

VISION SCIENCE PROBLEMS IN MEDICAL IMAGING: A RESEARCH  
INITIATIVE OF THE NATIONAL CANCER INSTITUTE BASIC BIOBEHAVIORAL  
AND PSYCHOLOGICAL SCIENCES BRANCH

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00:00:06 Moderator: I think yesterday went really well on all counts. A couple of programmatic notes. We are going to start as scheduled with Alejandro followed by Jay and then Matt and then we will follow with Preeti's presentation. So I haven't left anybody out, right? And Vinay Pai will be our moderator this morning and I think that should cover it. If you have any travel questions, Donna at the moment is not sitting there - oh, there she is. So for travel questions, Donna is sitting over there and is your connection. And with that, I think let's get started. Alejandro?

00:01:41 Alejandro Lleras: We'll get started.

00:01:45 [no audio]

00:18:43 Jay Hegde: Before I get to the mammography part of my talk, I will describe another visual search, namely that for a camouflaged object, a camouflaged object that led to the mammography work and I'll talk about the mammography work during the third hour of my talk.

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00:19:06 About camouflage is - searching for camouflage is searching for objects that are hidden in plain view and Cathleen showed examples of that yesterday. And the way we do it in the lab is we synthesize camouflage images so we know what we have put in. We start with natural cancers, in this case mushrooms or foliage, and we use Portia [phonetic] and Salmoncelli's [phonetic] steerable pyramid to synthesize additional examples of that background.

00:19:44 And we take one of the backgrounds and put, in this case, a face target. It could be any of these and in this case, it is this one. And so this is the thing that the subject looks at, they are given them one at a time and they have to, in this case, perform a very simple detection task.

00:20:06 And the reason for synthesizing them is that we know the ground truth because we have either put in the target or we don't. We can precisely manipulate the scene features because the steerable pyramids are potentially a multi-level image transplant.

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00:20:29       And to make the task truly statistical in the sense that the subject never sees the same image twice so they cannot do the task by remembering any of the pixels or episodic details of the image. They have to learn what is common about the background.

00:20:51       And the data I am going to show you are from one of the simplest experiments, public. There is a single target [indiscernible] and the task is, as I said, a very simple detection task, is there a target present or not. The conclusion is that if you know the statistic of a given thing, if there is something in there that doesn't belong, you should be able to use an odd man out strategy to report if there is something there that doesn't belong in the detection test.

00:21:26       So here are the results. So before training, the subject performed at the task level and this is their performance over various training blocks and in the post-training, so their performance continues to improve. This is statistically significant.

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00:21:45 This is one of the earlier set of results but now we can routinely get D Prime of 2 or higher. If you want the subject to learn a particular background, you can give them a novel target, in this case we call these digital embryos. These are novel objects that we can be certain that the subject has never seen before and they have no problem finding it because they know what the scene ought to look like and they can tell that it's the odd man out, so to speak.

00:22:21 But if we use another background that the subjects are not familiar with and it is unrelated to the original background, there's no transfer, there's no improvement in performance. And this is averaged across the subjects.

00:22:38 Now I said it doesn't transfer to unrelated backgrounds, but we have done additional experiments where we have taken an image like this. So if this is learned, obviously it transfers well to additional instances of the same background. But if you simply systematically manipulate the texture [indiscernible] like this, so this is in the textured space is

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orthogonal and the transfer is poor over the tuning  
data points I showed you, the performance transfer is  
phonotically [phonetic] decreased.

00:23:26 And so one of the intriguing findings, recent  
findings we have had is that the probability of  
microsaccades significantly increases during the pre-  
asymptotic phase and significantly decreases during  
the asymptotic phase, and here's what I mean.

00:23:44 So microsaccades are these small eye movements, non-  
volitional eye movements that are under a degree or  
less. So this is one subject's eye movements, when  
the subjects goes untrained, this is the asymptotic  
phase. Notice a lot of things are happening here, but  
we are interested in microsaccades precisely because  
they are non-volitional. The number of saccades also  
go down.

00:24:16 And as was alluded to yesterday, when the subjects  
become experts, they may tend to make very few  
saccades and also the frequency of occurrences of  
microsaccades go down. And this is summarized here  
for one subject. The red dots are the [indiscernible]

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of the subject's past performance and the blue diamonds are the frequency of microsaccadic - [indiscernible], it is a V shaped curve.

00:24:50 Finally, as Brandon was alluding to yesterday, surcast [phonetic] makes a huge difference and we also have a lot of FRMRI and current FMRAE, etc. We know that other parameters, such as crowding, etc., also make a huge difference.

00:25:14 But the mammogram work, we just wanted to see whether we can use and to what extent whether you can use this approach. And we use the same, we use several methods. You can also do a transform like principle components analysis. In this case, this is the original image and this is the synthesized image using the steerable pyramids method. And these are the data for one subject.

00:25:46 And so the point is using this method of mammographic data, we can train them if these are people off the street, both in camouflage and mammography. They become pretty good at looking at, detecting an object that doesn't belong.

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00:26:08      And here's another message, the image analysis method of Aaron Hertzmann [phonetic] of NYU. This is the original mammogram, screen mammogram and these are up a couple of synthesized examples. We are able to change the viewpoint from CC, cranial caudal [phonetic] or MLO. And so this is one of the things that we are interested in, chains of the various parameters, viewing parameters that the radiologists have to contend with. I am done.

00:26:49      Female Speaker: So I didn't catch, when you do transformations and tests for generality, can you change it in a way that maintains the overall scene statistics, like scramble it and does that transfer well?

00:27:06      Jay Hegde: Can you scramble the image?

00:27:07      Female Speaker: Yes. So what I am after is whether what they are learning are almost like learning specific feature, like if it's the exact same background over and over again, you can -

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00:27:17 Jay Hegde: With team learning, we know those are not the features. We have not quite scrambling because as you know, scrambling introduces information, usually noisy information, noise, but it also, it essentially changes the transform. We know that because what we put in are basically values along the basic functions, we know those are orthogonal by definition. And we have done experiments, I didn't show you the data, if you add noise along an orthogonal axis, you can actually use that information and it should affect performance and it doesn't, it acts as noise. And so what we expect there does pan out psycho-physically [phonetic].

00:28:08 Male Speaker: You were doing this in free viewing, right?

00:28:12 Jay Hegde: Right.

00:28:12 Male Speaker: Do you have any idea whether or not your trained subjects can be chance in a single glance without an eye movement?

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- 00:28:22 Jay Hegde: Yes. In fact, they can, after the training, after they become experts, the trained subjects don't even make eye movement, even when given a chance.
- 00:28:34 Male Speaker: And are trained subjects localizing the target or are they simply picking up on the disruption of the statistics?
- 00:28:42 Jay Hegde: We have done both and even if you have them localize the target and it's even it's the scene presentation is for camouflage [indiscernible], it is a similar duration is as short as 50 milliseconds they can still do the task at D Prime, highly significant -
- 00:29:02 Male Speaker: Okay, so when they are doing it with the brief exposure, are they localizing or are they doing -
- 00:29:08 Jay Hegde: In this particular example I showed you, they are simply reporting whether there is the target or not. But we have done experiments where there are

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actually no applies [phonetic] and data for which I  
did not show.

00:29:25 Female Speaker: Just a quick question - the  
background. When you use a novel target,  
[indiscernible] cancer, but that actually started out  
at that same low D Prime [indiscernible] and you  
would expect to kind of pick up where learning  
[indiscernible]?

00:29:39 Jay Hegde: Are you referring to the bar plots that I  
showed you?

00:29:42 Female Speaker: At the beginning.

00:29:45 Jay Hegde: Right. That was an example where we were  
testing a texture that they were not exposed to begin  
with and it was un-orthogonal axis. So in other  
words, it truly was an unrelated background texture.

00:30:05 Female Speaker: No, the first plot had blue lines.  
The blue lines starts again there -

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- 00:30:19 Jay Hegde: No, no. So this was basically we tested them before they were trained for both the novel target and the paved [phonetic] target and then we did them, trained them in the background and then we tested them in novel and on - yeah.
- 00:30:40 Male Speaker: Jay, if camouflage breaking was due to just a local disruption in the background statistics, how would that relate to the satisfaction of the search stuff that we talked about yesterday? It would seem that the second target would pop out equally well.
- 00:30:55 Jay Hegde: And in fact I didn't show you the data and in fact, that might be happening, yes. In other words, the crowding effect are roughly along the lines of satisfaction of cert -
- 00:31:13 Male Speaker: It would be interesting to see that, I would be very curious.
- 00:31:17 Jay Hegde: Yeah, but you would kill me if I showed you some of these.

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00:31:21 Male Speaker: But also with respect to your microsaccades data, those are really cool and I was wondering if you were thinking about this in terms of some sort of way of evaluating when maybe radiologists have been sufficiently trained whenever they spot, exhibiting these microsaccades. Because my inference is that microsaccades are indications of them still learning the background statistics.

00:31:46 Jay Hegde: Right. In fact, they are thinking of doing that. My radiology colleagues at North Thompson [phonetic] and James Ross [phonetic] have been very cooperative. We indeed plan to do that. I just want to add one other thought. The claim here is that certificates of learning explains everything, but it explains quite a bit. So there's a very good question as to how much, whether it explains that we have all the relevant non-random information and we do not know the answer to that.

00:32:17 Male Speaker: I wonder, maybe I missed something, but with respect to your microsaccades, I wonder if you think of them as having a functional, play a functional role in establishing the segregation

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signal, right? Like if I move my eyes a little bit, I am going to have more variation. It allows me - not me, the visual system - to pick up more of the variation of this uncertain world. Once that is learned, it falls up, so that means that it would be very much like I have seen organization -

00:32:55 Jay Hegde: Right - I agree.

00:32:57 Male Speaker: So I am puzzled by the mammogram learning results. Am I interpreting that correctly, you are saying that the Portias and Mencelli [phonetic] texture synthesis of mammograms has, captures all of the, lots of the statistics of -

00:33:14 Jay Hegde: No, I hope I didn't say that. No, no. One, you see and above them, you are developing enormous respect for the complexity that radiologists have to contend with. This is the particular class of screening mammograms. Screening mammograms are mammograms in which the patient doesn't have any breast health, previous known breast health complaints.

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00:33:42        And these are so-called magnification views thereof,  
okay? And so it doesn't have the breast outline and  
the various things that come with being a view,  
curvature of it. So this is essentially applied to  
the picture and the algorithm does very well tweaked  
by us.

