ПОЛИТЕХ
Санкт-Петербургский политехнический университет Петра Великого

Институт компьютерный наука и технологии (ИКНТ)

COMPUTO ERGO SUM

РЕШЕНИЕ ПРИКЛАДНЫХ ЗАДАЧ МЕТОДАМИ МАШИННОГО ОБУЧЕНИЯ

SCHEMA OF PROJECT

INTELLIGENT SYSTEM BASED ON ENSEMBLES OF TRANSFORMER VISION ARCHITECTURES FOR SKIN CANCER CLASSIFICATION

Студенты:
Эспинола Ривера, Хольгер Элиас
Ван Сиюй

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Руководитель:
Заборовский Владимир Сергеевич

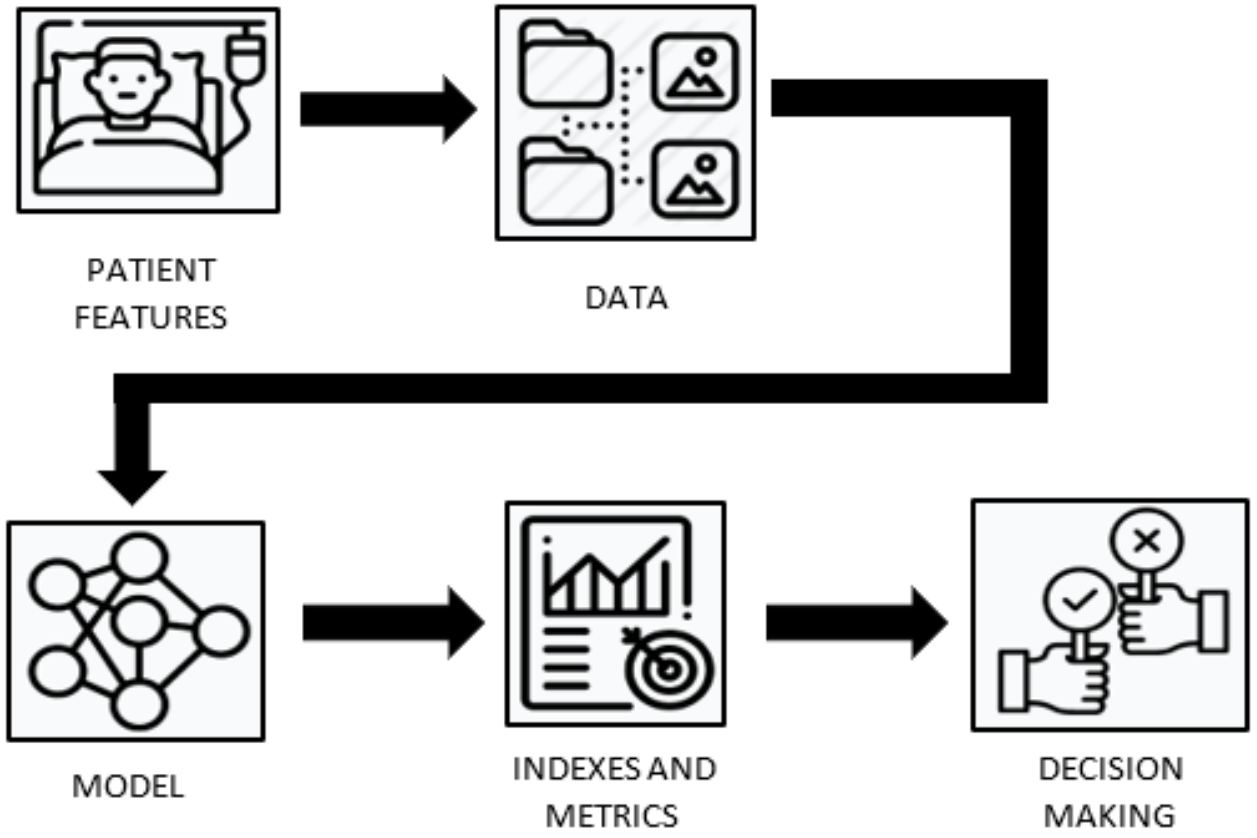
Contents

- Problem Statement
- Database
- Models and Experiments
- Results and Discussion

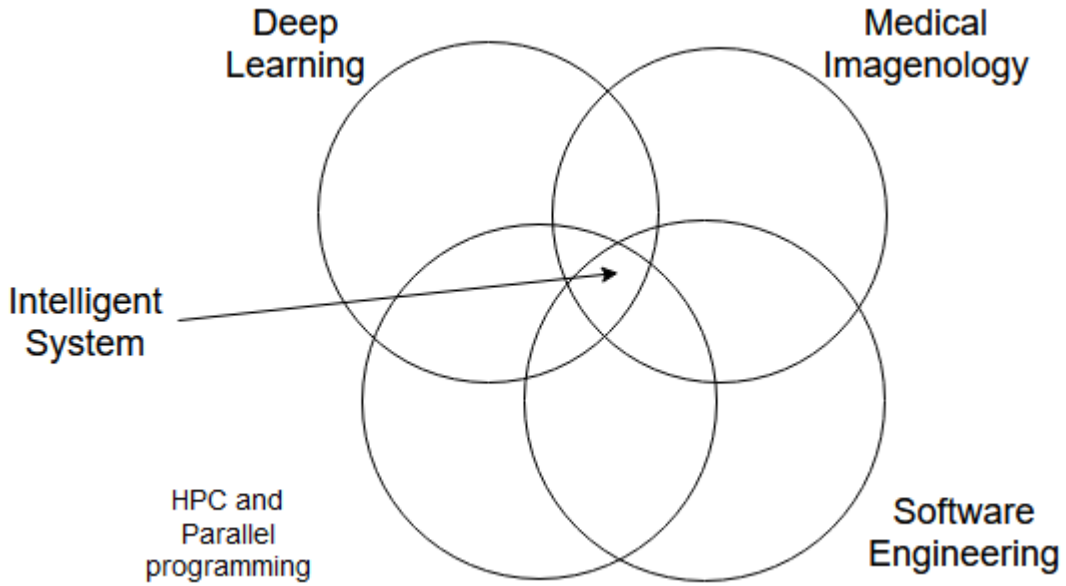
Problem Statement

RESEARCH IDEA

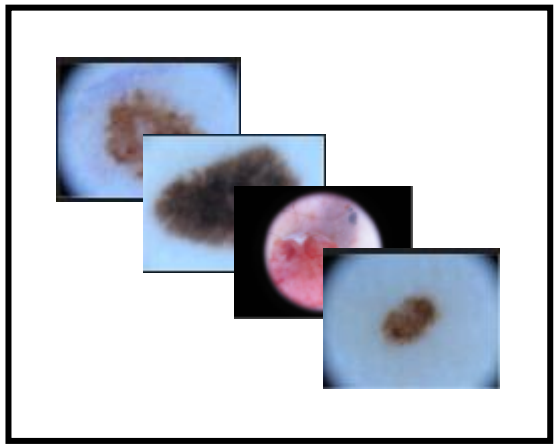
Decision-making flow for medical diagnosis and treatment in a data-driven approach



