Week 4 Progress

This week we cleared up the most important detail of the project: the ability to get enough data to train our neural network. In order to train a neural network to classify Rheumatoid Arthritis activity, we will need at least 1000, and possibly 3000 images. Obviously the more images we have the more accurate our application will be. But since the main commercial value of our classifier will come from its ability to beat patient self-diagnosis, there isn't much use gathering more patient self-assessment beyond what we need to show that a neural network can accurately classify Rheumatoid Arthritis activity.

Our overall plan at the moment is to use images labeled with patient self-assessments to show the viability of using a neural network to measure Rheumatoid Arthritis activity. This working prototype will hopefully be enough to get the venture funding required to collect images labeled by the more accurate methods of assessment: blood tests or DAS28 scores.

In the shorter term, we have a couple of tasks: first, we want to collect some sample images from friends and colleagues by giving them the same instructions that real patients with RA would get. We'll look at these images to get a better idea of the variability we'll get in our real data set. We'll also use it to refine our instructions. For example, if people we give the instructions to are consistently taking a picture of their hands at an incorrect angle, we may add an instruction about taking the picture at a specific angle. We'll then collect another dozen or so pictures with those new instructions to see if the new instruction fixes the problem. Only when we are satisfied with the sample pictures will we move on to the next phase of data collection: collecting real pictures that cost real money.

I still need to make a GitHub for the group. And we need to complete our Requirements document first draft by next week on Thursday. Brett (our project manager), said that he would send us their roadmap for the project by next week. So we will be incorporating that into our own roadmap. Another thing that I am very excited to start working on is the neural network architecture itself. When we get the data set, we are going to need a pipeline of image processing before we feed it to the neural network.

Another resource we have talked about, and one that I think would be very helpful, is consultation help from a graduate student doing research in deep learning, and consultation from someone in the healthcare field who specializes in Rheumatoid Arthritis. Ethan and I went to a Machine Learning Club meeting on Thursday of this week to try to meet some graduate students there who might be able to help us. Unfortunately, all attendees were undergraduates.

This will begin with resizing and cropping the images to get them to the correct dimensions. We'll then have to choose our hyperparameter values, such as learning rate, activation function, number of layers, dimension of layers, and many other characteristics. We may be able to automatically optimize some of these hyperparameters using an evolutionary method.

Week 5

Progress
Most of the progress we made this week was related directly to the Requirements Document. Ethan, Jared and I met once to draft the first part of the document, then Ethan and I met again to finish it.
During the meeting with all three of us, I outlined the various sections I thought needed to be in the document, then we divided up work. Ethan worked on the Neural Network Development section, Jared worked on the App Development part, and I worked on the app deployment section. All three of those sections were grouped under the heading “Road Map.”
During the next meeting, which was attended by Ethan and I, he worked on adding a few more things to the Neural Networks section, and on formatting what we had written into a LaTeX file. I worked on writing the section titled “Performance Metrics”, which covered four metrics of performance: accuracy of the neural network, ease of use of the final application, the apps utility for patients, and the business potential of the app.

Problems
We still haven’t made any progress on making the neural network. Personally, I feel as though I don’t have a very solid understanding of how to add multiple layers to my network. I’ve read about “convolution layers”, in which features seem to be encoded in a matrix, but I’ve also read that modern neural networks can extract features automatically, and with greater efficiency than any programmer. And adding layers to the neural network in the way I was doing it while playing around with the Tensor Flow tutorial is clearly not the correct way to go about it, because I got lower accuracy the more layers I added.

Plans
We need to finish our requirements document. This is important for three reasons: first, it is due and it counts for points. Second, we need time to do the technical review, which is due 2 days after the requirements doc. Third, Professor McGrath has told us that we don’t be able to access the graphics cards we will need to train until we finish the requirements doc.

We also need to start collecting the sample images to get a sense of image variance.

Week 6

Progress

This week focused mostly on the tech review. Ethan and I will be working on the Neural Network and Jared will be working on the mobile app. I would like to be involved in the creation of the mobile app. Making a progressive web app sounds fun and useful. It may also be helpful for Jared to have someone else who knows what he is doing.

In the tech review, I focused on the data collection portion of the assignment, with some additional discussion of the neural network. Ethan had a much more detailed discussion

of the neural network in his tech review, including use of automatic hyperparameter optimization, which is something I have been interested in for a while now.

We've also updated our roadmap to include the creation of a data collection app, which is our next step now that the tech review is done. We'll be using a progressive web app, since it will allow us to develop a platform-independent app, will reduce friction for people who click on the Facebook ads we use to collect data, and may be useful skill to put on our resumes once we make it into the workplace.

Problems

I am becoming increasingly worried that it will be impossible to achieve the basic functionality that we want from our neural network. I am just not sure that the immune system activity will show up in cell phone pictures. I hope I am wrong about this. It will be important for us to have some type of cutoff for data collection so that we don't waste any more money if we know that the classifier don't work. I will need to spend some more time thinking about how to do this. It's going to be so lame if we spend 3 terms on this project only to find out that it doesn't work.

Plans

Since I have very few assignments due over the course of this coming week, I am going to spend some time teaching myself how to make a progressive web app. I also want to do some coding in python to make a multi-layer neural network with convolutions, max pooling, and some of the other features I've read about.

