Cataract Classification

Import libraries

In [1]:

```
!pip install -q efficientnet >> /dev/null
```

In [2]:

```
!pip install openpyxl
```

```
Requirement already satisfied: openpyxl in /usr/local/lib/python3.6/di
st-packages (2.5.9)
Requirement already satisfied: et-xmlfile in /usr/local/lib/python3.6/
dist-packages (from openpyxl) (1.0.1)
Requirement already satisfied: jdcal in /usr/local/lib/python3.6/dist-
packages (from openpyxl) (1.4.1)
```

In [3]:

```
import os, glob, cv2
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import tensorflow as tf
from tensorflow.keras.layers import *
from tensorflow.keras import backend as K
from tensorflow.keras.models import Sequential
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.utils import get_custom_objects
import efficientnet.tfkeras as efn
from tqdm import tqdm
from google.colab import drive
```

Importing dataset from google drive

In [4]:

```
# Mounting drive
# This will require authentication
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

In [5]:

```
# Viewing the data in the folder present from the drive
!ls "/content/drive/MyDrive/unik/cataract-mat-model"
```

```
cataract_classification.ipynb  input
```

Set configurations and read metadata

In [6]:

```
SEED = 42
EPOCHS = 100
BATCH_SIZE = 32
IMG_HEIGHT = 192
IMG_WIDTH = 256

APP_PATH = '/content/drive/MyDrive/unik/cataract-mat-model'

def get_full_path(*pathes):
    path = ''.join(map(str, pathes))
    return os.path.join(APP_PATH, path)

# cataract dataset
IMG_ROOT = 'input/dataset/'
IMG_DIR = [IMG_ROOT+'1_normal',
           IMG_ROOT+'2_cataract',
           IMG_ROOT+'2_glaucoma',
           IMG_ROOT+'3_retina_disease']

# ocular-disease-recognition dataset
OCU_ROOT = 'input/ODIR_5K/'
OCU_IMG_ROOT = 'input/ODIR_5K/Training_Images/'

FULL_IMG_ROOT = get_full_path(IMG_ROOT)
FULL_OCU_ROOT = get_full_path(OCU_ROOT)
FULL_OCU_IMG_ROOT = get_full_path(OCU_IMG_ROOT)
FULL_OCU_DATA_ROOT = get_full_path(FULL_OCU_ROOT, "data.xlsx")

ocu_df = pd.read_excel(
     FULL_OCU_DATA_ROOT,
     engine='openpyxl',
)
```

In [7]:

```
def seed_everything(seed):
    np.random.seed(seed)
    os.environ['PYTHONHASHSEED'] = str(seed)
    tf.random.set_seed(seed)

seed_everything(SEED)
```

Process Cataract dataset

In [8]:

```
cat_df = pd.DataFrame(0,
                  columns=['paths',
                           'cataract'],
                  index=range(601))

filepaths = glob.glob(FULL_IMG_ROOT + '*/*')


for i, filepath in enumerate(filepaths):
    filepath = os.path.split(filepath)
    cat_df.iloc[i, 0] = filepath[0] + '/' + filepath[1]


    if filepath[0] == IMG_DIR[0]:    # normal
        cat_df.iloc[i, 1] = 0
    elif filepath[0] == IMG_DIR[1]:  # cataract
        cat_df.iloc[i, 1] = 1
    elif filepath[0] == IMG_DIR[2]:  # glaucoma
        cat_df.iloc[i, 1] = 2
    elif filepath[0] == IMG_DIR[3]:  # retine_disease
        cat_df.iloc[i, 1] = 3

# only sample normal and cataract
cat_df = cat_df.query('0 <= cataract < 2')
cat_df
```

Out[8]:

	paths	cataract
0	/content/drive/MyDrive/unik/cataract-mat-model...	0
1	/content/drive/MyDrive/unik/cataract-mat-model...	0
2	/content/drive/MyDrive/unik/cataract-mat-model...	0
3	/content/drive/MyDrive/unik/cataract-mat-model...	0
4	/content/drive/MyDrive/unik/cataract-mat-model...	0
...	...	...
596	/content/drive/MyDrive/unik/cataract-mat-model...	0
597	/content/drive/MyDrive/unik/cataract-mat-model...	0
598	/content/drive/MyDrive/unik/cataract-mat-model...	0
599	/content/drive/MyDrive/unik/cataract-mat-model...	0
600	/content/drive/MyDrive/unik/cataract-mat-model...	0

601 rows × 2 columns

In [9]:

```
print('Number of normal and cataract images')
print(cat_df['cataract'].value_counts())
```

```
Number of normal and cataract images
0    601
Name: cataract, dtype: int64
```

Process Ocular disease recognition dataset

In [10]:

```
ocu_df.head()
```

Out[10]:

	ID	Patient Age	Patient Sex	Left-Fundus	Right-Fundus	Left-Diagnostic Keywords	Right-Diagnostic Keywords	N	D	G	C	A	H	M
0	0	69	Female	0_left.jpg	0_right.jpg	cataract	normal fundus	0	0	0	1	0	0	0
1	1	57	Male	1_left.jpg	1_right.jpg	normal fundus	normal fundus	1	0	0	0	0	0	0
2	2	42	Male	2_left.jpg	2_right.jpg	laser spot，moderate non proliferative retinopathy	moderate non proliferative retinopathy	0	1	0	0	0	0	0
3	3	66	Male	3_left.jpg	3_right.jpg	normal fundus	branch retinal artery occlusion	0	0	0	0	0	0	0
4	4	53	Male	4_left.jpg	4_right.jpg	macular epiretinal membrane	mild nonproliferative retinopathy	0	1	0	0	0	0	0

In [11]:

```
def has_cataract_mentioned(text):
    if 'cataract' in text:
        return 1
    else:
        return 0

ocu_df['left_eye_cataract'] = ocu_df['Left-Diagnostic Keywords']\
                                    .apply(lambda x: has_cataract_mentioned(x))
ocu_df['right_eye_cataract'] = ocu_df['Right-Diagnostic Keywords']\
                                    .apply(lambda x: has_cataract_mentioned(x))
```

In [12]:

```
le_df = ocu_df.loc[:, ['Left-Fundus', 'left_eye_cataract']]\
        .rename(columns={'left_eye_cataract':'cataract'})
le_df['paths'] = FULL_OCU_IMG_ROOT + le_df['Left-Fundus']
le_df = le_df.drop('Left-Fundus', axis=1)


re_df = ocu_df.loc[:, ['Right-Fundus', 'right_eye_cataract']]\
        .rename(columns={'right_eye_cataract':'cataract'})
re_df['paths'] = FULL_OCU_IMG_ROOT + re_df['Right-Fundus']
re_df = re_df.drop('Right-Fundus', axis=1)
```

In [13]:

```
le_df.head()
```

Out[13]:

	cataract	paths
0	1	/content/drive/MyDrive/unik/cataract-mat-model...
1	0	/content/drive/MyDrive/unik/cataract-mat-model...
2	0	/content/drive/MyDrive/unik/cataract-mat-model...
3	0	/content/drive/MyDrive/unik/cataract-mat-model...
4	0	/content/drive/MyDrive/unik/cataract-mat-model...

In [14]:

```
re_df.head()
```

Out[14]:

	cataract	paths
0	0	/content/drive/MyDrive/unik/cataract-mat-model...
1	0	/content/drive/MyDrive/unik/cataract-mat-model...
2	0	/content/drive/MyDrive/unik/cataract-mat-model...
3	0	/content/drive/MyDrive/unik/cataract-mat-model...
4	0	/content/drive/MyDrive/unik/cataract-mat-model...

In [15]:

```
print('Number of left eye images')
print(le_df['cataract'].value_counts())
print('\nNumber of right eye images')
print(re_df['cataract'].value_counts())
```

```
Number of left eye images
0    3341
1     159
Name: cataract, dtype: int64

Number of right eye images
0    3346
1     154
Name: cataract, dtype: int64
```

There is a large bias in the dataset. So make it even.

In [16]:

```
def downsample(df):
    df = pd.concat([
        df.query('cataract==1'),
        df.query('cataract==0').sample(sum(df['cataract']),
                                       random_state=SEED)
    ])
    return df


le_df = downsample(le_df)
re_df = downsample(re_df)

print('Number of left eye images')
print(le_df['cataract'].value_counts())
print('\nNumber of right eye images')
print(re_df['cataract'].value_counts())
```

```
Number of left eye images
1    159
0    159
Name: cataract, dtype: int64

Number of right eye images
1    154
0    154
Name: cataract, dtype: int64
```

In [17]:

```
ocu_df = pd.concat([le_df, re_df])
ocu_df
```

Out[17]:

	cataract	paths
0	1	/content/drive/MyDrive/unik/cataract-mat-model...
81	1	/content/drive/MyDrive/unik/cataract-mat-model...
103	1	/content/drive/MyDrive/unik/cataract-mat-model...
119	1	/content/drive/MyDrive/unik/cataract-mat-model...
253	1	/content/drive/MyDrive/unik/cataract-mat-model...
...	...	...
940	0	/content/drive/MyDrive/unik/cataract-mat-model...
2320	0	/content/drive/MyDrive/unik/cataract-mat-model...
2850	0	/content/drive/MyDrive/unik/cataract-mat-model...
198	0	/content/drive/MyDrive/unik/cataract-mat-model...
375	0	/content/drive/MyDrive/unik/cataract-mat-model...

626 rows × 2 columns

In [18]:

```
cat_df
```

Out[18]:

	paths	cataract
0	/content/drive/MyDrive/unik/cataract-mat-model...	0
1	/content/drive/MyDrive/unik/cataract-mat-model...	0
2	/content/drive/MyDrive/unik/cataract-mat-model...	0
3	/content/drive/MyDrive/unik/cataract-mat-model...	0
4	/content/drive/MyDrive/unik/cataract-mat-model...	0
...	...	...
596	/content/drive/MyDrive/unik/cataract-mat-model...	0
597	/content/drive/MyDrive/unik/cataract-mat-model...	0
598	/content/drive/MyDrive/unik/cataract-mat-model...	0
599	/content/drive/MyDrive/unik/cataract-mat-model...	0
600	/content/drive/MyDrive/unik/cataract-mat-model...	0

601 rows × 2 columns

Create datasets

Combine the two metadata and use them to load the image data and create datasets.

In [19]:

```
df = pd.concat([cat_df, ocu_df], ignore_index=True)
# df = df[df['paths'] !=0]

df
```

Out[19]:

	paths	cataract
0	/content/drive/MyDrive/unik/cataract-mat-model...	0
1	/content/drive/MyDrive/unik/cataract-mat-model...	0
2	/content/drive/MyDrive/unik/cataract-mat-model...	0
3	/content/drive/MyDrive/unik/cataract-mat-model...	0
4	/content/drive/MyDrive/unik/cataract-mat-model...	0
...	...	...
1222	/content/drive/MyDrive/unik/cataract-mat-model...	0
1223	/content/drive/MyDrive/unik/cataract-mat-model...	0
1224	/content/drive/MyDrive/unik/cataract-mat-model...	0
1225	/content/drive/MyDrive/unik/cataract-mat-model...	0
1226	/content/drive/MyDrive/unik/cataract-mat-model...	0

1227 rows × 2 columns

In [20]:

```
train_df, test_df = train_test_split(df,
                                     test_size=0.2,
                                     random_state=SEED,
                                     stratify=df['cataract'])

