In [ ]:
```
import os
import cv2
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
import splitfolders
from sklearn.model_selection import GridSearchCV
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.ensemble import GradientBoostingClassifier
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, AveragePo
from tensorflow.keras.utils import to_categorical
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.layers import LeakyReLU
```

In [ ]:
```
# Function to extract features from images
def extract_features(image_path):
    image = cv2.imread(image_path, cv2.IMREAD_GRAYSCALE)
    resized_image = cv2.resize(image, (32, 32))  # Resize the image to a fixed size
    flattened_image = resized_image.flatten()  # Flatten the image into a 1D array
    return flattened_image
```

In [ ]:
```
# Split dataset into training and testing sets
input_dataset = "datasets/screws"
output_dataset = "datasets/screws"
splitfolders.ratio(input_dataset, output=output_dataset, seed=42, ratio=(.8, .2), g

# Load training and testing datasets
train_dataset = os.path.join(output_dataset, "train")
test_dataset = os.path.join(output_dataset, "val")
```

```
Copying files: 300 files [00:00, 528.05 files/s]
```

In [ ]:
```
# Load training data
X_train = []
y_train = []
for root, dirs, files in os.walk(train_dataset):
    for filename in files:
        image_path = os.path.join(root, filename)
        label = os.path.basename(root)
        X_train.append(extract_features(image_path))
        y_train.append(label)
```

In [ ]:
```
# Load testing data
X_test = []
y_test = []
for root, dirs, files in os.walk(test_dataset):
    for filename in files:
        image_path = os.path.join(root, filename)
        label = os.path.basename(root)
        X_test.append(extract_features(image_path))
        y_test.append(label)
```

In [ ]:
```
# Convert lists to numpy arrays
X_train = np.array(X_train)
y_train = np.array(y_train)
X_test = np.array(X_test)
y_test = np.array(y_test)
```

In [ ]:
```
# Define hyperparameters to tune
param_grid = {
    'C': [0.001, 0.01, 0.1, 1, 10, 100, 1000],
    'solver': ['newton-cg', 'lbfgs', 'liblinear', 'sag', 'saga'],
}


# Initialize and train Logistic Regression model
model = LogisticRegression(max_iter=10000)
```

In [ ]:
```
# Initialize GridSearchCV
grid_search = GridSearchCV(estimator=model, param_grid=param_grid, cv=5, scoring='a
```

In [ ]:
```
# Perform grid search to find the best hyperparameters
grid_search.fit(X_train, y_train)
```

Out[ ]:

▸ GridSearchCV i ?

▸ estimator: LogisticRegression

▸ LogisticRegression ?

In [ ]:
```
# Get the best hyperparameters and the corresponding accuracy
best_params = grid_search.best_params_
best_accuracy = grid_search.best_score_

print("Best Hyperparameters:", best_params)
print("Best Accuracy:", best_accuracy)

# Use the best model for prediction
best_model = grid_search.best_estimator_
y_pred = best_model.predict(X_test)

# Evaluate model performance
accuracy = accuracy_score(y_test, y_pred)
print("Test Accuracy:", accuracy)
```

```
Best Hyperparameters: {'C': 0.001, 'solver': 'sag'}
Best Accuracy: 0.8166666666666668
Test Accuracy: 0.7833333333333333
```

Not great, lets try other models, starting with Random Forest

In [ ]:
```python
# Define hyperparameters to tune
param_grid = {
    'n_estimators': [50, 100, 150],
    'max_depth': [None, 10, 20],
    'min_samples_split': [2, 5, 10],
}

# Initialize Random Forest model
model = RandomForestClassifier(random_state=42)
```

In [ ]:
```python
# Initialize GridSearchCV
grid_search = GridSearchCV(estimator=model, param_grid=param_grid, cv=5, scoring='a

# Perform grid search to find the best hyperparameters
grid_search.fit(X_train, y_train)
```

Out[ ]:

▸ GridSearchCV i ?

▸ estimator: RandomForestClassifier

▸ RandomForestClassifier ?