00:33:59        Because remember, it is the steerable pyramid and the  
algorithm. And so we had to tweak it to basically get  
at the right bandwidth. Once we do that, it does a  
pretty good job. And in this case, the input image  
data set are fairly homogenous and picked out for  
that reason and the malignancy in this case was an  
undefined mass.

00:34:27        Male Speaker: One quick question is that or a quick  
comment, I guess. I think thinking a little bit  
maybe too simplistically of expert radiologists go  
right to the target and it's a very simple thing. I  
know -

00:34:40        Jay Hegde: I didn't say that.

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00:34:41 Male Speaker: I know you didn't, but I hear that in the discussion. I just wanted to say that people who have studied radiologists and that oftentimes find other behaviors. And in particular I am thinking about Claudia Mellenkamp [phonetic] who finds that even expert radiologists will oftentimes go to a lesion and make a series of what she calls cellate saccades [phonetic] which basically is acting really different from the background. And so they are trying to discriminate it from the local backgrounds so the saccades are being driven by, or at least that's the hypothesis.

00:35:09 Jay Hegde: No, I understand that. And that is also, Jeremy talks about drillers [phonetic] and the scanners and so forth, so there's different kinds of search behavior. We see that in camouflage. Hopefully some of that came across using the - from our eye movement data, there's a whole lot going on, a whole lot of things going on. And what we present is necessarily, we have to present it in a little figure, it is simplistic for that reason, but there's a whole lot more going on.

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00:35:40 Male Speaker: I thought you were going to talk about Art's [phonetic] results, how that sort of goes that sort of - and that Jan was saying, background statistics, no? That is not worth mentioning? This goes well with the body of literature that studies, we've come to - there's just a lot of studies that were after, not exactly, but similar ideas which I mentioned in my talk which is whether people and radiologists take into account the statistics of the background.

00:36:10 And I think there's been a lot of [indiscernible], including classification images and stuff like that that Craig has done. And the idea that indeed this is one of the things that we haven't assessed well the learning of it, but that indeed when you become good at this, you are actually taking into account your template, how you equate different frequencies, takes into account the statistics.

00:36:33 Not only just the spatial frequencies, there are also studies by others that actually - if the noise is oriented a little bit so it's not like a subtropic [phonetic] orientation, humans or people that are

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good at this are actually also differentiating,  
different orientations, instead of orientations that  
are more noise free.

00:36:50 So not only just the spatial frequency, but all of  
that comes into account and they learn that and they  
adjust their strategy. Instead of use parts of,  
whether it's single information, but there's no  
noise. So that sides really well with a lot of that.

00:37:04 Male Speaker: Thanks, Jay. So Todd, do you want all  
the stuff to go back to back or do you want to have a  
discussion now? Okay.

00:37:10 [break in audio]

00:38:12 Male Speaker: I have a first degree of approximation.  
I think that one thing that you can do is you can  
imagine that when you are trying to accumulate  
evidence in favor of, right, your, the template that  
you are looking for, you could do it, my experiment  
is easy because you have very good segmentation of  
the object at a particular location.

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00:38:37 But I have talked to other people who do just an analysis, not different objects because they do just overall pictures and convolutions and things like that. And you could basically run something very similar because it would be just a little bit more noisy, but you could imagine doing the same sort of process.

00:38:59 And instead of doing it over an object, you would do it over a patch of the image and you could do it at different spatial scales. And I think that one of the things that is interesting is that as you develop expertise with a background, what you might be able to do is learn the characteristics of this background so that allows you to reject that as background.

00:39:26 Male Speaker: It would be interesting to take those textures of this thing and actually have perhaps two different sets of textures in the same background where you learn that the target lives on this kind of background and not on that kind of background and take a look at the eye movement. You would probably pick this up implicitly, find out if the eye movements start restricting you to the set of

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statistics that goes with the background where the target lived - you have already done it.

00:40:08 Jay Hegde: Yes. And the eye movements, Jeremy has a terrific conclusion and he is exactly right. And generally if you create a saliency map, not a contrast map, but some kind of saliency map, the eye movement, the high saliency regions essentially act like a refractor for eye movement.

00:40:33 Male Speaker: I am a little confused about the suggestion. Wouldn't that piece of background then just give somebody a primary target followed by the secondary target where the little guy lives?

00:40:40 Male Speaker: Well, it kind of depends on what you might call scene guidance. If I am looking for water pictures, in some sense I suppose you could say yes, horizontal surfaces and tables in this room become sort of a primary target and the pictures become a secondary target. Or you could think that the structure of the scene is constraining where you are going to search for actual targets.

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00:41:12 We have done this where we constrain different types of targets to live on different, basically colors of background, found that the eye movements constrained themselves to the right neighborhood. And then when we asked people after the experiment - gee, where did the targets live and they all lived on like red background or something, they had absolutely no idea, but their eyes sure had an idea.

00:41:52 Male Speaker: - you get these overall average response times, but actually if you look at the eye movement, it looks like it's really just a small percentage, a different path, a small proportion of [indiscernible] is actually corresponding. 10 percent of the time people recognize it and they have super-fast reaction time or else they don't recognize the scene at all.

00:42:12 Male Speaker: The contextual cuing one is with repeated - and with repeated displays of the same set of Ts and Ls whereas the texture one is different texture. You are learning something about the scene or the texture, but you're not learning about the

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specific configuration. You were changing textures,  
changing texture on every scene.

00:42:43 Jay Hegde: One other thing, we also did an experiment  
to see if it just - properties of the background  
because that's what, that's the thing that we ended  
up [indiscernible] first. But no, it is actually if  
you systematically change the properties of the  
foreground you can show that the transfer is also a  
function the overall [indiscernible] of the image  
including the [indiscernible] target object. So it's  
not just purely background learning; they do know  
something about the statistics, learn something about  
the statistics of the foreground, which is useful for  
us going forward in radio mammography.

00:43:24 Male Speaker: So apart from Craig's talk, I haven't  
heard much about using the kinds of things that you  
are doing to actually improve image or image  
processing to increase the saliency based on psycho-  
physical properties. What kind of smoothing or  
sharpening of an image will actually improve search  
statistics and presumably work on real stuff? So I am

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not in the field, but I would think that this would  
feed well into that.

00:43:55 Male Speaker: So Andrew Maidment used those kind of  
models to develop an entire imaging system.

00:44:06 Male Speaker: Yes, so we actually call this is an  
observer based design and we are sort of trying to  
perfect that process. And BARCO [phonetic] has sort  
of led that, so we have an industry, an academic  
partnership grant and there are our industry partner.

00:44:23 And I think I mentioned this a bit yesterday, the  
cost of creating these displays is enormous. To go to  
the point where you can sort of go to a foundry in  
the Orient and have them fabricate a glass panel that  
is structured so it will act as an LCD display,  
you're talking about tens of millions of dollars at  
that point.

00:44:44 And then you have to sort of make them, fabricate  
them, put them into clinics, get people to observe  
them, start looking at getting feedback. A lot of  
that is very soft stuff, are you fatigued or things

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like this. It's not like - oh, I am suddenly missing cancer; it's indirect measures of performance.

00:45:05 They had a graphic example a few years ago where they increased the, they would decrease the focal spots, like they wanted to decrease the focal spot size in the CRT. But they didn't match the bandwidth of the amplifiers in the horizontal direction appropriately. And so what you ended up having was like little black lines between each stripe on the CRT.

00:45:29 And in fact, they actually found that although in theory it was a sharper monitor, it didn't have particularly worse noise performance, observer performance was worse. And they ended up pulling that product after two years. So that's one that actually went through this pipeline.

00:45:44 And things that have been done, one of the things we have done is or they have done is in an LCD panel like that, they will tell you the statistics that most manufacturers of what will it take to drive from zero to - from black to white or white to black and it can be 3 milliseconds or something like that.

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00:46:02 But what it won't tell you is what it takes to drive from a gray level of 120 to a gray level of 122. And that can actually be something like 500 milliseconds. And so what they ended up doing was looking at the impact of this through virtual clinical trials. Basically it was identified what were the sort of necessary timings and then they worked down drive curves to get the LCDs to drive from one level to another at every gray level. And so their monitors are now calibrated at each drive level, so there's big tables, huge look up tables of oh, I need to get at this pixel from 128 to 134.

00:46:47 Male Speaker: A quick intuition that you can give us about why that is true?

00:46:52 Male Speaker: On the LCD monitors? It has to do with the driving voltages. It's a non-linear function, the driving voltages and so the change in voltage is very small and so the resultant effect is also very slow.

00:47:08 Male Speaker: Oh dear.

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00:47:12 Male Speaker: So they actually got a monitor approved. They then went on to show that if you take a regular mammo monitor and you - calcification cluster images on them, they are blurred. Because you are scrolling through relatively rapidly and mammo monitors were designed to static images. And you can actually get a - if you go to the BARCO booth, go to RS and go to the BARCO booth, they have a situation where they will show you a roving magnifying glass.

00:47:33 And if you move the roving magnifying glass, the electronic magnifying glass, over a calcification cluster, it will disappear, right? As soon as you stop it, as soon as you stop it, it will be sharp and it will be a beautiful image of a calcification cluster.

00:47:47 You move it and it goes away, it just disappears because of the monitor. And then they will take it to their new monitor and they will show that the calcification cluster persists. The price you are talking about - that is about right. A pair of those

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monitors are about \$25,000 dollars, but a pair of the blurring ones is about \$23,000 dollars. So you are getting the sharpness for two grand. I mean, that could be probably a pretty good deal.

00:48:19 The new monitor that they just came up with that they did is a backlight. And the backlight shines on the wall and depending on the darkness of the screen, the lighting on the wall changes. So it changes your accommodation so that you get better visual acuity at different gray levels on the displays. So depending on how gray the display is, the display of your visual acuity will compensate.

00:48:42 Another thing they have is they have an ability that you can just touch it and it will highlight that area. You get higher luminance very briefly in that area so that you can get better reception. These are things that are going on in clinical trials.

00:48:57 Male Speaker: I am sort of wondering what is going on with our sort of standard psychophysics with the Gabor patches that are ramping on and off over 500 milliseconds.

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00:49:09 Male Speaker: The CRTs do not have that problem; they have different problems. I still have a few CRTS in my lab, five mega pixel.

00:49:58 [Break]

01:07:03 [Break ends]

01:08:46 Preeti Verghese: Okay, so I have been looking at, searching for an unknown number of targets. And so the question here is, some of you have seen this image before. If you have, you can't participate. The question is find all the beer bottles in the fridge and you have one second.

