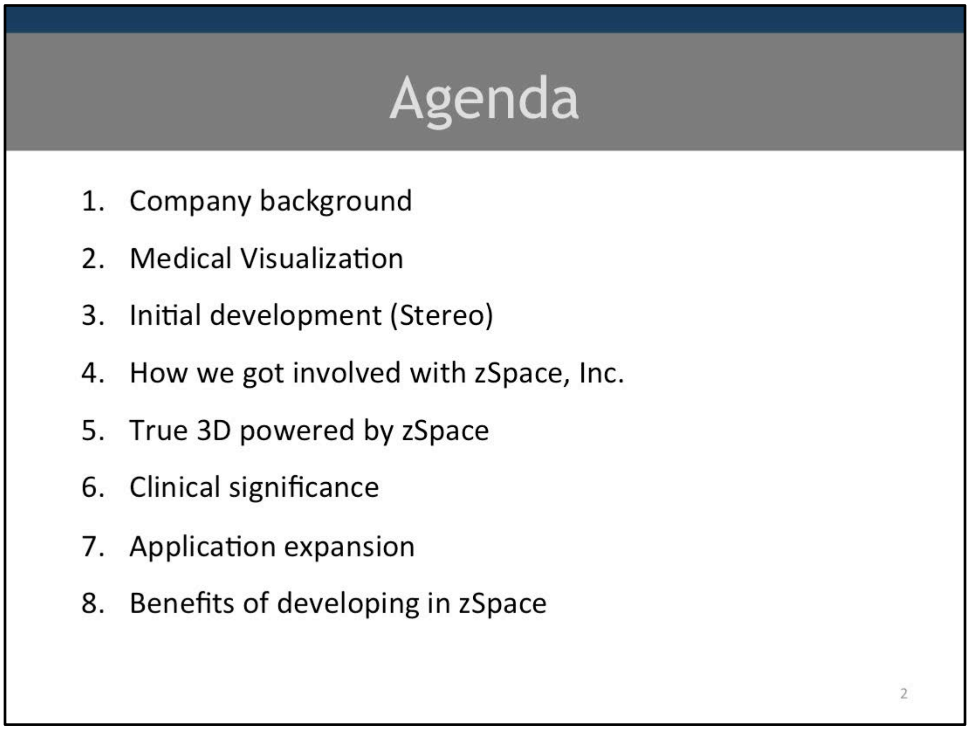
Presenter, Sergio Aguirre, is a founder and CTO of EchoPixel, a company creating medical visualization solutions to optimize clinical efficacy and workflow, while leading the way for a paradigm shift in medical diagnostics, surgical planning and treatment. EchoPixel's solutions utilize zSpace to present meaningful 3D representation of anatomy, and an interactive toolset and methodology that increases knowledge and promotes clinical decision making.

Sergio Aguirre:
I'd like to thank everybody for their time, and especially thank zSpace for the opportunity to talk about EchoPixel and the exciting work that we're doing with zSpace. And so, as part of our agenda for today, what I'll be talking about is the background of EchoPixel and our status as a company, how we see medical visualization, and how EchoPixel started working with stereoscopic displays and imaging. I'll later talk a little about how we got involved in zSpace and began to work with this very exciting technology, and how we have evolved our technology, through 3D, by leveraging the capabilities that zSpace provides. So after that, we'll go on to explain what we see as the clinical significance of True3D and zSpace, and some of the new applications that EchoPixel's working on, and what we see as a benefit of developing in zSpace.



So let's start by talking about EchoPixel and the company background. So we're definitely a startup company. We have venture capital funding, and we have some programs established where we're doing some clinical trials. Our vision is really to build a new world of patient care where we can leverage EchoPixel's technology, which is True3D, and achieve business success by expanding medical and scientific visualization applications in the market.

Company Background

Vision
Build a new world of patient care

Purpose
Through True 3D technology, achieve business success by expanding the medical and scientific visualization market

Mission
1. Achieve clinical excellence and improved workflow driven by the Clinical-Technical Tie
2. Engage with Luminary Centers to establish effective clinical protocols
3. Partner with corporations to create paths for market penetration
4. Leverage C-T Tie resources into a powerful IP strategy
5. Seek opportunities to accelerate business financial success

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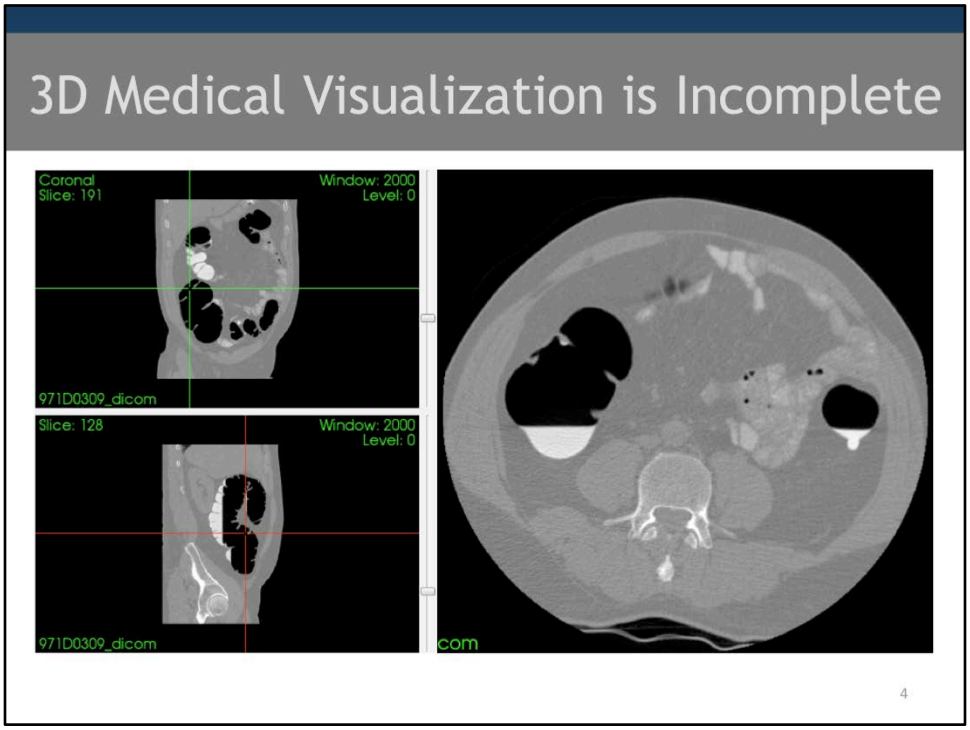
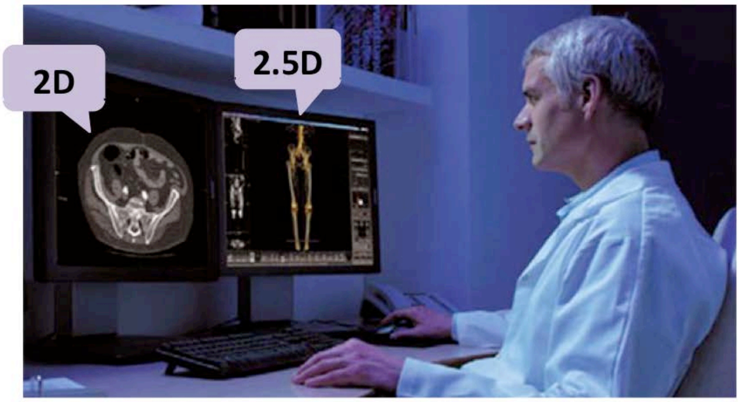
We believe that True3D and zSpace really provide a new visualization paradigm that can help us achieve clinical excellence and improve workflow. So basically we want to have doctors deliver better outcomes for their patients, in a faster more productive way, through something that we call the clinical technical tie. So how does the technology improve clinical outcomes? And so we focus a lot by engaging, or we focus on engaging with luminary centers, or luminary doctors, so we seek out the best doctors that we can find the world to establish new ways of working through clinical problems, leveraging zSpace and True3D. And we also partner with large corporations so that we can get to the market, and we leverage our clinical technical tie to be able to get to the market and deliver great value.



The problem that we see in 3D medical visualization is that it's incomplete. You have a series of imaging devices, like CT scanners, MRI, ultrasound, all of them acquiring 3D volumetric datasets of 3D anatomy, but ultimately you'll have a doctor sitting at a desk looking at a series of 2D images and reconstructing in their mind the 3D anatomy that they want to evaluate.