train_df, val_df = train_test_split(train_df,
                                    test_size=0.15,
                                    random_state=SEED,
                                    stratify=train_df['cataract'])
```

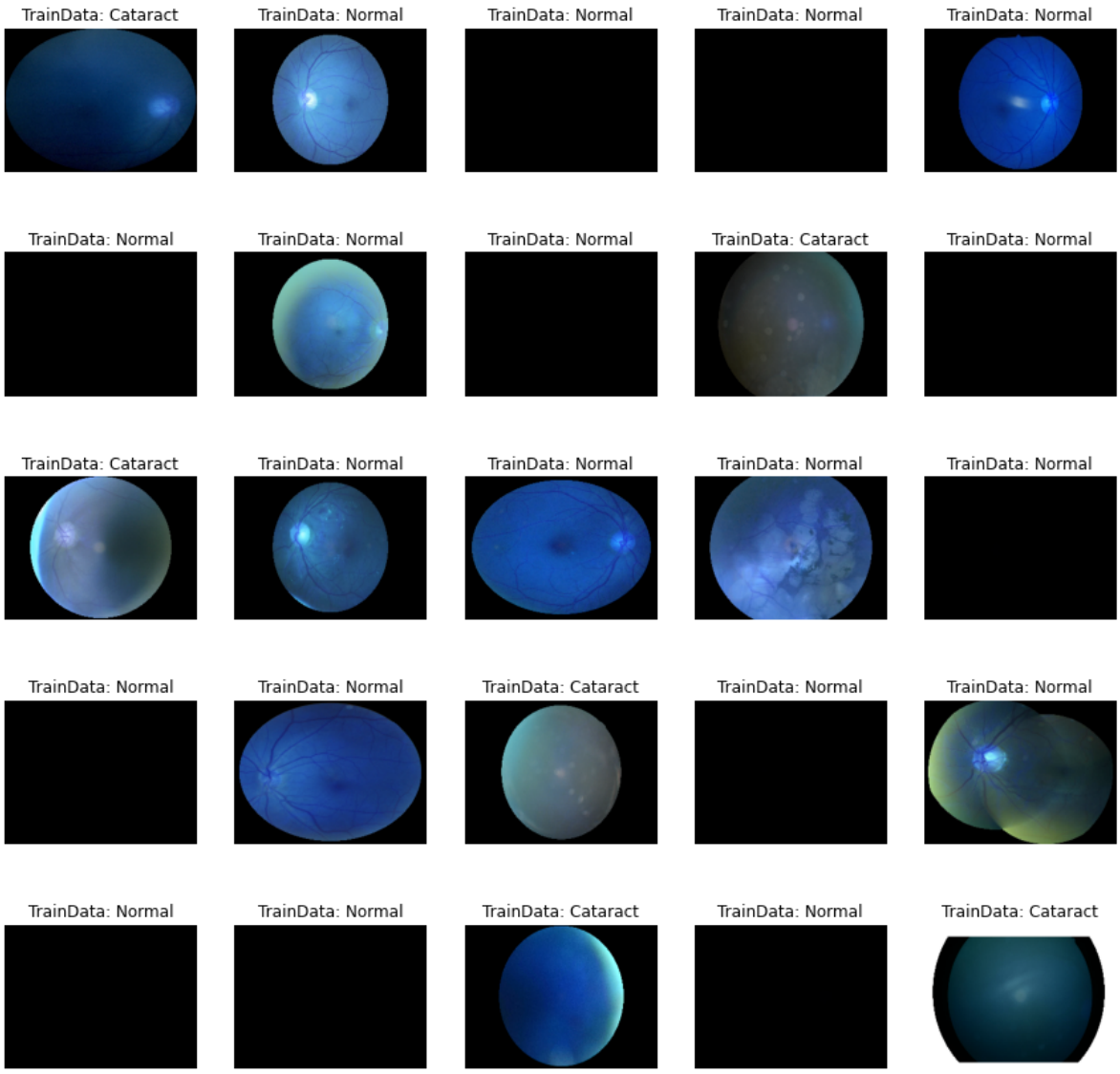
In [21]:

```
def create_datasets(df, img_width, img_height):
    imgs = []
    for path in tqdm(df['paths']):
        img = plt.imread(path)
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)
        img = cv2.resize(img, (img_width, img_height))
        imgs.append(img)

    imgs = np.array(imgs, dtype='float32')
    df = pd.get_dummies(df['cataract'])
    return imgs, df


train_imgs, train_df = create_datasets(train_df, IMG_WIDTH, IMG_HEIGHT)
val_imgs, val_df = create_datasets(val_df, IMG_WIDTH, IMG_HEIGHT)
test_imgs, test_df = create_datasets(test_df, IMG_WIDTH, IMG_HEIGHT)

train_imgs = train_imgs / 255.0
val_imgs = val_imgs / 255.0
test_imgs = test_imgs / 255.0
```