01:09:15 Okay, how many? Not one - all. Basically what most people do is maybe you will look at the beer bottles in the door because they are very clearly visible, maybe you'll look at the beer bottle in the bottom, but very few people look at the uncertain locations.

01:09:51 So this is what I have been looking at. If you give people multiple targets and you don't give them all

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the time in the world, where do their eye movements go? I mean, some of these beer bottles are so visible you don't need to go and confirm that there is indeed beer there. If the task was indeed to find all the beer bottles or all the potential masses in the imaging view and you didn't have all the time in the world - of course, radiologists have all the time in the world, maybe.

01:10:24 This is the question we are asking. And what do people do? Of course, we don't work with beer in the lab. So this is kind of what we did, boring stimulus, five dots vertically arranged, six potential locations, those are the ones in the circles and a target would appear in each of those locations independently.

01:10:47 So you could have, a particular image could have zero, one, two, three, four, five six targets. You didn't know, you had to actually localize the locations that had targets and you had to find all the targets, but you were only given one second to do it.

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01:11:04 So where do people look, that's what I am asking.  
And in this particular case if you are looking for  
that, a string of vertical dots, perhaps it is easier  
for you to see it in that bottom most image, you can  
see that vertical thing. The circle at the 10:00  
position is less easy to see. So if you had one  
second, it would probably make less sense to kind of  
look at the ones that you can already see. Instead,  
it would make more sense to look for the ones that  
you are not sure about and go and verify there is or  
there is not a target there.

01:11:42 So we call locations like the one at the bottom  
highly probable target locations, we call them MAP  
for short because the maximum Equal Sterority  
[phonetic] locations. The ones in the 10:00 position,  
for example, are uncertain or high entropy locations.  
They are likely to have a target or not, equally  
likely to have a target or not.

01:12:05 Okay, so this is actually what the display really  
looked like. See this one I showed you was a cartoon?  
There are six locations here and there are some

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targets. And the verifying verb may be can find  
this, maybe cannot. How many targets? No idea.

01:12:24 I highlighted the targets for you. Okay, so this is  
a hard test. And what did observers do? They made  
inefficient saccades, they fixated the locations that  
looked most target-like, they did not go to the  
uncertain locations and we trained them with complete  
feedback.

01:12:42 This is more complete than is shown here. We actually  
showed them their scan test, we showed them the  
locations they selected and we showed them where the  
targets were after each trial and that did not  
improve performance and I was one of the subjects,  
one of eight, but nobody improved performance.

01:13:02 So we said okay, specifically, I don't want to go  
into the model too much, but here is the intuition.  
What is happening here? Everybody is behaving as if  
these targets very rare. So they are always going to  
these most probable locations.

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01:13:22        So in green is - let's do blue. Blue is the prediction of a model that goes to locations where the targets are most likely. So I am plotting on the Y axis the proportion of time the model that is correct, identified all the targets in a trial versus the number of saccades. So obviously if you look up more locations, you are more likely to get them correct.

01:13:49        And what this graph is plotting is data for a very low prior probability of targets at a location. .17, much higher than in cancer, but still, quite low. So here in green is the prediction of a model that specifically goes to locations that maximize information. So I am going to the most uncertain locations so you can see in this particular case the green is slightly better, but not much better. So when target probability or prior probability is low, these two strategies are not very different.

01:14:25        Let's go and look at the other end of the spectrum. Here targets are very frequent. You have .83 probability of a target at a location - sorry, and the red one is just making saccades at random, that

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is a random model. You can see that now going to uncertain locations is highly informative and going to the most likely targeted locations is even worse than random. And what do observers do in this particular study? Regardless of the prior probability, they always went to the most probably target locations.

01:15:07 So why? Maybe the task is too difficult, maybe observers are unaware of their visibility function, how it falls off with distance from fixation. Maybe most multiple targets search task is very infrequent. But we were interested in this last issue, maybe the feedback at the end of the trial was not effective.

01:15:30 So what we did is we came up with a really simple display - no noise, just targets, very easily visible, no visibility function involved. The targets were drawn from a distribution brighter than the background, the distractor, the ones that have no noise, if you want, were drawn from a distribution darker than the background.

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- 01:15:56      Importantly, these two distributions overlapped considerably so something that was a patch that was close to the background was equally likely to be target or distractor. And these are the most uncertain locations.
- 01:16:07      The question is, can observers go here and how do we make this useful for their eye movements to go there? So what we did is - they started there, they started the display [break in audio] - when their eyes went there artificially, as soon as a saccade landed there, we changed the mean value of that disc to the - the value of that disc to the mean value of the distribution from which it came.
- 01:16:40      So we gave them this artificial feedback, here we were just checking to see if you got this feedback, this immediate saccade-based feedback, would it make you more efficient, it would make the saccades more efficient. Okay, and the answer yes.
- 01:16:55      So here I am plotting the proportion of saccades that went uncertain, certain and those went to the most probable locations. Here is efficient as you can see

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as the prior increases, people are doing much better.  
And this is in contrast to previously where  
regardless of the prior success of [break in audio]  
prior locations. And that's all I wanted to say.

01:17:25 Male Speaker: Do you have the performance for the  
same subject as they change their strategy? How did  
their overall performance change and does that track  
with the model predictions?

01:17:36 Preeti Verghese: So you could do it - I don't have it  
just yet, pull it up to you, it will take a little  
while. So in the experiment with feedback, if you do  
a trial by trial analysis of the proportion of trials  
- the model's performance, if it were making  
uncertain saccades to informative locations and the  
observer's performance and you see a really good  
correlation. And if you compare observer performance  
to a model that is going to the most probable  
locations, they all do better than the model, yes.

01:18:18 Male Speaker: [inaudible]

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01:18:27 Preeti Verghese: Okay, so in this particular case it is artificial, right? They are not going to know anything about the - so not here. But to answer that question what we have to do is, it seems to take quite a long time for people to get trained. So when I did those noise experiments, I also did Gabors [phonetic] in white noise and people were equally bad at that. But we have slowly got some people who have been with us the longest and have slowly gotten trained to make these more information seeking saccades, but it seems to take a very, very long time.

01:19:10 Male Speaker: I rather - when you put up the list of explanations, I kind of like the one where you said observers don't know their own likelihood function. And I am wondering whether your experiment has still considered the second occurrence consistent with that. Because when you show people - in this case, not knowing the likelihood function and us not knowing the distribution around the mean of any given group and the luminance patches, right?

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- 01:19:33        And so if you give them immediate feedback about the mean for the group with the saccade there, you are also helping them learn the appropriate likelihood function for the patches. So do you know - so to what extent do you think the delayed versus the immediate feedback is really just a mechanism for better learning of the likelihood function or do you think that there is something else there?
- 01:19:58        Preeti Verghese: That is a very good question, but all the reinforcement learning, they don't delay the feedback. And I don't think they are giving people any information on the mean of the likelihood function. And that could be a component, it's a very interesting thing to explore, but I'm not sure that that is the main thing.
- 01:20:18        I mean, they were getting plenty of feedback before; it was just completely ineffective. I mean, they knew where their eyes went, they knew the locations they picked, they saw their scan pass, but it didn't transfer into - oh, that's the kind of thing I am supposed to be looking for.

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- 01:20:36 Male Speaker: I have a multitude of questions and I am going to try to be organized here. One of the issues here is what people are trying to optimize, whether they are trying to optimize some perceptual experience or whether they are trying to optimize a payout [phonetic] in the past, for example.
- 01:20:52 So if you tell me that I am going to get ten dollars for every one or a beer for every one of the targets that I correctly located, at the end of the trial, I need to click on all of them, right? Maybe I will go the uncertain locations to see if I know if there are some obvious ones out there.
- 01:21:15 But if what I am trying to do is learn something about my perception or something, I am doing this differently, I want to go and - oh, I think my target template is this. I go to the location - yes, that's where my target template is. So they are not satisfying a maximum likelihood of anything, they are just trying to -
- 01:21:34 Preeti Verghese: Yes, they are not optimizing - I mean, you are saying did we look at - so I gave them,

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we made a calculation about how much more, we didn't give them money, but we said we would weight, give more points to saccades that went to uncertain locations and then after each trial they saw their score and they saw their score increments.

01:22:04 And we told them that the top two out of eight would get, excluding me, would get a bonus, made a difference. It was just something, especially for the first experiment, it was just too hard. So maybe I didn't do the experiment correctly, but we did that.

01:22:30 Male Speaker: Maybe you try rewarding them not with a beer for each one of the targets they find, but you get a beer if you find the last target, that you have to actually get the number right. We actually did that with a mammographer. We ran an experiment at a meeting with, basically at the exhibit during happy hour and my post-docs who actually ran this, do report that data quality goes down with consumption of alcohol.

01:23:13 Male Speaker: At the risk of wasting my last few credits for talking too much, but it is the end of

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the meeting. Preeti, two things - one, a very detailed question. Did you compare the model that does MAP, but not maximum posterity, but minimum posterity? So you actually go to the locations that is least likely and doesn't that work one way, the probability kind?

01:23:37 Preeti Verghese: So for example, on the probability side you could say I am just going to look for those and yes, we did look at those. But that would be also an efficient model you could use, but they don't do that, either. So we looked at saccades to non-targets, they go to the most visible non-target and that's not what they do, either.

01:24:00 Male Speaker: And then the second question is a little bit larger and more relevant, a more philosophical question which I think you share a bit of the - yeah, the observation, we just talked about this. Which is there is, in the eye movement literature, there are a lot of tasks, and this relates a little bit to medical imaging, there are tasks where humans seem to be quite optimal in how

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they deploy their eye movements when you compare it  
to [indiscernible] optimal strategy.

01:24:28      And there are tasks, some of these lab tasks, tend to  
be to show a lot of differences. People have a hard  
time learning this, but when we look like things that  
we have worked in the recent years, like faces, I can  
bring anybody from a subject one pool and they are  
looking at the optimal plates to look at to acquire  
information about a face.

01:24:48      And I can show you that if I force them to fixate  
somewhere else, they are worse. When I bring them to  
do these tasks like Preeti, if it is the subject one  
pool, they are pretty - they are all inefficient. So  
they have to learn these things and it is much  
harder. So it is interesting about really having to  
do with practice, things that we are involved in  
every day and when we bring them to these new sort of  
tasks, it is not straightforward that they will  
actually start doing some optimal eye movement  
strategies.