3D Medical Visualization is Incomplete



Intense deliberation, not anatomically meaningful with distortion, increasing challenges to productivity with few experts.

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You'll notice in the image that this doctor is looking on his left screen at a single 2D slice. And from that slice he's reconstructing the 3D anatomy in his mind.

You'll see on the right screen a 3D representation of the anatomy that he's looking at, which is something that we now call 2.5D. The reason that we call it 2.5D is because there's a 3D rendering done as a 2D perspective in a 2D flat image. So there's no depth perception, and basically you don't have the same anatomical significance that you would see when you're looking at a body part.

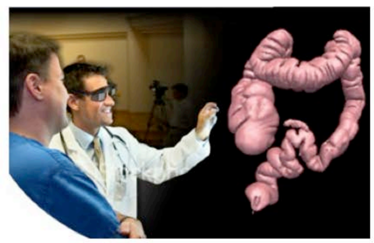
So what happens is, when doctors are looking at 3D medical visualization, they are deliberating through the images and really struggling through how to understand the data that they're trying to evaluate. It's not anatomically meaningful and many times they will some distortions that they have to work through, and this really poses a challenge to the whole community for achieving good productivity and there's very few experts.

EchoPixel – Initial Development

Combines Computed Tomography Colonography (CTC) software and proprietary stereoscopic 3D visualization imaging platform.

Faster and easier with increased accuracy for identifying benign, pre-malignant and malignant polyps.

Stereoscopic 3D CTC



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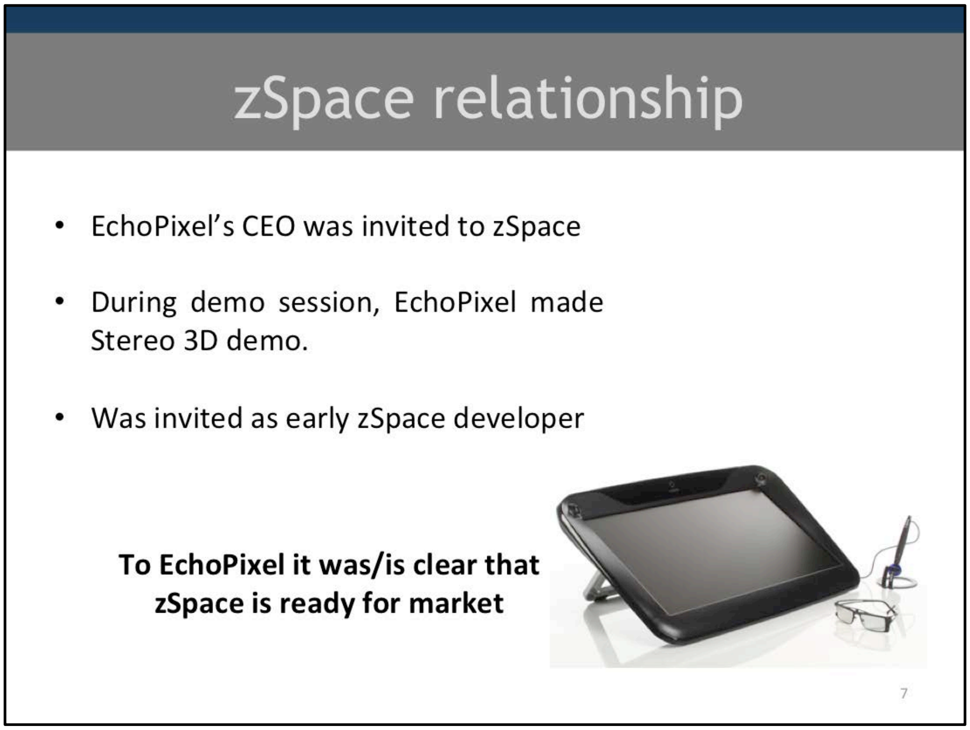
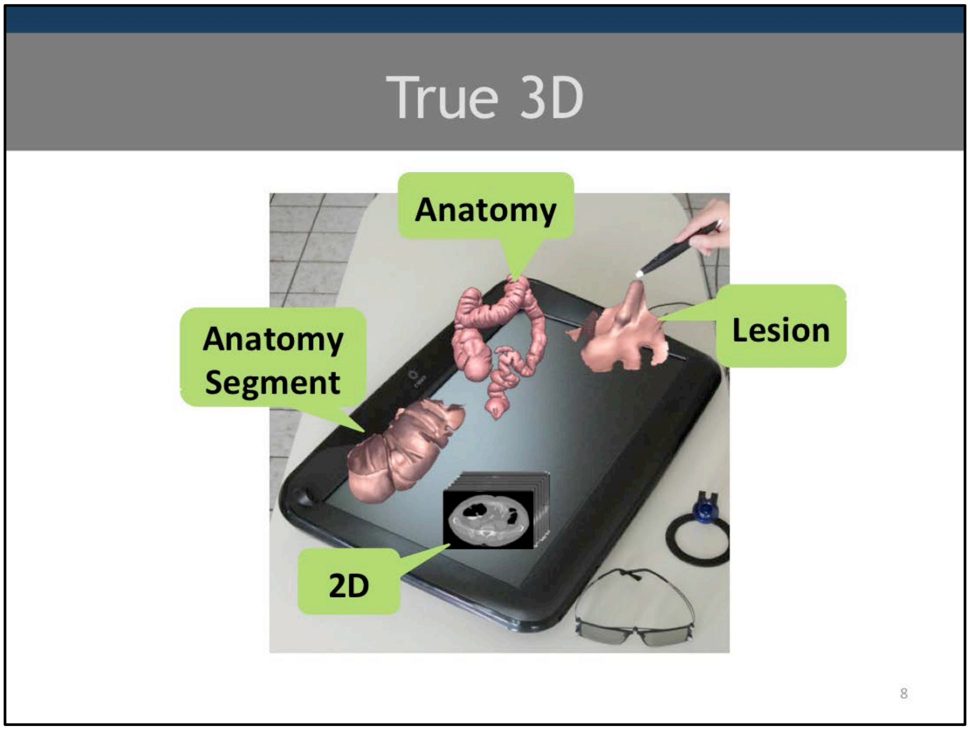
So EchoPixel identified this problem some time ago, and we started working with virtual colonoscopy, or computed tomography colonography, for doing virtual colonoscopy in stereo. And so basically we started by reconstructing colon images acquired from CT, and presenting those in stereo to doctors. And what we found was that by providing accurate depth perception, we could enable doctors to have a better and easier way of working through the data, and identifying polyps which are malformations that grow on the lining of the colon that later become tumors.



So as we were doing this, our CEO, Ron Schilling, was invited to see a demonstration of zSpace. And there was a demo session where the EchoPixel technical team was invited, and we were able to present our stereo 3D demo on virtual colonoscopy. So at that time, we were invited as one of the earlier developers of zSpace, and from that point on, to us it was really clear that zSpace was ready for the market and was really the future of visualization in many, many ways.

So not only are you talking about that in zSpace you've got a stereoscopic display that gives you very good stereo imaging, but you also have the capability to do virtual colonography in terms of the motion parallax and the head tracking and the direction of action with the stylus. So to us that is very, very, a very powerful set of tools because basically by EchoPixel driving zSpace, we can provide three sensory inputs that are very, very valuable to doctors. And so the stereo provides an input, which is depth perception through parallax, that allows doctors to understand depth location of objects, minimizing the deliberations that they have to do.

