26.160 --> 00:18:36.420
Amanda Randles: So the first step is how do we actually make this tractable and only keep in memory what's in the fluid nodes we cut it down by using typically indirect addressing will touch on a little bit of semi direct addressing as well.

135
00:18:36.810 --> 00:18:46.530
Amanda Randles: And then we want to deal with, you know how do you handle load balancing challenges and how do we go from there, but the first step is really how do we just get it to fit in memory, and that is always going to be a big constraint for us.

136
00:18:47.340 --> 00:19:00.510
Amanda Randles: At this stage, even with the biggest supercomputers in the world, we are using as much as we are using as much of the memory of the supercomputer as we possibly can, and a lot of our research is focused on how do we actually minimize the amount of memory that has been used.

137
00:19:02.130 --> 00:19:09.390
Amanda Randles: We have looked at, you know how, what is the right memory layout scheme, meaning array of structure structure Ray collection structures around that side.

138
00:19:09.750 --> 00:19:19.770
Amanda Randles: and trying to optimize that for the underlying architectures it's a little interesting and you know if you're trying to tune it for a cpu versus a gpu you have different memory layouts that are more optimal.

139
00:19:20.070 --> 00:19:32.400
Amanda Randles: We spent a lot of time thinking about how do we actually map the algorithm we're working on and the way the data is being laid laid out to these different types of architectures and then trying to embed that in the code is tenable and easily portable.

140
00:19:32.850 --> 00:19:42.750
Amanda Randles: So we can switch between the memory layouts when necessary, as we're switching between you know your cpu based component versus your gpu and how do we really make the best use of these heterogeneous architectures.

141
00:19:44.610 --> 00:19:55.350
Amanda Randles: By focusing on this, we have been able to scale extremely well on both cpu based architectures as well as these accelerated gpu systems, the image i'm showing here is just one of our graphs.

142

00:19:56.070 --> 00:20:03.000
Amanda Randles: On sequoia which was you know it is a cpu based bluejeans system but allowed us to scale up to the 1.6 million processors.

143
00:20:03.600 --> 00:20:09.900
Amanda Randles: If you're not used to thinking of these graphs and looking at these the way to think about it is along the X axis, you have the mpi tasks.

144
00:20:10.290 --> 00:20:19.050
Amanda Randles: If you put know to mpi tasks you want your time to cut in half, you want, if you have foreign PR tasks you want your your overall runtime to cut by a four by four.

145
00:20:19.410 --> 00:20:24.540
Amanda Randles: So that dashed line for each row each each run is showing what the ideal.

146
00:20:25.500 --> 00:20:33.210
Amanda Randles: With the ideal scale up would be, and you can kind of see if you're looking for the Oracle financials is complex geometry that's a if you look at the black line.

147
00:20:33.630 --> 00:20:46.050
Amanda Randles: There we are getting about 99% scaling efficiency, all the way up to 1.6 million the 1.6 million processor, so we are actually running about 1.6 million times faster and able to achieve that, for the real femoral.

148
00:20:46.770 --> 00:20:54.300
Amanda Randles: You can see it starts to veer off slightly for the cerebral and that gets sent to more interesting questions of the surface area to volume ratio.

149
00:20:54.570 --> 00:21:01.200
Amanda Randles: And it's opened up a lot of you know where we focused a lot of research, since, since this paper initially came out to try to address that questions well.

150
00:21:01.620 --> 00:21:06.960
Amanda Randles: we've also shown that we can scale to all of summit and focused on the gpu architectures as well.

151
00:21:07.620 --> 00:21:16.200
Amanda Randles: I won't get into all the details of how we're optimizing how we optimize for these architectures we're definitely happy to answer that and go into more detail if you're interested in the question section.

152
00:21:16.620 --> 00:21:25.770
Amanda Randles: I wanted to spend the next bit kind of going through a few vignettes of different different ways we're applying these models and different disease areas that we're looking at.

153
00:21:26.940 --> 00:21:34.200

Amanda Randles: One of the main main questions we really target is cardiovascular disease, this is the initial motivation, even in my PhD.

154
00:21:34.770 --> 00:21:40.080
Amanda Randles: We originally created Harvey to focus on cardiovascular disease, the video that you're seeing here.

155
00:21:40.800 --> 00:21:45.600
Amanda Randles: is vastly slow sped up this would happen over the course of weeks or months, if not years.

156
00:21:45.930 --> 00:21:54.030
Amanda Randles: But it's showing the build up of lifted and plaque development within the wall of an artery and developing a we have a lesion developing within that corner artery.

157
00:21:54.540 --> 00:21:59.550
Amanda Randles: What we want to identify and what we're trying to develop our non invasive techniques to identify.

158
00:21:59.910 --> 00:22:04.860
Amanda Randles: Where those lesions are, how you know what is this like how how schema are these lesions.

159
00:22:05.070 --> 00:22:14.370
Amanda Randles: But also, can we predict where those lesions are likely going to occur and can we tell help to inform the physicians of how should they actually treat these lesions and when, should they treat these lesions.

160
00:22:15.270 --> 00:22:23.490
Amanda Randles: So starting on the diagnostic side we're seeing large acceptance of computational modeling for what's called fractional reserve.

161
00:22:24.030 --> 00:22:34.860
Amanda Randles: This is the gold standard for determining how a schema collision is and it's basically a pressure gradient across that lesion and if that pressure gradient is above or below point eight.

162
00:22:35.580 --> 00:22:41.190
Amanda Randles: It determines whether or not that patient, whether or not the doctor should place a stunt or not.

163
00:22:42.090 --> 00:22:56.310
Amanda Randles: we're seeing acceptance are currently FDA approved practically a software packages that can calculate fractional reserve and we're really seeing this is one of the first areas that computational fluid dynamics is playing a key role and being translated directly into the clinic.

164
00:22:57.840 --> 00:23:09.930
Amanda Randles: For our work we've developed a method to go from angiogram so you have to 2d images that are extremely high resolution and are currently the gold standard for how clinicians determine whether or not they should.

165
00:23:10.590 --> 00:23:16.140
Amanda Randles: Whether or not, they should place is done for the patient, they building this off of angiograms.

166
00:23:16.590 --> 00:23:23.730
Amanda Randles: We work with a team at Denver, to create a 3D reconstruction, where we when we have two angiograms taken from two different angles.

167
00:23:24.060 --> 00:23:36.570
Amanda Randles: reconstruct the 3D geometry run our flow simulations run them at hyperthermia so the La an elevated ELENA elevated flow rates and mimicking hyperthermic state for the patients and we extract that fractional reserve.

168
00:23:38.610 --> 00:23:48.150
Amanda Randles: Along the way we have identified some key pieces of using of why it's important to use these large scale computational models and one one.

169
00:23:48.780 --> 00:23:57.150
Amanda Randles: Important finding was depending on what you're really interested in looking at if you're interested in complex human dynamics like potentially will shear stress.

170
00:23:57.450 --> 00:24:06.330
Amanda Randles: Which is a quantity that has been strongly associated with the development of these lesions the progression of atherosclerosis fluorosis it can help predict.

171
00:24:07.410 --> 00:24:17.880
Amanda Randles: Help us identify the trajectory of this disease is essentially the fictional flow for the fictional forest along the wall of those coronary arteries if you're trying to determine this accurately.

172
00:24:18.390 --> 00:24:25.140
Amanda Randles: You need to simulate more than just a single vessel and that's what we're showing here is on a is is.

173
00:24:25.920 --> 00:24:29.190
Amanda Randles: The vessels that you get from a reconstruction from the angiogram.

174
00:24:29.520 --> 00:24:42.240
Amanda Randles: Be is where you match, and you pull out those are all the vessels, you would have gotten simply from getting from A CT so you do have a difference in Resolution from a CT versus an angiogram and that can impact, how many side branches are getting and how.

175
00:24:43.320 --> 00:24:53.550
Amanda Randles: What what you're reconstructing for that tree and this first question was like How important is that we really need to have all of the side branches when can we look at just a single vessel, which is obviously less computationally intense.

176
00:24:53.910 --> 00:25:04.410
Amanda Randles: And when do we really need to include the cyber inches and we did find that for quantities like wash your stress you do see a significant difference when you don't include some of these cyber inches.

177
00:25:05.520 --> 00:25:13.860
Amanda Randles: By using a more like the high resolution models from the angiography and from these large scale 3D flow models we're also able to capture flow.