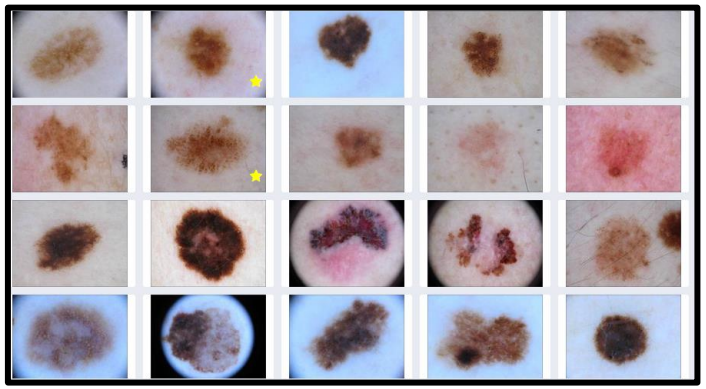
Multidisciplinary approach to research



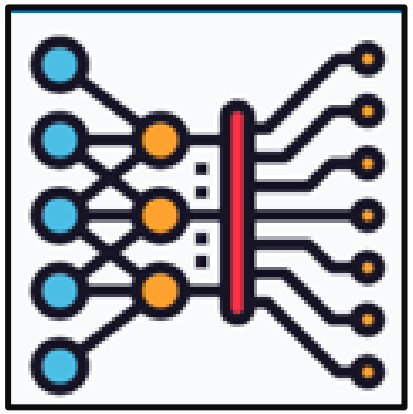
Methodology



ISIC Archive 2023 Dataset



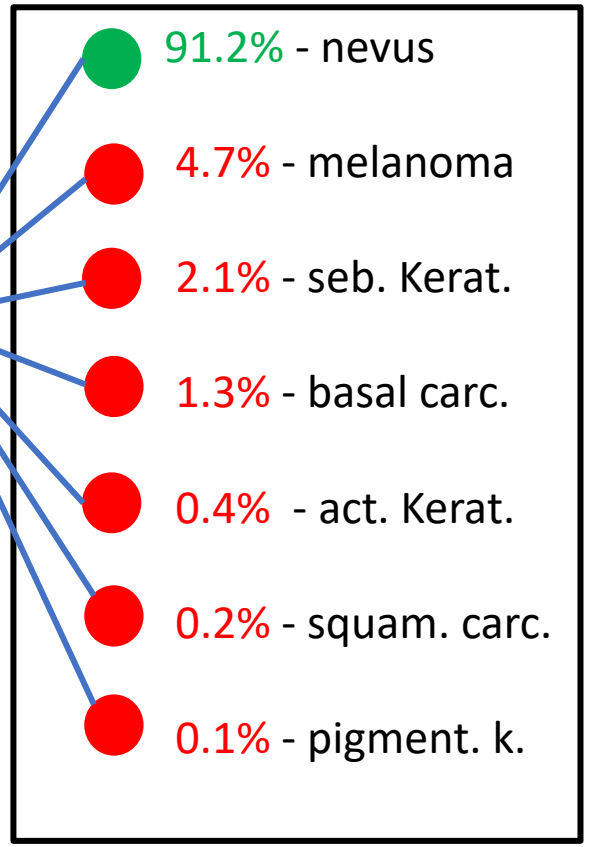
Preprocessing



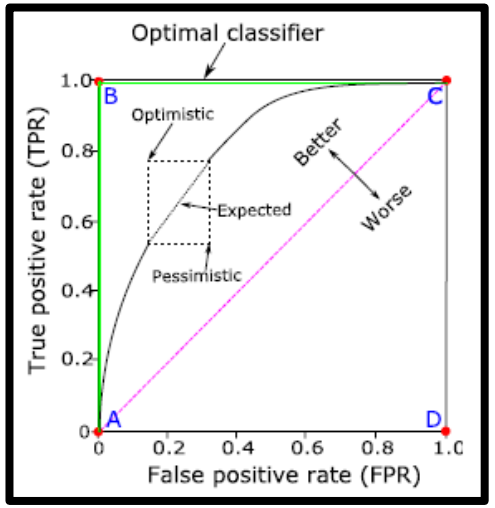
Build model

Methodology

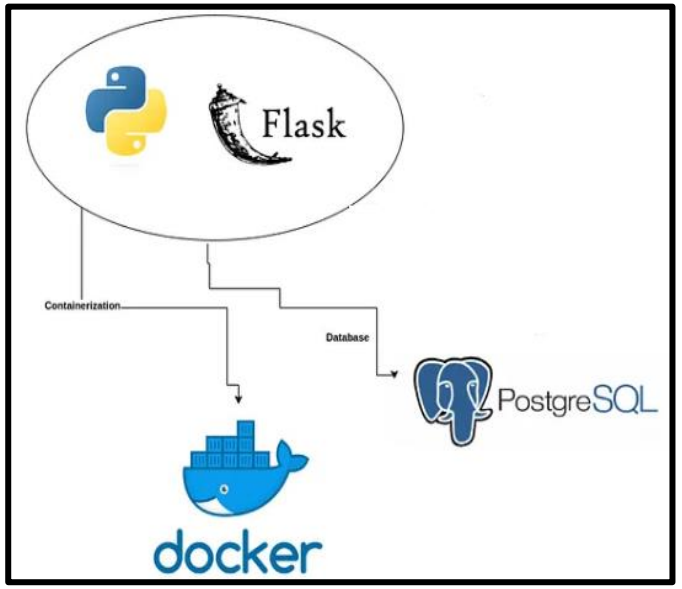
Train/Test



Predict

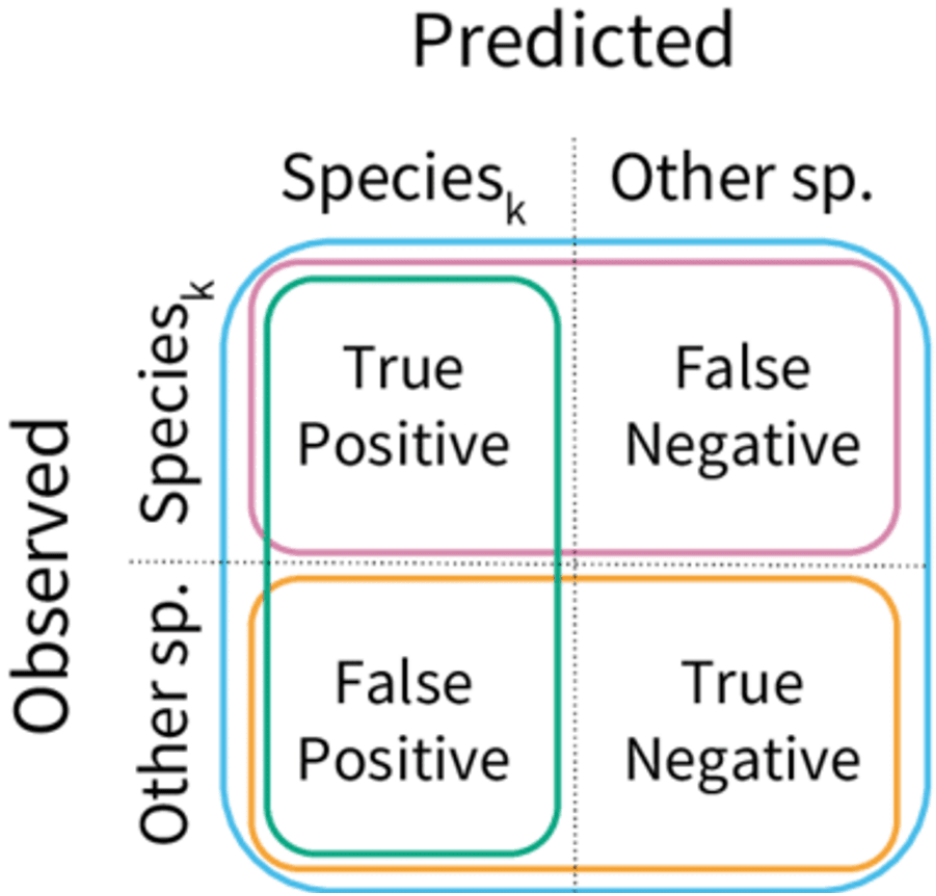


Monitory results



System Implementation

METRICS FOR DATA MONITORING



$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

$$\text{Specificity} = \frac{TN}{TN + FP}$$

$$\text{Precision} = \frac{TP}{TP + FP}$$

$$\text{Recall} = \frac{TP}{TP + FN}$$

Database

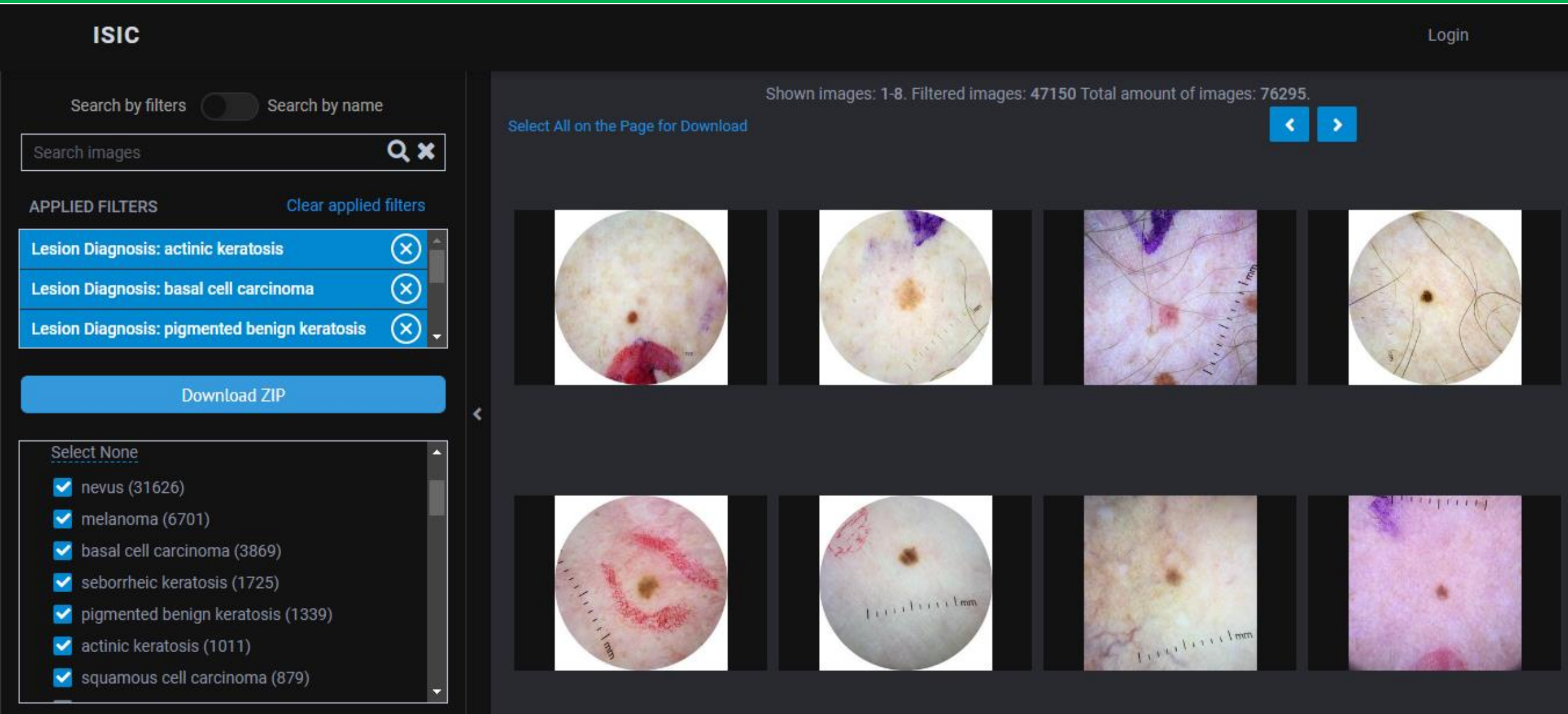
Database description

- Public dataset: International Skin Imaging Collaboration (ISIC Archive)
- Content:

47, 150 files of biopsies and dermoscopic images with 1 csv file of annotations

- Volume: ~ 10.3 GB
- Source of data:
- https://gallery.isic-archive.com/#!/topWithHeader/onlyHeaderTop/gallery?filter=%5B%5D

Database - images



Database – tabular metadata

```
[28]: df.columns

[28]: Index(['isic_id', 'attribution', 'copyright_license', 'acquisition_day',
             'age_approx', 'anatom_site_general', 'benign_malignant',
             'clin_size_long_diam_mm', 'dermoscopic_type', 'diagnosis',
             'diagnosis_confirm_type', 'family_hx_mm', 'image_type', 'lesion_id',
             'mel_class', 'mel_mitotic_index', 'mel_thick_mm', 'mel_type',
             'mel_ulcer', 'melanocytic', 'nevus_type', 'patient_id',
             'personal_hx_mm', 'sex'],
            dtype='object')
```

Database – tabular data

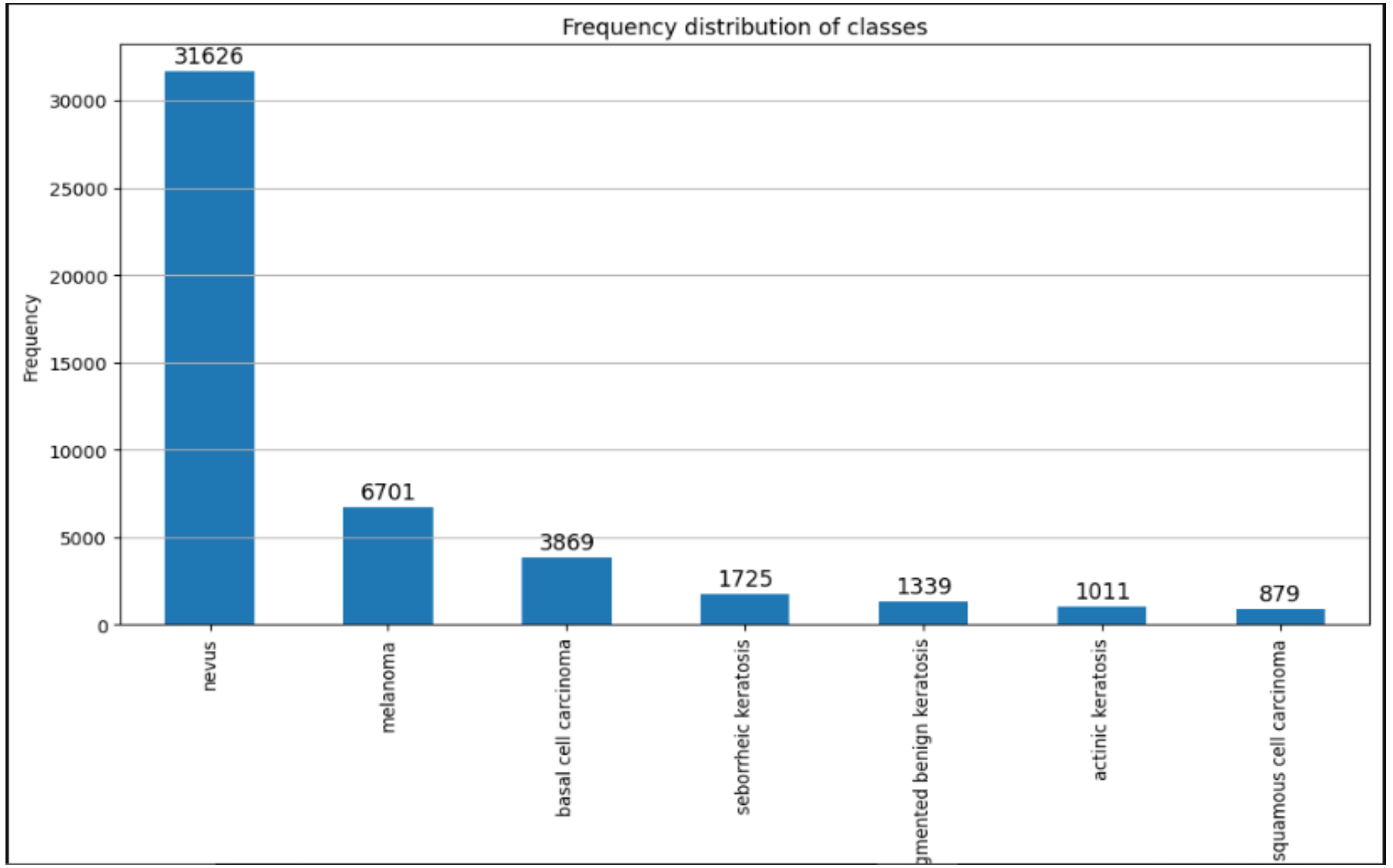
isic_id	attribution	copyright_license	acquisition_day	age_approx	anatom_site_general	benign_malignant	clin_size_long_diam_mm	dermoscopic_type	diagnosis	...
ISIC_9990676	ViDIR Group, Department of Dermatology, Medica...	CC-BY-NC	NaN	55.0	lower extremity	benign	NaN	contact polarized	nevus	...
ISIC_9991967	ViDIR Group, Department of Dermatology, Medica...	CC-BY-NC	366.0	70.0	lower extremity	benign	NaN	contact polarized	nevus	...
ISIC_9995691	ViDIR Group, Department of Dermatology, Medica...	CC-BY-NC	NaN	50.0	upper extremity	benign	NaN	contact polarized	nevus	...
ISIC_9997367	Hospital Italiano de Buenos Aires	CC-BY	NaN	70.0	head/neck	benign	NaN	NaN	actinic keratosis	...
ISIC_9997614	Memorial Sloan Kettering Cancer Center	CC-BY-NC	407.0	50.0	upper extremity	benign	NaN	NaN	nevus	...
ISIC_9998679	Hospital Italiano de Buenos Aires	CC-BY	NaN	65.0	head/neck	malignant	NaN	contact polarized	basal cell carcinoma	...

Database – distribution of classes

Classes:

1) Nevus
2) Melanoma
3) Seborrheic keratosis
4) Basal cell carcinoma
5) Pigmented benign keratosis
6) Actinic keratosis
7) Squamous cell carcinoma

IMBALANCED DATA!



Models and Experiments

VISION TRANSFORMER ARCHITECTURE

IMAGE

DATA ARGUMENTATION

RESTRUCTURING BLOCK

PATCHES

LINEAR EMBEDDING

POSITIONAL EMBEDDING

CLASSIFICATION BLOCK

OUTPUT

BATCH NORMALIZATION

RELU

BATCH NORMALIZATION

LINEAR

TRANSFORMER BLOCK

MLP

LAYER NORMALIZATION

MULTIHEAD SELF-ATTENTION

LAYER NORMALIZATION

VISION TRANSFORMER ARCHITECTURE

```
(module): ViTModel(
  (vit): ViTForImageClassification(
    (vit): ViTModel(
      (embeddings): ViTEmbeddings(
        (patch_embeddings): ViTPatchEmbeddings(
          (projection): Conv2d(3, 1024, kernel_size=(32, 32), stride=(32, 32))
        )
        (dropout): Dropout(p=0.0, inplace=False)
      )
      (encoder): ViTEncoder(
        (layer): ModuleList(
          (0-23): 24 x ViTLayer(
            (attention): ViTAttention(
              (attention): ViTSelfAttention(
                (query): Linear(in_features=1024, out_features=1024, bias=True)
                (key): Linear(in_features=1024, out_features=1024, bias=True)
                (value): Linear(in_features=1024, out_features=1024, bias=True)
                (dropout): Dropout(p=0.0, inplace=False)
              )
              (output): ViTSelfOutput(
                (dense): Linear(in_features=1024, out_features=1024, bias=True)
                (dropout): Dropout(p=0.0, inplace=False)
              )
            )
            (intermediate): ViTIntermediate(
              (dense): Linear(in_features=1024, out_features=4096, bias=True)
              (intermediate_act_fn): GELUActivation()
            )
            (output): ViTOutput(
              (dense): Linear(in_features=4096, out_features=1024, bias=True)
              (dropout): Dropout(p=0.0, inplace=False)
            )
            (layernorm_before): LayerNorm((1024,), eps=1e-12, elementwise_affine=True)
            (layernorm_after): LayerNorm((1024,), eps=1e-12, elementwise_affine=True)
          )
```

VISION TRANSFORMER ARCHITECTURE

```
                (output): ViTOutput(
                  (dense): Linear(in_features=4096, out_features=1024, bias=True)
                  (dropout): Dropout(p=0.0, inplace=False)
                )
                (layernorm_before): LayerNorm((1024,), eps=1e-12, elementwise_affine=True)
                (layernorm_after): LayerNorm((1024,), eps=1e-12, elementwise_affine=True)
              )
            )
          )
          (layernorm): LayerNorm((1024,), eps=1e-12, elementwise_affine=True)
        )
        (classifier): CustomClassifier(
          (fc1): Linear(in_features=1024, out_features=512, bias=True)
          (bn1): BatchNorm1d(512, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
          (relu): ReLU()
          (fc2): Linear(in_features=512, out_features=256, bias=True)
          (bn2): BatchNorm1d(256, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
          (fc3): Linear(in_features=256, out_features=64, bias=True)
          (bn3): BatchNorm1d(64, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
          (out): Linear(in_features=64, out_features=7, bias=True)
        )
      )
    )
  )
```