Week 7

Progress

This week the main progress we made was related to our Tech Reviews, collecting sample images, and doing initial research on creating a progressive web app. Jared is going to be doing the bulk of the app development, though I will likely join him because I want to learn about progressive web apps. Ethan and I are going to be focusing on the neural network portion.

Problems

My javascript skills are rather lacking. I want to work on the progressive web app, but the initial learning barriers are going to be rather large. I also haven’t had very much

time to work on the project. Most of my time has been spent on writing assignments for this class and projects for other class.

Another issue we have to solve is figuring out how to set up the database that will accept our images we'll use to train the neural network. Whenever someone takes a picture with the app, the phone will need to send that picture to our database along with the accompanying survey so we can train the network with it. We're not sure how to do this. Christopher, our TA, recommended using Azure.

Plans

I plan on spending some more time on learning how to make a progressive web app this week. I also want to finish collecting the sample images to finalize the instructions we will be giving people who download the app and take pictures of their hands for us.

One useful classifier that might be useful to ship with the data collection app is a left-hand vs right hand classifier. Based on some blogs I read, I know that sometimes just a single hand can swell up during a flare, so if we use just a single hand to identify flares, we may end up with a lower accuracy.

Week 8

Progress

This week we collected a few sample images to validate our data collection survey. These images made it seem likely to us that we'll need some way to mask out the background in our images of hands before we feed them to the neural network. There's a lot of variation in the backgrounds. The more variation in our images, the more of them we'll need to collect to achieve high classification accuracy. The idea with masking out the backgrounds is that we reduce variations that are irrelevant to the task of Rheumatoid Arthritis measurement.

We also had a meeting with Arif and Brett this week about the progress of our app and some discoveries they've made regarding HIPPA compliance. On November 6th, 2018, the FDA released the FDA MyStudies App, which is sort of like a template app that is HIPPA compliant. It has various modules that can be configured to support general desired functionality, like taking pictures within the app and other common tasks. Given the difficulty of making a HIPPA compliant backend, we have decided to abandon our previous plan to make a progressive web app and we will now focus on creating a rebranded mod of MyStudies (this is explicitly allowed by the FDA).

Arif and Brett actually hired someone to help them understand how they can use MyStudies in a more general sense (not just for the Rheumatoid Arthritis App), so we may not start making our own mod until he gets back to us.

Problems

The biggest problem I see right now (apart from actually building our app), is the difference in views of Arif and I when it comes to how to build the Neural Network. In every meeting with Arif so far, he has brought up explicit measurements of hands such as the ratio of finger waist diameter to knuckle diameter, area of the hand, and others. His vision, as best I can tell, is to make a bunch of tools to explicitly measure these factors, then use those measurements as inputs to our model. My understanding of Neural Networks is that they do this type of feature extraction automatically, and can do so better than humans. Feature extraction involves convolution kernels and multiple hidden layers weighting the output of those convolutions.

But I have not pushed back on Arif's ideas very hard in meetings yet for one simple reason: I don't actually know enough of the details about neural networks to make my case. And I may be wrong. I want to be able to answer very specific questions about how the feature extraction process works, how the performance of automatic feature extraction compares to the performance of manual feature selection, and be able to explain what kind of steps we can take to retire risk before incurring the costs of data collection.

By this I mean that he (and Brett) want to make sure that we don't overlook any obvious, knowable causes of failure before we begin collecting data.

Plans

Jared is going to start looking into the FDA MyStudies app and trying to figure out how we can integrate our neural network with their framework. Ethan and I are going to start researching OpenCV hand masking techniques to try to do image preprocessing to eliminate the background from each image, and trying to determine whether we should take that approach or try a segmentation network.

We also have to finish the design document. The plan is to make an overleaf document and paste everyone's parts in there, then do some editing (assuming that we are allowed to just copy stuff from our Tech Document, which I'm guessing Kevin will object to). If that's not allowed then I guess we'll just rewrite what we've already written and then add to that with some of the new things we've learned (like MyStudies and an OpenCV approach to hand masking).

Week 9

Progress

This week I watched a number of lectures from the MIT Intro to Deep Learning lecture series, did some work on the Design Document, and ate a large amount of turkey. Apart from that I didn't really do much.

Problems

We need to do some data cleaning on the images we collect before feeding them into the neural network. The problem is, we don't really know what that means in the context of our particular data set.

Another issue relates to manual vs automatic feature extraction. Arif (one of our project managers), seems to think that we need to perform manual feature extraction on the images of hands we collect and feed those extracted features to some kind of model. My understanding is that this is an outdated technique that results in worse performance than the automatic feature extraction that convolutional layers in neural networks perform. But I feel as though I don't really understand CNNs well enough to persuasively make this argument to Arif.

Lastly, we could really use someone with expertise in the disease to consult with. I feel as though our poor understanding of rheumatoid arthritis represents the biggest risk to the success of this project. It may be that our hypothesis that it is possible to measure RA disease activity from an image is completely wrong, and that someone with expertise in the disease would be able to tell us this.

Plans

I plan to contact a graduate student who has experience in deep learning and hopefully schedule a meeting in which we can ask them questions about deep learning that we haven't been able to find answers to online.

I am also going to think about how we can contact someone with disease expertise that might be able to help us get a better idea of which data streams would have high diagnostic potential.