178
00:25:14.310 --> 00:25:26.970
Amanda Randles: and complex lesions that are difficult to attribute and difficult to identify quantities like a puff are in what's considered a complex legion So these are when you're looking at the far left, we see the bifurcation lesions.

179
00:25:27.570 --> 00:25:32.190
Amanda Randles: lesions that are off the costumes we have asked you lesions serial lesions where you have back to back legions.

180
00:25:32.550 --> 00:25:43.500
Amanda Randles: These are the more complicated lesions to to diagnose to determine treatment and to accurately resolve flow properties, so we initially targeted some of these complex lesions to see if creating.

181
00:25:43.830 --> 00:25:52.020
Amanda Randles: Three dimensional topology is from the high resolution data that you find in angiograms allows us to really have a better sense of calculating out.

182
00:25:53.010 --> 00:26:07.800
Amanda Randles: What you get for the fractional flow reserve what i'm showing here was our initial pilot study with Kate we had 14 cases, most of these had complex legion So these are representative of bifurcation lesions serial lesions.

183
00:26:08.490 --> 00:26:15.480
Amanda Randles: And those are typically the types of lesions that are excluded from these large clinical studies so it was important to us to really target and identify can we.

184
00:26:16.050 --> 00:26:31.470
Amanda Randles: Can we accurately get flow properties from these lesions and the initial pilot study we were able to get an average of 3% error and that's from the exact pressure gradient that is measured in the patient, using a guide wire compared to what we're getting out of our.

185
00:26:32.520 --> 00:26:41.370
Amanda Randles: getting out of our flow simulation not necessarily not you know categorizing as above or below point eight exactly but actually trying to get the real number of what was.

186
00:26:41.610 --> 00:26:53.280
Amanda Randles: What was measured with that diagnostic guide wire, this is showing this incredibly promising and we

do have we have recently completed our 200 patients study extending this this case study that should be coming out within the next year.

187
00:26:55.830 --> 00:26:58.500
Amanda Randles: we've also looked at other questions and i'll kind of give.

188
00:26:59.310 --> 00:27:08.850
Amanda Randles: The give a little bit of background on what I mean by VI ecmo, but I wanted to touch on this, because I think I think people in this audience may really appreciate the role of multi scale and modeling and the combined.

189
00:27:09.420 --> 00:27:18.150
Amanda Randles: In the work that we did for this project so here we're targeting what's called va ecmo, and this is an external heart or lung it's creating.

190
00:27:18.480 --> 00:27:26.490
Amanda Randles: where you are taking the blood out of the body and oxygen putting it outside of the body and then infusing it back in the body through an insertion Canyon.

191
00:27:26.760 --> 00:27:34.590
Amanda Randles: And this, can you can be located in your femoral artery in your accelerator artery or in the order so we wanted to answer questions regarding.

192
00:27:36.090 --> 00:27:41.520
Amanda Randles: Where does where should you know what what is the impact of that calculation what flow rate should they be using.

193
00:27:41.820 --> 00:27:53.700
Amanda Randles: There are attainable parameters of the physician can change when they're setting up ecmo and give them more guidance of what you know how, what is the best way to set up this ecmo system to improve to improve outcome.

194
00:27:54.330 --> 00:28:01.650
Amanda Randles: 15% of patients going on V ecmo end up having neurological complications, this is often tied to hypoxia.

195
00:28:01.980 --> 00:28:11.070
Amanda Randles: So basically not having oxygenated blood get up to the brain, we need to ensure that we are getting oxygen oxygen and blood up to the brain one the patients are an ecmo.

196
00:28:11.430 --> 00:28:17.310
Amanda Randles: And this ends up being tied very closely to what's called the mixing zone and the location of the mixing zone impacting.

197

00:28:17.640 --> 00:28:21.600
Amanda Randles: Where how the blood is moving through the body and that's what you're seeing in this video.

198
00:28:21.990 --> 00:28:27.630
Amanda Randles: So in this video we're showing calculation and a leg, so we have flow coming from the ecmo circuit.

199
00:28:27.900 --> 00:28:37.830
Amanda Randles: Up that's the flow that you see coming up on the bottom, and that is going to be oxygen oxygenated blood going into the body, and this is for when your heart is really not working you're not getting a lot of flow from the heart.

200
00:28:38.130 --> 00:28:48.330
Amanda Randles: you're getting some flow, which is what you're seeing coming through the order there and that mixing zone is where you see the flow that's coming from the heart and coming up from the ecmo system and where they hit.

201
00:28:48.840 --> 00:28:56.010
Amanda Randles: And that's going to strongly influenced how much of the oxygenated blood is going to get into your cerebral vasculature and other parts of the body.

202
00:28:57.450 --> 00:29:04.200
Amanda Randles: were able to set up a multi scale model to try to attack this problem to get at.

203
00:29:04.740 --> 00:29:11.760
Amanda Randles: You know the effect of having calculation and somewhere like femoral calculation, so we needed we needed a model that could capture the vasculature.

204
00:29:12.030 --> 00:29:16.110
Amanda Randles: From the leg, all the way up to the brain and do this in a patient specific manner.

205
00:29:16.440 --> 00:29:20.100
Amanda Randles: and get the information that we needed, so we were interested in.

206
00:29:20.310 --> 00:29:29.640
Amanda Randles: properties like well shear stress like pressure in the cerebral vasculature to get just start attacking and understanding why we're getting these neurological defects.

207
00:29:29.820 --> 00:29:43.410
Amanda Randles: So we needed to have complex flow models within within the cerebral vasculature, but we also wanted to capture the full body scale and see what is the impact of different calculation strategies in Sydney order or the leg or an excellent excellent arteries.

208
00:29:44.400 --> 00:29:54.240
Amanda Randles: So we ended up introducing a one dimensional model of the full body and coupled that with the 3D

region of interest in this case we're looking at the cerebral vasculature.

209
00:29:55.920 --> 00:30:06.840
Amanda Randles: that allowed us to identify the effect of the flow rate on the position of the mixing zone and then also the effect of the Expo floor rate on how much blood flow is getting to.

210
00:30:07.380 --> 00:30:13.440
Amanda Randles: The cerebral vasculature so we can bring this together to start providing guidance back to the physicians to identify.

211
00:30:13.890 --> 00:30:24.570
Amanda Randles: What the trade offs are for increasing ecmo flow rate and how do they determine which calculation strategy, they should use and how that's going to change flow for the specific vasculature is of that patient.

212
00:30:26.670 --> 00:30:32.190
Amanda Randles: we're also very interested in using using these virtual models to improve treatment planning.

213
00:30:33.330 --> 00:30:36.150
Amanda Randles: What I mean is, you know when you're looking at in this case.

214
00:30:36.390 --> 00:30:44.820
Amanda Randles: we're talking about collocation of the order you see that they have a narrowing so kind of like the lesions that you see that, with the we were talking about before, but in this case you have a large narrowing.

215
00:30:45.300 --> 00:30:56.190
Amanda Randles: In the order when you're going to treat that you have many different options, you could you know go forward with angioplasty where you just remove that gnosis and essentially suture it back together put an.

216
00:30:57.720 --> 00:31:04.080
Amanda Randles: Sorry, the analyst of Moses, where you're switching back together angioplasty we're going in with the balloon separating it back out and.

217
00:31:04.380 --> 00:31:14.700
Amanda Randles: Moving but like restoring the diameter of the vasculature or we may couple that with a stunt and place that in the hole that vasculature in that new remodeled state.

218
00:31:15.810 --> 00:31:27.750
Amanda Randles: We want ways to to simulate that before the doctor ever goes into the operating room and identify what is the best option for that patient, so we have this patient specific 3D mesh and we can virtually change this.

219
00:31:28.350 --> 00:31:37.350
Amanda Randles: change this mesh represent different treatment options and help that doctor and help inform their decision and try these out virtually before they're ever in the operating room.

220
00:31:38.100 --> 00:31:49.650
Amanda Randles: One of the first pilot studies we completed was trying to understand if we could capture and use these large scale 3D models to capture the effects of local changes like placing a stent or changing.

221
00:31:50.220 --> 00:32:00.210
Amanda Randles: The degree of Cork station on global quantities of interest so for diseases like peripheral vascular disease so diseases of your like femoral artery and and the legs.

222
00:32:01.110 --> 00:32:07.950
Amanda Randles: They look at quantities with like ankle Dracula index so it's the pressure gradient between your ankle on the ankle and your wrist.

