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APPENDIX

Appendix A Pre-processing Algorithm

Table 15 First Pre-processing Algorithm

```
#Import library needed for this algorithm

import numpy as np
import cv2 as cv
from matplotlib import pyplot as plt
import numpy as np
import matplotlib.pylab as pylab
import skimage.color
import skimage.util
import glob
import pandas as pd
import os

#Main Pre-processing code

input_path = "LINK/*.*"
output_path ="LINK/"

def preprocessing(input_path, output_path):
    img_number = 1
    for file in glob.glob(input_path):
        try:
        #Reading Image
            img = cv.imread(file,0)
            if (len(img.shape)== 3):
                img = cv.cvtColor(img, cv.COLOR_BGR2GRAY)

        # Otsu's thresholding after Gaussian filtering
            blur2 = cv.GaussianBlur(img,(61,61),0) #for Otsu
thresholding
             _,th3 = cv.threshold(blur2,
             0,255,cv.THRESH_BINARY+cv.THRESH_OTSU)

        #Contour
            cont,_ = cv.findContours(th3, cv.RETR_EXTERNAL,
             cv.CHAIN_APPROX_NONE)
            Max_cont = max(cont,key = cv.contourArea)
            x,y,w,h = cv.boundingRect(Max_cont)


        #Cropping image
            chr_mask= img[y:y+h, x:x+w]

        #Second CLAHE
            clahe2 = cv.createCLAHE(clipLimit = 4)
            final_image_2= clahe2.apply(chr_mask)
```

```
        #Median Blur after the contrast is enhanced
            final = cv.medianBlur(final_image_2,ksize=3) #for
removing noise

        #Saving the Preprocessed Image
            cv.imwrite (output_path + " " + str(img_number)+
                        "_Preprocess.jpg", final)
            print("Done Processing: ", file)
            img_number +=1

        except:
            print ("Failed to process: ", file)
            img_number +=1

preprocessing(input_path, output_path)
```

Table 16 Padding Algorithm

```
input_path2 = "LINK/*.*"
output_path2 = "LINK/"

def preprocessing(input_path2, output_path2):
    img_number = 1
    for file in glob.glob(input_path2):
        try:
        #Reading Image
            img = cv.imread(file,0)
            if (len(img.shape)== 3):
                img = cv.cvtColor(img, cv.COLOR_BGR2GRAY)

        #Padding the image
            nrows, ncols = img.shape
            if nrows != ncols:
                if ncols < nrows:
                    change_shape = (nrows, nrows)
                elif nrows < ncols:
                    change_shape = (ncols, ncols)

                # pad.
                padding_img = np.zeros(change_shape)
                padding_img[:nrows, :ncols] = img

            #If padding is not required:
            elif nrows == ncols:
                padding_img = img

        #Saving the Preprocessed Image
            cv.imwrite (output_path2 + " " + str(img_number)+
                        "_Padded.jpg", padding_img)
            print("Done Processing: ", file)
            img_number +=1

        except:
            print ("Failed to process: ", file)
            img_number +=1

preprocessing(input_path2, output_path2)
```

Table 17 Resize Algorithm

```
input_path3 = "LINK/*.*"
output_path3 = "LINK/”

def preprocessing(input_path3, output_path3):
    img_number = 1
    for file in glob.glob(input_path3):
        try:
        #Reading Image
            img = cv.imread(file,0)
            if (len(img.shape)== 3):
                img = cv.cvtColor(img, cv.COLOR_BGR2GRAY)

        #Resize
            Size = 224
            resize_img = cv.resize(img,(Size,Size))

        #Saving the Preprocessed Image
            cv.imwrite (output_path2 + " " + str(img_number)+
".jpg", resize_img)
            print("Done Processing: ", file)
            img_number +=1

        except:
            print ("Failed to process: ", file)
            img_number +=1

preprocessing(input_path3, output_path3)
```