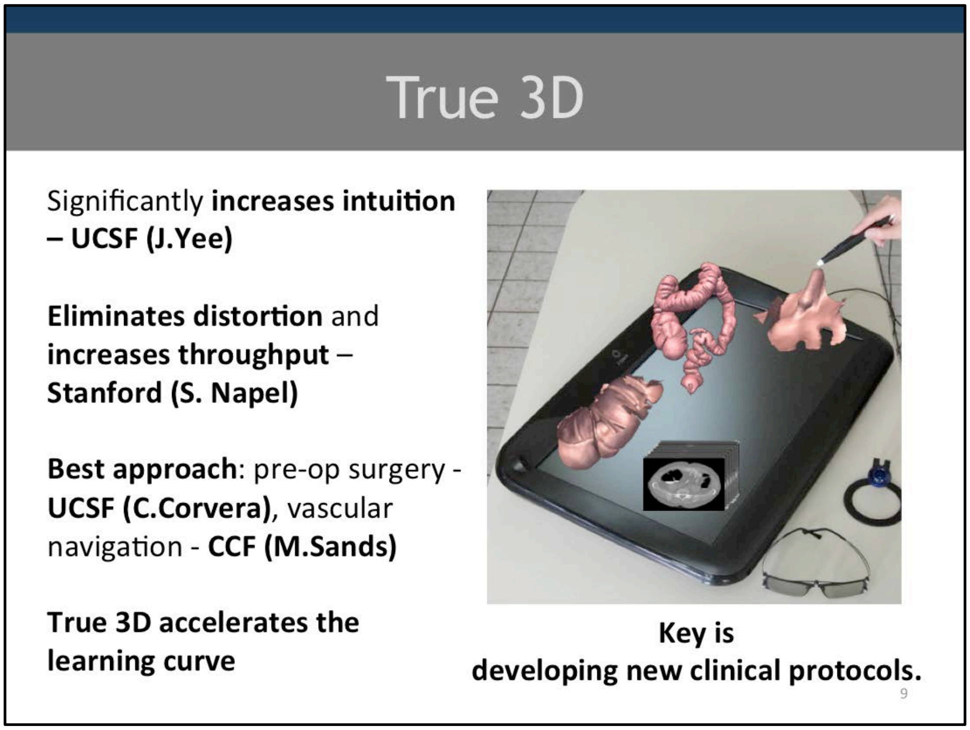
The motion parallax, or the head tracking, also is another depth sense that doctors will not have to deliberate through, so they will understand the 3D anatomy that they're seeing very, very quickly. And when they use the stylus to reach in and grab tissue and pull it towards them, we're basically allowing them to generate a kinesthetic feedback into their mind that also gives them additional sensory information of 3D and the objects that they're seeing



So we're basically reinforcing their understanding of the 3D anatomy that they're seeing in a very, very powerful way. And so it's almost like when you go to school, you read something, you say it and you write it, you're reinforcing your learning. Here we've got a very robust set of tools to give doctors a very robust understanding of the 3D anatomy that they will need to evaluate.

And so with zSpace in mind, we developed True3D, which is basically our view and our vision of how medical visualization should be done. And so you'll notice that at the bottom we have the zSpace display where we can show 3D objects in a virtual holographic manner. And the idea is to be able to show the source data, that series of 2D images that together create a collection of voxels that represent the 3D anatomy of the patient. And so we can show that precisely as a volumetric set of voxels, or a series of slices that you can extract and work through in open 3D space.

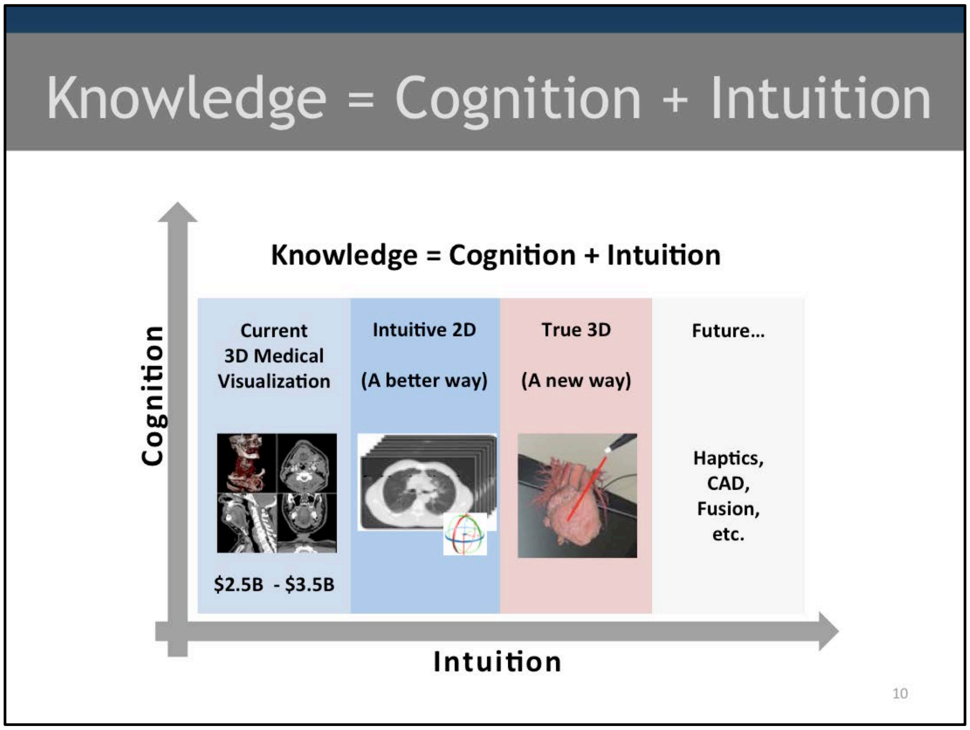
At the same time, we can do anatomy reconstructions, like the colon that we're showing here, where you can see a body part and work with body parts. Many times body parts, tissue or organ, are actually systems that have different context in different parts of the system. And so we'll do image processing to get anatomy segments so that we can have doctors focus on the contextual issues that they want to look at when they're identifying lesions, or when they're working through specific clinical problems. And many times they will need to focus on a particular lesion, say a



So the paradigm really changes very significantly from one where doctors are resolving the 3D problem from the images that were acquired from CT and MRI or ultrasound, to one where they're really working with body parts, and they can really focus their energy on resolving the clinical problem. So this is something that to EchoPixel has been very, very valuable.

So we started working with doctors and seeing how True3D and zSpace can really improve clinical outcomes in several clinical applications. And so as we've been mentioning before, we've been working on virtual colonoscopy at UCSF with Dr. Judy Yee, and her insight is that it really significantly increases her intuition. And we'll talk a little bit more about what intuition means, but basically she doesn't have to deliberate through the images, she will most easily understand the clinical problems that she wants to solve.

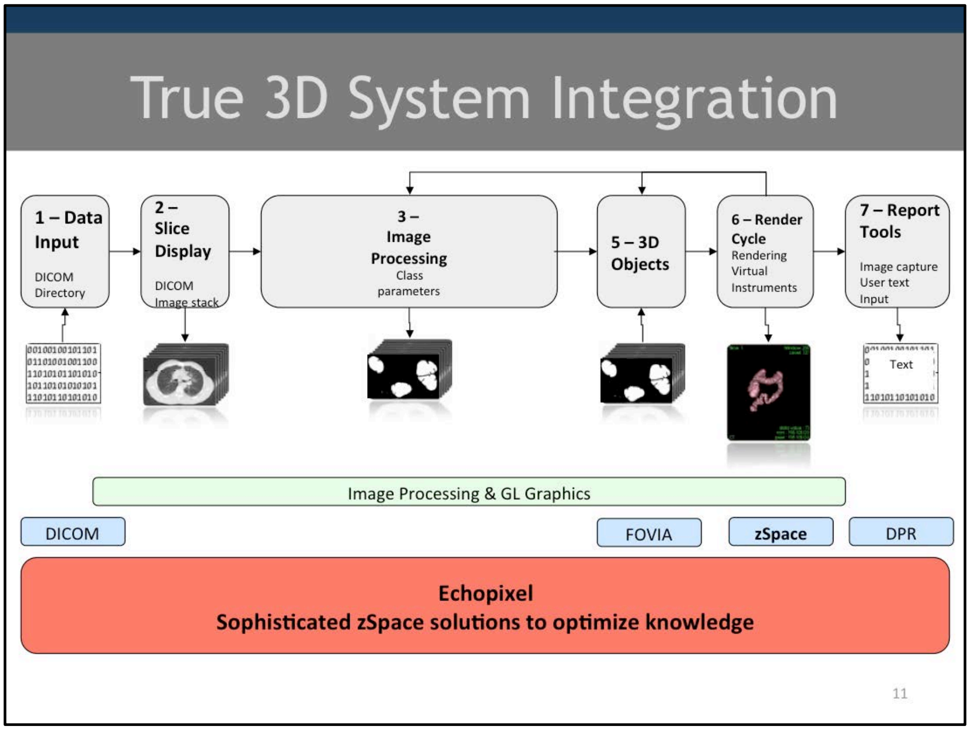
At Stanford, with Professor Sandy Napel, he believes that we minimize or eliminate the opportunities to (inaudible) distortion, therefore increasing throughput, because we can show images, or the information in the images as body parts, and therefore there's no need to map images in a different way and the distortion opportunities are really minimized or eliminated. Also at UCSF Dr. Carlos Corvera, a liver surgeon, and at Cleveland Clinic, Dr. Mark Sands, also an interventional radiologist and specialist in liver, believe that this is the best approach for pre-op surgery and vascular



And one thing that we find is that because there are very few experts, there's a steep learning curve for doctors to achieve clinical excellence. And so we truly believe that through True3D and zSpace can really accelerate that learning curve and have all doctors achieve clinical excellence in a shorter time. So the key to this is really to develop these new clinical protocols, these new methodologies of interpreting the images and working through them to be able to resolve a specific (ph) problem.