223
00:32:09.120 --> 00:32:17.070
Amanda Randles: And the question here was if we change that car station in the order can we actually accurately reflect that using our simulations and understand how.

224
00:32:17.640 --> 00:32:22.860
Amanda Randles: treatment options are how changes and a local setting like you know the degree of connotation.

225
00:32:23.070 --> 00:32:32.400
Amanda Randles: How is that going to affect biomarkers that we're using to guide disease treatment like ankle broccoli index and can we actually capture those local effects on these global metrics.

226
00:32:32.820 --> 00:32:37.200
Amanda Randles: And that's what you're seeing here is, we really you know went in and did that first proof of concept of.

227
00:32:37.590 --> 00:32:48.960
Amanda Randles: Can we modify the geometry in a local sense and then you'll see in the bars, I will see the effect of that ankle brackpool index in different locations responding to having different degrees of communication.

228
00:32:50.970 --> 00:33:00.630
Amanda Randles: Building on this, we wanted to create a tool that is intuitive and interactive for the clinicians because at the end of the day, clinician is not going to go.

229
00:33:01.500 --> 00:33:07.050
Amanda Randles: use a supercomputer from command line processing with the c++ based code, so we wanted to add in something.

230
00:33:07.320 --> 00:33:15.000
Amanda Randles: You know, not just a gooey but like trying to understand how do they interact with us in the best way and how do we do, how do we set up a tool in a way that makes us usable for them.

231
00:33:16.380 --> 00:33:27.210
Amanda Randles: From a computer scientist and there are a few pieces, you may you may really appreciate it and find interesting and this work is is the kind of gift showing this is an automated manner of adding in a shunt between the geometry.

232
00:33:29.010 --> 00:33:36.270
Amanda Randles: Some of the interesting features of this tool it, as in the shunt and it will automatically in the background, cut the hole in the.

233
00:33:36.600 --> 00:33:44.640
Amanda Randles: In the 3D triangulate it mesh automatically rematch the geometry and prepare it for running in our fluid dynamics software.

234
00:33:44.790 --> 00:33:52.710
Amanda Randles: So all of that happens behind the scenes in an automated fashion, so the clinician just us to create the Sean they don't know how to know about blender and mesh mixer interacting with.

235
00:33:53.430 --> 00:34:01.320
Amanda Randles: 3D topology and it will prepare the simulation for running on the cloud or on your heart, whatever your on Prem systems may be.

236
00:34:01.680 --> 00:34:08.670
Amanda Randles: And that will pull back the simulation results and that's what you're seeing on the bottom with htc Vive setup as he's actually interacting with the pressure field.

237
00:34:09.060 --> 00:34:16.050
Amanda Randles: That came back so that you know, the current condition can see this in virtual reality or an augmented reality with a Z space setup.

238
00:34:16.440 --> 00:34:20.400
Amanda Randles: We have different you know it's written in unity, so that it can work with different extended reality.

239
00:34:20.820 --> 00:34:28.110
Amanda Randles: devices and try to provide a more intuitive interaction for those clinicians to to try different treatment planning options.

240
00:34:28.440 --> 00:34:37.620
Amanda Randles: So we have features like you know, removing that's to know says, putting a shenton you can change the geometry and anatomy of the stunt placing placing extent questions like that.

241
00:34:39.090 --> 00:34:46.020
Amanda Randles: we've also started embarking on you know, a series of user studies to really understand the human

computer interaction.

242
00:34:46.290 --> 00:34:52.770
Amanda Randles: Of what is like you know we don't want this to be a kitschy tool of it's great that it's a virtual reality, but how do we actually make it useful for the clinicians.

243
00:34:53.130 --> 00:35:06.030
Amanda Randles: Does it improve their error when is it useful, and when, should they be using a fully immersive device versus a semi and immersive device like you see what the Z space where you just put the 3D glasses on it allows you to interact in that space.

244
00:35:07.530 --> 00:35:17.820
Amanda Randles: we're very interested in trying to kind of delineate which types of behavior and what kind of interactions are best suited for the different types of virtual reality so we've shown that.

245
00:35:18.480 --> 00:35:31.950
Amanda Randles: For reproducing if we say you know, please place the conduit in this location, can you reproduce this accurately fully immersive devices are actually like what more optimal for placing conduits places like virtual re vascular.

246
00:35:32.580 --> 00:35:36.900
Amanda Randles: Virtual revascularization we even had clinicians go through and place.

247
00:35:38.040 --> 00:35:48.000
Amanda Randles: place doesn't identify where they're going to place their stunts on a 2d representation, the semi immersive and the fully immersive and they were more accurate with the fully immersive devices, they also.

248
00:35:48.360 --> 00:35:55.440
Amanda Randles: there's a lot of the subjective feedback, of how they really enjoyed the 3D the 3D interactions much more, you may expect.

249
00:35:56.040 --> 00:36:04.080
Amanda Randles: we're also interested to see you know do does knowing what the fluids you're like what the fluid mechanical properties are of.

250
00:36:04.290 --> 00:36:12.510
Amanda Randles: The coronary arteries also contribute to whether it where they're going to place their stunts and how accurate, they are, and like does it change their decision and where they're going to place their students.

251
00:36:12.930 --> 00:36:21.150
Amanda Randles: And one of the interesting findings that kind of came out of that work was showing the fluid dynamics as part of this actually reduced the differences between your.

252

00:36:21.450 --> 00:36:31.770
Amanda Randles: The accuracy that we saw across devices, so it made the to the device, and the results of the 2d device much more similar to what we saw with the semi immersive device and the fully immersive device and actually.

253
00:36:32.190 --> 00:36:38.370
Amanda Randles: decrease that gap for using the virtual reality which was kind of an interesting finding and direction on that on that end.

254
00:36:38.910 --> 00:36:45.120
Amanda Randles: But we are you know we're not only trying to think of how do we build these models and how do we do this in an accurate way, but how do we get it into the clinic.

255
00:36:45.930 --> 00:36:53.250
Amanda Randles: And I think that's something that people in this Community could really help with and and you guys may be really interested in how do we push that forward as well.

256
00:36:55.320 --> 00:37:04.380
Amanda Randles: As on the cardiovascular on the last part that I want to touch on is just you know coming back to this conversation I won't spend a lot of time, but it's the it's a congenital heart defect.

257
00:37:04.680 --> 00:37:15.870
Amanda Randles: It affects three to 5000 patients, a year, the main piece here is when the pressure gradient across us to gnosis is greater than 20 millimeters of mercury that's when they will come in and intervene.

258
00:37:16.980 --> 00:37:25.170
Amanda Randles: The question that the doctors had for us was you know they can measure the pressure gradient in the office under maybe an exercise condition or under a rest condition.

259
00:37:25.440 --> 00:37:28.350
Amanda Randles: But they wanted to have a more holistic view of that patient so.

260
00:37:28.680 --> 00:37:37.140
Amanda Randles: What is that pressure gradient when that patients that are mild exercise versus heavy exercise, what happens if they go to Denver and they're at altitude, or if they're shoveling snow when it's really cold.

261
00:37:37.410 --> 00:37:47.700
Amanda Randles: There are many, there are many different situations at the patient could be in many different physiological conditions that could be under that can't be captured in the doctor's office immediately.

262
00:37:48.270 --> 00:37:54.000
Amanda Randles: So they were asking if there was a way to you know, through these simulations capture that entire state space.

263

00:37:55.890 --> 00:38:03.840
Amanda Randles: While while you know we could simulate each of these in our first pass we first started this project was to just brute force let's simulate all of these options.

264
00:38:04.080 --> 00:38:07.830
Amanda Randles: We ended up using about 290 million compute hours to do that, for one, patient.

265
00:38:08.220 --> 00:38:17.820
Amanda Randles: And while that was great, for you know, a proof of concept we can actually calculate you know we can calculate calculate these different situations that's not viable and that's not tractable for moving forward.

266
00:38:18.120 --> 00:38:24.240
Amanda Randles: For a new patients when they come in to try to predict what their entire on get that get that holistic view of their state space.

267
00:38:24.810 --> 00:38:32.820
Amanda Randles: So we we developed a project that was more a combination of kind of design of experiments with machine learning a little bit.

268
00:38:33.720 --> 00:38:44.010
Amanda Randles: Little you know turning the machine learning on its head, a little bit of like instead of trying to get as much data as physically possible but you traditionally see with machine learning, we were trying to identify the minimal number of simulations you needed to complete.