Table 18 Splitting Algorithm

```
#Separating Train and Test dataset

import os
import shutil
import random

# creating train/test
input_folder = "LINK"
train_folder = "LINK"
test_folder = "LINK"

allFileNames = os.listdir(input_folder)
np.random.shuffle(allFileNames)
print(allFileNames)

split_1 = int(0.8*len(allFileNames))
train_FileNames = allFileNames[:split_1]
test_FileNames = allFileNames[split_1:]

#Converting file names from array to list
train_FileNames = [input_folder+'/'+ name for name in
train_FileNames]
test_FileNames = [input_folder+'/' + name for name in
test_FileNames]

print('Total images  : ' +str(len(allFileNames)))
```

```
print('Training : '+ str(len(train_FileNames)))
print('Testing : '+ str(len(test_FileNames)))

## Copy pasting images to target directory

for name in train_FileNames:
    shutil.copy(name, train_folder )

for name in test_FileNames:
    shutil.copy(name, test_folder )
```

Table 19 Augmentation Algorithm

```
#Import Library for Augmentation Algorithm
import Augmentor

#Input File
p = Augmentor.Pipeline("LINK")

#Define Operation
p.rotate90(probability=0.5)
p.rotate270(probability=0.5)
p.rotate(probability=0.8, max_left_rotation=5,
max_right_rotation=5)
#p.flip_top_bottom(probability=0.5)
p.flip_left_right(probability=0.7)
p.random_distortion(probability=0.4, grid_width=5,
grid_height=5,magnitude=5)

#Number of Output
p.sample(460)

#Start the Process
p.process()
```