```
100%|██████████| 833/833 [06:49<00:00,  2.03it/s]
100%|██████████| 148/148 [01:07<00:00,  2.18it/s]
100%|██████████| 246/246 [01:54<00:00,  2.15it/s]
```

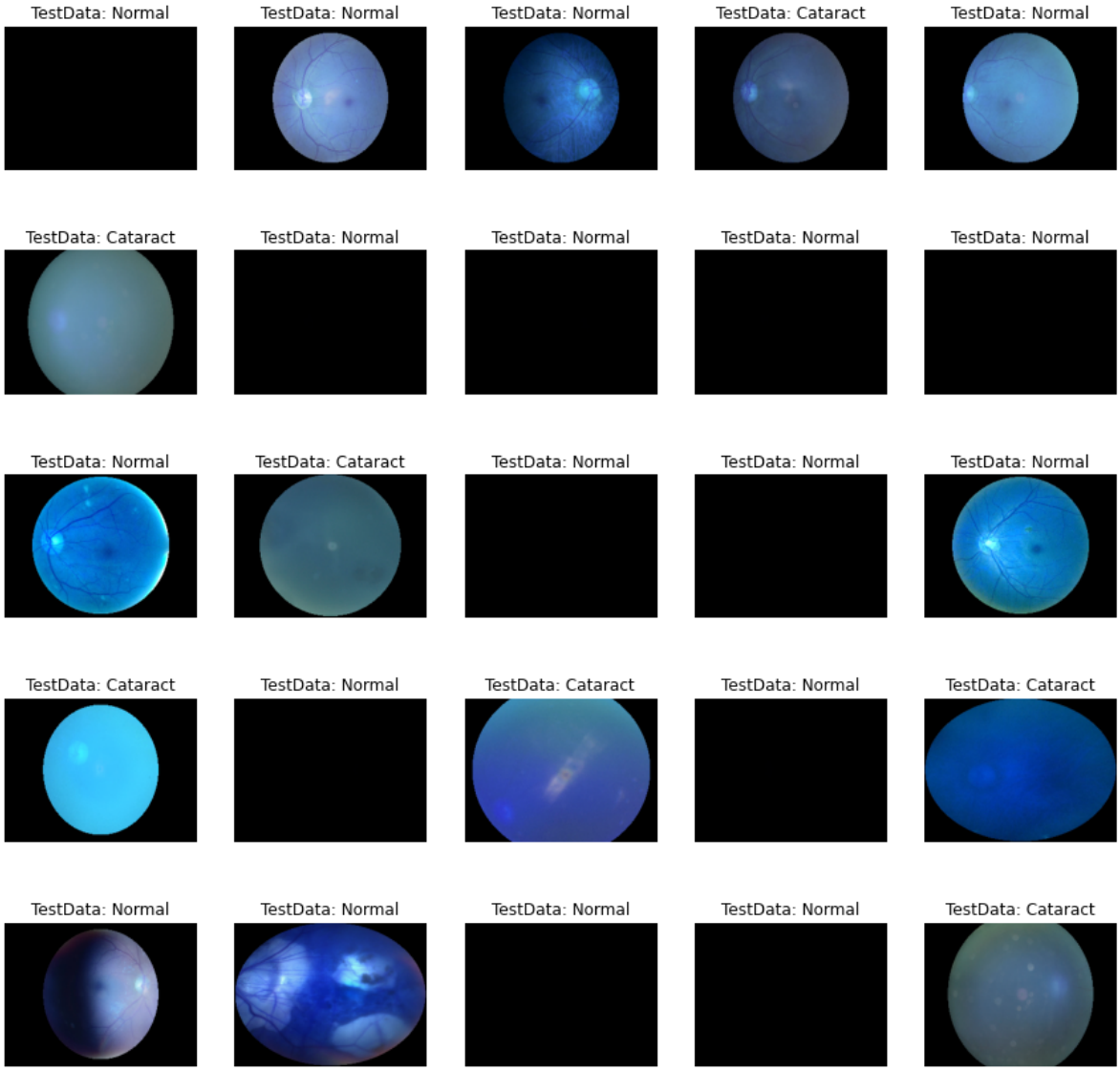
In [22]:

```
# plot the first 25 sheets of image data for training

f, ax = plt.subplots(5, 5, figsize=(15,15))
norm_list = list(train_df[0][:25])
for i, img in enumerate(train_imgs[:25]):
    ax[i//5, i%5].imshow(img)
    ax[i//5, i%5].axis('off')
    if norm_list[i] == 1:
        ax[i//5, i%5].set_title('TrainData: Normal')
    else:
        ax[i//5, i%5].set_title('TrainData: Cataract')
plt.show()
```



In [23]:

```
# plot the first 25 sheets of image data for Test
f, ax = plt.subplots(5, 5, figsize=(15,15))
norm_list = list(test_df[0][:25])
for i, img in enumerate(test_imgs[:25]):
    ax[i//5, i%5].imshow(img)
    ax[i//5, i%5].axis('off')
    if norm_list[i] == 1:
        ax[i//5, i%5].set_title('TestData: Normal')
    else:
        ax[i//5, i%5].set_title('TestData: Cataract')
plt.show()
```



Build the model(1)

In [24]:

```
class Mish(tf.keras.layers.Layer):

    def __init__(self, **kwargs):
        super(Mish, self).__init__(**kwargs)
        self.supports_masking = True

    def call(self, inputs):
        return inputs * K.tanh(K.softplus(inputs))

    def get_config(self):
        base_config = super(Mish, self).get_config()
        return dict(list(base_config.items()) + list(config.items()))

    def compute_output_shape(self, input_shape):
        return input_shape
def mish(x):
    return tf.keras.layers.Lambda(lambda x: x*K.tanh(K.softplus(x)))(x)

get_custom_objects().update({'mish': Activation(mish)})
```

In [25]:

```
input_shape = (IMG_HEIGHT, IMG_WIDTH, 3)

model = Sequential()
model.add(Conv2D(16, kernel_size=3, padding='same',
                 input_shape=input_shape, activation='mish'))
model.add(Conv2D(16, kernel_size=3, padding='same', activation='mish'))
model.add(BatchNormalization())
model.add(MaxPool2D(3))
model.add(Dropout(0.3))
model.add(Conv2D(16, kernel_size=3, padding='same', activation='mish'))
model.add(Conv2D(16, kernel_size=3, padding='same', activation='mish'))
model.add(BatchNormalization())
model.add(MaxPool2D(3))
model.add(Dropout(0.3))
model.add(Flatten())
model.add(Dense(2, activation='softmax'))
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy


model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 192, 256, 16)      448
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 192, 256, 16)      2320
_________________________________________________________________
batch_normalization (BatchNo (None, 192, 256, 16)      64
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 64, 85, 16)        0
_________________________________________________________________
dropout (Dropout)            (None, 64, 85, 16)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 64, 85, 16)        2320
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 64, 85, 16)        2320
_________________________________________________________________
batch_normalization_1 (Batch (None, 64, 85, 16)        64
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 21, 28, 16)        0
_________________________________________________________________
dropout_1 (Dropout)          (None, 21, 28, 16)        0
_________________________________________________________________
flatten (Flatten)            (None, 9408)              0
_________________________________________________________________
dense (Dense)                (None, 2)                 18818
=================================================================
Total params: 26,354
Trainable params: 26,290
Non-trainable params: 64
_________________________________________________________________
```

Use some image data augmentation to generate randomly augmented image data from the ImageDataGenerator Object.

In [26]:

```
generator = ImageDataGenerator(horizontal_flip=True,
                               height_shift_range=0.1,
                               fill_mode='reflect')



es_callback = tf.keras.callbacks.EarlyStopping(patience=20,
                                               verbose=1,
                                               restore_best_weights=True)
reduce_lr = tf.keras.callbacks.ReduceLROnPlateau(factor=0.1, patience=10, verbose=1
```

In [27]:

```
history = model.fit(generator.flow(train_imgs,
                                   train_df,
                                   batch_size=BATCH_SIZE),
                    epochs=EPOCHS,
                    steps_per_epoch=len(train_imgs)/BATCH_SIZE,
                    callbacks=[es_callback, reduce_lr],
                    validation_data=(val_imgs, val_df))


pd.DataFrame(history.history)[['accuracy', 'val_accuracy']].plot()
pd.DataFrame(history.history)[['loss', 'val_loss']].plot()
plt.show()
```

```
8 - accuracy: 0.8532 - val_loss: 0.3335 - val_accuracy: 0.8581
Epoch 64/100
26/26 [==============================] - 8s 311ms/step - loss: 0.462
5 - accuracy: 0.8270 - val_loss: 0.3249 - val_accuracy: 0.8581
Epoch 65/100
26/26 [==============================] - 8s 313ms/step - loss: 0.387
9 - accuracy: 0.8295 - val_loss: 0.3278 - val_accuracy: 0.8581
Epoch 66/100
26/26 [==============================] - 8s 313ms/step - loss: 0.371
6 - accuracy: 0.8319 - val_loss: 0.3264 - val_accuracy: 0.8581
Epoch 67/100
26/26 [==============================] - 8s 315ms/step - loss: 0.408
9 - accuracy: 0.8433 - val_loss: 0.3298 - val_accuracy: 0.8581
Epoch 68/100
26/26 [==============================] - 8s 313ms/step - loss: 0.419
2 - accuracy: 0.8398 - val_loss: 0.3360 - val_accuracy: 0.8581
Restoring model weights from the end of the best epoch.