269
00:38:44.370 --> 00:38:51.930
Amanda Randles: For each patient to then effectively train a machine learning model to predict the rest of that state space so we're able to.

270
00:38:52.680 --> 00:38:57.210
Amanda Randles: identify that goes between depending if you were looking at wash your stress or pressure and trying to.

271
00:38:57.690 --> 00:39:08.430
Amanda Randles: Trying to predict trying to work, these predict these quantities you needed between nine and 30 simulations on you can get down to only nine simulations when you had a new geometry and new patient come in.

272
00:39:08.790 --> 00:39:13.170
Amanda Randles: Rather than using 290 million hours just simulate these these key.

273
00:39:13.830 --> 00:39:21.780
Amanda Randles: These keys of these minimal number of simulations and from there, you had enough data to then predict the state space for the rest, for the rest of these conditions.

274

00:39:22.050 --> 00:39:25.890
Amanda Randles: And we verified that for several new patients and showing that this would hold, I think.

275
00:39:26.280 --> 00:39:31.200
Amanda Randles: kind of thinking through the use of machine learning of like, how do we couple it with the with the simulations.

276
00:39:31.410 --> 00:39:39.810
Amanda Randles: and minimize you know, the number of simulations, we need to run for each new patient, but still maximize the benefit that we're getting out and be able to predict these these new State spaces.

277
00:39:40.080 --> 00:39:48.270
Amanda Randles: These other conditions of you know what if this patient goes running in Denver, how would that affect them and how do we really capture not just what you can measure in the office.

278
00:39:49.200 --> 00:39:54.270
Amanda Randles: I do want to touch a little bit on some of our cellular models, because that is a lot of what i'm focused on in the career word as well.

279
00:39:54.780 --> 00:40:03.690
Amanda Randles: As everything i've kind of talked about and shown here has been looking at bulk fluid and how do we use these bulk fluid models to diagnose and treat disease and that's.

280
00:40:04.290 --> 00:40:15.390
Amanda Randles: The work in the book foot space is much more you know ready to go into the clinic and that side of things, the fluid structure interaction is much more basic science and how do we understand cellular interactions and what's happening on on that level.

281
00:40:16.260 --> 00:40:18.840
Amanda Randles: Our first kind of foray into the space.

282
00:40:19.830 --> 00:40:30.990
Amanda Randles: was starting small, can we actually create a model that replicates a cancer cell and matches you know just on one cancer, so can we actually tune our simulation to get the behavior a specific cancer cells.

283
00:40:31.260 --> 00:40:38.670
Amanda Randles: So here we were collaborating with Scott analysis lab up at MIT and taking the data, where he was putting different cancer cells.

284
00:40:39.060 --> 00:40:45.360
Amanda Randles: Cancer cells from different cancer cell lines, through his microfluidic devices and you can kind of see a schematic of that at the top.

285

00:40:45.690 --> 00:40:55.380
Amanda Randles: And we have the passage time and the behavior of those cancer cells moving through that microfluidic device and we're replicating that with our with our simulation tool was your call Harvey.

286
00:40:57.090 --> 00:41:08.250
Amanda Randles: You can see the graph on the right is really showing where the simulations and how we were really able to tune our computational model to specific cancer cells so here we're looking at team at and the cell line all 1210.

287
00:41:08.970 --> 00:41:15.780
Amanda Randles: But the goal is really establishing a method to get specific cancer cells model accurately and get their mechanical behavior on that.

288
00:41:17.460 --> 00:41:24.330
Amanda Randles: Once we could model specific cancer cells, we then want to look at you know how do we actually use these cancer cells to understand cellular behavior.

289
00:41:24.660 --> 00:41:31.440
Amanda Randles: So we're working with a team at Lawrence livermore national lab where they were 3D bio printing endothelial endothelial is channels.

290
00:41:31.770 --> 00:41:39.540
Amanda Randles: Putting cancer cells in these channels and watching where they were adhering so we were coupling that with these computational models to try to understand.

291
00:41:39.930 --> 00:41:52.230
Amanda Randles: What is it about the flow environment, the cellular interactions, how do we understand you know what is happening in that micro environment to drive that cancer metastasized but, but the adhesion of those cells in a certain locations.

292
00:41:52.740 --> 00:42:00.120
Amanda Randles: One of the initial interesting like findings really just came out of the bulk fluid simulation before we even started looking at the structure interaction.

293
00:42:00.450 --> 00:42:08.940
Amanda Randles: And what you're seeing at the bottom is a shear stress map and what we found was the shear stress actually correlated very strongly with where we saw.

294
00:42:09.480 --> 00:42:16.920
Amanda Randles: Higher higher degrees of occasion and sell themselves being located so we then coupled that with the fluid structure interaction model.

295
00:42:17.250 --> 00:42:25.830
Amanda Randles: To get a better understanding of like what are the interactions of the cells at those locations and why are they really causing, why are they more likely to it here in that location.

296
00:42:26.220 --> 00:42:34.260
Amanda Randles: We also have a student in the lab who is building on this work and his PhD thesis is focused on building individual individual cell cell.

297
00:42:35.190 --> 00:42:40.050
Amanda Randles: receptor looking interactions adding that occasion model into these types of these types of models.

298
00:42:40.470 --> 00:42:52.380
Amanda Randles: So you can kind of appreciate now why that might be more even more computationally intense, but how we kind of build on this multi scale multi scale and will type physics approach to building up from the ground up of understanding, these behaviors.

299
00:42:53.460 --> 00:43:03.990
Amanda Randles: Coming back to the computer science and we always care about how to actually use the systems on efficiently so we had a highly scalable fluid dynamic system, and then we added in.

300
00:43:04.530 --> 00:43:10.620
Amanda Randles: You know you have your you larian based fluid model we're adding in our look around janice immerse boundary focused.

301
00:43:12.150 --> 00:43:22.620
Amanda Randles: On selling model and we spent a lot of time and effort figuring out, you know how do we actually scale that efficiently as well how to do the domain decomposition of the of the cellular model, how do we own the cells and share them across.

302
00:43:22.980 --> 00:43:33.870
Amanda Randles: across different processors, and this is just one of the initial scaling graph showing us showing this work with the immerse boundary scaling very strongly up to here it's 192 gpus.

303
00:43:34.230 --> 00:43:48.690
Amanda Randles: We have scaled it to all of summit, and at this stage, I think the most we've modeled about an hour at like 590 million red blood cells is at the top, where we've topped out at this stage we're really focused on how do we really scale these models to extremely large simulations.

304
00:43:49.980 --> 00:43:53.400
Amanda Randles: And wrapping up the fluid structure interaction and.

305
00:43:54.090 --> 00:44:04.530
Amanda Randles: The other piece we're looking at is you know it's very important to capture sell sell interactions if we want to understand how a cancer cell moves in the body, why it metastasizes in different locations.

306
00:44:04.830 --> 00:44:09.780

Amanda Randles: it's not just both fluid is this micro environment, it is the interaction of the individual cells.

307
00:44:10.140 --> 00:44:19.350
Amanda Randles: But at the same time, it does not, you know we can't take a brute force approach and we can't just model, all of the cells in the entire body and that will not fit in a supercomputer with today's methods and it will not fit on.

308
00:44:19.590 --> 00:44:29.100
Amanda Randles: supercomputers in the next 50 years so we're trying to develop new methods to get cellular resolution but, at the scale of the full body so.

309
00:44:29.610 --> 00:44:37.020
Amanda Randles: We kind of have to terms as our adaptive physics refinement but also are moving window of Essentially, we have a moving window that is tracking the cancer cell.

310
00:44:37.350 --> 00:44:44.460
Amanda Randles: Inside the moving window and you have explicit cells are capturing the cellular interactions, you have the red blood cells interacting with the cancer cells.

311
00:44:45.000 --> 00:44:53.100
Amanda Randles: Outside the moving window, you have the bulk fluid and you're getting that entire like the larger scale image of what's happening in that entire domain.

312
00:44:53.580 --> 00:45:00.330
Amanda Randles: And by doing that we're really able to capture cellular scale interactions but on a much, much larger much larger scale.

313
00:45:00.810 --> 00:45:07.740
Amanda Randles: And we're we've we've completed a lot of work that should be coming out shortly looking at, you know how do we really optimize that for.