In [ ]:
```python
# Get the best hyperparameters and the corresponding accuracy
best_params = grid_search.best_params_
best_accuracy = grid_search.best_score_

print("Best Hyperparameters:", best_params)
print("Best Accuracy:", best_accuracy)

# Use the best model for prediction
best_model = grid_search.best_estimator_
y_pred = best_model.predict(X_test)

# Evaluate model performance
accuracy = accuracy_score(y_test, y_pred)
print("Test Accuracy:", accuracy)
```

```
Best Hyperparameters: {'max_depth': None, 'min_samples_split': 5, 'n_estimators': 5
0}
Best Accuracy: 0.8375
Test Accuracy: 0.8333333333333334
```

Lets try Support Vector Machines

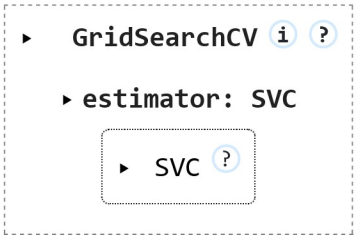
In [ ]:
```
# Define hyperparameters to tune
param_grid = {
    'C': [0.1, 1, 10],
    'gamma': [0.01, 0.1, 1],
    'kernel': ['linear', 'rbf'],
}

# Initialize SVM model
model = SVC()
```

In [ ]:
```
# Initialize GridSearchCV
grid_search = GridSearchCV(estimator=model, param_grid=param_grid, cv=5, scoring='a

# Perform grid search to find the best hyperparameters
grid_search.fit(X_train, y_train)
```

Out[ ]:



In [ ]:
```
# Get the best hyperparameters and the corresponding accuracy
best_params = grid_search.best_params_
best_accuracy = grid_search.best_score_

print("Best Hyperparameters:", best_params)
print("Best Accuracy:", best_accuracy)

# Use the best model for prediction
best_model = grid_search.best_estimator_
y_pred = best_model.predict(X_test)

# Evaluate model performance
accuracy = accuracy_score(y_test, y_pred)
print("Test Accuracy:", accuracy)
```

```
Best Hyperparameters: {'C': 0.1, 'gamma': 0.01, 'kernel': 'rbf'}
Best Accuracy: 0.8333333333333334
Test Accuracy: 0.8333333333333334
```

Lets try Gradient Boosting

In [ ]:
```
# Define hyperparameters to tune
param_grid = {
    'n_estimators': [50, 100, 150],
    'learning_rate': [0.05, 0.1, 0.2],
```

```
    'max_depth': [3, 4, 5],
}

# Initialize GBM model
model = GradientBoostingClassifier()
```

In [ ]:
```
# Initialize GridSearchCV
grid_search = GridSearchCV(estimator=model, param_grid=param_grid, cv=5, scoring='a

# Perform grid search to find the best hyperparameters
grid_search.fit(X_train, y_train)
```

Out[ ]:

▸ GridSearchCV

▸ estimator: GradientBoostingClassifier

▸ GradientBoostingClassifier

In [ ]:
```
# Get the best hyperparameters and the corresponding accuracy
best_params = grid_search.best_params_
best_accuracy = grid_search.best_score_

print("Best Hyperparameters:", best_params)
print("Best Accuracy:", best_accuracy)

# Use the best model for prediction
best_model = grid_search.best_estimator_
y_pred = best_model.predict(X_test)

# Evaluate model performance
accuracy = accuracy_score(y_test, y_pred)
print("Test Accuracy:", accuracy)
```

```
Best Hyperparameters: {'learning_rate': 0.05, 'max_depth': 3, 'n_estimators': 50}
Best Accuracy: 0.8125
Test Accuracy: 0.8333333333333334
```

Now lets try a CNN and see if that does better

In [ ]:
```
# Function to extract features from images
def extract_features(image_path):
    image = cv2.imread(image_path)
    resized_image = cv2.resize(image, (32, 32))  # Resize the image to a fixed size
    return resized_image
```

In [ ]:
```
# Load training data
X_train = []
y_train = []
for root, dirs, files in os.walk(train_dataset):
    for filename in files:
```

```
        image_path = os.path.join(root, filename)
        label = os.path.basename(root)  # Assuming class labels are encoded as fold
        X_train.append(extract_features(image_path))
        y_train.append(label)
```

In [ ]:
```
# Load testing data
X_test = []
y_test = []
for root, dirs, files in os.walk(test_dataset):
    for filename in files:
        image_path = os.path.join(root, filename)
        label = os.path.basename(root)  # Assuming class labels are encoded as fold
        X_test.append(extract_features(image_path))
        y_test.append(label)
```