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01:25:21 Preeti Verghese: So is the upshot of that you have to  
hide a face in every mask?

01:25:27 Male Speaker: No, maybe. I thought - yeah, I don't  
know how you solve it, but I think it is something to  
keep in mind.

01:25:33 Preeti Verghese: I mean, when you are training a  
radiologist.

01:25:35 Male Speaker: So when you are training a radiologist  
- no, I think it is unclear. We don't know how  
radiologists or a way to evaluate the optimality of  
their eye movements. It's an open question. So that  
is harder problem, but I think that would be  
interesting to evaluate how good, how optimized their  
strategy is. So that perhaps is really because we  
don't fully understand that, but that might be the  
difference between the novice and the expert that we  
put up yesterday, although we do not fully understand  
how these are optimal because images are complex.

01:26:14 Male Speaker: [inaudible]

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01:26:14 Male Speaker: I think learning background statistics, good templates, whatever your eye movement strategy, whatever you are doing, if you are using an optimal one or a sub-optimal, that you bring you up in everything because you are able to discard -

01:26:29 Male Speaker: [inaudible]

01:26:34 Male Speaker: It's a good question I don't know. I mean, these are fascinating research questions.

01:26:40 Male Speaker: Thanks, Preeti. I think now the floor is open for general questions, we have quite a few questions.

01:26:48 Male Speaker: So what would be wrong with taking mammograms, putting them up into tiles and showing them every 200 milliseconds?

01:26:56 Male Speaker: Putting the individual mammogram into pieces or showing the whole - well, if you cut the mammogram into little squares you are losing any useful, you are losing a lot of useful -

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- 01:27:09 Female Speaker: You are losing the organization.
- 01:27:13 Male Speaker: Appropriate sized squares or whole mammograms every 200 milliseconds.
- 01:27:17 Male Speaker: Well, whole mammograms every 200 milliseconds, expert mammographers have a  $D'$  prime of about what in our - what would a  $D'$  prime of one translate to in the area under the curve roughly? They would comfortably be chance, but they are nowhere near as good as they are at, if you actually let them loose on this.
- 01:27:51 Male Speaker: I am just wondering if that study isn't a function of resolution, like the [indiscernible] start off with resolution - what is the RSVP detection rate and what is the resolution?
- 01:28:04 Male Speaker: Oh, this isn't RSVP, this is single flash and unmasked. So what we were doing with single flash unmasked gave us a rating between 0 and 100 on a callback, on a [indiscernible] callback scale and you can beat chance in a quarter of a second. And

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interestingly, you can't localize the problem at all,  
your localization performance is zero. You are  
reading something global.

01:28:32 And we have never tried hooking them up to EEG and  
see whether their little brains are - I mean, I think  
the evidence from the image triage stuff is it works  
quite nicely if you are looking for, I mean, it's the  
classic example of heliports with a great big H on  
them and it doesn't tend to work that nicely once you  
start getting more complex, but that may be that  
people haven't built the right EEG classifier yet.

01:28:59 Male Speaker: Hal conducted both of these with chest  
x-rays and with mammograms and the results, but they  
were pretty obvious cancers. There were separate  
cancers there -

01:29:06 Male Speaker: - subtle ones. We were deliberately  
not using obvious ones, so no calcification, only  
masses and architectural distortion and they were  
still beating chance. And they couldn't localize it,  
so it wasn't just that - oh, look at that big honking  
white spot.

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01:29:24 Male Speaker: Richard, could I just comment that the pathologist is suggesting that the radiologist do this. And why not, how would you feel about sitting there, the thing flashing at you trying to make some sort of a complicated differential diagnosis, having now for the last hour and a half worn this little hat that is pressing into your head? How does that grab you?

01:29:44 Male Speaker: It depends on my valium dose, but his pigeons will do it.

01:29:58 Male Speaker: - but the overall structure in the image, right?

01:30:03 Male Speaker: Au contraire.

01:30:04 Male Speaker: I guess I am thinking of, like those slides where you have like a bunch of individual cells - pap smear kind of images.

01:30:16 Male Speaker: That is cytology, not pathology. Let's not get confused. With pathology you have lots of

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meaningful area and lots of meaningful uninteresting area, so one of the big challenges is not to spend time on the fat or the muscle and focus in on where the action is. So I think it is very similar to the satellite thing where you have lots of trees and ocean and stuff that doesn't matter, but still fills up the data.

01:30:53 Male Speaker: Can I bring up a slightly different topic? So we have seen a lot of examples of different observers and this is something that comes up a lot in medical, in this perception research, particularly in the area of funding, is who are your subjects going to be?

01:31:12 Because it is difficult to get radiologists and difficult in a census. It's also difficult to get through a study session with non-training observers. And this is an issue of where are you going to go in that balance.

01:31:25 And so using an example of Alejandro's data, where you have all these subjects, I wonder if there isn't a happy medium where you don't just take - I mean, to

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just take that group of people and use that as preliminary data in a grant proposal would likely encounter difficulty in study sessions, would be my suspicion. I'm not saying you're going to do that, I am just saying if you were to.

01:31:51 But if you went and then said okay, we did this, we selected out the ten percent of highest performers and then we reran them again with a different kind of feedback and then we reran them again after that and see what happens to that group. Because radiologists, pathologists, people who do this in the medical context are highly selected. I mean, it is not easy to get to that position, so it's really not the same as signing up for a subject pool at a university or something like that.

01:32:17 On the other hand, getting access to those people in sufficient number to prove a hypothesis is extremely difficult as well. And so somewhere some sort of a medium has to, a happy medium has to be found. And it would be great if there was some guidance for that because I can tell you as one of the people who

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writes those grants, sometimes you feel like it's a moving target.

01:32:42 If you say okay, I am going to go to the radiologist, they say - ah, that's too expensive or something. And if you say I am not going to go to the radiologist, they say, well your subjects are well trained enough. It's a little hard to know in advance where is the sweet spot for this kind of thing - because I am willing to take directives from outside on that.

01:33:02 If the community says this is reasonable, then I will work with that and if this is unreasonable, I will avoid working with that kind of thing. But I think that issue of what your subjects are going to be is a very important one and I hope it is something that would be useful to address at sort of a broader level.

01:33:23 Male Speaker: Pigeons - let me just jump in and really ask you guys - I think that's, I am not in the field, but it sounds to me like they would be a good intermediate cost reducing hypothesis testing step

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that might also have appeal to study sections because  
it's so whacky.

01:33:46 Male Speaker: I've got friends in the pigeon trade  
who swear they can't get anywhere near study  
sections, that they simply can't get funding for  
animal behavioral research, period at this point.

01:34:00 Male Speaker: Well, are they looking at clinical  
data?

01:34:05 Male Speaker: Admittedly, they do not have their  
pigeon reading clinical images.

01:34:11 Male Speaker: I think this may be a Rubicon that has  
been crossed - flown across.

01:34:21 Male Speaker: Let us know how it works because I do  
have friends who would be very happy to know that  
somebody will find their pigeons.

01:34:30 Male Speaker: Well, I have to say we tried talking  
to the FDA, but they are not in an external granting  
situation, ever, ever. But I thought maybe as

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internal collaborators, but apparently we weren't doing things the right way. Yes?

01:34:52 Male Speaker: As to using radiologists versus non-radiologist subjects, I agree with what Craig was saying. There was another additional wrinkle that IRB's [phonetic] already pointed out, that IRBs nationwide would benefit from NCI guidance. And that is they said if you take a trained radiologist and provide him or her feedback during training, aren't you messing with their actual clinical training?

01:35:20 Our radiologists are very protective of their training and their credentials. So what if somehow your training is really as effective as you think it is, what if you mess up their actual training? And so we didn't want to risk that. But then I bet as usually happens, IRBs are kind of all over the place across institutions about this subject. So is it possible for NCI to provide or NIH or DHHS to provide some sort of guidance on this?

01:36:15 Male Speaker: I don't know, I am still kind of new at this. I don't really think we have much authority

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to tell IRBs to chill out. I wish we did. I mean, if this turned out to be a systemic problem, it could probably be addressed at the DHHS level, but I can't help you.

01:36:43 Male Speaker: From everything we have done with radiologists, we have never had that problem. I think it's also very [inaudible].

01:37:03 Male Speaker: What Craig brings up is important because it is very reoccurring that we get always the same thing. And the one of radiologists versus trained observers and it is the same thing to knock the discord down. And if it is always the same reply, you know, we show - okay, there's like many papers that have radiologists and trained observers.

01:37:30 And it is true, the trained observers cannot do the clinical thing, but for the sort of stuff that we are studying, you can actually show, and there are papers showing that, that you can get for the simpler tasks with embedded tumors and real backgrounds, their performance can be comparable.

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01:37:49        And most importantly, if you do something to the images, it improves performance of these trained observers, it will have the same effect on radiologists. Except for the fact that if you actually had to develop the whole thing with radiologists, it would not ever get done because they just don't have the time and the grant, you would be spending \$200,000 dollars in reading time for radiologists.

01:38:07        So you can't, it's a little bit of a - like you said, if you go with a radiologist grant, then they say it's too expensive and it's not going to be done. If you go with the thing, it's - oh, you don't have enough radiologists. And how do you solve this? Well, I think it goes back to, I think the only time I saw this try to be mitigated in some way is, like I said, there was, ten years ago or something like that, the MITV [phonetic] had a workshop of this type, but it actually included reviewers.

01:38:43        Because in these study sections that funds this sort of stuff, there are people from physics, MDs, there are all sorts of things who have no idea about

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perception issues and stuff like that. So they brought them on and they had people give a whole set of talks to basically tell them, orient them about what are the issues and what are the parameters of where these experiments or these studies exist. And that sort of helped for a few years, but now it's a brand new set of people and they are raising the same issues as that of ten years ago.

01:39:09 Preeti Verghese: So I want to shift the discussion a little bit and I wanted to talk about training and feedback. So yesterday when we were talking, Ragini mentioned feedback, but people said - well, you don't really know the truth in some cases; they look like masses, you need further investigation to determine whether they are actually cancer. And then she said - well, they are [indiscernible].

01:39:36 But I think in these statistical learning cases, you can synthesize these backgrounds, you can synthesize the masses and since you know the classes from which these stimuli were created, there is actual real ground proof there. And so the question is would radiologists benefit from such a training, would that

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be something that would be worth looking at because  
this is -

01:40:06 Jay Hegde: I think they benefit and they worry that  
they benefit too much in the sense that my training  
parameters would be too effective and it would go  
against their ACR training and so forth. But I do  
think, and we have done this in radiology residents,  
and it is effective and it is just as effective as a  
person off the street.

