

BME 590 – Medical Software Design
Instructors: Dr. Mark Palmeri, Mr. Suyash Kumar

Melanoma Classification Project
Final Report
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Final project requirement:

https://github.com/mlp6/Medical-Software-Design/blob/master/Assignments/final_project_fall_17/final_project_f17.pdf

Final RFC Document:

<https://docs.google.com/document/d/10zwrlYD09Ox9loRAPnOqVUvyigVB17V5fiFTYvP5Vgl/edit?usp=sharing>

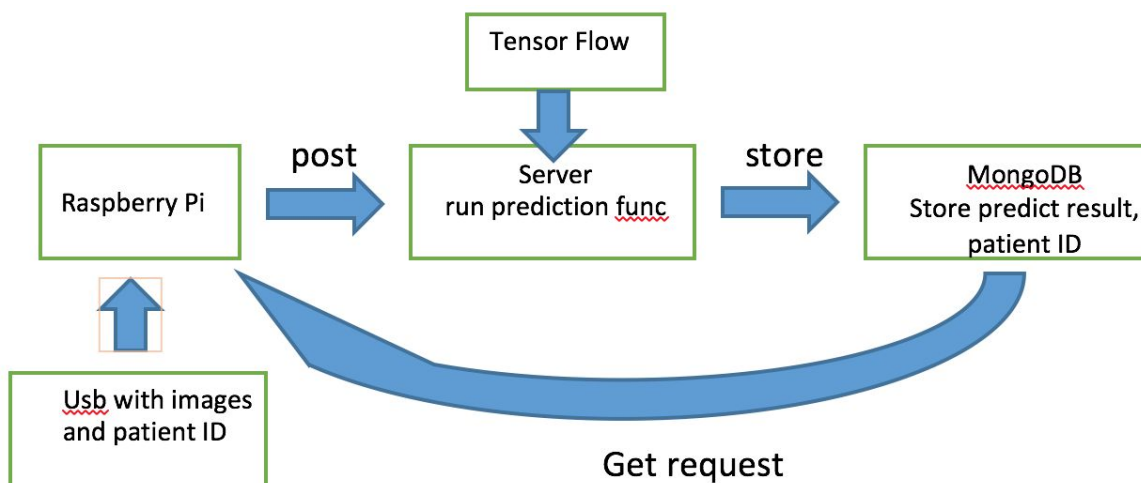
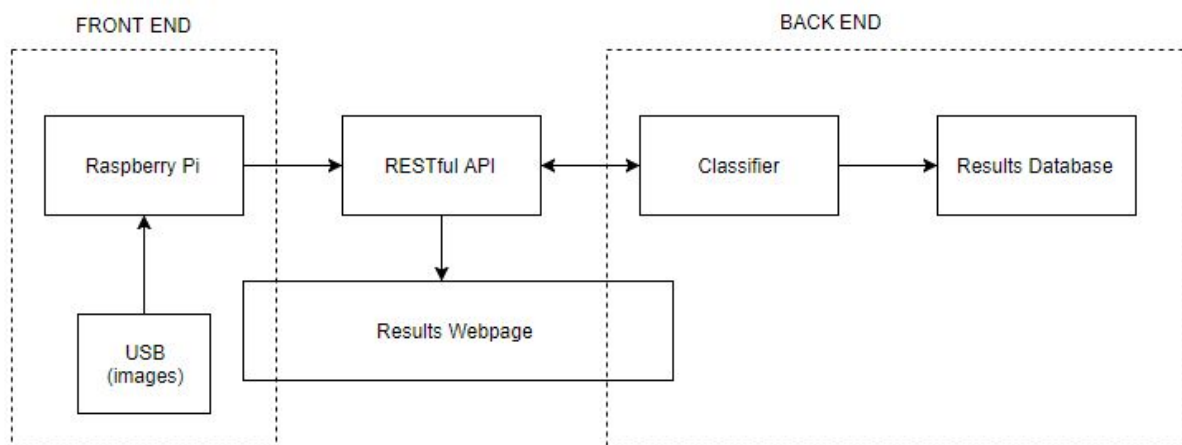
Introduction

Melanoma is one of the most dangerous forms of skin cancer in which triggered mutations cause skin cells to multiply rapidly and form malignant tumors. Annually, Melanoma kills an estimated 10,130 people in the US alone. However, if Melanoma is diagnosed and treated early, it is almost curable, with a 98% 5-year survival rate when treated with simple excision.