314
00:45:08.070 --> 00:45:19.800
Amanda Randles: These heterogeneous architecture so putting the bulk fluid simulation on the cpus the fluid structure interaction of the gpus and how do you really leverage these new supercomputers and that most optimal way to get the larger domains.

315
00:45:21.090 --> 00:45:29.310
Amanda Randles: The next steps are really preparing for us to scale with your work, and I only want to mention this just just very briefly about that the.

316
00:45:29.640 --> 00:45:36.750
Amanda Randles: Some of our focus there is on in situ visualization in situ analysis and situ machine learning training and.

317
00:45:37.290 --> 00:45:44.400
Amanda Randles: kind of just pointing out, you know when we run these simulations we are using the entire like as much memory, as you can possibly get on the supercomputer.

318
00:45:45.360 --> 00:45:53.580
Amanda Randles: We are using your the model that we're using creates millions and millions of time steps, so it is really just not tractable to output.

319
00:45:53.820 --> 00:46:00.150
Amanda Randles: You know, five petabytes of data or more than that you know every single time step for a million times steps like we are.

320
00:46:00.690 --> 00:46:06.510
Amanda Randles: You know approaching the point where it is not feasible to just do post hoc analysis post hoc training post talk visualization.

321
00:46:06.870 --> 00:46:17.490
Amanda Randles: And it's no longer just you know, a nice feature to have in situ visualization and such you like making the movies, while the simulation is running and doing the analysis, while the simulation is running is it's really.

322
00:46:17.700 --> 00:46:23.490
Amanda Randles: we've hit a point where it really is imperative to have that be a part of our models and in bed, you can sit you.

323
00:46:23.820 --> 00:46:29.670
Amanda Randles: Sit your component in a way that does not slow down our simulation so we're really focused and thinking a lot about the Institute.

324
00:46:30.000 --> 00:46:39.780
Amanda Randles: in situ analysis and instance your components of our work, which, again, I think, is something that this director, it may be, really, really, really interested in it'd be great to hear more from people in those areas.

325
00:46:41.400 --> 00:46:48.840
Amanda Randles: So I know I only have about 10 minutes left, so I wanted to just touch on some of the work that the lab had completed with the ventilator splitting project.

326
00:46:49.380 --> 00:46:55.590
Amanda Randles: And it is a little different but it's I think it's a really good story and good good to think about of.

327
00:46:56.070 --> 00:47:05.220
Amanda Randles: How we can kind of make make a difference and plan, I think that the students that really ran this project were just absolutely phenomenal in this work, the collaboration.

328
00:47:05.940 --> 00:47:08.490
Amanda Randles: We can learn a lot for how we can learn a lot for how we can go for.

329
00:47:09.030 --> 00:47:14.280
Amanda Randles: This type of work and i'm sure I don't have to give that much her preface of you all remember it was happening last year.

330
00:47:14.670 --> 00:47:24.300
Amanda Randles: um in the news we're seeing you know everything about how there was a ventilator shortage, there was there's that you know we're really hitting up against you know just fundamentally there were not enough ventilators.

331
00:47:24.630 --> 00:47:31.650
Amanda Randles: For the patients and we're running out of ventilators and it was it was i'm sure you all recall, was it was a massive problem.

332
00:47:33.210 --> 00:47:40.980
Amanda Randles: There was a researcher at Duke who was an md with had just finished his PhD within the biomedical engineering program and he.

333
00:47:41.700 --> 00:47:51.540
Amanda Randles: I think like immediately jumped in and wanted to figure out how he could help and really came up with a great idea, and he worked with a team of researchers at the at the Duke medical Center.

334
00:47:51.840 --> 00:47:55.320
Amanda Randles: To develop a technique and a device and that's what you're kind of seeing here.

335
00:47:56.130 --> 00:48:07.290
Amanda Randles: To actually split ventilators to allow you to effectively split the ventilator between two patients, which would double our capacity, you could even potentially split up between multiple other on multiple patients and really.

336
00:48:07.650 --> 00:48:13.530
Amanda Randles: You know, take what ventilator capacity we had and push that as far as it possibly could and help as many patients as we could.

337
00:48:15.090 --> 00:48:26.520
Amanda Randles: He started working on this, you know it was like he had the device developed in like sometime in March, like it was you know it hit the news, it was an issue, and he jumped right in and was right there, which was incredibly impressive.

338
00:48:27.000 --> 00:48:38.760
Amanda Randles: They were using chemical lungs to validate it working with the FDA for emergency use approval and like really pulling pulling this together, very quickly, we had worked with him previously on blood flow simulation so

he came to us.

339
00:48:40.320 --> 00:48:47.670
Amanda Randles: With the question of if we could help him because of our experience with blood flow modeling and what he wanted the issue was.

340
00:48:48.780 --> 00:48:54.300
Amanda Randles: The way that, if they were ever splitting ventilators and I should say as a caveat that you should never split a ventilator, it is not.

341
00:48:54.780 --> 00:49:05.310
Amanda Randles: This is not recommended, we do not like that that's not how you should be using a ventilator and that's not what we want to have happen, but it is you know it is better than the alternative in a dire situation, which is where we were.

342
00:49:06.930 --> 00:49:16.530
Amanda Randles: And they wanted to be able to split the ventilators between patients that weren't necessarily matched for compliance, because if you have an emergency situation you want to be able to split it between whatever to patients who have there.

343
00:49:16.740 --> 00:49:24.090
Amanda Randles: And what is on hand you don't want to have to like find a patient that matches patient to patient be and say, well, I can only split it between these two patients, we really want.

344
00:49:24.420 --> 00:49:32.700
Amanda Randles: To be able to on the fly figure out how do we tune this device to allow quick and effective accurate and safe splitting between any kind of patients.

345
00:49:33.090 --> 00:49:42.660
Amanda Randles: No matter what their weight their compliance on the tube diameter that was being used so he was asking us if we could create a computational fluid model that the doctors could use to.

346
00:49:43.350 --> 00:49:55.920
Amanda Randles: guide their their tuning of this device and determine know which restricts that which resistors they want to use and how they change the use of device for any to patients that they may run into for any ventilator that they may be using.

347
00:49:57.540 --> 00:50:07.230
Amanda Randles: So they came to us probably like late March early April and I went to my students and asked you know who wanted, who could really help, and I think everyone is just really excited.

348
00:50:07.530 --> 00:50:16.200
Amanda Randles: I think i'm sure I feel like a lot of you probably had this experience, like in the beginning, you really wanted to do something, and you want to be able to help, but in our side of the House fluid dynamics ever going to be

able to help them in the pandemic.

349
00:50:16.560 --> 00:50:22.470
Amanda Randles: And I think everybody was just really excited to have something to work on feel like they're able to help them, they kind of get involved.

350
00:50:22.830 --> 00:50:31.800
Amanda Randles: And the students just really dived in we had to we had a few teams kind of come together one trend to create a 3D model based on our normal work one making one day model and really trying to.

351
00:50:32.370 --> 00:50:36.810
Amanda Randles: identify what is the right model, how do we turn this around, how do we validate this quickly.

352
00:50:37.230 --> 00:50:45.480
Amanda Randles: And within about a week and a half, were developed a brand new model that we had never worked with before there was a one dimensional model actually building off a lot of capability within matlab.

353
00:50:46.080 --> 00:50:56.430
Amanda Randles: and worked closely with their team with multiple Chavez team with what they were doing to validate the model kind of touched on in a second the end goal of what we were trying to create.

354
00:50:56.700 --> 00:51:04.230
Amanda Randles: is essentially a mobile APP that would allow the doctors to put in information about each patient about the ventilator they're using.

355
00:51:04.530 --> 00:51:12.660
Amanda Randles: And then give them the data that you see on the rate that allows them to select which resistor radius they were going to use and identify how to tune this ventilator splitting up or others.

356
00:51:13.080 --> 00:51:21.660
Amanda Randles: We needed all this information quickly, so we could get it into the an emergency use applications, the FDA and have all of these results available for the FDA to review.

357
00:51:22.560 --> 00:51:33.090
Amanda Randles: The first step was validating and that's just what i'm showing here are simulations are the dotted lines and measured with mechanical lungs the Meta data from mechanical lungs is are the.

358
00:51:34.140 --> 00:51:43.260
Amanda Randles: Are the circles that you're seeing there and the main point was like within you know, a week and a half to two weeks, we had to create the model and then validated against these experimental experimental data.