01:40:50 Preeti Verghese: They go to their regular radiology  
training, then they do yours or they do yours first  
and then they are [indiscernible] and look at the  
differential between the radiology, standard  
radiology and -

01:40:59 Male Speaker: Right.

01:41:07 Jay Hegde: And remember, and this was mentioned  
multiple times yesterday, radiologists, especially  
radiology trainees, residents, fellows, etc., are  
subject to assessments and it affects their careers.  
So this is actually a really -

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01:41:21 Male Speaker: I think rather than talking to NIH, I think you are better off talking to the ACR because, I mean, the ACR is very interested in like clinical decisions. [indiscernible] and that would encourage them to push the radiology training program to accept it.

01:41:40 Male Speaker: So along those lines, these people have been proposing simulations for that very reason in the [indiscernible] perception. The Headwin [phonetic] encounter that Andrew actually got around with their virtual clinical trial, although I imagine he can probably tell you Headwin stories also, is that okay, you are stimulating, how do you know that stimulation doesn't leave some critical aspect of the mammogram?

01:42:07 The burden is on you to prove to me that that is as good as the real thing. And now you have this ground truth. And so I think - again, that is a reoccurring issue and it's one that I don't know that there is an absolute proof that you could ever construct that

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would say this is as good as training on mammograms  
except now we have ground truth.

01:42:33 But maybe you don't need to - again, it's kind of a  
gray area and it's one of the many gray areas that  
when you try to do this research, we try to get it  
funded, at least, or when you try to get published  
also, you encounter potentially different opinions  
about it and you have to sort of figure out how to  
deal.

01:42:55 Preeti Verghese: But you raise a good point. I was  
just kind of making a much more limited point. It  
appears that very targeted feedback is effective. And  
if you could come up with situations where you know  
the ground truth and you could provide feedback based  
on absolute ground truth, that might be a component  
in their learning.

01:43:15 Male Speaker: You are talking about harmless electric  
shock?

01:43:21 Male Speaker: Sorry, I can't speak to training, so  
that wouldn't recommend our model for training

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radiologists. But I can speak a little bit about sort of validation and realism issues. I mean, one of the things that gets pushed with what we are doing is just different ways you could create the original data.

01:43:40 So we have an algorithmic approach to stimulating BRAC. And so we actually went back to anatomy books, back into the 19<sup>th</sup> century, Ashley Cooper [phonetic] and stuff, and we developed heuristics [phonetic] to stimulate the anatomy of the breast.

01:43:56 There are other groups, for example Duke University, that are taking CT data from John Droon [phonetic] and are then deforming it, to stimulate de novo breasts. And then there's this which one is more realistic and which one is more valid and such. And it comes down to, it would be realistic to a task or it would be validated to a task.

01:44:22 And this gets into what is called microsimulation modeling which is a statistical tool for simulating, for example, clinical trial. So typically if you look at clinical trials, you are looking at groups, you

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are using group statistics. So what is the mean,  
standard deviation, and how do you [indiscernible]  
branch out.

01:44:38 The microsimulation modeling actually simulates  
individuals and so then you can create these sort of  
much more complex sort of hierarchical trials where  
okay, some individuals will go for mammography, some  
will go for MRI, some will go for ultrasound  
depending on their breast characteristics, their  
predisposition to breast cancer and things like that.

01:44:56 And so what we are doing is effectively a  
microsimulation, but we are creating the images, so  
we are creating them and looking at the consequences  
of them entering screening programs. And so what you  
end up having to do is do what is called calibration.  
And so you will choose certain criteria in which you  
can validate the experiment against some sort of  
human experiment.

01:45:19 So we will do selected 2AFC [phonetic] trials or RSC  
[phonetic] trials with human observers to a  
particular task, demonstrate that we can calibrate

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our system against that task at a specific point. And then basically using sort of an analysis of variance, en nova [phonetic] and other things, you can then sort of look at what is the strength of your ability to simulate uncalibrated conditions and draw conclusions from those uncalibrated conditions and what is the, basically the accuracy, either the trueness or the precision of those calculations based upon the number that you are simulating and the sort of biases that you can estimate.

01:45:57 So then you can sort of ask de novo questions from this simulation. But it's hard and it becomes very domain specific because you have to have specific tasks that you are -

01:46:11 Male Speaker: Alright, on that note I think it's time for us to take a little break and we'll come back at 11:00 and start talking about the big picture.

01:46:20 [Break]

02:02:05 TODD HOROWITZ: So again I'd like to thank all of the speakers and maybe we could, we could all give

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each other a round of applause here. Because I think this has been really a fabulous set of talks and even more important from my perspective I think the quality of the discussion has been really fantastic.

02:02:28 So now I'd like to shift to like I said a slightly bigger picture. So the question is where should this sort of, this field if we can call it, this sort of endeavor go from here? What are the big opportunities you think we've identified over the last couple of days, what kind of research have people not been doing that really needs to be done and like I said we could also revisit some of the issues that we've talked about yesterday in terms of what NIH is doing and what kind of advice you might have for NIH in general.

02:03:05 So let's open up the floor.

02:03:08 MALE: I've barely opened my mouth here, but I do have a couple of points, one is that I have pals in the optical community who are doing diffuse optical thermography, which is like fMRI but using a bunch of

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fibers stuck on a skull cap, to look at very rapidly  
at cortical responses to blood flow.

02:03:36 But the time, and can be combined with EEG or MEG and  
it's 75% equivalent if you will to FMRI, functional  
magnetic resonance imaging, which looks at brain  
activity. And I think it would be very interesting  
to use, to extend this to the visual perceptual world  
and my pal Joseph Culver at University of Washington  
has already done, DOT, retinal...

02:04:08 What am I trying to say, retinoscopy? Basically,  
retintopy, thank you, so you can actually use this to  
map the visual field to the cortical activations.  
Cheaper, faster, better perhaps than FMRI and I think  
this is a fruitful area, so.

02:04:27 MALE: I think that perhaps the biggest structural  
issue is how to make it worth it to expert  
radiologists to participate in this sort of work  
without driving the NIH budget you know, into the  
ground. It's easy enough to get a radiologist who's  
interested in the project to collaborate with you.

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02:04:56 But it's really difficult to get a population of, well readers in effect. We can't pay them enough, we can't, the old model used to be you looked at my images for a half hour, now you're an author on my paper. But even the radiology journals don't buy that one anymore.

02:05:21 So are there things structurally that one could do that would make it worth significant numbers of radiologists to give us even modest amounts of time as part of what they do.

02:05:37 MALE: So I have a colleague that I went to school with who is now, runs the accreditation program at ABR, American Board of Radiology in Chicago and this process has something like 100 radiologists sitting in a big auditorium each with their own computer looking at images and studying images. And he has offered me the ability to set up a side experiment in that same building.

02:06:06 Maybe not in that big room or perhaps even in the big room and I think he's looking to have some research

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opportunities and so I can confirm with him that I  
can share his email and put it out there.

02:06:23 MALE: Yeah, that would be great, one of the models  
that has worked is testing at ABR or testing at...we're  
actually running an experiment at RSNA in  
collaboration with one of the workstation  
manufacturers in, next month. So that is one model  
that you know, give away a free iPad on the exhibit  
floor, not ideal for experimental control but it  
beats nothing.

02:06:54 MALE: In fact the ABR has 800 work stations in  
Chicago, I go there fairly often, and they're all  
calibrated, they're all [inaudible] calibrated there.  
They're pretty much [inaudible] formally for the  
process, for the good experiments, the lighting is  
variable, the sound [inaudible] all those things  
you'd like to have.

02:07:17 MALE: Well, it would be great if that could be in  
some fashion institutionalized. Yeah. Well, I  
should say that we also, the gorilla experiment got  
us disinvited to the ABR at Louisville, sadly. Which

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we feel very bad about because we really don't think we were saying anything bad about them, but.

02:07:45 MALE: Could I throw in, so for serving out of my own personal interest here, what I would love to say is efforts made into translational research that goes from vision to cancer imaging. And, so we just today from a bunch of people in various areas of vision, lots and lots of interesting ideas and the discussions show that there's some quirks and things about how to actually do the translation.

02:08:12 But if there's a will to do that, I think those things are mostly overcome-able and we'll learn some new things about the perceptual processes as related to the, at least the testing and diagnosis.

02:08:29 MALE: Yeah, no that's, that's exactly what I'm trying to encourage here, so. But, I'm sort of, I guess I'm sort of looking for something, like a little more specific isn't the right word. But yeah, absolutely we want people to start doing something that's got a more translational flavor and taking all these great ideas.

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02:08:50 MALE: If you want to break translational down then, it, to me it goes into two distinct components and one is showing that the phenomenon is operational, that was the term I used yesterday, that whatever it is you've done in a different context, in vision, is actually functioning in the medical and perception world. And then, in some regards that's the fun part.

02:09:18 The next part is then working out the mechanics of it, the actual nuts and bolts of how does it work? So I think the example we had yesterday was the context of digital prediction for surgery. So it's one thing to say, you could easily imagine that a study, I was thinking about this last night, it's easy to imagine a study where you take those surgeons and you say okay here's the MRI of the brain, just not with the DPI set, how far would you cut?

02:09:49 And you'll know, they'll stop somewhere, and then you give them the track. And you say okay, if I give you these tracks and tell you this is what we're measuring on DPI, how far do you cut now? Or maybe a

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different group of surgeons, I'm not, the details of that experiment are something different. And then show that it's modified or something like that and say that this is how the actual mechanics of something crept in and modified what might get done and that says how far someone might be willing to cut in an operational setting.

02:10:21 So good, those I think would be two particular parts of translation.

02:10:30 FEMALE: The problem with I guess that is every kind of imaging shows a different boundary of the [inaudible]. And the question, you can and we have done that, we can combine and collate them and you get some kind of a shadow around. So that is what they call their level of uncertainty. And then you draw the tracks because you are, the tracks are just the visualization of the white matter. If all you want to know is they don't want to cut into the white matter, they can get it from a C1 or a C2 image.

02:11:02 And they basically depend on the radiologist who looks at where or [inaudible] contrast at hand which

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has a very sharp boundary of the enhancement and they  
say cut through the boundaries, its maximum  
[inaudible] at least in the U.S. So the boundary is  
defined by the imaging and the imaging has,  
[inaudible] not in the diffusion sense but it's  
uncertainty as to where the boundary is, so.