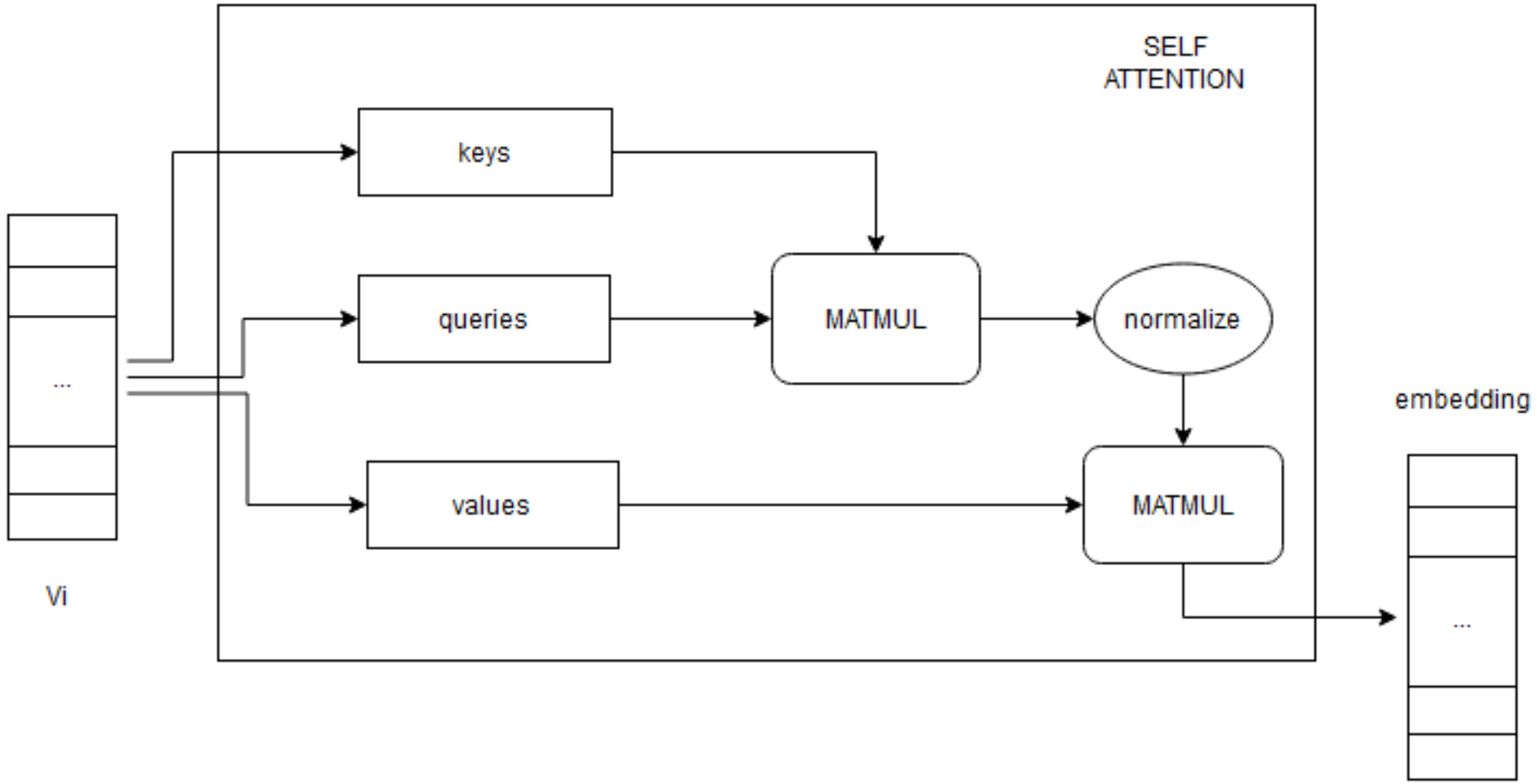
[151]:
```
# number of parameters in entire VIT structure
print("Model", list_models['vit-L/32'], "have", round(model.module.total_parameters()/10**6, 2), "M parameters")
```

```
Model google/vit-large-patch32-384 have 306.28 M parameters
```

[153]:
```
# number of parameters in classifier structure
print("Model", list_models['vit-L/32'], "have", round(model.module.vit.classifier.total_parameters()/10**6, 2), "M parameters")
```

```
Model google/vit-large-patch32-384 have 0.67 M parameters
```

MULTIHEAD SELF-ATTENTION MECHANISM



Benchmark purpose

Variants

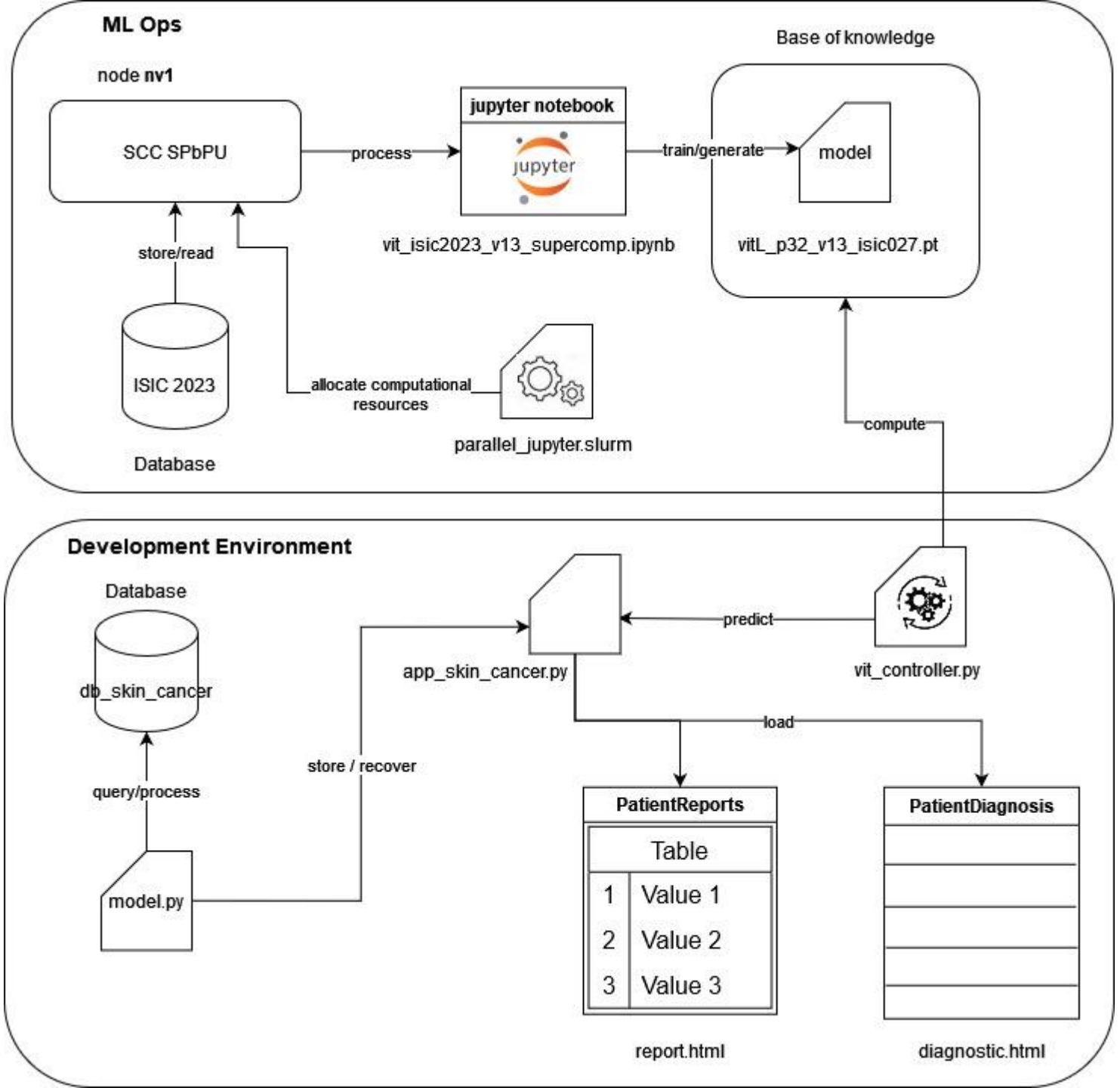
Datasets	Feature Extractor Architectures	Classifiers
ISIC Archive 2023 (binary and multiclass)	VIT-L/32-384-1k	DNN-3hidden
HAM-10 000	VIT-H/14-224-21k	

Ensemble methods	Metrics
VIT-L/32-384-1k + DNN-3h	Train loss
VIT-H/14-224-21k + DNN-3h	Train accuracy
	Validation loss
	Validation accuracy
	Precision
	Recall
	Sensibility
	F1-score / AUC