Epoch 00068: ReduceLROnPlateau reducing learning rate to 1.000000111
```

In [28]:

```
model.evaluate(test_imgs, test_df)
```

```
8/8 [==============================] - 0s 35ms/step - loss: 0.3204 - a
ccuracy: 0.8659
```

Out[28]:

```
[0.3204319179058075, 0.8658536672592163]
```

In [ ]:

```
model.save(get_full_path('custom_model.h5'))
```

Build the model(2)

We will train using a model that has been pre-trained.

In [35]:

```
def build_model(img_height, img_width, n):
    inp = Input(shape=(img_height,img_width,n))
    efnet = efn.EfficientNetB0(
        input_shape=(img_height,img_width,n),
        weights='imagenet',
        include_top=False
    )
    x = efnet(inp)
    x = GlobalAveragePooling2D()(x)
    x = Dense(2, activation='softmax')(x)
    model = tf.keras.Model(inputs=inp, outputs=x)
    opt = tf.keras.optimizers.Adam(learning_rate=0.000003)
    loss = tf.keras.losses.CategoricalCrossentropy(label_smoothing=0.01)
    model.compile(optimizer=opt, loss=loss, metrics=['accuracy'])
    return model

model = build_model(IMG_HEIGHT, IMG_WIDTH, 3)
model.summary()
```

```
Model: "model_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_3 (InputLayer)         [(None, 192, 256, 3)]     0
_________________________________________________________________
efficientnet-b0 (Functional) (None, 6, 8, 1280)        4049564
_________________________________________________________________
global_average_pooling2d_1 ( (None, 1280)              0
_________________________________________________________________
dense_2 (Dense)              (None, 2)                 2562
=================================================================
Total params: 4,052,126
Trainable params: 4,010,110
Non-trainable params: 42,016
_________________________________________________________________
```

In [30]:

```
generator = ImageDataGenerator(horizontal_flip=True,
                               height_shift_range=0.1,
                               fill_mode='reflect')



es_callback = tf.keras.callbacks.EarlyStopping(patience=20,
                                               verbose=1,
                                               restore_best_weights=True)
reduce_lr = tf.keras.callbacks.ReduceLROnPlateau(factor=0.1, patience=10, verbose=1
```

In [31]:

```
history = model.fit(generator.flow(train_imgs,
                                   train_df,
                                   batch_size=BATCH_SIZE),
                    epochs=EPOCHS,
                    steps_per_epoch=len(train_imgs)/BATCH_SIZE,
                    callbacks=[es_callback, reduce_lr],
                    validation_data=(val_imgs, val_df))


pd.DataFrame(history.history)[['accuracy', 'val_accuracy']].plot()
pd.DataFrame(history.history)[['loss', 'val_loss']].plot()
plt.show()
```

```
Epoch 94/100
26/26 [==============================] - 11s 418ms/step - loss: 0.11
62 - accuracy: 0.9720 - val_loss: 0.1558 - val_accuracy: 0.9459
Epoch 95/100
26/26 [==============================] - 11s 418ms/step - loss: 0.10
99 - accuracy: 0.9769 - val_loss: 0.1596 - val_accuracy: 0.9459
Epoch 96/100
26/26 [==============================] - 11s 429ms/step - loss: 0.13
08 - accuracy: 0.9647 - val_loss: 0.1519 - val_accuracy: 0.9527

Epoch 00096: ReduceLROnPlateau reducing learning rate to 3.000000248
221113e-09.
Epoch 97/100
26/26 [==============================] - 11s 414ms/step - loss: 0.12
40 - accuracy: 0.9649 - val_loss: 0.1514 - val_accuracy: 0.9527
Epoch 98/100
26/26 [==============================] - 11s 414ms/step - loss: 0.12
30 - accuracy: 0.9759 - val_loss: 0.1495 - val_accuracy: 0.9527
Epoch 99/100
26/26 [==============================] - 11s 413ms/step - loss: 0.11
```

In [32]:

```
model.evaluate(test_imgs, test_df)
```

```
8/8 [==============================] - 1s 88ms/step - loss: 0.1388 - a
ccuracy: 0.9472
```

Out[32]:

```
[0.1388092041015625, 0.9471544623374939]
```

In [34]:

```
model.save(get_full_path('efficientnet-b0_model.h5'))
```