02:11:35 I don't know, I think it all, most surgeons will tell  
you that they will open the brain and decide, so.  
Yeah, so.

02:11:48 MALE: Okay, I don't think that that, that those  
specific details take away from that there's a  
perceptual process that's operational and that  
there's features in those images that either the  
radiologist or the surgeon is using to say this is  
how far you should go or this is how far I'm going to  
go. And then those are the components that are  
modifiable by an imaging and those are the things  
that we ought to be trying to optimize to make sure  
that they do this process as well as possible.

02:12:24 FEMALE: Modeling of the uncertainty is very  
important. So if you can give them a measure of how

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uncertain they are versus how uncertain the image is,  
that might help a lot.

02:12:34 MALE: Well, could I ask, how much of this could be  
done in a simulation? All the major trade teaching  
centers now have simulation, we have an extensive one  
and a lot of surgery that was initially done with  
people is done in simulation, you know you do CPR,  
resuscitation, you do that in simulation. If we  
could think about a radiology simulation suite where  
we have a couple of workstations where radiologists  
could on a regular basis be going in to be  
incorporated into their training structure in some  
way.

02:13:05 That they have to spend time in the simulation suite  
or actually do experiments in the simulation suite,  
you know part of their track is that they've got to  
do some sort of simulation like that.

02:13:18 MALE: Like where you make Psych 101 students do  
experiments.

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02:13:22 MALE: Right, because I mean one of the ways you could do this with what [inaudible] was talking about is do it in simulation, simulate with the feedback loop so you have to keep that loop so that you're doing a surgery but then you can sort of say oh, okay when should I give you this plan, when should I give you that plan? How does that alter your decision, you know.

02:13:48 MALE: Greg was mentioning yesterday and that is creating some kind of maximum national or international database of [inaudible]. It is basically a demonstration of what Andrew has been doing but it gives overall population idea, probability [inaudible] and I think if NCI undertook something like that it would be a tremendous ask resource for vision [inaudible] and radiology.

02:14:26 I don't know if mammogram is the choice, the initial starting point or not based on my pre-test phase or something like that, but I think it is worth going for.

02:14:39 MALE: Greg first and then Brandon.

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- 02:14:42 MALE: Akron has a database, ran a big study of images and also has the lung imaging database and sources so there are some resources out there if you want images.
- 02:14:52 MALE: Right, no, no, there are a lot of databases [inaudible].
- 02:15:12 MALE: So, the difference being, I think what Greg was looking for yesterday if I recall correctly is the clear breasts, the negative examples, right?
- 02:15:26 MALE: Well, I was talking about, and I think that if you know if you're looking for some really big direction that might have some big future payoff, I think that we're a little bit on the brink of a scientific flip here with advances in machine learning. I mean with learning, these things really do seem to be able to learn just about anything. And if you really spend some time to create a good, clean data set of positives for each of these categories of pathology.

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02:16:01       And then create this hard negative data set that I was talking about yesterday that differs by about ten orders of magnitude with regard to each of the positive samples, then and then just to you know sell the idea say that, open it up to an almost a competition. Saying, that is open to you know engineers and applied mathematicians and computational vision people and computer vision people.

02:16:29       And just tell them to throw whatever you have at it, now build me the best possible cancer detector as per these levels that you can make. And just see what happens, my gut tells me that would be resources very well spent.

02:16:44       MALE:       So, I think that's a great idea but here's, I want to sort of differentiate of what our mission is a little bit. Is our mission really to tell you how radiologists do this or build a set of algorithms that replace radiologists. And to be honest, I think that there are people that are much better positioned and much better skills than we are to actually do that. In fact there are millions of dollars, there's

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a whole industry in that, millions of dollars into  
the whole field of computer aided detection.

02:17:13 No representative here but the whole representative  
of the whole field and maybe Brandon could comment  
more on that. So I think it's a great idea but you  
know, I just, maybe you know more about this. I just  
don't know if we're in the position to make, if  
that's our, if that's the best place to make our  
contribution. I think isn't it really to really  
understand the perceptions of what we know, that's  
just a thought, I don't know.

02:17:37 MALE: I guarantee you the CAD companies are not  
sitting there going I wonder what this deep learning  
stuff is all about? They know, they have experts,  
they hire people for a lot of money to go in and  
write this code and they pay a lot of money to apply  
it to lots of cases because that's where their  
intellectual process [inaudible].

02:17:57 MALE: Well, the other thing too is that in any  
imagine you've got cycles of renewal and  
obsolescence. So pretty much anything that you're

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doing on cheating mammography by the time we all figure it out on NIH funding, you know we're going to be way beyond [inaudible] in the breast imaging. So I have to agree with Miguel and with Craig, I don't, I think it's a great opportunity but not for this group and not for NIH.

02:18:32 MALE: But what I...

02:18:34 MALE: Can we get Jerry in the back there?

02:18:43 MALE: [inaudible].

02:20:05 MALE: So, you're certainly describing my life and probably Miguel's and several other people's here. I am not an applied researcher by trade, my interest is in talking to radiologists or other experts, learning cool problems, and figuring out what the, where that gives me leverage on the problems I care about in basic science. And in my case one of the clear examples is the question of when do you stop searching?

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02:20:34 And it goes very much to the sourcing that Preeti was talking about, if you don't know how many targets there are or there's seemingly nothing there, you have to make a decision about when to stop. This is something that is of high interest to radiologists who have to get through this big stack of images by the end of the day because that's what's getting, because the metrics that are being recorded are whether they got their cases read by 5 o'clock.

02:21:02 So they are a lovely test set for people who are really, really, really concerned with when's the right time to stop search so that I get my cases done but I don't get sued for missing cancer. But what I really want to know is the more, the basic science of that so when I'm looking for the cat, you know. I've got to figure that's a similar sort of process so nobody sues me if I can't find the cat.

02:21:29 So that sort of trade back and forth is absolutely what I want to do for a living and I think what some of us have been trying to sell to other parts of the vision community, you know.

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02:21:44 MALE: Well, maybe...Andrew?

02:21:46 MALE: I think the other way to approach this might be observational studies. I'm not sure how well these work but the eye trackers that the new ones that are not sort of not calibrated the same way that you can sort of put on the desk, can you put eye trackers into clinics? I mean could we record what people are doing on a...it isn't, okay.

02:22:06 MALE: But no, it's a really, really, really good idea.

02:22:08 MALE: Oh, no but I think it is becoming easy.

02:22:13 MALE: It is becoming easier.

02:22:13 MALE: With the Microsoft, new systems that are detect systems you're going to be able to...I don't know, how do radiologists typically view mammograms now? Is it against, is it on the computers screen...

02:22:34 [CROSSTALK]

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02:22:36 MALE: [inaudible] on the bottom.

02:22:44 MALE: I don't think...

02:22:45 MALE: Typically they go through a...

02:22:47 MALE: [inaudible].

02:23:17 MALE: Right. But they are wearable, they're  
wearable eye trackers.

02:23:22 MALE: I don't want the wearable ones.

02:23:23 MALE: You don't wearable ones.

02:23:25 MALE: I want the one that sits on the counter and  
you know.

02:23:27 MALE: Yeah, something that you can integrate into  
the simulation suite. I think that could be done  
easily and it shouldn't be a...

02:23:31 MALE: Yeah, so that's maybe another question where  
the simulations you know, or where you have

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controlled experiments. Okay, you're going to be sitting at the quiet console, you know, someone else is going to be answering the phone for you for the next hour, you know we're going to record. Because for us the sort of observational experiment is becoming more powerful, you know especially with the, like the, you know like big data sort of initiatives.

02:23:54

So we're basically in our prosper brand is integrated all the breast health information in the hospital into one central repository and so we've been putting things in that really have never gone there before so you know for our clinical trials work, our virtual clinical trials work, we're using the observational data of our patient population to inform our simulation studies. So we're you know, what is a population at Presbyterian Hospital, which is one of our hospitals.

02:24:20

Well, it's largely African-American, it's you know it's serving West Philadelphia so I can tell you okay they have you know larger breasts, lower density, you know larger surface area, things like that and then I can simulate breasts like that whereas you can then

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say oh well, what about the main hospital or one of our outpatient clinics so I can simulate different populations of women. So if we can use these sort of observational, you can gather data observationally you know that might solve some of the problems of having to have the...

02:24:51 I don't want to use the word lightly, contrived scenarios where you know you're putting people into a room for an hour and reading certain films.

02:25:00 MALE: So at the present time you can potentially do this sort of desk mounted eye tracking and keep an eye on what images they're looking at and you know sort of statistics of the eye movements. It's much less trivial if you want to know did they fixate on this lesion because you, at least, I'm not a real eye tracking expert but I've had them in the lab.

02:25:31 The calibration doesn't hold long enough for you to get the sort of resolution that you would need to say they fixated here but not half a degree over and the sort of resolution that you need in, if you're looking at mammo. But this is beautiful area where

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the technology has been moving fast enough that these  
sort of things should be possible in the you know,  
not too distant future.

02:25:59 I mean that's, you're never going to get, we eye  
track radiologists but in terms of getting them to do  
this in clinical practice you're never going to be  
able to do that until you make it sufficiently  
unobtrusive that, well that it's unobtrusive.

02:26:15 MALE: Can we get back to Jerry's question for a  
minute? Can, I'd like maybe some of the people who  
are not doing direct, doing research that is directly  
related to medical imaging to sort of comment on  
what, on problems they found intriguing from the last  
couple of days? Yeah, Alejandro, let's start with  
you.

02:26:46 MALE: The things that I find interesting, for me  
when I think about my theory of visual search, has to  
do with how people are going to accrue information  
throughout the scene [inaudible] what's the  
information that has been accumulated, what are the

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thresholds that are driving decisions at different locations.

02:27:18 So I think that the, in the past we have a lot of us in my field have always done very positive oriented visual search series. Meaning that we have a template and we're looking for positive evidence or that in particular regions of the display but as it becomes evident today and yesterday from studies of the recognition of the background and what people are getting from the background.

02:27:49 Maybe they, maybe we need to combine positive and negative assimilators of templates so that we can learn to reject backgrounds because what's unusual about this is that the backgrounds are not well structured, they're like a wall. I can put my displays on top of a [inaudible] and the [inaudible] is not going to change anything about how fast people are finding the target [inaudible].

02:28:19 But the backgrounds here are not [inaudible], they're very, and I don't think we've ever actually looked at that problem. The problem of collecting evidence or

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the background or qualified as backgrounds, or maybe I'm wrong. But that to me was very cool and interesting and a new problem from our perspective how we develop this.