So the value that we see that we can bring to medical visualization is really about knowledge, and True3D and zSpace really are about improving knowledge. So we see knowledge as being the combination of cognition and intuition. On the one (inaudible) side, the vertical axis, we're defining the cognition axis where most of the medical, or current medical visualization solutions, or the current state of the art is, so these high density, rich data solutions that rely on the cognitive abilities of doctors to resolve 3D anatomy from 2D view. The cognition really comes from doctors deliberating through the data to understand the 3D anatomy.

On the horizontal axis, what we're showing is intuition. So the intuition is really about how do we provide sensory inputs that minimize or eliminate the need to deliberate through the data so that you can understand the 3D anatomy that you will want to evaluate. And so when you combine these two things, you're really driving knowledge, or clinical knowledge to a different level. And so we see True3D and



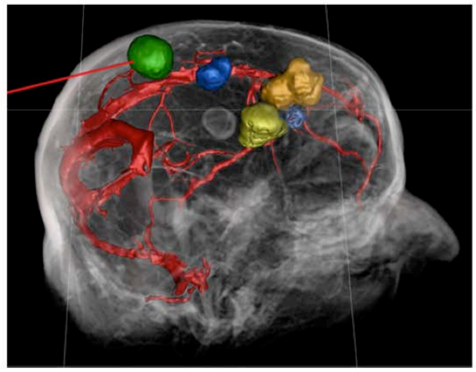
So the bottom line is that because we can provide the opportunity to doctors to not deliberate through the images, their knowledge can really improve because they can focus their energy on resolving the clinical problems.

So our True3D system, and so this is something that's going to be familiar to some in our audience that have worked with, or done medical image processing. So we've set up a pipeline where we can input any type of DICOM data and we generate those slices with images that were acquired by the MRI or the CT scan. And then we go into a phase where we do image processing where we will be identifying the tissue or the organ of interest, or potentially even identifying lesions. And we generate a series of 3D objects that really determine the methodology that we want to going along through that methodology.

And so once they're displayed in our render cycle, we can have doctors really follow the interpretation methodology that we want them to do. And so the idea is that by focusing all of our development efforts into providing these applications that implement these new interpretation methodologies, doctors can really have an easier time, not only understanding the images as body parts, but also an easier time really focusing on the areas where they need to focus on.

New Protocol = Clinical Significance

- **Enhanced Accuracy**
- **Intuitive Visualization**
- **Accelerated path to expertise**
- **Increased confidence / throughput**
- **Reduced Radiology-Surgery Gap**



New Medical Visualization Protocols

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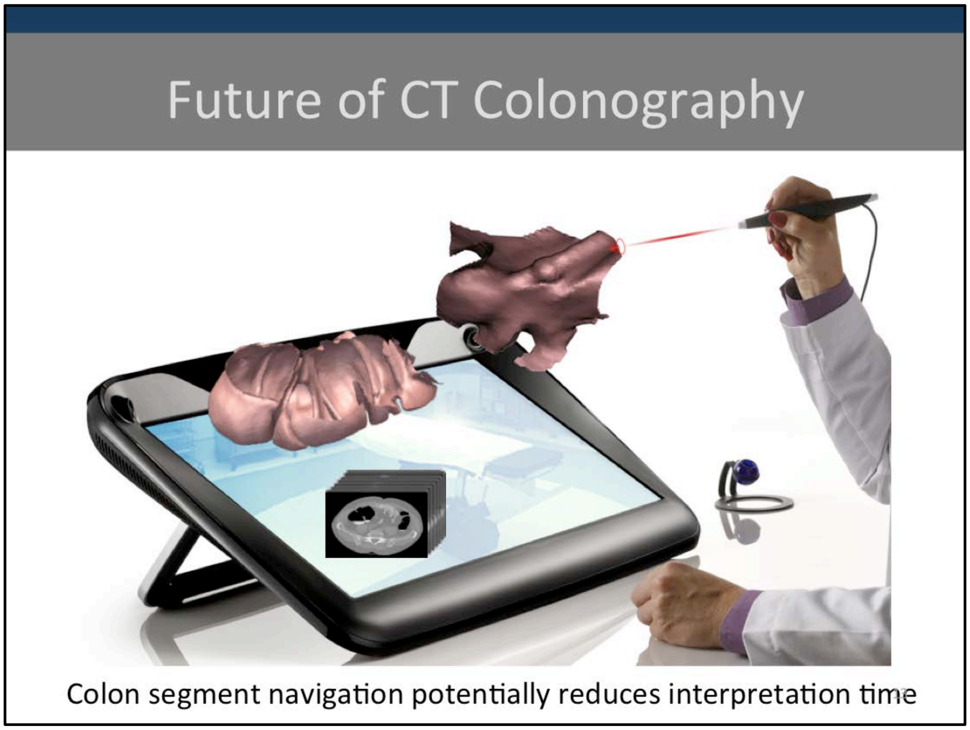
So a lot of times it's about clearing healthy tissue and identifying what is normal anatomy, and really focusing on what is abnormal. So many times, when doctors get a dataset, they will have to review all of it, but they really have to discern what is okay and what is the area where they really want to focus. And so that methodology becomes very, very crucial so that in a very quick way they can discriminate what is healthy anatomy and then focus really all of their energy and time on the lesions. So that's what this pipeline is all about, it's all about providing that set of 3D objects, either tissue or organs, so that doctors can work through that in an orderly fashion.

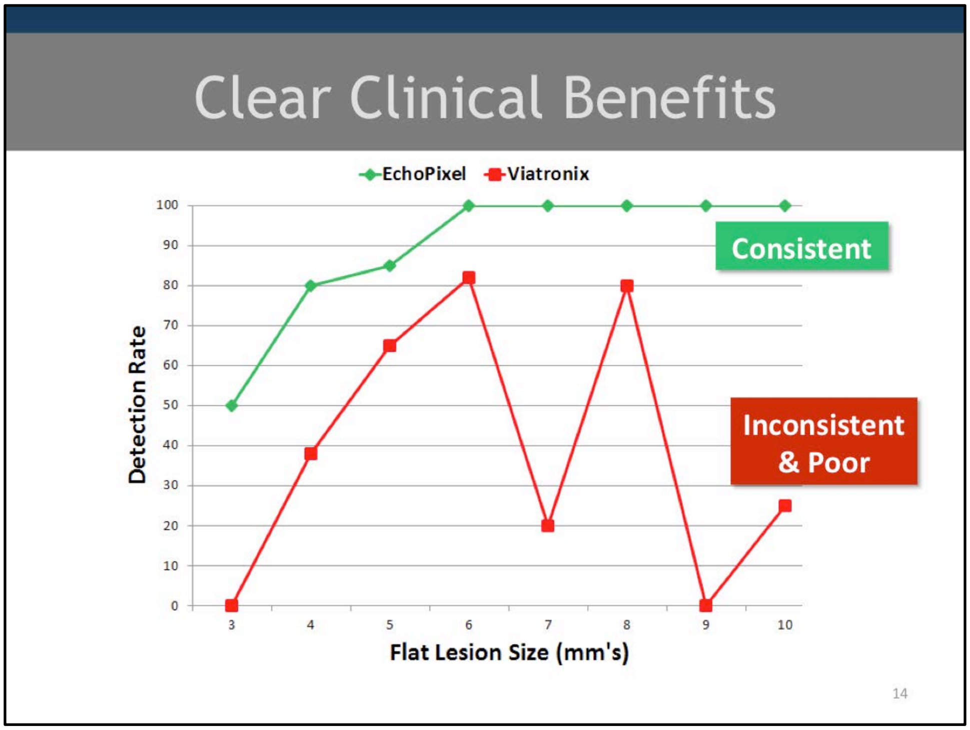
So these protocols focus on achieving five things. We want doctors to have enhanced accuracy. We want them to detect more tumors, more lesions. We also want them to have an intuitive visualization so that they can understand clearly where lesions are, what abnormal anatomy is, and how it's related to neighboring tissue or neighboring organs. We also want them to have an accelerated path to expertise. We don't want to show them a very difficult technique that a lot of times will require years and years of work to achieve clinical excellence.