The Melanoma classification project consists of a system computes the likelihood that a lesion is malignant by analyzing skin images, in order to facilitate early diagnosis of melanoma. A Raspberry Pi accesses images stored on a USB and sends them to a cloud-base web service that hosts a trained classifier. The results of the classification can then be accessed by visiting a web page.

Specification and Consideration

Final Design



1. Front-end

At the front end, we have a Raspberry Pi that access images hosted on a USB drive. The detected images are encoded as unique base64 strings. Each encoded image is then posted to the web server as key-value pairs of a dictionary at the URL : https://vcm-2217.vm.duke.edu:5000/patient_classification. Currently, the Pi will only post to the web service it detects images on the USB.

2. Web Service

RESTful Flask API is used to connect the front and back ends together. There are two main functions in the Flask web service, the POST and GET methods. For the POST method, it receives the dictionary from raspberry pi and decodes base64 strings back to image in .jpg format. The image then becomes the input of the melanoma classification function and gives a prediction result as the output. The image ID (patient ID) and the prediction results will store in a MongoDB database. For the GET method, the user specified the patient ID and it will extract the corresponding prediction value from MongoDB database and return it to the web browser (specified web URL).

3. Backend

The MongoDB side of things is a work in progress. There have unfortunately been too many bugs and issues with the actual processing, which didn't afford Inje the full time to delve into the Mongo side of the repo. As of 12/14/17, the problem is a runtime error with the .save() mongo function, which doesn't allow for saving the structured dictionary into the created mongo database on our VM.

Performance

We can post a base64 image string to our VM and have it return predictions, should the input be in the correct format and not empty.

1)

The image shows a terminal window on the left and a Postman client on the right. The terminal window displays the output of a Flask application running on a Raspberry Pi. It shows the receipt of a POST request to the endpoint `/patient_classification` and the successful execution of the `find_melanoma` function, which returns a prediction result. The Postman client on the right shows the details of the POST request, including the URL `http://0.0.0.0:8000/patient_classification` and the JSON body. The response body is also shown, indicating a successful prediction for "Patient_590" with a "malignant" prediction and a probability of 0.6542973518371582.

```
server_1 | File "/usr/local/lib/python2.7/dist-packages/flask/app.py"
server_1 | in full_dispatch_request
server_1 | rv = self.dispatch_request()
server_1 | File "/usr/local/lib/python2.7/dist-packages/flask/app.py"
server_1 | in dispatch_request
server_1 | return self.view_functions[rule.endpoint](**req.view_args)
server_1 | File "notebooks/main.py", line 49, in patient_prediction
server_1 | from find_melanoma import Melanoma
server_1 | File "notebooks/find_melanoma.py", line 5, in <module>
server_1 | import matplotlib.pyplot as plt
server_1 | File "/usr/local/lib/python2.7/dist-packages/matplotlib/p
server_1 | ne 69, in <module>
server_1 | from matplotlib.backends import pylab_setup
server_1 | File "/usr/local/lib/python2.7/dist-packages/matplotlib/t
server_1 | t_.py", line 14, in <module>
server_1 | line for line in traceback.format_stack()
server_1 |
server_1 | matplotlib.use('Agg')
server_1 | 2017-12-14 16:49:36.048314: I tensorflow/core/platform/cpu
server_1 | .cc:137] Your CPU supports instructions that this TensorFlow binary was
server_1 | to use: SSE4.1 SSE4.2 AVX AVX2 FMA
server_1 | 2017-12-14 16:49:37.163172: W tensorflow/core/framework/op
server_1 | 34] Op BatchNormWithGlobalNormalization is deprecated. It will cease to
server_1 | Def version 9. Use tf.nn.batch_normalization().
server_1 | 172.19.0.1 - - [14/Dec/2017 16:49:37] "POST /patient_classi
server_1 | /1.1" 200 -
```