02:28:49 MALE: Just to follow up on that point, if you do think of a search template rather than being a template of the target, if you think of the template as a classification boundary then as that classifier is learning you would expect signal enhancement, the target should get more target like and the background should begin to slowly disappear.

02:29:14 MALE: But I guess what I'm trying to suggest is that I think that's shortsighted and I think what I'm trying to say is that maybe we should think about multiple account accumulators to point towards different points, different decisions, right? So you can imagine [inaudible] but you're trying to make a binary decision, just target/non-target, do something like target, background noise, stuff in between, right?

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- 02:29:39        Because there's all these three things, these three types of things going on.
- 02:29:46        MALE:        That's an interesting question.
- 02:29:49        MALE:        I mean relatedly I think it seems like an interesting question how we start parsing out the scene. So we know that in visual search if you've got things that are grouped together and form little groups of squares your search for them is inefficient because you've lumped them together and then explained away by the overall shape. And so in mammograms the same thing is going to happen wherein various kinds of anomalies are going to form larger structures.
- 02:30:13        And so it seems that the joint issue of parsing the scene while searching for elements in it is, generally we do drill searching of either entirely parsed scenes or in very low structure noise scenes whereas in this case what you've got is a bunch of overlapped structures and so the search process is jointly parsing and searching and that seems like a

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wide open and important question, both in basic perception and in medical image analysis.

02:30:46 FEMALE: Yeah, I definitely agree that that's one of the issues and one of the things that struck me about what we've been talking about is it's not clear to me you know, when we try to think of this as a search task, which is a common way of modeling it in our world, is what are we searching over? I mean in the kinds of tasks that we do and models like you were talking about Greg, it's clear what the units are and what am I applying the template to?

02:31:14 But in talking, hearing about Jay's work I'm thinking it's the whole image, right? What they were learning to do was treat that image, is this an image with an anomaly in it, yes or no. They're not searching over a set of defined units or we don't, it's not clear to me that we know what we're searching and that's the parsing problem, how does it get parsed? Are they parsing it into units and searching for you know this area is a tumor and this is that or are they...

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02:31:42 I don't know, it doesn't feel like they're necessarily doing that. It feels very different than the kinds of pre-parsed [inaudible].

02:31:50 MALE: They're probably doing some piece of both.

02:31:52 FEMALE: Right, yeah, yeah, and then whatever.

02:31:56 MALE: Because it's been my experience in talking to experts in a whole range of different domains is that at some point everybody will tell you that the image, whatever the class of images comes up on the screen and I know this is an important one or I know this is a bad one or something like that. And it's the sort of thing that drives that EEG signal too and that's presumably the global texture kind of signal.

02:32:30 That we don't, I mean you don't really understand, at least anywhere near as much as we have an idea about these sort of template matching kinds of targets and things but it's certainly the case that experts talk to you about that. They all think they have magic powers.

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02:32:52 Yes, and that shows, and we have that in the basic literature as well, whether or not we believe it's real, in the change detection literature where people get a feeling that there's a change here before they've localized, before they've localized the change.

02:33:09 FEMALE: Right, that's...

02:33:14 MALE: [inaudible].

02:33:20 FEMALE: I guess I'm not, I'm a perception researcher, I need to ask the question, what is the aim? Is the aim to replace the radiologist, to make them better? Is it to understand what he's doing? Or is the whole perception research? We have to kind of define that because if you're trying to translate this [inaudible] what do you want to achieve?

02:33:42 MALE: So I think when you know Greg's fantasy comes true and the deep learning algorithm does it all, fine we'll go on and work on other problems. But that's not going to happen for a while and I think in the meantime we're, what we're about is the

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human in the loop piece of it. Even with good technology there's going to be a human who is part of that and a human is going to have a perceptual system that we need to, that we need to understand.

02:34:18 MALE: [inaudible].

02:34:20 MALE: Sure you're...[inaudible]

02:34:22 FEMALE: Improve or accommodate, right.

02:34:29 FEMALE: I mean there is a lot of it about the power of suggestion. I mean we gave two lesions, the same lesion to two radiologists. One was a chairman and one was a chief...actually both of them are considered excellent. They had 30% risk in what they identified as lesions. 30%. The problem was the boundary, right? But then we gave them something that we extracted and suggested and there was an aha moment for both of them.

02:34:59 Ah, yeah, we could have considered that the boundary could have gone. I'm coming back to the question that maybe it's an issue of people say that tumor

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boundary or tumor detection is fully [inaudible],  
it's not, it's the most difficult thing to do.  
However it could be both sides, you use your deep  
learning to get the best possible classifier of  
tumors so that the person perceives it differently.

02:35:27 That's, so I, it doesn't have to be just one sided.  
I mean you said that should we do that, no, no,  
that's a classification problem, we shouldn't go into  
medical imaging. I do the tumor detection part, but  
I think our ground truth in our [inaudible].

02:36:00 [inaudible]

02:36:06 MALE: So in the absence of the ground truth  
problem which I think is, isn't completely  
intractable and that's because there are other  
techniques for determining where the tumor is with  
molecular imaging for example or new florescent dyes  
that will go to a brain tumor, many other tumors, and  
actually light them up so you can actually see them  
in the operating room as a nice near infrared glow.

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02:36:31 But I mentioned this before and got a response on the display side but I think the tremendous opportunity is for this community to work with, I'm sort of gradually figuring out what should we do which I think is what you do is to take the images as given and work with them. But I think there's an awful lot of pre-processing and image process that can be done by differential histories processing, to improve the saliency of the features and you can work with them to test and validate the new image processing actually improves things and makes it work.

02:37:06 And so I would, that's to me where I think you need to partner, I think, with the other guys who are actually investing with the images before you get them and see how that works.

02:37:15 MALE: Reprocessing or workflow even, keep track of where people looked, are they blinking in the right direction, it kind of has feelings of [inaudible] but also understand it from the vision rather than just the data mining results of CAD. I want to swing into a little bit different issue, obviously I'm always into technology evaluation and everyone, there's a

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lot of search discussions here. Most studies today have a small element of location as part of the end point in determining the performance of a human looking at the image.

02:37:51 Most of the time it's just is this patient diseased or not diseased because it's easier to analyze because we, it's not a really well formulated end point to determine how successful you are at finding the disease. So there's this tension between the clinical task which is search and the study, the controlled lab study which determines and helps us understand the performance of a technology by not evaluating that they got the location right.

02:38:26 There is plenty of good work out there trying to link the two and many people have kind of gone with an assumption that especially in the very controlled kind of phantom work that if you do a study that puts the signal in the same place every time, signal known exactly, study design that comparison of imaging techniques translates to the search problem.

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02:38:54       And that's the basic assumption is that you can do your performance evaluation with a signal known location but it translates to the search problem which I mean I think there's certainly not 100% convinced opinion that that is exactly transferable. But that's a length that would really help the evaluation process, either to have really good methodology for evaluating performance in a search path.

02:39:26       And making the link to the detecting path where the signal is known and in a known location.

02:39:32       MALE:       I'm sorry, so you're saying there's a statistical challenge in quantifying localization performance as its compared to quantifying [inaudible]. Okay.

02:39:41       MALE:       There's lots of techniques that FROCA, FROCLC [ph.] but especially the industry hasn't embraced something and it's always a very uncertain path to talk about that because it's, ROC and binary pack is a really solid methodology that people are convinced already. Sensitivity plus 50 is where

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people normally start, you get them to ROC that's  
even better because you get more information.

02:40:13 If you can get them to FROC there's a lot of people  
believe that there's even more information and what  
does that mean? Smaller trials, that's really what  
the whole industry of medical imaging is to do  
smaller trials that you understand or at least have a  
good hypothesis of what's going to happen at the end.  
You don't do it, I mean for research we love to do a  
study and not know how it could end up. But for  
industry they like to do studies where they know  
where it's going to end up. And there's some  
definite work there.

02:40:42 FEMALE: Some of the work that's happening in what  
Brandon was talking about, oh and Miguel did you want  
to go first? Sorry. [inaudible] does a lot of work  
with the FROC task and when I work with industry  
people there's always this confusion about well he's  
constantly updating his website. He's constantly  
updating the figure of merit. So it's really tough  
for them to get their heads around well we're going  
to make a submission to FDA that says we're going to

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use the latest version of what's on Dr. Chadawarthy's  
[ph.] website.

02:41:17 But we've had success with it, so that's one issue.  
Then there's also this tension between what Dr.  
Chadawarthy's doing and what Dr. Obechowski [ph.] has  
done where you take an organ system and you split it  
into different regions of interest which works very  
well with something like the colon which has the six  
anatomical regions when you combine the lectures with  
adjacent regions.

02:41:43 It's more difficult when you think about something  
like the breast because that's very subjective when  
people are talking about the quadrants and sub areola  
and things like that. So there's a tension between  
the two of them, I guess what I'm saying is there's  
really good room for research in this area and I  
don't know where it would come from, from this group  
or from the perception people but it is a good open  
pocket.

02:42:12 MALE: Could I zoom out a little bit? So I think  
it's a good question is what is the objective, what

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are the objectives, what are possible contributions that this group could provide. I think a good starting point is to Elizabeth Kaminski [ph.] I don't know, are we in webinar today, are we? Okay, so she might be listening. But she's written herself on how there's a bunch of pieces being written about the priorities of medical image perception.

02:42:38 In fact there is such a thing called the medical image perception society, which you should know about. Which is a little bit small, but I would like to, I would like to see you know because obviously part of the reason is there are not the resources to support you know, vision scientists doing this type of work and if that's going to happen, which would be great, I would like to see that group be integrated with the image perception society.

02:42:59 You know, they're people coming from different, I mean, you know advances in science to me come about bringing people together and having them talk. Not building powerful worlds and powerful societies, that we don't want to have the medical image perception vision society. We want to really sort of integrate

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those two forces and I think looking at what their mission is, is a good starting point and see how this group could add on, obviously it's clear what you could add.

02:43:27 It's sort of what we sort of pushed for years, it's bringing vision science ideas and integrating them and bringing some of that creativity and novelty, those ideas and bringing them to the point of medical image perception and through those ideas sort of advance our understanding of how doctors do this, which might lead to sort of image quality tools which could you know, lead to better systems and better ways to display things though that doctors do fear mistakes and just find things easier.