We also want them to have a high level of confidence. So a lot of times it really comes down to workflow, how confident is the doctor about what they're seeing, and how can they positively determine the treatment or the path that the patient should follow. So this is all about providing them the right views, and the right set of



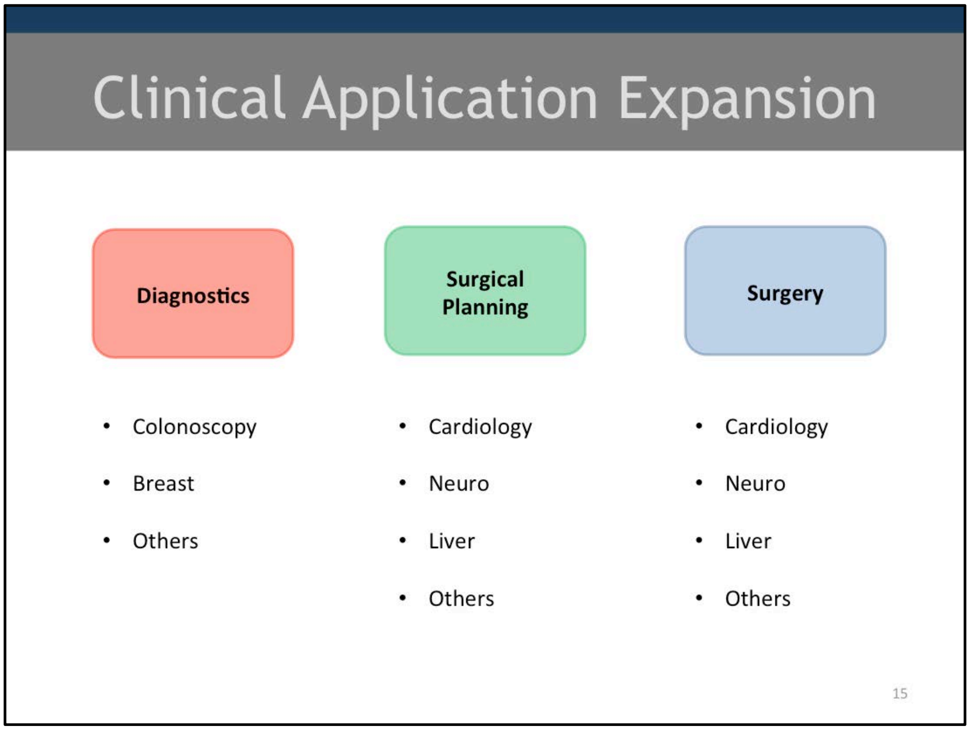
And one very meaningful thing that we also focus a lot on is reducing the gap between radiology and surgery. So radiologists work with these series of 2D images and they're accustomed to communicating with other doctors in 2D slices. But surgeons, when they go into the operating room, they see body parts. And so the resulting images from radiology is really not anatomically meaningful to them, and a lot of times we've heard that they really don't use the 3D workstations that are available on the market right now.

So in virtual colonoscopy we've developed this new protocol, and it's a colon segment-based navigation strategy that has doctors doing a different way of evaluating the colon wall to identify polyps. And it's based on reviewing colon segment by colon segment so that they can clear areas of the colon that don't have polyps and areas of the colon that do, then they will basically bookmark the polyp so that they can evaluate it. This really has a big potential to reduce interpretation time.

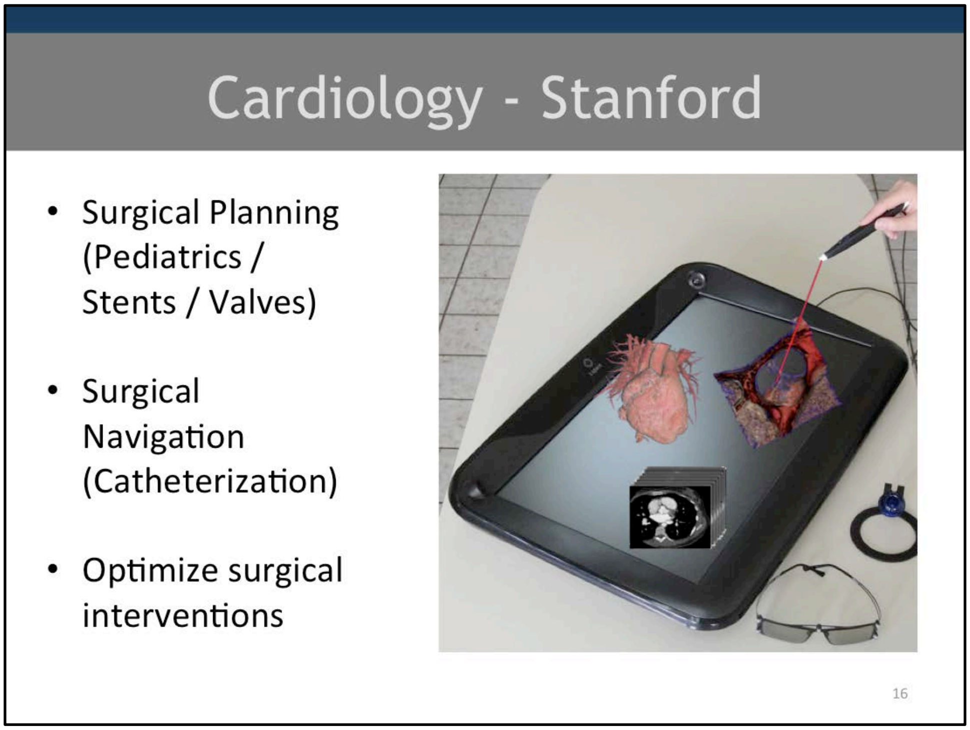


We've done what we call the benchmark test where we've found that we could consistently locate flat lesions. So flat lesions are a different type of polyp that is twice as likely to be cancerous, and it's very, very hard to detect with optical colonoscopy, which is the standard of care for screening right now, and it's an invasive procedure. And they're also very, very hard to detect with normal virtual colonoscopy based on 2D views.

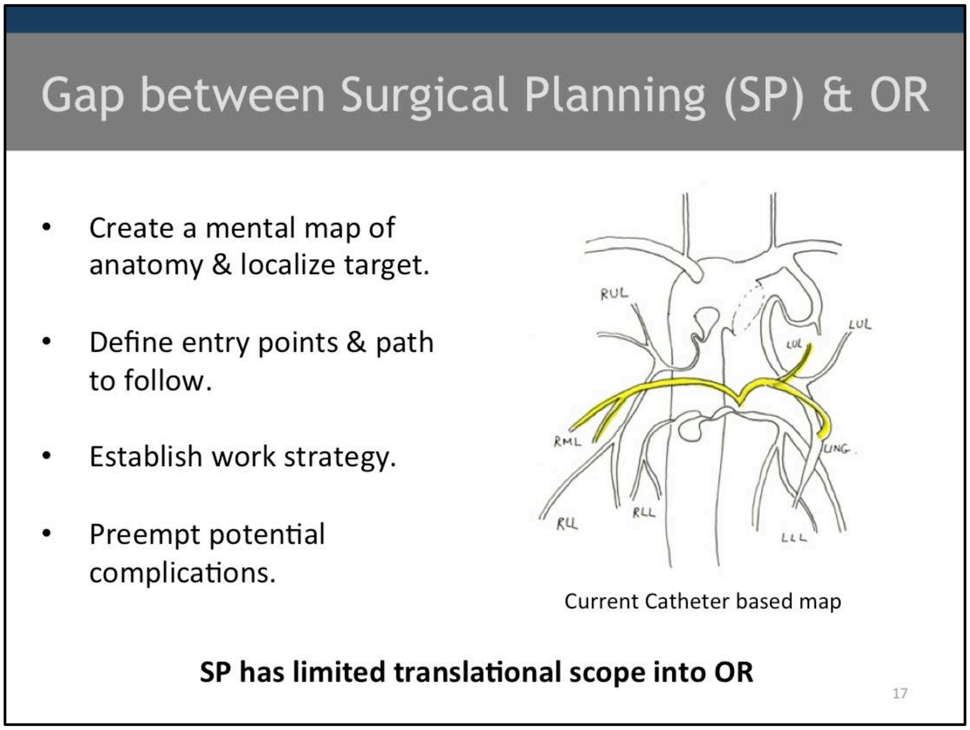
And so the reason for that is because flat lesions are very subtle differences in elevation between the colon wall and the lesion. And so because we can provide a highly detailed depth perception of the colon wall, that subtle difference in elevation is significantly magnified. And so therefore we can consistently locate the flat lesions versus the current state of the art, which is inconsistent and poor. And this is something that we're working on in a clinical trial at UCSF right now, so that's our first application.