359
00:51:43.500 --> 00:51:48.210
Amanda Randles: on using the bunch top models that we had and that's part of what we had to focus on initially.

360
00:51:49.230 --> 00:51:59.040
Amanda Randles: Then, when you think about the different components that could go into how we tune it is at the patient's wait, the peak pressure the tube diameter that was being used pulmonary compliance.

361
00:52:00.540 --> 00:52:05.970
Amanda Randles: We didn't want the clinicians to have to run a simulation and wait for a simulation, even if it was real time.

362
00:52:06.990 --> 00:52:11.460
Amanda Randles: We didn't want there to be any potential problems like you know they have to deploy matlab they have to like get this in Python.

363
00:52:11.910 --> 00:52:19.650
Amanda Randles: We want it, and we also wanted to provide all the data, so the FDA could could review exactly what we're what the guidance was going to be and what the information was going to be provided.

364
00:52:20.580 --> 00:52:27.120
Amanda Randles: So we wanted to have all of the simulations completed ahead of time and before we you know submitted everything for emergency use.

365
00:52:27.660 --> 00:52:37.950
Amanda Randles: which meant we had to run all of these different combinations and identifying you know for going on steps that she had like the first one, second implement our compliance going from 10 to 100 at every you know what step sizes, can we run.

366
00:52:39.330 --> 00:52:42.750
Amanda Randles: We kind of put this together and put the wish list of like if we had an.

367
00:52:43.290 --> 00:52:54.180
Amanda Randles: infinite compute power we would love to do every step size and it'd be great to give all the doctors, all of the information that we can possibly like provide with them and we went to the coven 19 hbc consortium and I requested.

368
00:52:55.170 --> 00:53:04.170
Amanda Randles: An initial put in the request was like you know we ended up using 800,000 compute hours, but I think i've ever requested like seven or 800,000 hours thinking there's no way they're going to give me this.

369
00:53:04.500 --> 00:53:09.240
Amanda Randles: And will kind of have to come back and maybe do stuff like you know widen our setup sizes and things like that.

370
00:53:10.470 --> 00:53:19.860

Amanda Randles: But I think it's it's worth kind of going over this is like the coven 19 hbc consortium was absolutely amazing and that you know we put in a proposal not targeting.

371
00:53:20.160 --> 00:53:31.260
Amanda Randles: We didn't say anything about which resource, we wanted to run on how we wanted to run, we were just like here's our code here's how it runs here's how many computer like you know how how many how many simulations we think we need to run help us.

372
00:53:31.800 --> 00:53:40.920
Amanda Randles: And they paired us with Microsoft we worked with Mike we ran on Microsoft azure and we submitted the application on a Monday we were paired with Microsoft by Wednesday.

373
00:53:41.520 --> 00:53:46.860
Amanda Randles: Thursday we had a call with Microsoft and they brought in 315 20 people on the call and they brought in.

374
00:53:47.250 --> 00:53:54.390
Amanda Randles: You know they had fluid dynamics experts in case we need to help with the model they had anyone, we could possibly need in the room to make this happen quickly.

375
00:53:54.870 --> 00:53:58.560
Amanda Randles: And then, by Friday we started running the simulations.

376
00:53:58.830 --> 00:54:00.420
Amanda Randles: And by Sunday.

377
00:54:00.660 --> 00:54:05.610
Amanda Randles: They had completed all of the simulations and used to 800,000 compute hours in one weekend to get everything done.

378
00:54:05.640 --> 00:54:12.450
Amanda Randles: With our entire wish list of like wouldn't it be great if we could run all of these simulations and it was completed within a weekend, less than a week from when we submitted the application.

379
00:54:13.380 --> 00:54:14.010
Amanda Randles: I don't think.

380
00:54:14.520 --> 00:54:21.330
Amanda Randles: The Microsoft team, and my students who are who are running it did not sleep, I was this this kind of in the context of like I had the twins that were like six months old at the time.

381
00:54:21.510 --> 00:54:26.760
Amanda Randles: So I was up at all hours watching the emails come in, but I will say like they were definitely the ones

doing the runs and completing this.

382
00:54:27.540 --> 00:54:34.470
Amanda Randles: But it was it was it was quite a weekend where they brought in people who weren't intending to stay up all weekend and work with us, and definitely were there to support us.

383
00:54:34.890 --> 00:54:40.680
Amanda Randles: It was it was it was impressive on that end, but it was great and that you're kind of coming together and.

384
00:54:40.980 --> 00:54:47.280
Amanda Randles: you're never having run an azure on Monday and being able to use that much compute time and have that effectively happen by the next week, I think, is.

385
00:54:47.910 --> 00:54:54.480
Amanda Randles: Is a great takeaway of like, how do we actually get that, how do we actually you know move science into being transmitted one you know kind of address.

386
00:54:55.410 --> 00:54:58.410
Amanda Randles: Address quick needs when when they when they come up, so it was.

387
00:54:58.980 --> 00:55:08.640
Amanda Randles: a really great great you know kind of coming together and use of that code, the coveted consortium That was really helpful from our end so I know i'm hitting up on time there, so I do want to stop there.

388
00:55:09.120 --> 00:55:21.120
Amanda Randles: And i'll pause and just you know think everyone in the love and kind of all of our collaborators all the research that we've been doing that i'm presenting I tried, everyone has his work i've touched on, as highlighted in blue here and it's.

389
00:55:22.590 --> 00:55:25.410
Amanda Randles: All i'll pause here and ask if anyone has any questions.

390
00:55:29.280 --> 00:55:36.720
Amy Walton: Well, thank you very, very much for interesting very exciting work that you're doing randalls and.

391
00:55:37.560 --> 00:55:43.440
Amy Walton: we're for to the audience we're starting to receive questions, if you would be so kind as to use the Q amp a.

392
00:55:44.280 --> 00:55:54.930
Amy Walton: To pose your questions, we will go ahead and start going through some of the questions in a moment, but you've had a chance to get a drink of water amanda but.

393
00:55:55.590 --> 00:56:11.100
Amy Walton: The first one was you mentioned that you only program serially as an undergraduate could should current computer science undergraduates learn how to program and analyze parallel programs, and if so, where, at what scale and how.

394
00:56:12.360 --> 00:56:24.390
Amanda Randles: um yeah I i'm very pro parallel computing so I definitely think I think learning as early as possible is great, I think, especially you know with the way computer like the way technology is gone today, and you know.

395
00:56:25.530 --> 00:56:33.750
Amanda Randles: topics we feel very old like what I started, we didn't have a lot of parallel computing in like you didn't have multiple processors, so you were really able to code to you as much in.

396
00:56:34.680 --> 00:56:36.630
Amanda Randles: Your laptops and desktops and everything and it is.

397
00:56:37.200 --> 00:56:49.320
Amanda Randles: it's really it's really becoming a way of life for that we can easily access the cloud, we can really easily access multiple processors gpus are really accessible, these days, so I think it they're very marketable and it's used, you know it.

398
00:56:49.680 --> 00:56:59.190
Amanda Randles: Is I know a lot of the undergraduates who take my parallel computing class they end up talking about that class when they're on the job like on the job hunt and interviews and it really is helpful and makes them.

399
00:56:59.550 --> 00:57:08.160
Amanda Randles: It has been incredibly helpful and I think getting started in undergrad and just having an appreciation for how do you think about coding How does that change how you know.

400
00:57:09.180 --> 00:57:22.860
Amanda Randles: How you how you approach setting up a program to run in parallel is is incredibly important, even just from a like, how do you approach Problem Solving in parallel and the skill sets you derive from from thinking about things in parallel can be incredibly helpful, so I think.

401
00:57:24.060 --> 00:57:28.620
Amanda Randles: I think yeah I think it is something that we should be embedding into the undergraduate curriculum a bit more.

402
00:57:30.000 --> 00:57:36.270
Amy Walton: Thank you amanda The next question we have Dr or Zani Thank you very much for your question on and sort of future directions.

403

00:57:37.560 --> 00:57:50.310
Amy Walton: That an issue in purely data driven machine learning for cardiovascular models is the incredibly large landscape of input geometry trees and the high dimensional output it's 3D time very vector fields.

404
00:57:50.880 --> 00:58:05.190
Amy Walton: So they have very poor generalization can your simulate simulations in the near future, Richard point to create very large 3D data sets perhaps 10s of thousands of simulations are more to create large databases suitable for these models.