In [ ]:
```
# Convert lists to numpy arrays
X_train = np.array(X_train)
X_test = np.array(X_test)
```

In [ ]:
```
# Normalize pixel values to the range [0, 1]
X_train = X_train / 255.0
X_test = X_test / 255.0
```

In [ ]:
```
# Initialize LabelEncoder
label_encoder = LabelEncoder()

# Fit and transform the training labels
y_train_encoded = label_encoder.fit_transform(y_train)

# Transform the testing labels
y_test_encoded = label_encoder.transform(y_test)

# One-hot encode the numerical labels
num_classes = len(np.unique(y_train_encoded))
y_train = to_categorical(y_train_encoded, num_classes)
y_test = to_categorical(y_test_encoded, num_classes)
```

In [ ]:
```
# Define the CNN architecture
model = Sequential([
    Conv2D(32, (3, 3), activation='tanh', padding='same', input_shape=(32, 32, 3)),
    MaxPooling2D((2, 2)),
    Conv2D(64, (3, 3), activation='tanh', padding='same'),
    MaxPooling2D((2, 2)),
    Conv2D(128, (3, 3), activation='tanh', padding='same'),
    MaxPooling2D((2, 2)),
    Conv2D(256, (3, 3), activation='tanh', padding='same'),
    MaxPooling2D((2, 2)),
    Conv2D(512, (3, 3), padding='same'),
    LeakyReLU(alpha=0.1),
    MaxPooling2D((2, 2)),
    Flatten(),
    Dense(64, activation='relu'),
    Dense(num_classes, activation='softmax')
])
```

In [ ]:
```
# Compile the model
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['accuracy

# Train the model
model.fit(X_train, y_train, epochs=10, batch_size=32, validation_data=(X_test, y_te
```

```
Epoch 1/10
8/8 [==============================] - 2s 188ms/step - loss: 1.0816 - accuracy: 0.72
92 - val_loss: 0.8125 - val_accuracy: 0.8333
Epoch 2/10
8/8 [==============================] - 1s 156ms/step - loss: 0.7922 - accuracy: 0.83
33 - val_loss: 0.7764 - val_accuracy: 0.8333
Epoch 3/10
8/8 [==============================] - 1s 143ms/step - loss: 0.7225 - accuracy: 0.83
33 - val_loss: 0.8215 - val_accuracy: 0.8333
Epoch 4/10
8/8 [==============================] - 1s 135ms/step - loss: 0.8069 - accuracy: 0.83
33 - val_loss: 0.7417 - val_accuracy: 0.8333
Epoch 5/10
8/8 [==============================] - 1s 174ms/step - loss: 0.7621 - accuracy: 0.83
33 - val_loss: 0.8420 - val_accuracy: 0.8333
Epoch 6/10
8/8 [==============================] - 1s 153ms/step - loss: 0.7837 - accuracy: 0.83
33 - val_loss: 0.8103 - val_accuracy: 0.8333
Epoch 7/10
8/8 [==============================] - 1s 153ms/step - loss: 0.8281 - accuracy: 0.83
33 - val_loss: 0.7295 - val_accuracy: 0.8333
Epoch 8/10
8/8 [==============================] - 1s 155ms/step - loss: 0.7402 - accuracy: 0.83
33 - val_loss: 0.7810 - val_accuracy: 0.8333
Epoch 9/10
8/8 [==============================] - 1s 143ms/step - loss: 0.7242 - accuracy: 0.83
33 - val_loss: 0.7630 - val_accuracy: 0.8333
Epoch 10/10
8/8 [==============================] - 1s 185ms/step - loss: 0.7345 - accuracy: 0.83
33 - val_loss: 0.7336 - val_accuracy: 0.8333
```

Out[ ]: <keras.callbacks.History at 0x1bd94692bc0>

In [ ]:
```
# Evaluate model performance
test_loss, test_accuracy = model.evaluate(X_test, y_test)
print("Test Loss:", test_loss)
print("Test Accuracy:", test_accuracy)
```

```
2/2 [==============================] - 0s 11ms/step - loss: 0.7336 - accuracy: 0.833
3
Test Loss: 0.7335733771324158
Test Accuracy: 0.8333333134651184
2/2 [==============================] - 0s 11ms/step - loss: 0.7336 - accuracy: 0.833
3
Test Loss: 0.7335733771324158
Test Accuracy: 0.8333333134651184
```