So because we've found that we could really provide great clinical value to doctors, we saw that we could expand our applications beyond colonoscopy into diagnostics, for instance in breast imaging with tomosynthesis, and ultrasound for surgical planning in cardiology, neuro and liver imaging as well. And in surgery as well, once you have the surgical plan, you can execute that using True3D and zSpace as a dashboard to do surgery or even control a robot.

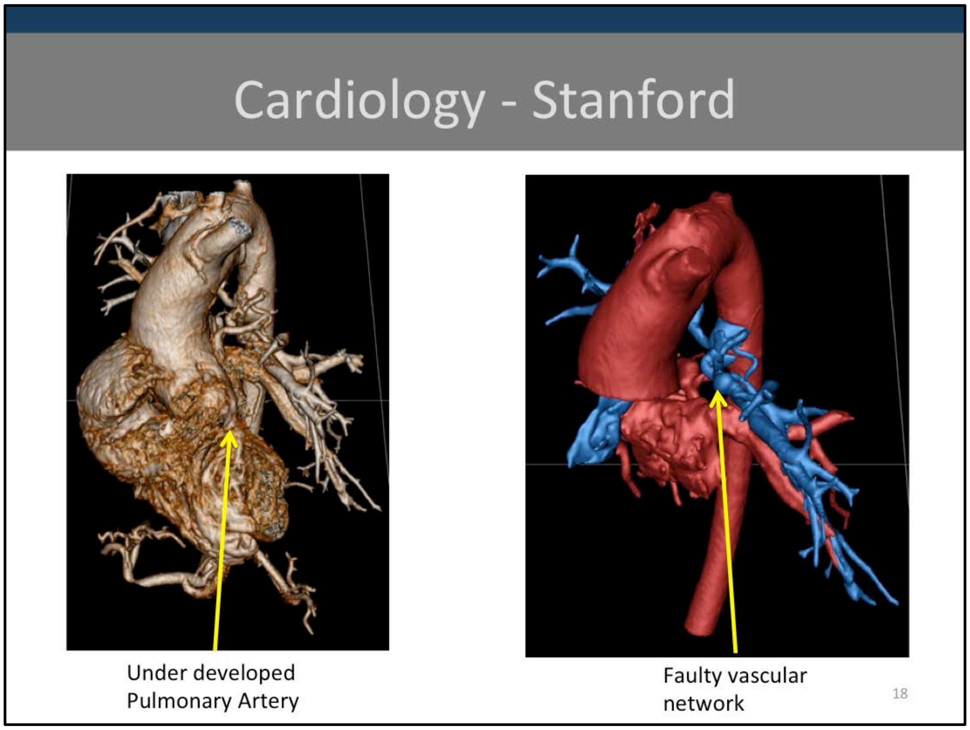


So let's talk a little bit about surgical planning in cardiology. We started a program on cardiology at Stanford, particularly for surgical planning in pediatrics, although we've evaluated valve and stent placement. So the idea here is to optimize surgical interventions. And what's exciting about cardiology is that you can really see a heart and see the specific heart of the patient, see a time sequence where you can see the valve open and close and you pick the valve as it's opening and closing and interact with it. But we started with pediatric congenital hearts. So the problem there is that it's very difficult to understand, and it's a very difficult problem to get the right surgery to the patient.

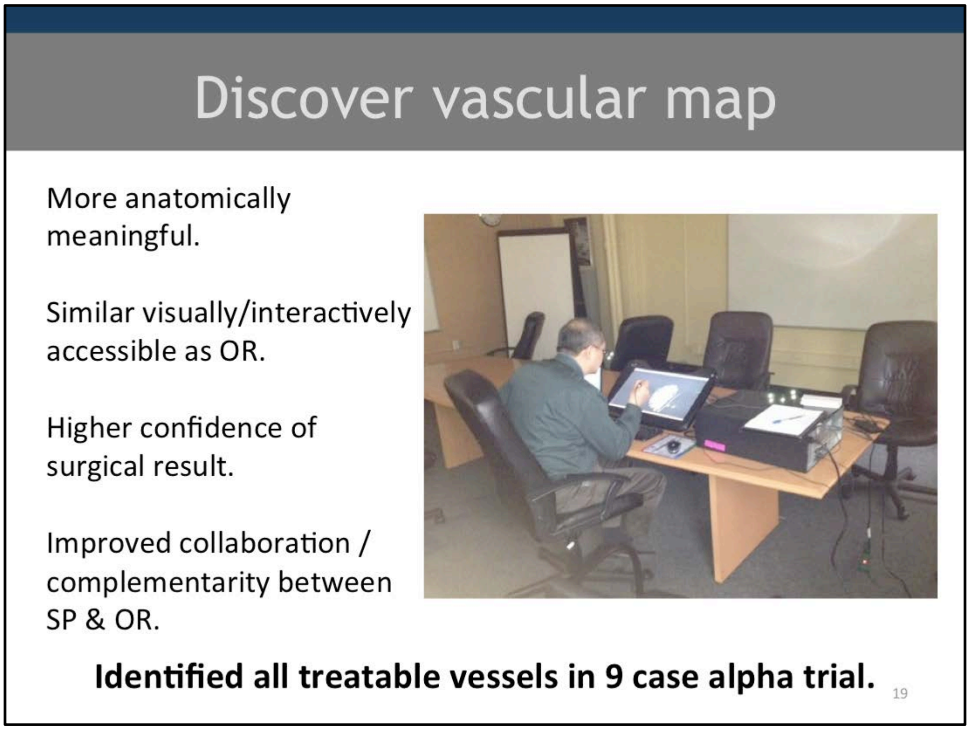


So there's a gap between the surgical planning and the operating room. And so when a patient has abnormal anatomy, doctors want to identify what the anatomy is so that they can determine the better way of operating on them. And so usually you'll be surprised that most doctors, when they do a surgical planning, they do a pencil and paper sketch, like the image that we have on the right side, which is for our congenital heart defect problem in Stanford. And this is the way that they will go about and plan the surgery.

And so with this pencil and paper drawing, they create a mental map of anatomy to locate the target that they want to treat, and then they define entry point and the path to follow, and what's the worst strategy to be able to minimize potential complications. But in the real world, once they open up a patient, it's not going to look like that pencil and paper drawing that they did. And so there's no anatomical meaningness from the 2D image that they've drawn and what they actually need to see.



So in our project at Stanford, we're basically doing work on congenital heart defect in pediatrics called MAPCAs. So these are major aortopulmonary collateral arteries that grow from the aorta. So the bottom line is that the patient is missing a pulmonary artery, or has a stunted or underdeveloped pulmonary artery. And so you'll notice that there's a yellow arrow on the left image where the pulmonary artery should be, and on the right image we've done some image processing to identify these MAPCA vessels. So the aorta is this large vessel in red, and there's blue vessels stemming from the aorta which should not be there. And the real problem here is that these MAPCA vessels have a low level of oxygen versus the blood that has -- that the aorta is pumping is a high oxygen level blood. And so when you have that connection and that mixture, you really have a faulty vascular network, and this is a big problem for the patient.



So we are helping doctors to discover that vascular map in True3D powered by zSpace. And so we initially did an alpha trial where Dr. Francis Chan (ph) at Stanford was working on nine cases in a blinded fashion. And so this was a very anatomically meaningful way of looking at the anatomy. The views that they can achieve were much more similar to what they would see in the operating room. And they also had a higher confidence of the surgical result because they can identify the actual structures that they will be working with in the operating room. So from our small trial, they were able to identify all treatable vessels in the nine cases.