405
00:58:06.480 --> 00:58:14.190
Amanda Randles: Great yeah that's a great question Elsa yeah, thank you for asking closer been following your work so i'm very excited to have you have you in this talk um.

406
00:58:15.060 --> 00:58:24.180
Amanda Randles: But I think that that's kind of where we're trying to go, and it really depends, you know if we're looking at questions like you know, in the in the cardiovascular space we've really pushed it.

407
00:58:25.620 --> 00:58:37.410
Amanda Randles: is running you know running a fractional reserve simulation can take maybe half an hour on a reasonable amount of compute like compute cores so it's much more tractable to start trying to get.

408
00:58:37.890 --> 00:58:45.810
Amanda Randles: Thousands of simulate you like we currently have our large database of 200 patients, but we have the resting state, we have like remix date we're looking at longer longer periods.

409
00:58:46.440 --> 00:58:48.870
Amanda Randles: Hopefully we'll be able to make that available in the future.

410
00:58:49.200 --> 00:58:56.790
Amanda Randles: And we're you know with that kind of capability we're at that stage we had one project we're looking at bifurcation lesions and we kind of did.

411
00:58:57.030 --> 00:59:08.430
Amanda Randles: very similar to like protein folding at home, like setup of whenever our cluster was was free in the last couple years we've been running bifurcation legion simulations of different geometries perturbing the geometries and seeing how that would.

412
00:59:09.600 --> 00:59:16.650
Amanda Randles: How that would work and we have created a few thousand like we have a large database of these geometries and these simulations I think that was just.

413
00:59:16.920 --> 00:59:24.150
Amanda Randles: You know not taking an active role in trying to do, and really just passively whenever the cluster is not being used, and I think that's that's the direction we're able to go and now Have we really.

414
00:59:24.420 --> 00:59:36.810
Amanda Randles: You know I think a lot of the cfd methods are getting to that stage where we can create that kind of data that you really I agree really are going to need for for what and for the data, the data science applications.

415
00:59:38.250 --> 00:59:56.160
Amy Walton: Great Thank you again great answer The next question is from Dr criminal for in astronomy Thank you and then, how do you obtain the detailed information about the individual patients physiology and vasculature to accurately guide the directed soon as a simulations of their blood flow.

416
00:59:57.240 --> 01:00:07.620
Amanda Randles: So we have we have a lot of collaborations with the hospitals, we work closely with brigham women's hospital in Boston and also the Duke hospitals We work very closely with the doctors to get this data.

417
01:00:08.370 --> 01:00:18.570
Amanda Randles: Every project in my lab does have either an experimental list or a Doc like a physician involved to make sure we can get data and we're also asking questions are actually relevant and useful to them um.

418
01:00:19.230 --> 01:00:26.550
Amanda Randles: We are and it's also worth mentioning like one of the projects that one of the graduate students is working on now is kind of the reverse of trying to identify.

419
01:00:27.030 --> 01:00:34.410
Amanda Randles: How much like it seems intuitively that you would want everything to be as patient specific as possible and you'd want to tune this to the patient as much as you possibly can.

420
01:00:34.770 --> 01:00:42.360
Amanda Randles: um one of the projects that the graduate students working on this train identify how much do we actually need to to to to the patient and when can we use patient average data.

421
01:00:43.020 --> 01:00:48.780
Amanda Randles: When is it really critical to get it from from the patient itself and what information can be used because it is hard to get.

422
01:00:49.080 --> 01:00:56.730
Amanda Randles: You may not have actually you may have the geometry, but you may not have the cardiac output of you may not have you know certain characteristics that you really need and when do you really need them, and one is that important and which.

423
01:00:56.760 --> 01:00:58.650
Amanda Randles: Which characteristics, so we are trying to get.

424
01:00:59.280 --> 01:01:06.360

Amanda Randles: more of a sense of you know how patient specific does it have to be in one can you can one can kind of cut corners and use literature based values and it's.

425
01:01:06.690 --> 01:01:15.930
Amanda Randles: it's it's a bit surprising, depending on the problem like there are there are many cases where you can use, you can get away with patient average data and still get very accurate results so.

426
01:01:15.930 --> 01:01:22.050
Amanda Randles: it's we're trying to figure out what is that, like I guess similar the Cartesian project and what does that minimal and unit of patient specific data.

427
01:01:23.040 --> 01:01:35.790
Amanda Randles: But I guess the short answer the questions we do work very closely with the clinicians and get a lot of data are we're about a five minute walk from the hospital so that ends up being very helpful that the doctors, we can work or easily with the physicians we're lucky on that sense.

428
01:01:37.290 --> 01:01:46.320
Amy Walton: Thank you again and it's an indicator of how widely interesting your talk is is that basically just about every director, it has been asking you questions.

429
01:01:47.250 --> 01:02:02.730
Amy Walton: Afterwards, here, the next one is from Dr oberg who's been engineering and his question is in the lb computation is the local pressure evaluated assuming the fluid is invested If so, is there an uncertainty for smaller vessels were viscous forces are significant.

430
01:02:03.390 --> 01:02:12.930
Amanda Randles: yeah that's a great question so it's we've spent a lot of time figuring out how to move from a lot of people spend units over to active real pressure as well that that is a.

431
01:02:13.710 --> 01:02:20.490
Amanda Randles: yeah figuring out the pressure side is a huge question, it does kind of vary depending which project what we're looking at and how.

432
01:02:20.850 --> 01:02:32.730
Amanda Randles: how large the vessels are, and you know when we're looking at the smaller vessels, we are looking at like we do actually have you know it's, not even a newtonian model anymore, you are actually explicitly modeling the soul, so it does kind of does kind of change i'm.

433
01:02:34.590 --> 01:02:37.650
Amanda Randles: Sorry now i'm not remember exactly how sorry I I.

434
01:02:38.550 --> 01:02:41.970
Amy Walton: I want certainty for smaller vessels were discussed forces are significant.

435
01:02:42.480 --> 01:02:43.860
Amanda Randles: yeah so we're still.

436
01:02:46.170 --> 01:02:56.790
Amanda Randles: We don't have it too late, we haven't there is an uncertainty for in the smaller muscles that we haven't quantified for that we're in the process of quantifying and how we integrate that, but it is something you have to take into account.

437
01:02:58.320 --> 01:02:58.650
Great.

438
01:03:00.570 --> 01:03:07.140
Amy Walton: So any other questions from the attendees if you would post your questions.

439
01:03:09.900 --> 01:03:12.630
Amy Walton: will try to answer them and.

440
01:03:14.130 --> 01:03:18.090
Amy Walton: Give them another minute or two any any closing comments that you wanted to make.

441
01:03:19.320 --> 01:03:20.280
Amy Walton: Dr randalls.

442
01:03:22.200 --> 01:03:28.950
Amanda Randles: i'm not really just like just enjoy yeah I think i'm happy that they're people from so many different directors and here.

443
01:03:29.190 --> 01:03:40.290
Amanda Randles: I think there are there, just so many unanswered questions and areas that we can push forward that aren't just in the health space, but I think everything from you know how do we bring an edge computing and cloud computing to like tie in with the.

444
01:03:41.550 --> 01:03:50.550
Amanda Randles: tie in with you know where the electronic records are coming from and how we're addressing it to the virtual reality of how do you do the the interaction that it's it's great to have.

445
01:03:51.030 --> 01:04:01.050
Amanda Randles: We need an interdisciplinary approach to target these problems, we need we need we need help from all of these Directorate so it's really it's really great to have people people around.

446
01:04:05.310 --> 01:04:11.250
Amy Walton: Give them another minute to see if anybody else haha alright get another director material science.

447
01:04:12.300 --> 01:04:19.650
Amy Walton: Thank you Darrell so great talk, do you include the elastic response of the blood vessels can you predict their failure.

448
01:04:21.270 --> 01:04:30.240
Amanda Randles: Right so yeah it's a great question so everything I showed today the cells are too formidable but the walls are rigid and one of the students.

449
01:04:31.020 --> 01:04:40.650
Amanda Randles: We do have like there's someone's like a large part of their PhD project is adding in the different properties of the wall sweet, we can actually do it now, the first paper it's not out yet, but it should be, hopefully, in the next year.

450
01:04:41.730 --> 01:04:46.410
Amanda Randles: At this stage it's been it's been really interesting is like when do you actually need to take into account, like all of the work with the fractional.

451
01:04:46.650 --> 01:04:55.980
Amanda Randles: reserve, we have rigid walls and we're still getting within like three to 6% error and in those situations it's fine to get away with with you don't necessarily need the compliance of the walls.

