Title

Blood flow quantification of biopsied skin lesions using a laser speckle imaging dermatoscope (Conference Presentation)

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Transcript:

Hello. Thank you for that introduction. So today I'll be going over the background as to why we're looking at this new technology that we've developed. So we'll talk about biopsies and skin cancer. We'll also be talking about the LSI dermatoscope and the specs and components that have gone into building the device. We'll talk about the device validation. We'll also show some samples of lesions that we've imaged. And then, we'll come with a conclusion and talk about some of the future work.

So just some statistics concerning skin cancer. Non-melanoma skin cancer is most common cancer in the United States. Melanoma has an estimated five year mortality rate, as high as 23%. Dermatoscopes are used to assess 5.4 million suspect skin lesions annually in the US. And this is important because a lot of biopsies are taken. And so whenever there's a suspect lesion, you'll have a biopsy. It's the current gold standard. And so we're looking at ways that we can reduce the number of biopsies taken.

So current technology-- there are a lot of commercial dermatoscopes. Some of these may have special software for identification of lesions. There's also different technologies that use multispectral illumination, cross-polarized illumination to look at different features of skin lesions. And these are mostly focused on structure-- looking at different blood vessels, the edges of lesions. And so our thought process behind the technology I'm here to talk about is that functional information may provide additional information for legion characterization.

So what is laser speckle imaging? Laser speckle imaging is the use of coherent light. We use a coherent source. We shine it at an image using a camera detector. And so this coherent light with a constructive and destructive interference creates this sort of speckle pattern that we see here. And so it looks like a bunch of noise. However, when it runs into dynamic scatterers, there's actually a blurring in the speckle pattern. And so once you have a blur in the speckle pattern, we can make these sort of calculations that tell us approximately how much flow there is in the region.

Here we'll have a raw image taken with a monochrome camera, and we're going to run a window filtered through. Usually, we'll take a seven by seven pixel region area. And then we'll run this and we'll look at the standard deviation of the intensity. And so then we're going to get our speckle contrast value. So when we have our speckle contrast value, we start to see flow. Areas of low speckle contrast mean that we actually have high flow. And so we this sort of non-linear transformation, and then we look at what we call the SFI map, or blood flow map. And that's

how we're going to look at flow. And so there you can see the vessel now pretty clearly, and in the vessel and you see this increased flow.

How can this understanding of flow in the region help with our diagnosis? Angiogenesis closely accompanies tumor progression. And so the density of microvasculature should increase with squamous cell and basal cell carcinomas. So as you see here, you see this sort of increased blood flow compared to the surrounding regions. So we're hoping that LSI can help us monitor this increase in flow both spatially and temporally.

So what we've done to look at laser speckle in these skin lesions is we have taken a monochrome camera for the LSI measurements. We've also taken a color camera for our standard imaging so we can compare the two. And we have our laser diode and our LED lighting so we can look at both types of imaging. And it's all in this sort of convenient handheld form factor for use in the clinic.

And so if we look at some of the components, we have our laser diode right here. We're going to shine laser diode after diffusing it using this diffuser cone onto the tissue. Then we had the beam splitter, 50:50 beam splitter, and we'll shine it through. Then we have a collimating lens. We'll bring that to our other lens before the camera so that we can focus this onto the monochrome camera. And that's how we will look at the laser speckle images. Then up here we have our color camera. And so we're going to use the beam splitter, run this through another lens. And we have a filter to filter out our 785 nanometer diode, and then we can look at that through the color camera. So we should be able to look at both images without interference from the different light sources.

Currently, we're using two FLIR Firefly cameras, and they have a resolution of 640 by 480. We're going at a frame rate of 15 frames per second. For one measurement, it will take about 30 seconds per region of interest. The reason this takes a little bit longer is because there's a save time because we've been using Matlab. We do make the Nyquist criteria for our laser speckle at 2.32 pixels per speckle.

The device use will place this diffusing cone against the skin as you can see there. And then we can change the exposure time. We'll change it about between 5 milliseconds or 10 milliseconds depending on a patient's skin tone. And then the current iteration takes 200 monochrome and 200 color images in that 30 second time period. Our field of view is about 1 centimeter by 0.75 centimeters. And the reason we're taking so many color images is this can help with image registration in the future and making sure we have it aligned because this is a handheld device.

So we've developed this custom GUI in Matlab. And so we'll have our monochrome image right there, which a lot of times is actually hard to see. So we also have the color image which makes it a lot easier to visualize what you are looking at. And then we will compare the color images at the end because motion artifact does play a role in laser spackle, which I'll go over a little bit later. So you can look at either the raw images, the SFI images, and you can save it. This Increased Melanin button, I used to let the clinicians decide on this exposure time, however I found that this is lot easier. It helps with the measurement. And so if you clicked Increased Melanin, it just increases the exposure time to 10 milliseconds.