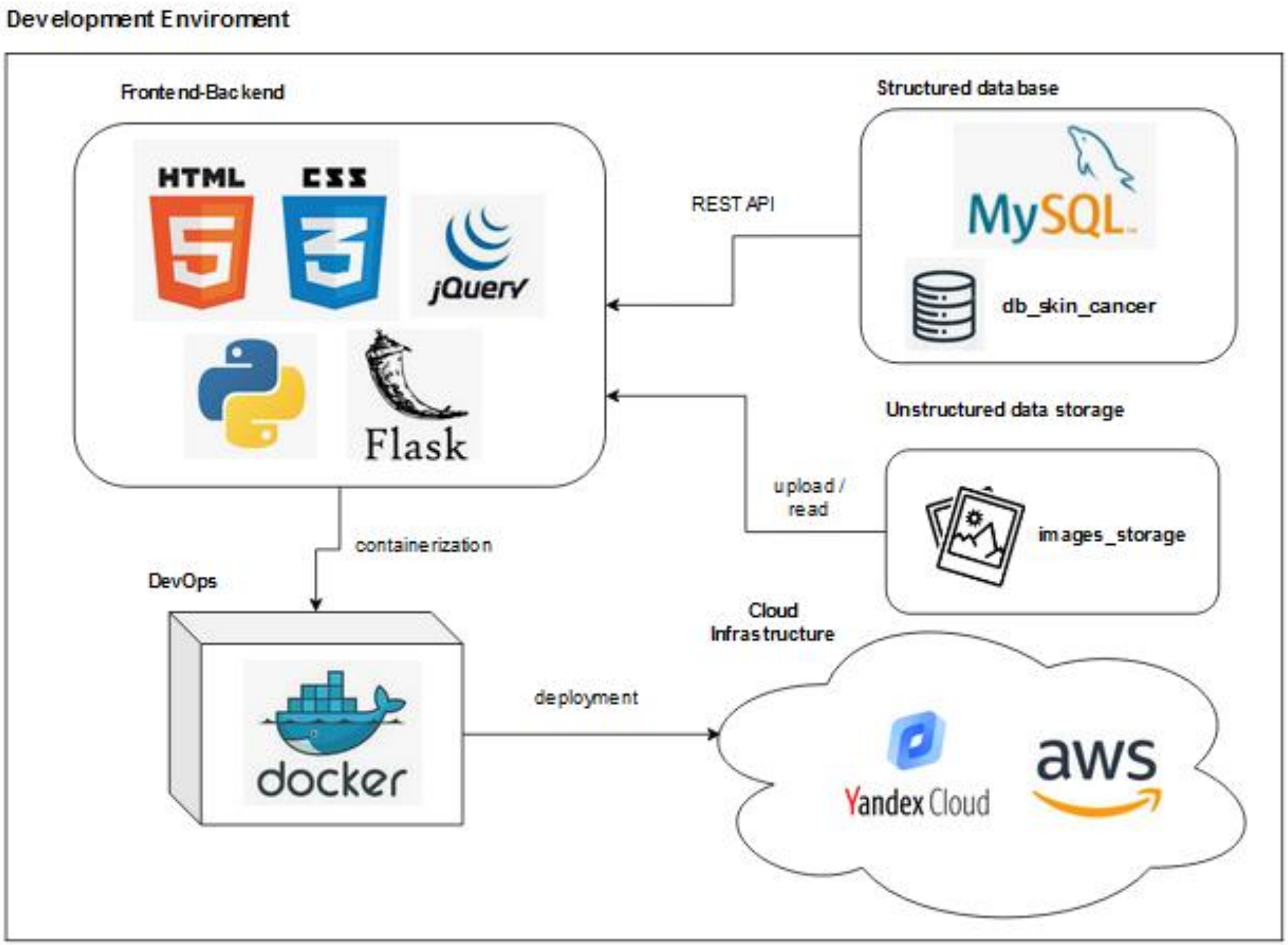
HPC Infrastructure:
Parallel processing with
CUDA +
1 node with 8 GPU
Tesla A-100
15.2 TFlops