452
01:04:56.520 --> 01:05:09.360
Amanda Randles: As we're looking at questions like AV fistula or they're like look at the vein site like there are different areas where you really need to take into account the flexibility of the walls, the material properties, and so we are, we are adding we have added that in and.

453
01:05:09.660 --> 01:05:18.390
Amanda Randles: it's very similar approaches it's very similar to how we have the where we're using the immerse boundary and capturing the affordability of the specific cancer cells.

454
01:05:18.990 --> 01:05:25.560
Amanda Randles: We just focused on sales first and now we've added that to the walls, but it's essentially the same model that you're tuning with different constituent of laws.

455
01:05:25.860 --> 01:05:33.660
Amanda Randles: For the walls versus the cells, but it's taking that same like immerse boundary approach of connecting the final element via the momentum exchange.

456
01:05:35.370 --> 01:05:46.170
Amy Walton: Excellent great, thank you very, very much the next question in the case of aneurism you'll end up with turbulent flow around the site, how is that handled.

457

01:05:47.280 --> 01:05:54.330
Amanda Randles: So yeah so interestingly, we haven't had to put at least we have modeled aneurisms we are, we can we can capture like the.

458
01:05:55.440 --> 01:06:04.860
Amanda Randles: way, we can capture the city and secondary flow in our models, we haven't hit a Reynolds number and we haven't hit a region we don't have an explicit turbulent model that we've had to add it yet.

459
01:06:05.310 --> 01:06:18.510
Amanda Randles: we've still been able to capture the physiological we've done a lot of work on aneurysms actually where we were for a little while we were able to capture a lot of the secondary flow characteristics and it is captured within.

460
01:06:19.710 --> 01:06:27.060
Amanda Randles: It is it is captured within the current models of Harvey it does lead to, in some cases, we had to run a higher resolution to make it stable and that.

461
01:06:27.900 --> 01:06:35.580
Amanda Randles: leads to a much more competition, intense model um, but it is actually captured with with the models we're currently using at this stage, I think.

462
01:06:36.270 --> 01:06:48.210
Amanda Randles: there's definitely a limit to you know if you hit real turbulence like depending on the Reynolds number, we may need to introduce or a proper turbulence model, but we haven't had we haven't we haven't hit a scenario where we need that at this stage.

463
01:06:49.770 --> 01:06:57.150
Amy Walton: Great Thank you very much, next question is from someone who has worked in both the computer science and social behavioral and economic directorate.

464
01:06:57.570 --> 01:07:05.220
Amy Walton: Is the virtual reality technology good enough for your clinical efforts, or does this technology still need to be improved and, if so, in what way.

465
01:07:07.380 --> 01:07:19.680
Amanda Randles: it's hard I think we're getting there it's I mean we've seen a lot of improvements we ended up having to do a lot of work, trying to understand, like the effect of like the controllers and that's like you know how accurate, are they and where they're picking and.

466
01:07:20.010 --> 01:07:23.280
Amanda Randles: And a lot of these devices it, I think we.

467
01:07:24.630 --> 01:07:27.540
Amanda Randles: Like I think we're very close like there's not um.

468
01:07:29.430 --> 01:07:31.590
Amanda Randles: yeah it does not there's there's.

469
01:07:33.090 --> 01:07:43.740
Amanda Randles: The accuracy and the interaction of what you think like where you think you're selecting and we're able to select like it's very responsive it's like near real time, it does not like a lag time between what you think is happening.

470
01:07:44.580 --> 01:07:48.000
Amanda Randles: One of the the you know what would be nice as more on our end of.

471
01:07:48.300 --> 01:07:58.140
Amanda Randles: It as soon as you change the geometry, can you predict what the flow would be, and right now there's a little bit of a lag because of the time it takes to run the simulations you don't get like a real time feedback of How does that change the simulation.

472
01:07:59.370 --> 01:08:03.780
Amanda Randles: But the vr side of it, I think, like it's very close and even.

473
01:08:04.350 --> 01:08:09.990
Amanda Randles: The latest user study we completed was trying to hit cabbage so when you're like trying to determine like Where are you going to put a bypass graft.

474
01:08:10.260 --> 01:08:20.280
Amanda Randles: And we kind of we just had the students whole up in the hospital for a few days, and you know, whenever the surgeons for free and had a few minutes to stop by and play with it and it's kind of amazing of just.

475
01:08:20.700 --> 01:08:30.840
Amanda Randles: How many people spent a lot of time, but they were very excited to go play with the devices like I think there's a lot of interest from the medical community, and it was interesting we worked with both.

476
01:08:31.800 --> 01:08:37.170
Amanda Randles: We worked with like the fellows and the act like attending physicians and we were kind of expecting.

477
01:08:37.950 --> 01:08:45.330
Amanda Randles: Basically, like the fellows probably who played more video games, most likely is what was our hypothesis of what they have more experience with the virtual reality interactions and.

478
01:08:45.930 --> 01:08:57.900
Amanda Randles: You know that site like there's there's the 10 things are still learning, but that everybody there's a huge interest in how do we integrate this um I think one of the issues we may have is.

479
01:08:58.050 --> 01:09:07.950
Amanda Randles: Like some of the work I was showing here the fully immersive we're really effective and very, very useful and fully immersive meaning with htc Vive The quest when you're like we have the head the head mounted devices.

480
01:09:09.210 --> 01:09:20.700
Amanda Randles: However, translating that into the clinic with a Z space is much easier and if they only have five seconds and they're very busy, and moving you know from room to room they're just throwing on the glasses that can interact with the geometry really easily and.

481
01:09:21.240 --> 01:09:27.840
Amanda Randles: The uptime for how do you get into the habit setup get into the like get into the virtual environment and that side of it.

482
01:09:28.470 --> 01:09:35.580
Amanda Randles: Like I did the hololens is making a lot of like there's a lot, a lot of great options on that end of like, how do you have multiple people interacting with it with the device.

483
01:09:36.780 --> 01:09:44.790
Amanda Randles: Basically it's the questions of how do we, how do we minimize how hard it is for them to set up set up the environment get immersed in the environment, quickly and make that.

484
01:09:45.180 --> 01:09:48.510
Amanda Randles: Make that hat like that side of it go go eat a little bit easier.

485
01:09:48.900 --> 01:09:56.280
Amanda Randles: And if there are options for having multiple people if they wanted to the treatment planning together, especially when you have the attendings tend to have a follow with them.

486
01:09:56.820 --> 01:10:10.740
Amanda Randles: How do you have multiple people in that environment interacting together kind of something open questions or We really do need to see improvement on that end um but the the actual manipulation for the virtual surgery I think we're very close to me not being deployable.

487
01:10:12.900 --> 01:10:22.320
Amy Walton: Greed answer good question darlene Thank you very much for that, so if there are other folks with questions again, we still have an open.

488
01:10:22.950 --> 01:10:30.690
Amy Walton: Please enter your question in the Q amp a on zoom and for those of you who will still probably have questions.

489
01:10:31.470 --> 01:10:43.140

Amy Walton: Dr randalls has generously offered to have an office hour with us this afternoon at three o'clock and so you'll be able to sign into zoom and talk with her at that time as well.

490
01:10:44.400 --> 01:10:46.710
Amy Walton: So let me check again for any.

491
01:10:47.880 --> 01:10:49.980
Amy Walton: Closing questions.

492
01:11:00.960 --> 01:11:08.400
Amy Walton: And anything else that you wanted to add to any of the questions that we were throwing at you, that have come to mind since.

493
01:11:10.620 --> 01:11:12.600
Amy Walton: you've been peppered with questions.

494
01:11:13.380 --> 01:11:15.390
Amanda Randles: I don't think I have anything else to add.

495
01:11:16.770 --> 01:11:17.280
Okay.

496
01:11:18.840 --> 01:11:28.260
Amy Walton: Well then, what i'd like to do is to ask everyone to check please join with me and thank you for a very interesting topic, the presentation that.

497
01:11:30.330 --> 01:11:33.210
Amy Walton: Every director, it was here listening to you today so.

498
01:11:34.260 --> 01:11:42.870
Amy Walton: Thank you very, very much for your time and then For those of you who have who have additional questions we'll we'll see you at three o'clock today Thank you again.

499
01:11:43.500 --> 01:11:44.670
Amanda Randles: Thank you so much.