Appendix B CNN Model Algorithm and Summary

Table 20 CNN Algorithm

```
import json
import math
import os
import cv2
from PIL import Image
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import scipy
from tqdm import tqdm

from keras.utils.np_utils import to_categorical
from sklearn.metrics import cohen_kappa_score, accuracy_score
import tensorflow as tf
from keras.models import Sequential
from keras.layers import BatchNormalization
from keras.layers import Dense, Dropout, Activation, Flatten
from keras.layers import Conv2D, MaxPooling2D, ZeroPadding2D
from keras import regularizers
from keras.models import Model
from keras.optimizers import Adam
from keras.losses import binary_crossentropy
from keras.applications.inception_resnet_v2 import
InceptionResNetV2
from keras.preprocessing.image import ImageDataGenerator

#LOADING DATASET
def Dataset_loader(DIR):
    IMG = []
    read = lambda imname:
           np.asarray(Image.open(imname).convert("RGB"))

    for IMAGE_NAME in tqdm(os.listdir(DIR)):
        PATH = os.path.join(DIR,IMAGE_NAME)
        _, ftype = os.path.splitext(PATH)
        if ftype == ".jpg":
            img = read(PATH)

            IMG.append(np.array(img))

    return IMG

normal9_train  =  np.array(Dataset_loader("/kaggle/input/500-normal-
9-train/"))
der9_train    =    np.array(Dataset_loader("/kaggle/input/300-der-9-
train/"))
normal9_test    =    np.array(Dataset_loader("/kaggle/input/newest-
normal-9-test/"))
der9_test   =   np.array(Dataset_loader("/kaggle/input/newest-der-9-
train/"))

normal22_train = np.array(Dataset_loader("/kaggle/input/500-normal-
22-train/"))
```

```
der22_train   =   np.array(Dataset_loader("/kaggle/input/500-der-22-
train/"))
normal22_test    =    np.array(Dataset_loader("/kaggle/input/newest-
normal-22-test/"))
der22_test  =  np.array(Dataset_loader("/kaggle/input/newest-der-22-
test/"))

# Create labels
normal9_train_label = np.zeros(len(normal9_train), dtype=int) #will
be labeled 0
der9_train_label = np.ones(len(der9_train), dtype=int) #will be
labeled 1
normal22_train_label = np.full(len(normal22_train), 2, dtype = int)
der22_train_label = np.full(len(der22_train), 3, dtype=int)

normal9_test_label = np.zeros(len(normal9_test), dtype=int) #will
be labeled 0
der9_test_label = np.ones(len(der9_test), dtype=int) #will be
labeled 1
normal22_test_label = np.full(len(normal22_test), 2, dtype = int)
der22_test_label = np.full(len(der22_test), 3, dtype=int)

# Merge data
X_train = np.concatenate((normal9_train, der9_train,
       normal22_train, der22_train), axis = 0)
Y_train = np.concatenate((normal9_train_label, der9_train_label,
       normal22_train_label, der22_train_label), axis = 0)

X_test = np.concatenate((normal9_test, der9_test, normal22_test,
     der22_test), axis = 0)
Y_test = np.concatenate((normal9_test_label, der9_test_label,
      normal22_test_label, der22_test_label), axis = 0)

#SHUFFLE THE DATA

#Shuffling the train dataset
datasets = np.arange(X_train.shape[0])
np.random.shuffle(datasets)
X_train = X_train[datasets]
Y_train = Y_train[datasets]

#Shuffling the test dataset
testdatasets = np.arange(X_test.shape[0])
np.random.shuffle(testdatasets)
X_test = X_test[testdatasets]
Y_test = Y_test[testdatasets]

#Categorical for labels
Y_train = tf.keras.utils.to_categorical(Y_train, num_classes=4)
Y_test = tf.keras.utils.to_categorical(Y_test, num_classes=4)

#Splitting between train dataset with validation dataset
from sklearn.model_selection import train_test_split

X_train, x_val, Y_train, y_val = train_test_split(X_train, Y_train,
      test_size=0.05, random_state=42)
```

```
#GENERATE DATA
BATCH_SIZE = 16

# Using original generator
train_generator = ImageDataGenerator(
        horizontal_flip=True,# randomly flip images

)

#CNN
img_rows, img_cols = 224,224
num_classes = 4

def inception_residual_network(input_shape):
    #model = Sequential()
    inception = InceptionResNetV2(include_top=False,
                                  input_shape= input_shape)
    model = Flatten(name='flatten')(inception.output)
    model = Dense(num_classes, activation='softmax')(model)
    model = Model(inception.input, model,
name='inception_residual_network')
    return model

model = inception_residual_network((img_rows,img_cols,3))
model.summary()

#Set optimizer
opt = Adam(lr = 0.0005)

model.compile(loss = 'categorical_crossentropy',
              optimizer = opt, metrics=['accuracy'])

# Learning Rate Reducer
learn_control = ReduceLROnPlateau(monitor='val_accuracy',
patience=3,
                                  verbose=1,factor=0.2, min_lr=1e-
7)

# Checkpoint
filepath="weights.best.hdf5"
checkpoint = ModelCheckpoint(filepath, monitor='val_accuracy',
verbose=1, save_best_only=True, mode='max')

#TRAINING
history1 = model.fit(
    train_generator.flow(X_train, Y_train, batch_size= BATCH_SIZE),
    steps_per_epoch=X_train.shape[0] / BATCH_SIZE,
    epochs=30,
    validation_data=(x_val, y_val),
    callbacks=[learn_control, checkpoint]
)

with open('history1.json', 'w') as f:
    json.dump(str(history1.history), f)

history_df = pd.DataFrame(history1.history)
history_df[['accuracy', 'val_accuracy']].plot()
```

```
history_df = pd.DataFrame(history1.history)
history_df[['loss', 'val_loss']].plot()

#TESTING
tta_steps = 10
predictions = []

for i in tqdm(range(tta_steps)):
    preds = model.predict(train_generator.flow(X_test,
batch_size=BATCH_SIZE, shuffle=False),
                                      steps = len(X_test)/BATCH_SIZE)

    predictions.append(preds)
    gc.collect()

Y_pred_tta = np.mean(predictions, axis=0)

#Confusion Matrix
from sklearn.metrics import confusion_matrix

def plot_confusion_matrix(cm, classes, normalize=False,
title='Confusion matrix', cmap=plt.cm.Blues):
    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    print(cm)

    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=55)
    plt.yticks(tick_marks, classes)

    fmt = '.2f' if normalize else 'd'
    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]),
range(cm.shape[1])):
        plt.text(j, i, format(cm[i, j], fmt),
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")

    plt.ylabel('True label')
    plt.xlabel('Predicted label')
    plt.tight_layout()

cm = confusion_matrix(np.argmax(Y_test, axis=1),
np.argmax(Y_pred_tta, axis=1))

cm_plot_label =['Normal 9', 'Derivative 9','Normal 22','Derivative
22']
plot_confusion_matrix(cm, cm_plot_label, title ='Confusion Matrix
Result')
```