IMPLEMENTATION OF INTELLIGENT SYSTEM

Software architecture:
MVT for Python + Flask



DEVELOPMENT ENVIROMENT



PROTOTYPE OF DIAGNOSTIC INTERFACE

VIT-SkinCancer App

Search

HOME

DIAGNOSTIC

REPORT

Skin Cancer Pacients Analysis

ID of pacient

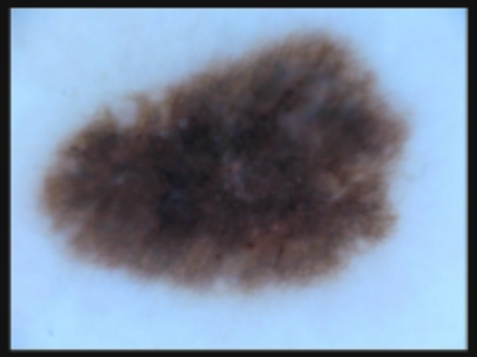
Age

Anatomy

Dermoscopy type

Male

SAVE



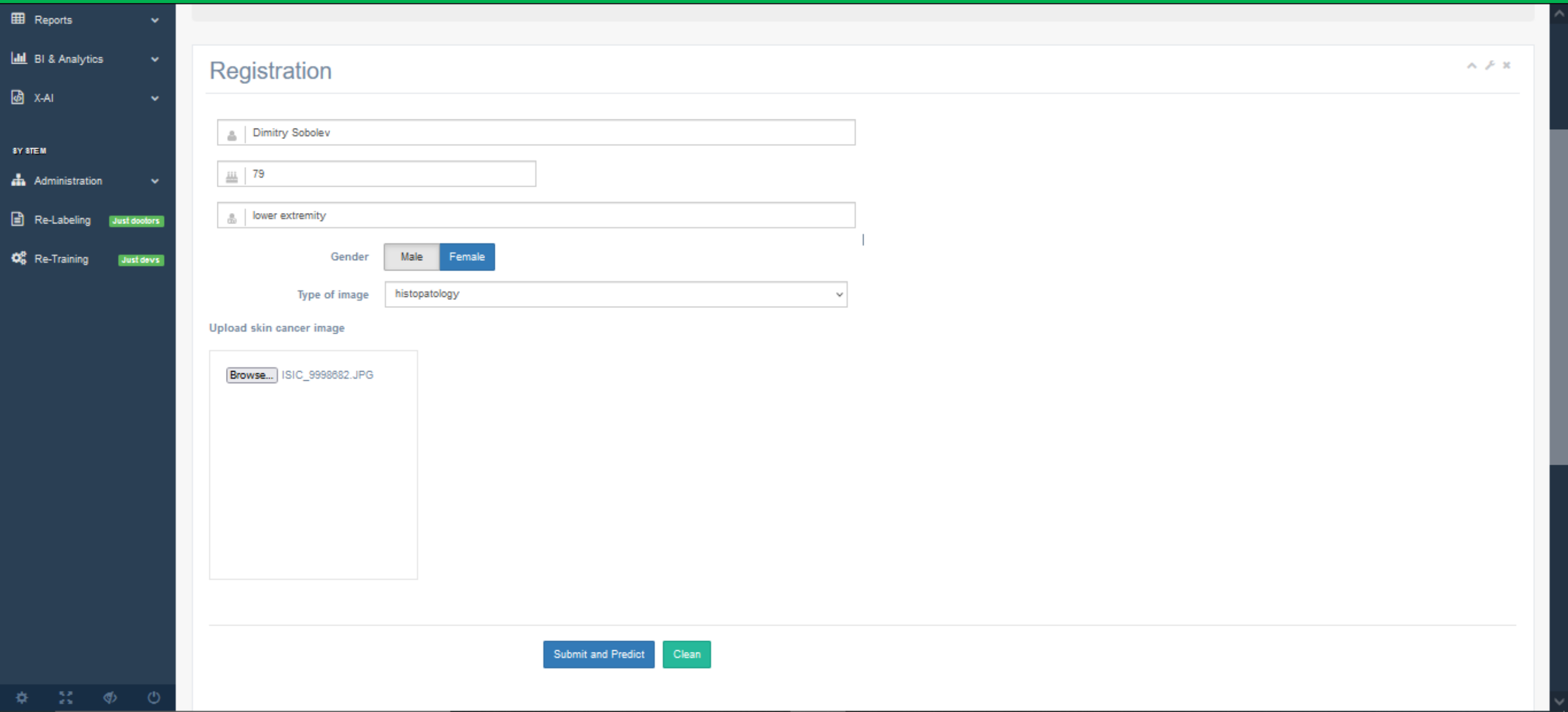
Upload new image

Type of cancer: Nevus

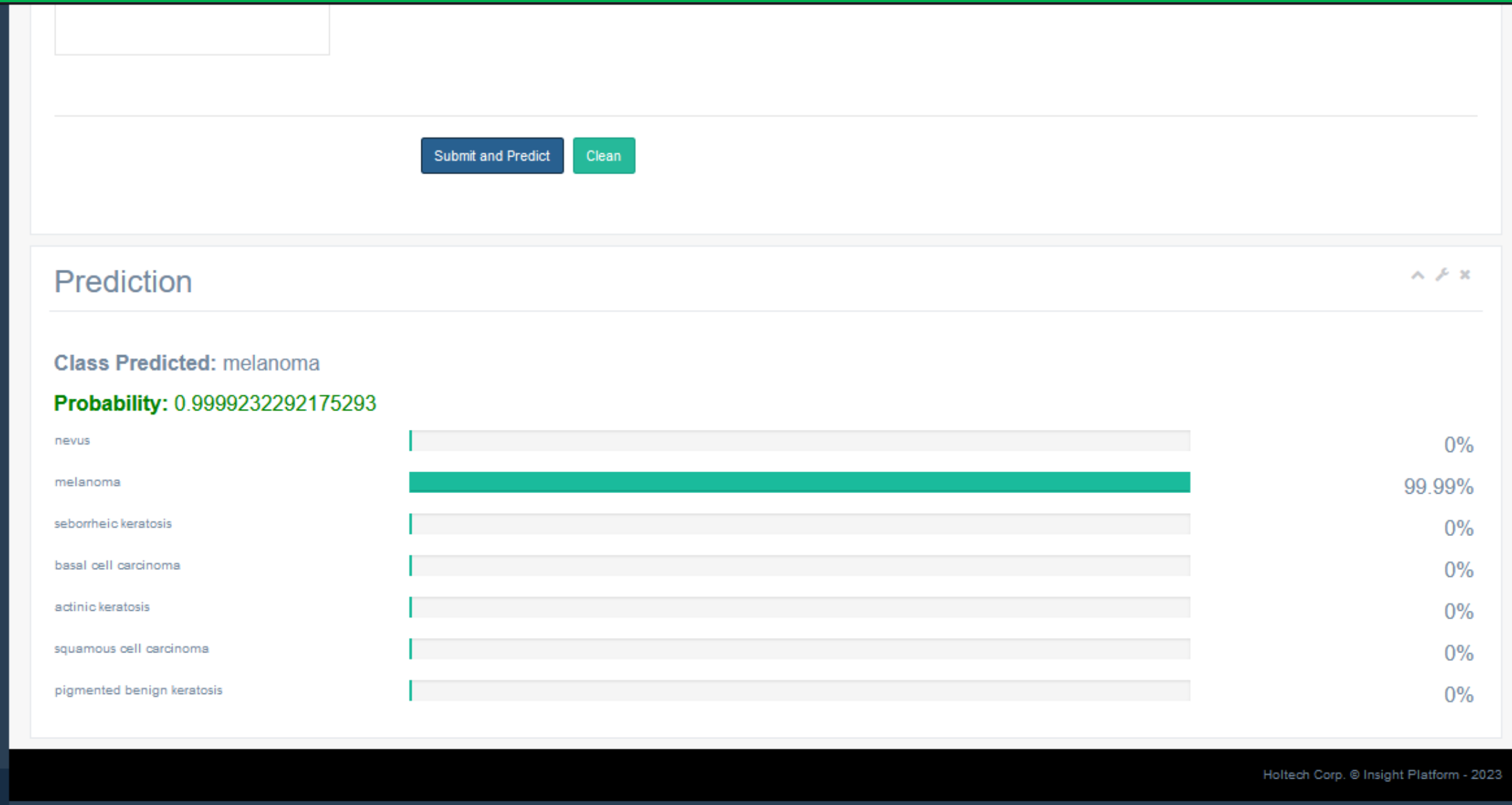
Probability: 93.735%

FIRST LINK SECOND LINK THIRD LINK FOURTH LINK

WEB DIAGNOSTIC INTERFACE I



WEB DIAGNOSTIC INTERFACE II



PROTOTYPE OF REPORT INTERFACE

VIT-SkinCancer App

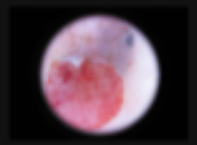
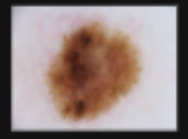
Search

HOME

DIAGNOSTIC

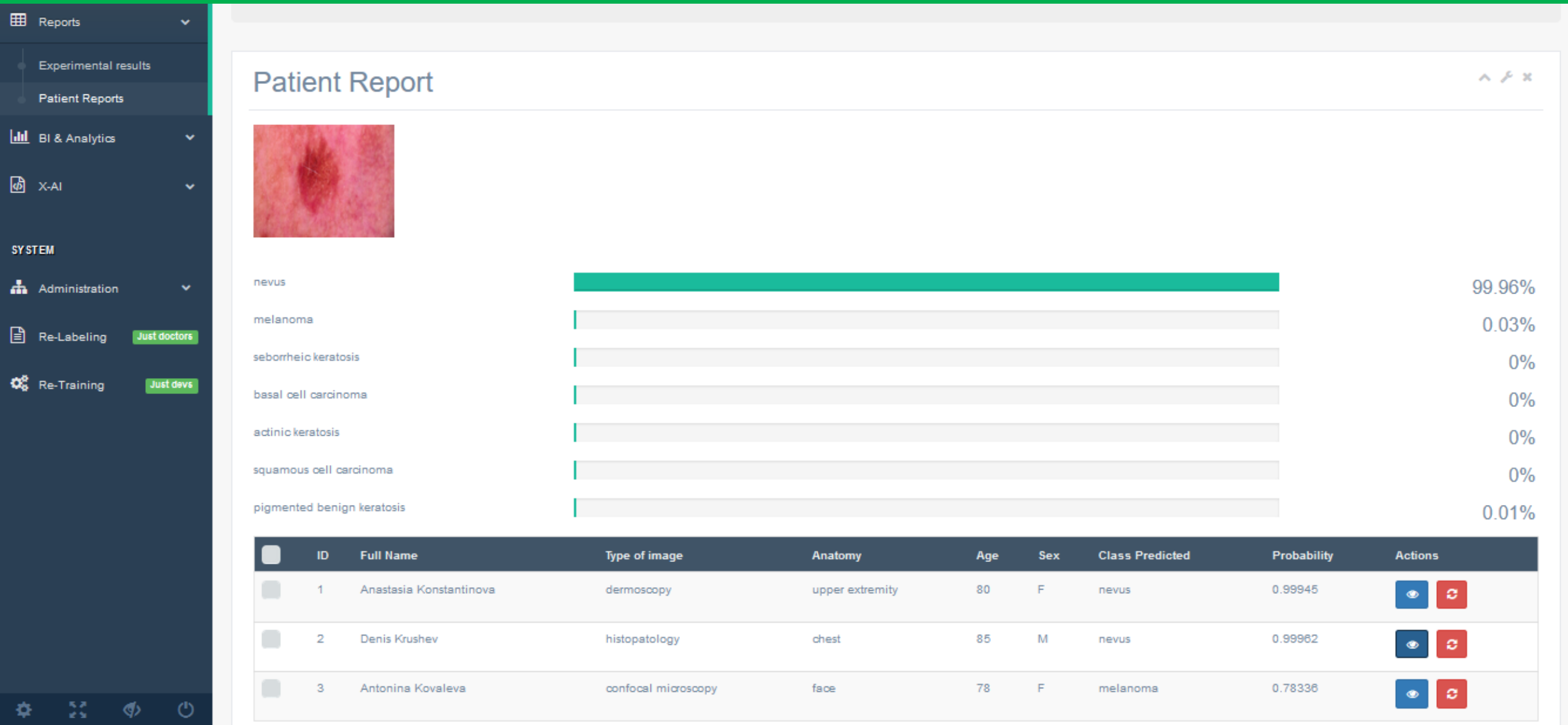
REPORT

Skin Cancer Pacients Report

ID	Image	Hospital	Diagnostic	Probability
ISIC_234464		Clinic of Buenos Aires	Nevus	93.735%
ISIC_098424		Neoplasic Institute of San Petersburg	Actinic keratosis	89.451%
ISIC_780091		Hospital Arzobispo Loaiza	Squamous cell carcinoma	43.164%
ISIC_5601490		Hospital Regional de Trujillo	Melanoma	97.315%

FIRST LINK SECOND LINK THIRD LINK FOURTH LINK

WEB REPORT INTERFACE



CONTAINERIZATION WITH DOCKER

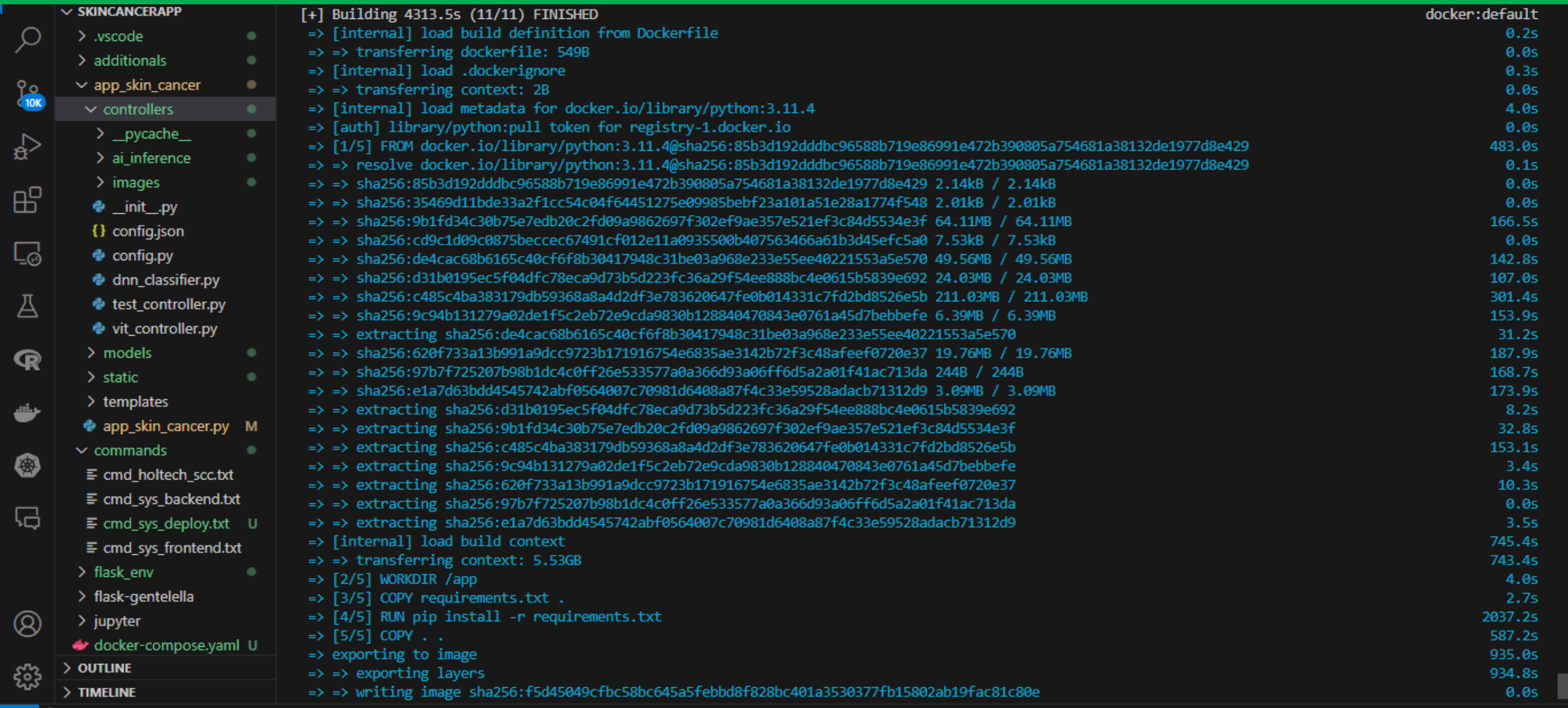
Dockerfile U | app_skin_cancer.py M | vit_controller.py | docker-compose.yaml U