Postman

http://0.0.0.0:8000/pa http://vcm-2117.vm.d

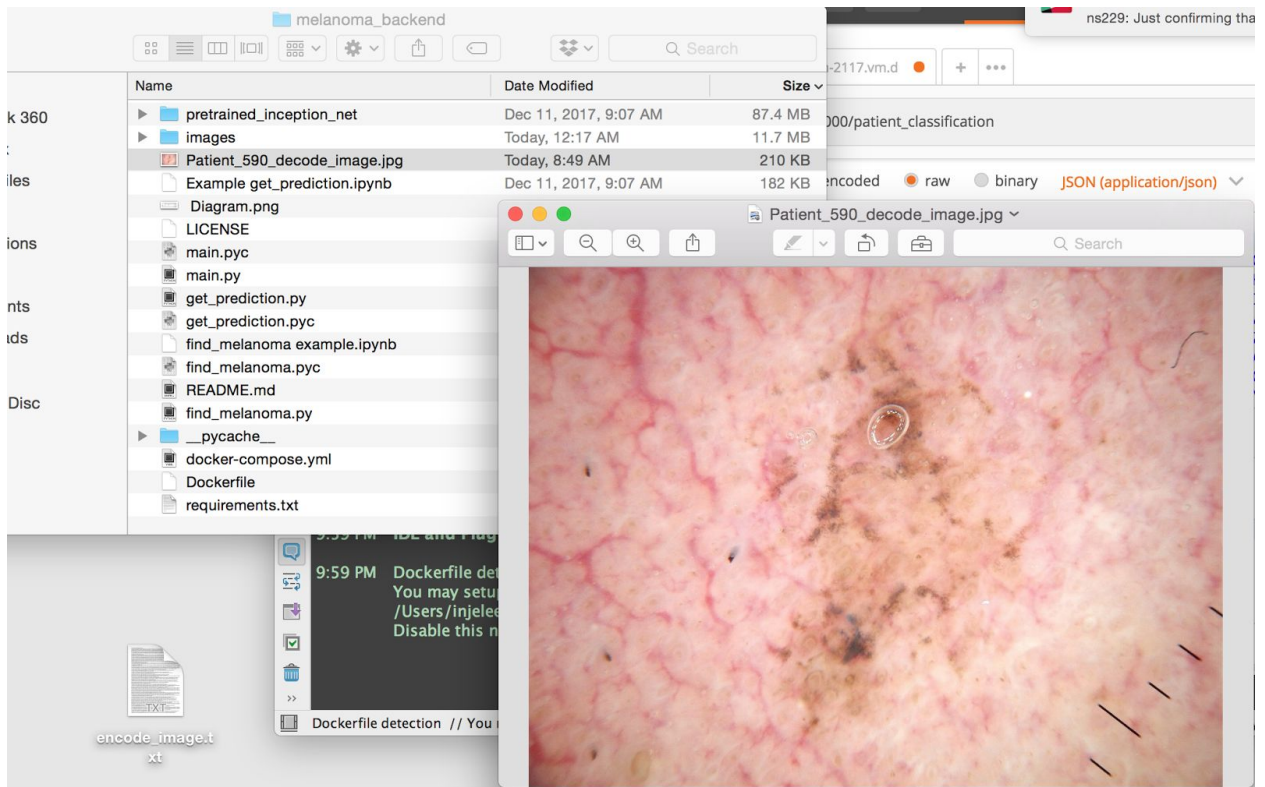
POST http://0.0.0.0:8000/patient_classification