So we want to do some device validation to make sure that we didn't have interference between the room lights and the LED lights. And so we just took speckle contrast measurements using a silicon phantom. And so as you can see, the values don't change when you have different combinations of the room lights on, the LEDs on, or the room goes off, LEDs on, et cetera. So that suggests that we should be able to just use this when the lights are on.

So we also looked at motion artifact because LSI is looking at this sort of blurring pattern. And so if you're wiggling the device, there is going to be this motion artifact. And so we compared the dermatoscope when you're holding it in your hand to when it's mounted. So we see very similar values in the speckle contrast on that phantom once more. So we believe that you should be able to just use it in the handheld format.

We also tested this on a flow phantom. So we ran intralipid through this embedded tube in the tissue simulating phantom, and then we took speckle contrast measurements. So in the static region, which is this region right here which is just the tissue simulating phantom, you see a standard speckle contrast value. And then when you look at the dynamic region, which is embedded tube, you see this relationship that as flow increases, the speckle contrast decreases. That's just the devices accurately measuring in the dynamic range we would expect for capillaries.

Then we looked at in vivo validation of the device. And so we looked at cherry angiomas, which you'd expect to have increased blood flow, and then we also looked at solar lentigos, where we would expect no increase in blood flow. And so as you can see, we have the color image, and then we also have our SFI image, which suggests, yes, there is increased blood flow in the region. And then for the solar lentigo, we don't see increased blood flow in the region. So this blood flow ratio is actually a comparison of this inner region versus this outer region where we don't see the increased flow because these SFI maps are relative. And so we see this increased

blood flow ratio in the cherry angioma when compared to solar lentigos, which is what we would expect.

So we figured going forward with this that we could start taking measurements of other interesting legions. We've been trying to take images of patients that are going to receive biopsies, so we've been able to take images of four patients that received biopsies. So far, the histopathologies determined that all four patients, the lesions that were biopsied were non-cancerous. However, we do see some sort of interesting features. When we look at this seborrheic keratosis, in the region with the increased melanoma we do see this increase in absorption. We see less flow. However, in the surrounding region, we see this increase in blood flow, which is reasonable with the histopathology because it was inflamed. And so we think with these sort of images and with the combination of color images and the SFI maps, we may be able to determine these without histopathology.

So we've also started to look at scars since we have had a bunch of biopsied patients. We also looked at different patients that have had scars and are going to be receiving these pulsed dye laser treatments. So a pulsed dye laser will help remove scars by targeting and destroying blood vessels in the skin. And so we're hoping the LSI can help monitor these scars before and after treatment, and possibly guide this treatment.

This is a patient that received PDL treatment on their head. As you can see, this is actually the image from earlier. After treatment, you see this increased flow in the region. And so this blood vessel obviously wasn't destroyed, but maybe the heating from the laser is what causes a significant increase relative to the surrounding area. So we think LSI might be a good way to monitor this treatment.

So here we just have another scar that we looked at quite recently. We have a hypertrophic scar along the arm. This is actually a wide field LSI map. And so as you can see, there's increased perfusion in the region of the scar. And then you look at the-- this was taken with the LSI dermatoscope. And you can see in the region where the scar is located there is increased profusion relative to the surrounding region. So these two images just suggest that this technique does have information that it can offer. It's also nice and convenient having the color image when you compare it to the SFI image.

And so when overfeed when we go for future work, we would like to take more measurements from biopsy patients. Also, we'd like to apply some classification techniques to help us separate cancerous from non-cancerous lesions. The device is a little bit heavy now with the two cameras, and so we'd like to replace some of the Thorlabs components with 3D printed components. This

should reduce the weight of the device. Also, every time we save the data, we're also saving these time series with the images. So we're interested in looking at blood pulsatility in the lesions because using laser doppler they've been able to distinguish cancerous from non-cancerous lesions, and we're hoping that using LSI we can do this as well. And also, we'd like to swap the cameras for a smaller overall form factor.

In conclusion, the LSI dermatoscope does provide a quick and easy to use method for acquiring not only standard dermatoscopy images, but also these blood perfusion maps. Hopefully combining the data from the two can help with classification concerning pigmented lesions. And then also, of course, more measurements are required. This year we had a patient a keloid, and as you can see, there's increased perfusion in the region. And so we're thinking that maybe this technology can be applied to a bunch of different lesions of interest

And so just my acknowledgements. I'd like to thank all my lab members for helping me and letting me take measurements off of them. Also, Adrian and Anna-Marie for helping with my recent measurements at Gottschalk. So thank you for your time.

Citation:

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