Dockerfile > ...

```dockerfile
# Use the official Python image as the base image
FROM python:3.11.4

# Set the working directory in the container
WORKDIR /app

# Copy the requirements.txt file into the container
COPY requirements.txt .

# Install the required Python packages
RUN pip install -r requirements.txt

# Copy the rest of the application source code into the container
COPY . .

# Expose port 5000 to the outside world
EXPOSE 5000

# Define the command to run the application
CMD ["python", "app_skin_cancer.py"]
```

```
(flask_env) PS G:\AREPO - TESIS\_PROYECT-TESIS-FINAL\AVERSION 2023 - THESIS PROJECT\SkinCancerApp> docker build -t holtech/app_skin_cancer .
[+] Building 1845.6s (8/10)                                    docker:default
```

CONTEINERIZATION WITH DOCKER



DEPLOYMENT OF APPLICATION WITH DOCKER + KUBERNETES

Dockerfile U | docker-compose.yaml U | app_skin_cancer.py M

docker-compose.yaml > {} services > {} db > {} environment

docker-compose.yml - The Compose specification establishes a standard for the

```yaml
version: '3'

services:
  app:
    build:
      context: .
      dockerfile: Dockerfile
    ports:
      - "5000:5000"
    depends_on:
      - db
    volumes:
      - app_skin_cancer:/app
    command: python app_skin_cancer.py
  db:
    image: mysql:latest
    ports:
      - "3306:3306"
    environment:
      MYSQL_DATABASE: 'db_skin_cancer'
      MYSQL_USER: 'root'
      MYSQL_PASSWORD: '$holtech123'
  nginx:
    image: nginx:latest
    ports:
      - "80:80"
    volumes:
      - app_skin_cancer:/usr/share/nginx/html

volumes:
  app_skin_cancer:

```

Deployment Commands

1) build and tag the docker image

$ docker build -t holtech/app_skin_cancer .

2) push docker image to docker hub

$ docker push holtech/app_skin_cancer

3) deploy application using docker-compose

$ docker-compose up -d

DEPLOY WITH DOCKER + KUBERNETES

```
(flask_env) PS G:\AREPO - TESIS\_PROYECT-TESIS-FINAL\AVERSION 2023 - THESIS PROJECT\SkinCancerApp> docker push holtech/app_skin_cancer
Using default tag: latest
The push refers to repository [docker.io/holtech/app_skin_cancer]
8086f31a3bfc: Pushing [=>                                                 ]  218.3MB/5.522GB
2562e2befbb0: Pushing [=>                                                 ]  228.9MB/7.998GB
ac1a8d8a067b: Pushed
486aacbb40b2: Pushed
640c66c56f14: Mounted from library/python
76d42947d3a7: Mounted from library/python
854c9b0c3191: Mounted from library/python
b2e5b1eee192: Mounted from library/python
b485c6cd33a6: Mounted from library/python
6aa872026017: Mounted from library/python
43ba18a5eaf8: Mounted from library/python
ff61a9b258e5: Mounted from library/python
```

```
(flask_env) PS G:\AREPO - TESIS\_PROYECT-TESIS-FINAL\AVERSION 2023 - THESIS PROJECT\SkinCancerApp>
(flask_env) PS G:\AREPO - TESIS\_PROYECT-TESIS-FINAL\AVERSION 2023 - THESIS PROJECT\SkinCancerApp> docker-compose up -d
time="2024-01-25T01:15:19+03:00" level=warning msg="The \"holtech123\" variable is not set. Defaulting to a blank string."
[+] Running 11/1
 ✓ db 10 layers [⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿⣿]      0B/0B      Pulled                                                                  249.8s
[+] Building 16.1s (5/10)                                                                                          docker:default
 => [app internal] load build definition from Dockerfile                                                                  0.3s
 => => transferring dockerfile: 549B                                                                                      0.1s
 => [app internal] load .dockerignore                                                                                     0.2s
 => => transferring context: 2B                                                                                           0.1s
 => [app internal] load metadata for docker.io/library/python:3.11.4                                                      3.8s
 => [app auth] library/python:pull token for registry-1.docker.io                                                         0.0s
 => [app 1/5] FROM docker.io/library/python:3.11.4@sha256:85b3d192dddbc96588b719e86991e472b390805a754681a38132de1977d8e429  0.0s
 => [app internal] load build context                                                                                    11.8s
 => => transferring context: 2.99MB                                                                                      11.8s
```

DEPLOY WITH DOCKER + KUBERNETES

```
(flask_env) PS G:\AREPO - TESIS\_PROYECT-TESIS-FINAL\AVERSION 2023 - THESIS PROJECT\SkinCancerApp> docker-compose up -d
time="2024-01-25T01:21:03+03:00" level=warning msg="The \"holtech123\" variable is not set. Defaulting to a blank string."
[+] Building 1061.4s (10/10) FINISHED                                                                                docker:default
 => [app internal] load build definition from Dockerfile                                                                      0.1s
 => => transferring dockerfile: 549B                                                                                          0.0s
 => [app internal] load .dockerignore                                                                                         0.1s
 => => transferring context: 2B                                                                                               0.0s
 => [app internal] load metadata for docker.io/library/python:3.11.4                                                          1.1s
 => [app 1/5] FROM docker.io/library/python:3.11.4@sha256:85b3d192dddbc96588b719e86991e472b390805a754681a38132de1977d8e429    0.0s
 => [app internal] load build context                                                                                        31.3s
 => => transferring context: 4.52MB                                                                                           6.9s
 => CACHED [app 2/5] WORKDIR /app                                                                                             0.0s
 => CACHED [app 3/5] COPY requirements.txt .                                                                                  0.0s
 => CACHED [app 4/5] RUN pip install -r requirements.txt                                                                      0.0s
 => [app 5/5] COPY . .                                                                                                      663.0s
 => [app] exporting to image                                                                                                365.0s
 => => exporting layers                                                                                                     364.8s
 => => writing image sha256:843ea6069251c0e5e10bba2098221704155695ec7daac0e69f1ca9955dab4cdc                                  0.0s
 => => naming to docker.io/library/skincancerapp-app                                                                          0.1s
[+] Running 5/5
 ✓ Network skincancerapp_default           Created                                                                            1.8s
 ✓ Volume "skincancerapp_app_skin_cancer"  Created                                                                            0.0s

[+] Running 3/3
 ✓ Container skincancerapp-nginx-1  Running                                                                                   0.0s
 ✓ Container skincancerapp-db-1     Started                                                                                   0.7s
 ✓ Container skincancerapp-app-1    Started                                                                                   1.1s
```