form-data x-www-form-urlencoded raw binary JSON (application/json)

```
1 {
2   "Patient_590": "/9j/4AAQSkZJRgABAQAAQABAAQ
3   /ZwBDAATBAQEBAQIBAQEACAgICAgQDAGICAgUEBAMEBgUGBgYFBgYGBwkIBgcJBWYGCAsICQoKCgoKBggl.DAsKI
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8   LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
9   /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
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107 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
108 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
109 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
110 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
111 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
112 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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115 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
116 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
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132 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
133 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
134 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
135 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
136 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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141 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
142 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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144 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
145 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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147 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
148 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
149 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
150 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
151 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
152 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
153 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
154 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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157 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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159 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
160 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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162 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
163 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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165 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
166 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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168 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
169 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
170 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
171 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
172 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
173 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
174 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
175 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
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177 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R
178 FkRkdiISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXQdIWhGh4iJipKTLLJWML1SiZmKjpKWWp6iparKztLW2t
179 LT1NXW19jZ2uHi4+T1SufoGerx8yP89fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAEAWQFBgcICQoL
180 /8QAtREAAgECBAQDBCFBAQAQJ3AAECAXEEBSEBxhBUQdhcRM1MoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8R

```

2) Successful image file save:



3) Full Stack Integration - Jing plugs in the Raspberry Pi at Duke, Niranjana posts up the encoded string from India, and Inje sees the response on his VM at Duke in California.

```
iel2@vcm-2117: ~/melanoma_backend — ssh — 85x28
bash
iel2@vcm-2117: ~/melanoma_backend
server_1 | File "/usr/local/lib/python2.7/dist-packages/flask/app.py", line 1982,
in wsgi_app
server_1 |     response = self.full_dispatch_request()
server_1 | File "/usr/local/lib/python2.7/dist-packages/flask/app.py", line 1612,
in full_dispatch_request
server_1 |     rv = self.dispatch_request()
server_1 | File "/usr/local/lib/python2.7/dist-packages/flask/app.py", line 1598,
in dispatch_request
server_1 |     return self.view_functions[rule.endpoint](**req.view_args)
server_1 | File "/notebooks/main.py", line 49, in patient_prediction
server_1 |     from find_melanoma import Melanoma
server_1 | File "/notebooks/find_melanoma.py", line 5, in <module>
server_1 |     import matplotlib.pyplot as plt
server_1 | File "/usr/local/lib/python2.7/dist-packages/matplotlib/pyplot.py", li
ne 69, in <module>
server_1 |     from matplotlib.backends import pylab_setup
server_1 | File "/usr/local/lib/python2.7/dist-packages/matplotlib/backends/_ini
t_.py", line 14, in <module>
server_1 |     line for line in traceback.format_stack()
server_1 |
server_1 |     matplotlib.use('Agg')
server_1 | 2017-12-14 16:54:00.205273: W tensorflow/core/framework/op_def_util.cc:3
34] Op BatchNormWithGlobalNormalization is deprecated. It will cease to work in Graph
Def version 9. Use tf.nn.batch_normalization().
server_1 | 10.194.138.121 - - [14/Dec/2017 16:54:00] "POST /patient_classification
HTTP/1.1" 200 -
```

a)

b) Note the RPI IP address accessing the VM

```
iel2@vcm-2117: ~/melanoma_backend$ ls
Diagram.png          find_melanoma.pyc    main.pyc
docker-compose.yml   get_prediction.py     melback
dockerfile            get_prediction.pyc   pretrained_inception_net
Dockerfile           image3_decode_image.jpg  __pycache__
Example_get_prediction.ipynb LICENSE               README.md
find_melanoma_example.ipynb main.py              requirements.txt
find_melanoma.py      Untitled.ipynb
```

c)

i) File saved as image3_decode_image.jpg on VM

Design Iteration

If there is no image at the front end, we return a response with error message from the POST and store it in the Raspberry Pi. However, the user needs to get access to the Raspberry Pi to be aware of that. Since there is a LED on the Raspberry Pi, we are thinking to report the status of the image with the light. If there is input image to the Raspberry Pi, the light is off (the state of the LED is LOW). If there is no image to the Raspberry Pi, the light is on (the state of the LED is HIGH). Currently, the melanoma classification function has only taken images as one feature to train. It does not consider other unique and relevant features such as statistical measures (mean, standard deviation and covariance) of the RGB color space and shape information (area, diameter, compactness and asymmetry). This data will be used in future classification training for the already existing classification model by utilizing either an averaging or logistic regression modification method with more features considered.

Citation

Suyashi BME590 Melanoma Detection: https://github.com/suyashkumar/bme590_melanoma_detection