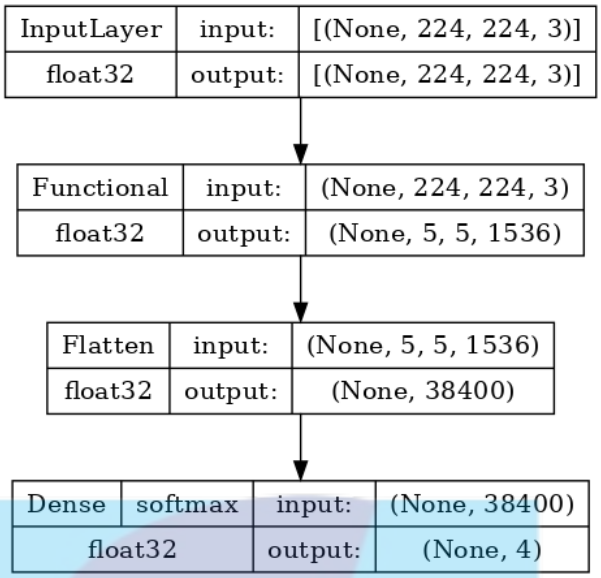

Figure 47 Model Summary of Inception-ResNetV2 Architecture

Appendix C Philadelphia Classification Algorithm

Table 21 Philadelphia Classification Algorithm

```
def get_image(DIR):
    IMG = []
    read = lambda imname:
np.asarray(Image.open(imname).convert("RGB"))

    for IMAGE_NAME in tqdm(os.listdir(DIR)):
        PATH = os.path.join(DIR,IMAGE_NAME)
        _, ftype = os.path.splitext(PATH)
        if ftype == ".jpg" or ".png":
            img = read(PATH)

            IMG.append(np.array(img))

    return IMG

#load the weight:
fname = "/kaggle/input/weight/weights.best (1).hdf5"
model.load_weights(fname)

chromosome9 = np.array(get_image("/kaggle/input/test-4-phil-krom-
9/"))
chromosome22 = np.array(get_image("/kaggle/input/test-4-phil-krom-
22/"))

prediction9 = model.predict(chromosome9)
prediction22 = model.predict(chromosome22)

print("Prediction 9: \n", prediction9)
print("Prediction 22:\n", prediction22)

print("\nPrediction: ")
if prediction9[0,0] >= 0.5 and prediction9[1,0] >= 0.5 and
prediction22[0,2] >= 0.5 and prediction22[1,2] >= 0.5:
    print("Normal Chromosome")
elif prediction9[0,0] >= 0.5 and prediction9 [1,0] >= 0.5 and
prediction22[0,3] >=0.5 or prediction22[1,3] >= 0.5 :
    print("Philadelphia Mutation is detected")
elif prediction9[0,1] >=0.5 or prediction9[1,1] >=0.5 and
prediction22[0,3] >=0.5 or prediction22[1,3] >= 0.5:
    print("Philadelphia Mutation is detected")
elif prediction9[0,1] >=0.5 or prediction9 [1,1] >= 0.5 and
(prediction22 [0,2] and prediction22[1,2]) >= 0.5 :
    print("Philadelphia Mutation is detected")
else:
    print("Out of range")
```