Results and Discussion

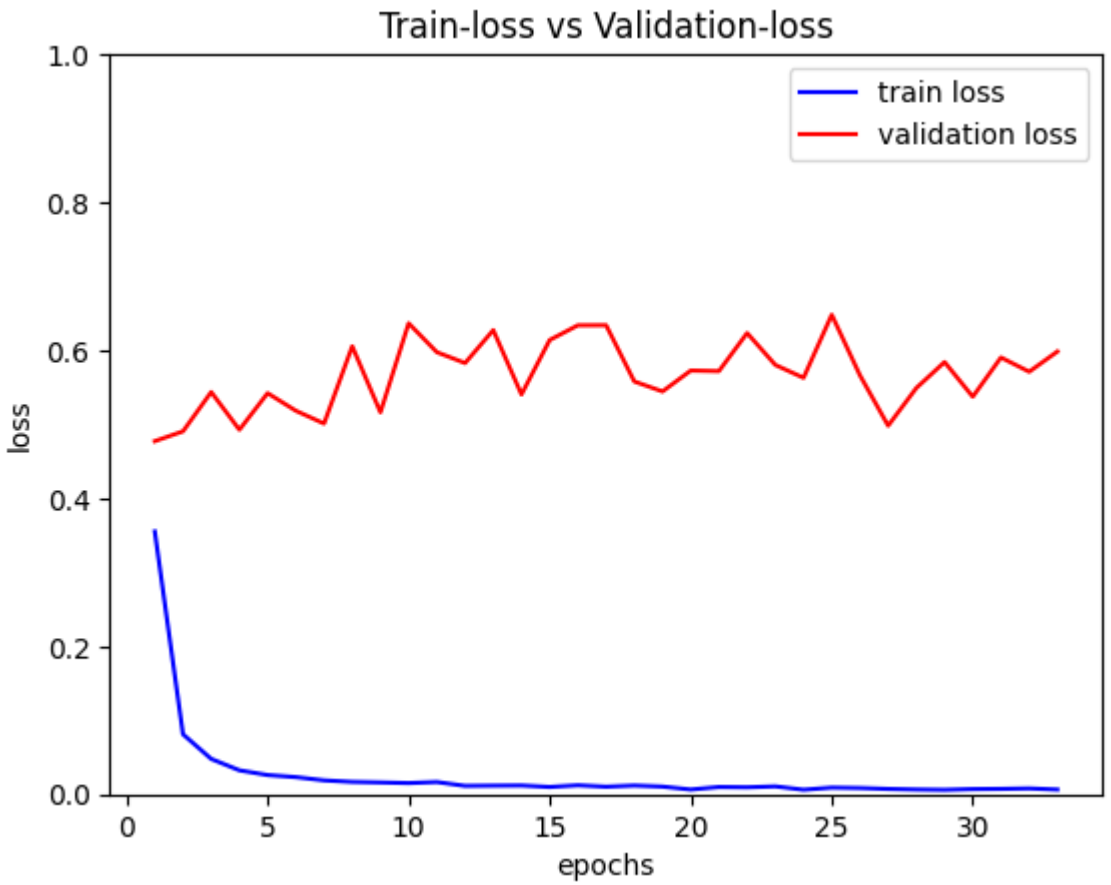
Preliminary results

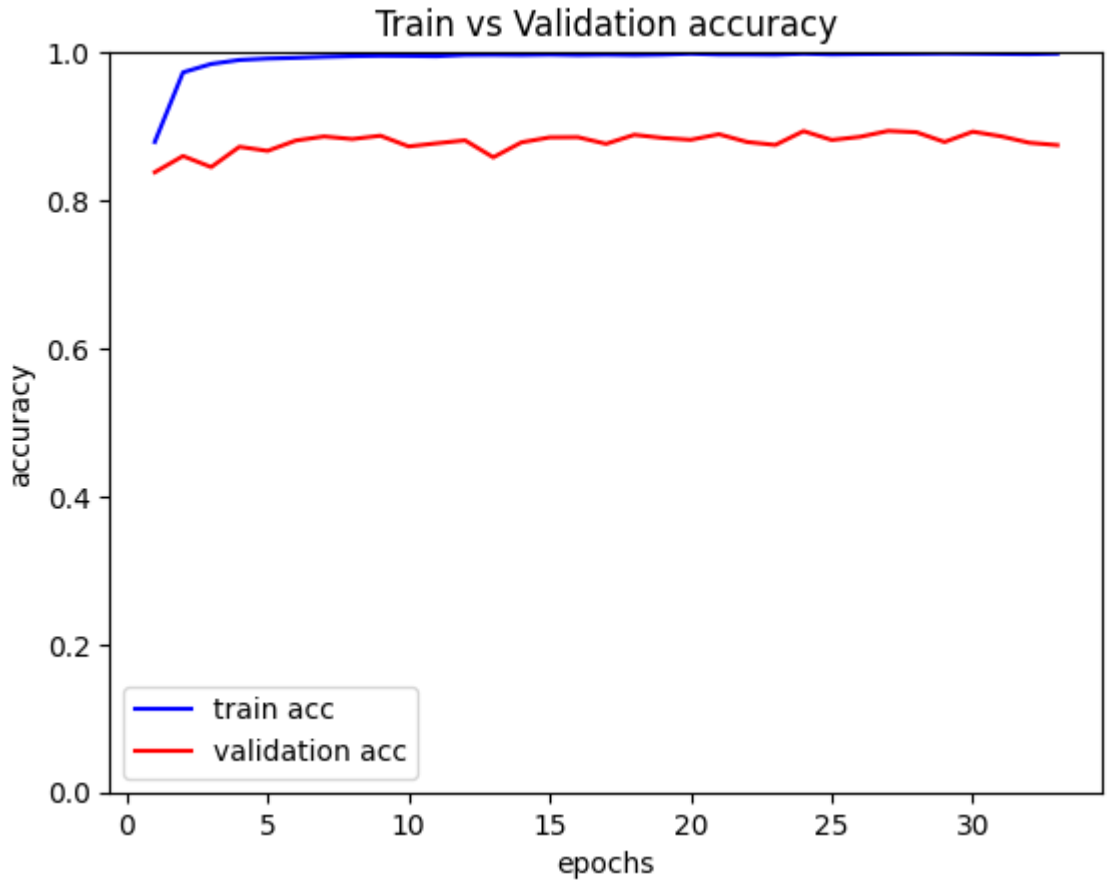
Results for VIT-L/32-384-1k + DNN-3h ensemble architecture

Training				
Loss		Accuracy		
0.0073		99.79%		
Validation				
Loss		Accuracy		
0.4981		89.38%		
Precision	Recall	Specificity	F1-score	AUC
70.20%	70.20%	97.30%	68.20%	44.8%

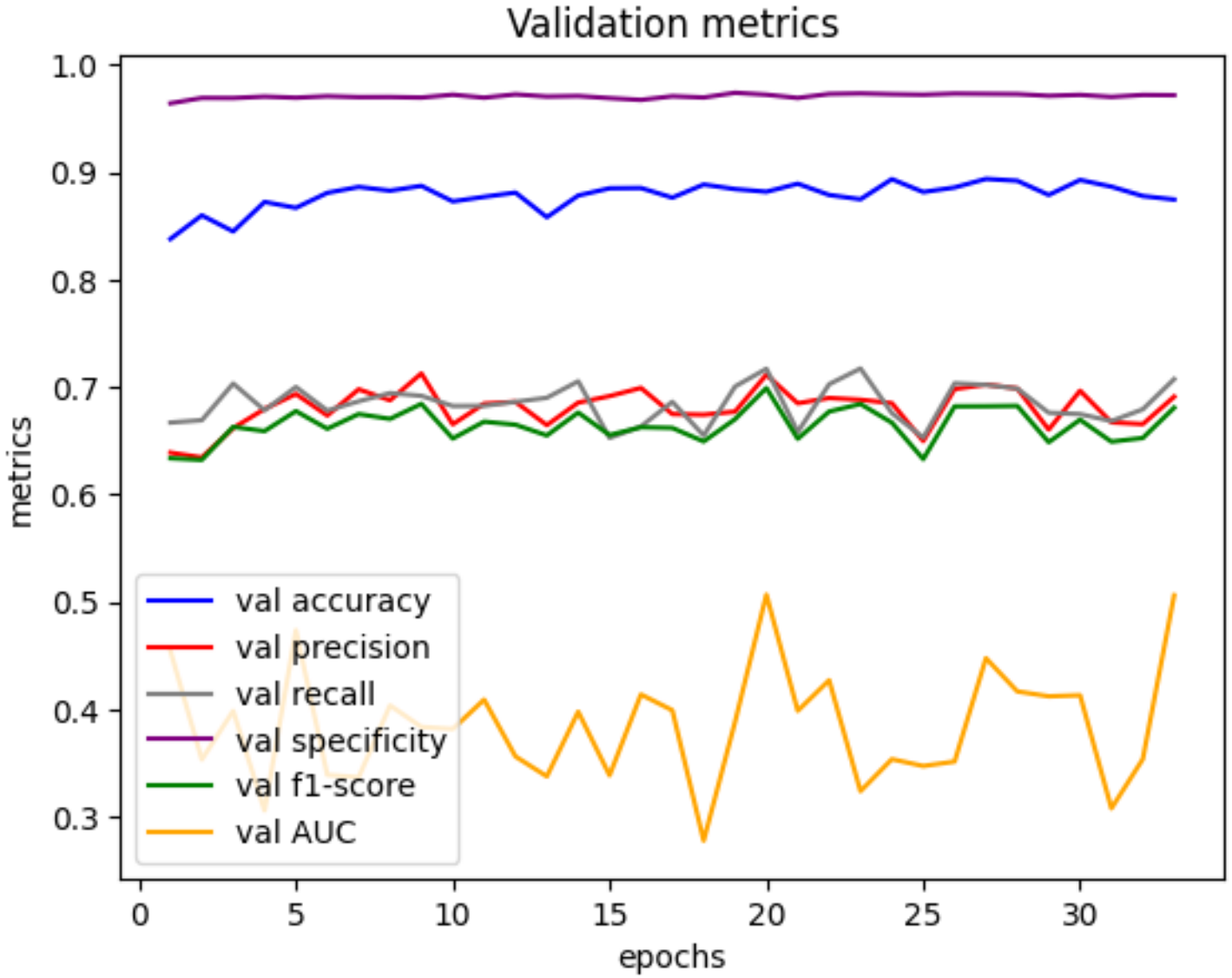
Testing				
Loss		Accuracy		
0.5450		88.37%		
Precision	Recall	Specificity	F1-score	AUC
67.30%	67.30%	97.00%	65.60%	38.40%

Preliminary results





Preliminary results



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Thank you for your attention!

Эспинола Ривера, Хольгер Элиас
espinolarivera.h@edu.spbstu.ru
holtech94@gmail.ru