Liver – Cleveland Clinic

- Surgical planning/ rehearsal using CT
- Image guided surgery overlaying Fluoroscopy and CT
- Currently "hunt & peck"

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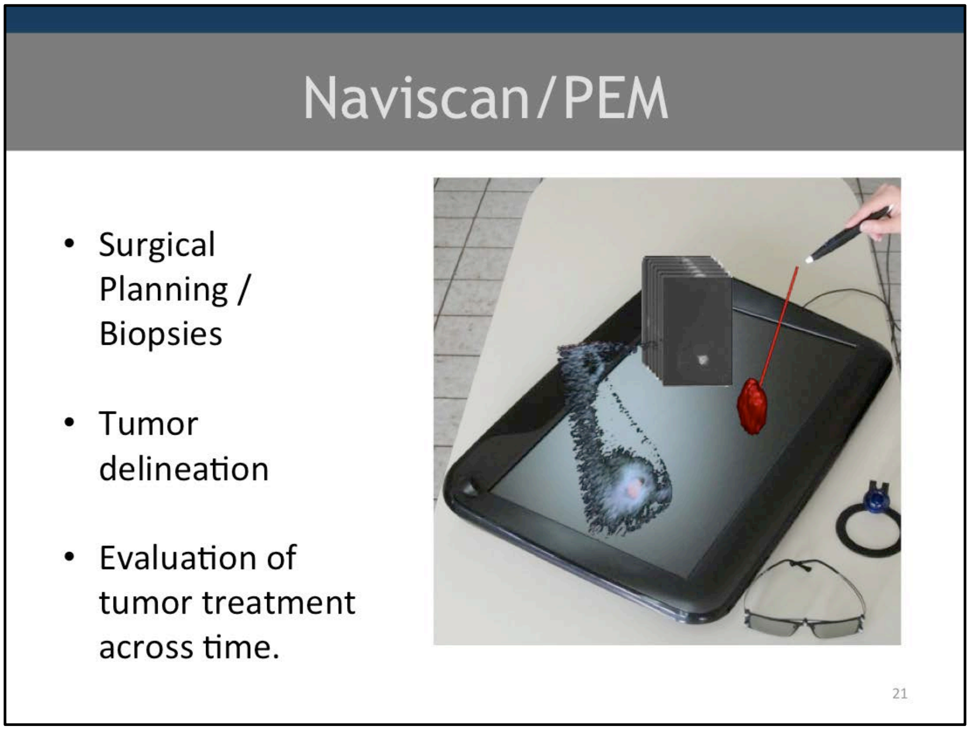
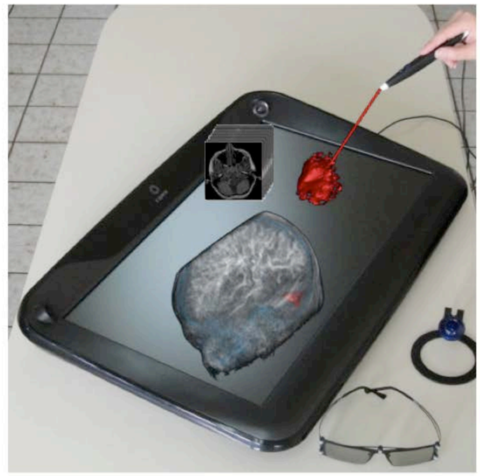
We've started a program as well at Cleveland Clinic to do liver imaging and navigation. And so here it's very similar to the cardiology problem where we want to do some surgical planning and then help doctors navigate through all the vessels in the liver so that they can do some accurate treatment and surgery.



We've also done some breast imaging with a company called Naviscan, and they have a technology called positron emission mammography. So this is imaging of the breast, with PET, to identify masses and do planning for biopsies and tumor delineation. So the nice part about PET is that it can really identify masses, but they really want to identify that contour or delineation of the tumor so that you can extract all of it. And so with zSpace we can show the shape of the breast and make it translucent so that you can see the mass, and you can really reach in and take out the tumor and analyze it and quantify its size.

Neuro – UCSD

- Surgical Planning / optimize approach
- Surgical Navigation
- Evaluation of tumor treatment across time.



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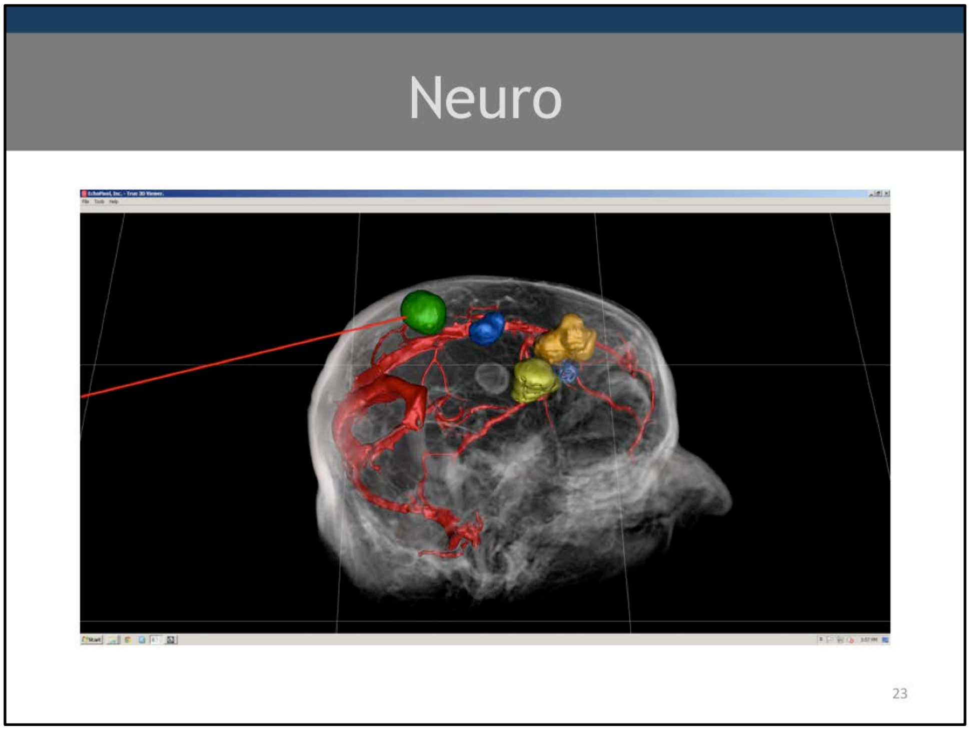
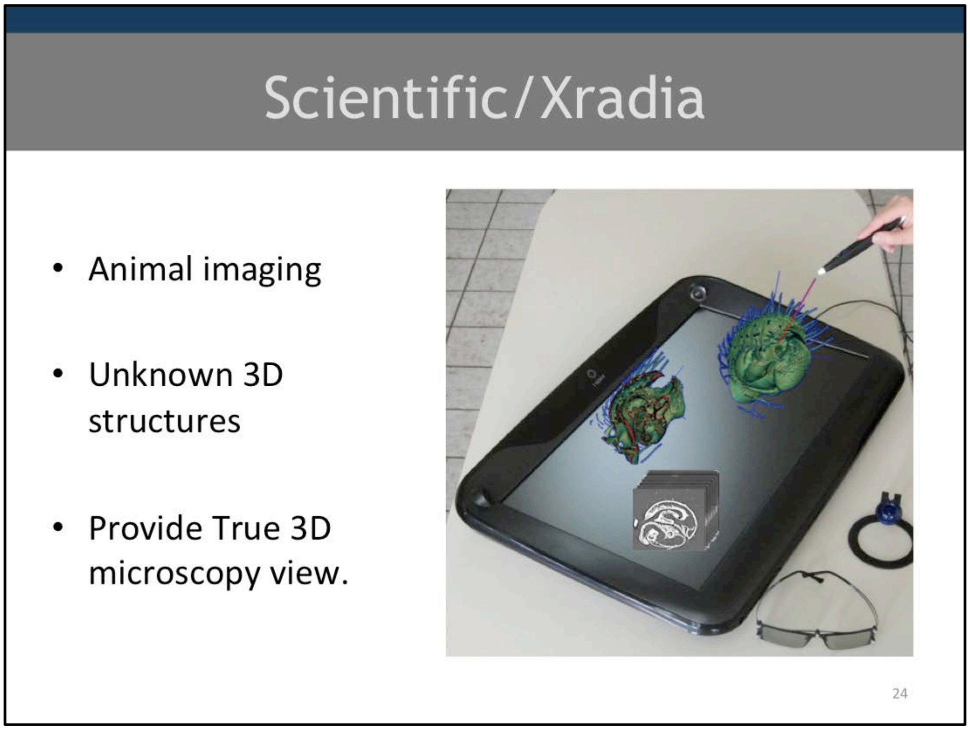
Here is a surgical planning opportunity where we want to optimize the approach to reach a particular tumor or malformation in the brain. And this could be navigation through vessels or even direct surgery. So the same idea as with the breast, we can show the patient's head, put it in the position that the doctors will see in the operating room, and have them optimize that surgical plan.