Appendix D Shuffling Training Set

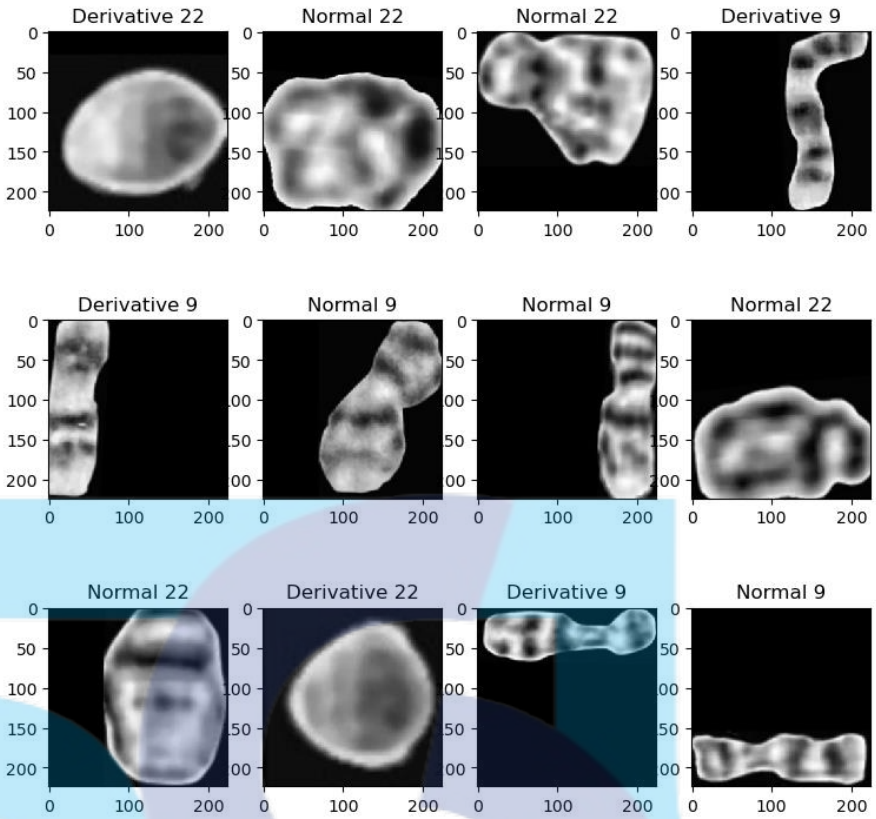

Figure 48 Training Set for CNN

CURRICULUM VITAE

PERSONAL DETAILS

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EDUCATION

SWISS GERMAN UNIVERSITY — Tangerang, Banten
Biomedical Engineering — July 2019-present

TUNAS DAUD HIGH SCHOOL — Denpasar, Bali
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WORK EXPERIENCECS

RUMAH SAKIT KANKER DHARMAIS — Feb, 2022-July, 2022
Internship at Clinical Pathology Laboratory

BRIN — June, 2021-Oct, 2021
Internship at Technology Material Center Department

ELEVEN LEARNING COURSE — Mar, 2019
Teaching English Course

SAVIO LEARNING CENTER — 2016-2019
Teaching Mathematics and Science for Elementary Student

HONORS AND AWARDS

Funding recipient of National Research Competition "Program Kreativitas Mahasiswa (PKM 2021) — October, 2021

Top 5 National Essay-Competition ForTi University Level — August, 2020

"Girls in Science: Even the Number!"

UTS INSEARCH Indonesian Prize: Winning Idea for Physical Fashion Business of the Future at University of Technology Sidney — August, 2018

ACTIVITIES AND MEMBERSHIP

HEAD OF STUDENT COUNCIL'S KADERISASI — October, 2021

- Managed and organized the overall Kaderisasi 2021 Event
- Headed 30 committee members with 40 participants in the Kaderisasi Event.

HEAD OF BIBLE FELLOWSHIP DEPARTMENT — Nov, 2020- Nov, 2021

- Organized Bible Fellowship Student Activity that have members of up to 100+ students
- Managed annual events such as Christmas and Easter, as well as monthly events which are one of the UKM work programs.

FACULTY LEADER OF LIFE SCIENCES AND TECHNOLOGY IN STUDENT AMBASSADOR 2019/2020 — 2019/2020

- Became a representative of Life Sciences and Technology Faculty as an ambassador for Swiss German University Students.

HEAD OF CREATIVE DIVISION IN BIOMEDICAL ENGINEERING ORGANIZATION — 2019/2020

- Designing the social media content of Biomedical Engineering Organization
- Responsible for designing the organization's projects such as banners, PowerPoint and others.

SKILL

Computer Skill:

- MS Work
- MS Excel
- MS Powerpoint
- Adobe Photoshop
- Adobe Premier Pro

Programming Language:

- Python

Language:

- Bahasa Indonesia
- English
- German