02:43:55 So that's that and then you know the other, what comes for free which is what Jeremy pointed out which I also get a lot of pleasure out of, is that these are complex tasks that have motivated a lot of basic science, at least you know I guess like Jeremy in my lab, a lot of basic science experiments to advance our understanding of how vision works. You know the

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basic vision scientist did not run across because  
they're looking at [inaudible].

02:44:21 But when you're looking at the problem of  
radiologists looking at tumors, there's a background,  
things that you know, things that led us to think  
about things that the brain has to deal with in that  
step that otherwise you would not run across and that  
enriches the basic science part of visual search, so  
yeah.

02:44:40 MALE: Craig?

02:44:42 MALE: I would just like to address a couple of  
these points, one is the relationship between the  
basic and applied interests and the other is this  
relationship between the computer assisted detection  
community and what our sort of commission should be.  
I think Miguel is right, I mean I was personally  
hoping to learn a little bit more about what the  
state of the art is in that neck of the woods.

02:45:19 And on you know, I agree with Miguel that it would  
have been helpful if these groups were a little

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better mingled so that we can talk about each other because I believe that we really do have a, that I believe that it is important that we look at a whole lot of these good hard negatives because we start training better things.

02:45:43 And whether that's best handled by us or best handled by them, I don't know, because I don't talk with them. And the other point that I want to make and how those hard negatives should be collected? You know, maybe we have a role to play with that, maybe it's the simulation suites where we can properly oversee the collection of these from radiologists using our eye tracking technology. Maybe that is our role to play.

02:46:11 But again I, you know I don't know enough about the state of the art to really weigh in on this at that point. With regard to the connections to the applied work and the basic work, I was delighted with what I learned here. I don't do, I don't do medical imaging. I've never done it before and I was just fascinated by the possibility that we maybe, that it

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may be possible to learn these categories of some pathologies.

02:46:39 You know if there's a small number and we could learn what these categories are, then it would be trivial to build the sort of, to make them more salient so that they could be, you know once you have the categorical target template you can just pass that, you can just pass that over the image and highlight those regions. You know, adjust your priority map, that wouldn't be a hard thing to do and whether the radiologist would believe it and find it useful and whether they would trust it is a whole different question. But we could build that sort of augmented system.

02:47:19 MALE: I wasn't entirely sure that we are the best people to be designing the computer aided diagnostic tools. But there is a place where we can help, I think at CSS a few years ago somebody showed that if you have to parse an amount of data and you're trying to train a machine vision system to recognize stuff based on that, if you also train that same system to

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reproduce the kind of errors people reproduce it  
yields better generalization performance.

02:47:41      Simply because the large amount of training the  
people have done over their lifetime yields a  
specific pattern of errors and if you train the  
machine to produce those errors that kind of reduces  
the same kinds of structures that people have  
learned. So yeah, I think you need, you need small  
training examples because then you, then you can take  
advantage of the human vast experience. So there's,  
that's a small measure where I can see human vision  
helping machine vision.

02:48:11      But generally I'm not, I mean there are people who  
are very good at using machine vision systems for  
doing stuff, much better than we are, I think.

02:48:23      MALE:      So, just for two notes, I would encourage  
you know, the vision people to try to attend some  
medical conferences. Either the RSNA or the SBIE or  
the medical perception society meeting which will be  
next year in Belgium, that might be the closest one  
to sort of key your interest. But you go to the RSNA

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I mean there's 9000 radiologists wandering around,  
it's the largest trade show in the world.

02:48:48 You'd be shocked at what it is. The second thing  
though is, is by and large people are not doing CAD  
research anymore. Not strictly algorithm development  
or things like that. There are a few small groups,  
they're doing it just like homosynthesis [ph.] system  
development, I'm probably the only lab that I know of  
that's doing strict homosynthesis system development.  
These are just too expensive.

02:49:14 You know research labs can't do them anymore, the  
manufacturers are doing them and they're doing a good  
job and you know they're priorities are different  
than ours perhaps. You know you can inform what they  
do by doing very focused [inaudible] work on  
resolution but ultimately you know there's no hope to  
produce anything that's close to a clinically  
performing CAD system today in a research lab or a  
clinically performing [inaudible] in research today,  
that's a hard fact. You're up against Goliath.

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02:49:48 MALE: So I think the CAD example is actually an interesting one for where this sort of a community might provide some help. Absolutely true that we're not in a position to design the CAD system at this point but the real problem, not the only problem, a real problem with CAD is how little benefit it provides and that seems to be a problem with the human in the loop, the human is good, the CAD is good, the combination is not as good as it should be.

02:50:21 And there is where we have the sort of expertise that should be relevant. Now, and what, you know in the lab you can make a CAD system with any old damn properties you want because you make stimuli like 3D and then stick a CAD signal on top of it with any known kind of validity and any kind of prevalence that you want and try to figure out why the human just ain't using that signal.

02:50:56 So we don't need, we don't need a half a billion dollars to do the sort of work that we're good at in the CAD domain.

02:51:04 MALE: Good, because we don't have that.

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02:51:06 MALE: The backseat driver problem, you know yellow light up ahead or my wife saying there are three parking places over there. Well, I see them, you don't have to tell me that. But she's right, there are three parking places over there.

02:51:19 MALE: Are you suggesting that what we really need is your wife?

02:51:24 MALE: No, I think maybe she could learn from some of your techniques of how to develop a good CAD system.

02:51:33 MALE: [inaudible].

02:51:43 MALE: Except, well there is this nice general problem that Matt may have more to say about which is the use of [inaudible], overuse/underuse of technology and, this is a specific application of it. They certainly work on it out there most of the time.

02:52:06 MALE: I also want to point out that the, we can also study which are the best ways to provide the CAD

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information because I can tell you that from an attention perspective these people are looking for a particular template that is like some diffuse greyish thing or tiny white dots. Things that you're telling your system to do is ignore hard white boxes, ignore, or red, or whatever information is overlaid.

02:52:43 That doesn't fall on your attention, in your attention template. That's stuff that your attention is trying to tell you don't look at that, that's obviously not the target. So there is a conflict there between what you're telling your attention to do in terms of finding the target and the way the CAD information is delivered to the attention system. SO I would imagine that we, if we made CAD delivery information more in tune with the attention template, maybe that's one of the sources where it's so annoying to have this information.

02:53:16 MALE: So, Elizabeth Krapinski, depending on how many of you are sitting on your email, says thanks for mentioning the various research endeavors of our community and MPS have been on the whole webinar but it's been one way no matter how many time I use the

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raise hand option or chat a comment. Is there some way we can get Elizabeth in on?

02:53:40 [inaudible].

02:53:42 MALE: You're not, Elizabeth if you're listening to us you're apparently not raising your hand correctly. If you, I'll send you my cell phone number.

02:53:54 MALE: So...sorry. I wanted to say, wait do we have...

02:54:05 FEMALE: Elizabeth you're on mute also.

02:54:14 MALE: Hello?

02:54:18 MALE: Elizabeth we can hear the background noise from your office but we can't hear you, speak more loudly.

02:54:37 MALE: So I also want to say in my opinion I looked and I tried for programmatic corrections but I kind of see it as to some extent you guys saying this is what's important to us and still we'll sort of

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figure out how to try and make it happen. That's a  
little bit the way I see it.

02:55:04 So I'm kind of curious, as you guy looked at this,  
what are [RINGING] [inaudible]. Oh, that means you  
have a phone on.

02:55:17 MALE: Oh, okay. [inaudible].

02:55:40 MALE: So, I mean to answer Craig, yes absolutely.  
It is our job to say what are the important questions  
that need to be answered and here is a pot of money  
to go do it or various other mechanisms. And this,  
but basically behind that there's an exercise of  
going in and figuring out where the best ways that  
these two fields can collaborate, that's my mission  
here.

02:56:07 So, I'm not sure exactly what I can, that there's,  
what I can say about this in terms of, yeah.

02:56:10 [NO AUDIO]

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02:56:40 MALE: Yeah, Paige could you repeat that into a  
microphone.

02:56:45 FEMALE: I'll do it.

02:56:46 MALE: Basically, let me, what might be a rephrase  
is sort of, well okay, go ahead.

02:56:54 FEMALE: Oh, you know I never repeat myself the same  
twice. But, so I think you know it's really  
essential for you guys to give us some guidance that  
will enable us to sort of turn your ideas as they  
sort of coalesce with our ideas into initiatives. So  
this is part of the process of us beginning to build  
sort of our rationale for the types of initiatives and  
sort of statements of interest that we will hope to  
release within the next year or so.

02:57:21 So, it's really critical, this meeting is not just to  
get together and talk about science necessarily but  
it really serves the purpose in terms of helping us  
determine the directions that we're going to go next.

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02:57:32 FEMALE: So I just wanted to put in, not a shame,  
well yeah a shameless plug for the Radiology  
Society's quantitative imaging biomarkers alliance.  
Because whenever people are working with medical  
images, if you're doing something, it's a total non-  
profit thing and I make no money from being involved.  
So if you're doing research and you're thinking about  
perception and you're thinking about somebody putting  
a size on an image or somebody looking at diffusion  
coefficients in an image or uptake values in an  
image.

02:58:07 There is this alliance out there, there's a website,  
there's a wiki, there are people who are working on  
how to make these numbers meaningful and when you  
have your reviewers looking at grants and somebody  
says oh yeah, well I'm going to do this, please make  
sure that they're doing it in a scientifically valid  
way and that they're interacting with the right  
people.

02:58:31 MALE: That's another possible idea here would be  
maybe, it comes up many times, some of the most  
useful things that have been out there is like the

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University of South Florida [inaudible] data set, and it's ancient, I mean it shouldn't even be used anymore, it's inappropriate but maybe it's time to sort of get a new data set. Maybe every decade or every five years or whatever there has to be a, you know someone's got to go out and get paid to gather in data.

02:58:57 MALE: Yeah. Alright, so at that point people since people have to run out the door and catch planes, again I'd like to thank everybody for the discussion, this has been fabulous. I'd like to apologize to everyone on the webinar, I guess we weren't properly integrating people's comments into the general discussion, that's just the way we set it up and we're going to have to think about how to make that better for the next time we do this.

02:59:28 But yes, but we love you anyway and again thanks to all of you for taking time out of your schedules and coming here and as Paige just said this is not, this is not merely an extremely fun exercise but we are going to take your opinion seriously and start integrating them into our development of initiatives

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because otherwise the intuitive would just be what I  
think we should do which is you know, lots more  
visual stuff so. So, yeah, exactly.

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