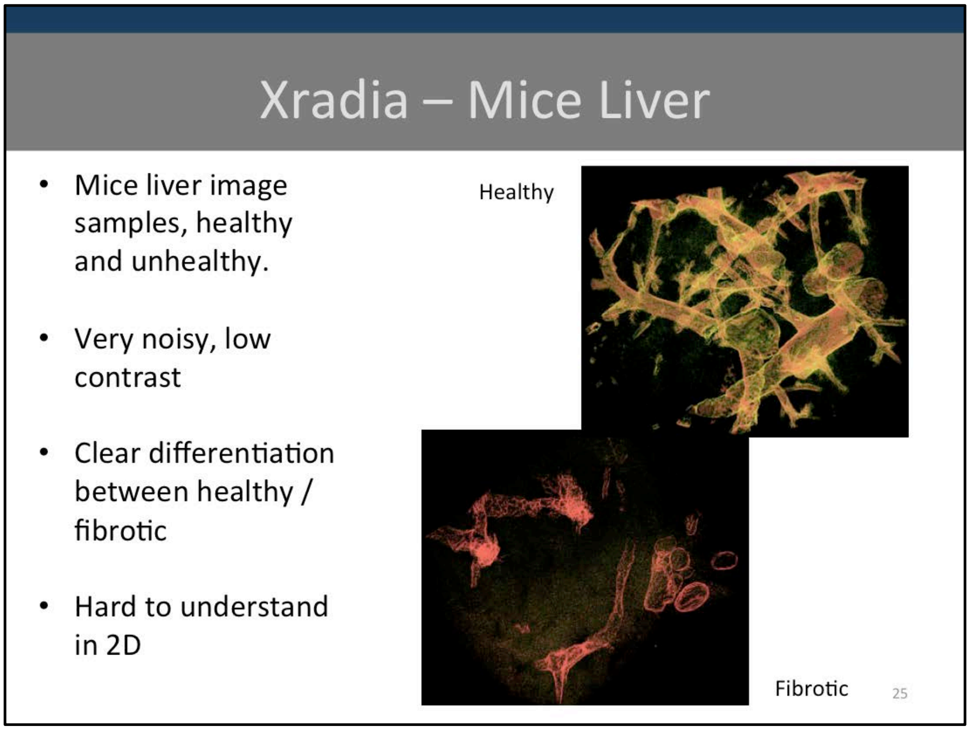


So this is one of the views that we've been working with of a particular patient from UCSD who had five tumors, and we can really highlight the vascular network of the patient's head and identify the tumors and extract them.

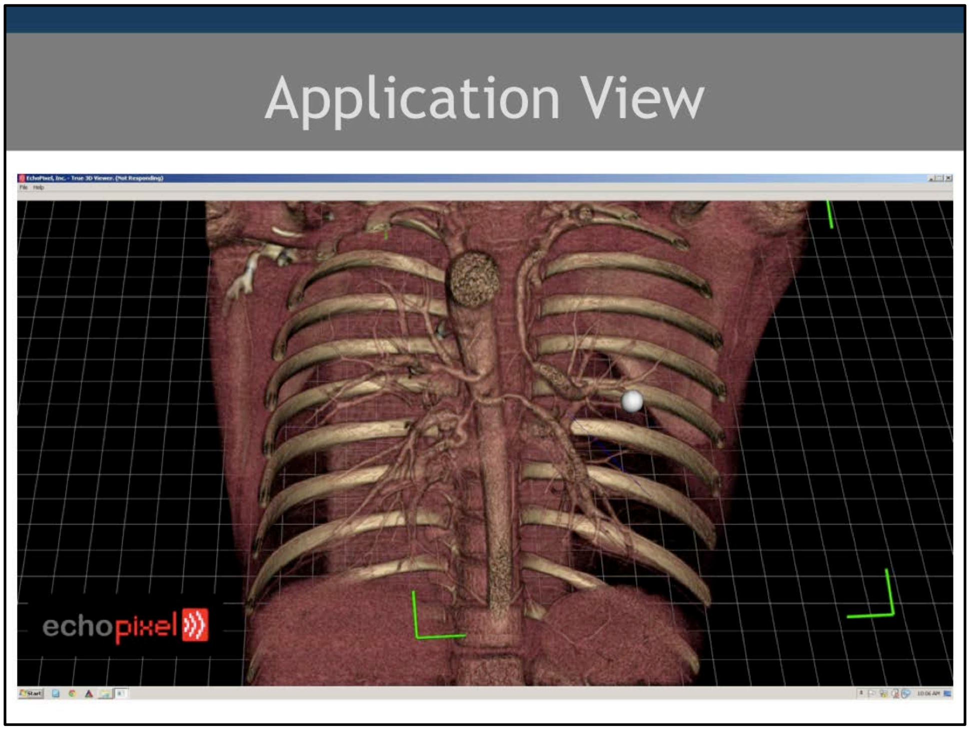


So we've also done some scientific visualization with a company called Xradia.

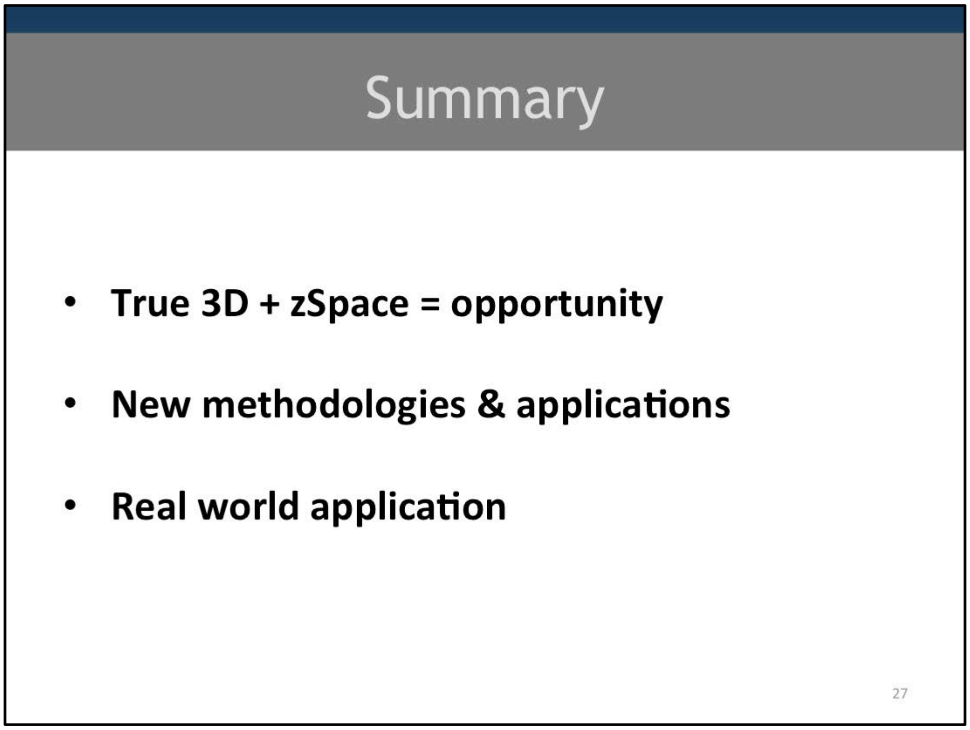
Xradia does a type of scanner called micro CT, and this is a high resolution scanner. The images that you can acquire are in nanometers. And so this is animal imaging, or tissue sample, or material samples. But the idea here is because the resolution is so high, you really have unknown 3D structures that you really want to understand fully. And so with True3D and zSpace, we can provide basically an amazing microscopic view of animal parts. And the image that we have here is actually a spider's foot where the researchers were really interested in understanding how the spider was really using its foot in reproductive strategies.



We've also done some testing on mice for fibrotic liver. And so the idea is to see how that liver degenerates once it has fibrotic tissue. So here there was a great opportunity to differentiate between healthy and fibrotic tissue. And the idea here is that it's very hard to understand these structures from following 2D images.



So just to finalize, we've got our application view. So this is our standalone volume rendering viewer where you can upload a series of images, be it DICOM or any series of images that describes a volume. And you can work on it with a cut plane and identify different transfer functions to uncover specific structures that you would be interested in.



So just to summarize, True3D and zSpace is really a great opportunity to work and develop new applications for medical visualization and also scientific visualization, for a lot of types of different datasets out there. That opportunity is really going to be leveraged through new methodologies of working through the data and achieving better results. And so medical imaging is a real world application that has amazing opportunity right now for anybody that would want to join in.

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