In [78]:
```
# Step 1: Import libraries
import os
import numpy as np
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from tensorflow.keras.preprocessing import image_dataset_from_directory
from tensorflow.keras import layers, models, Sequential
from tensorflow.keras.applications import ResNet50
from tensorflow.keras import layers, models
from sklearn.svm import SVC
from sklearn.metrics import accuracy_score
from tensorflow.keras.applications.resnet50 import preprocess_input, decode_predictions
from sklearn.model_selection import GridSearchCV
```

In [79]:
```
data_directory = "/Users/navd/Downloads/IndianCurrencyNotesDataset/AllImages"
batch_size = 32
image_size = (224, 224)
```

In [80]:
```
# Create a labeled dataset from a directory
train_data = image_dataset_from_directory(
    data_directory,
    labels="inferred",
    label_mode="int",
    image_size=image_size,
    batch_size=batch_size,
    validation_split=.2,
    subset="training",
    seed=123,
    shuffle=True
)

validation_data = image_dataset_from_directory(
    data_directory,
    labels="inferred",
    label_mode="int",
    image_size=image_size,
    batch_size=batch_size,
    validation_split=.2,
    subset="validation",
    seed=123,
    shuffle=True
)
```

```
Found 178 files belonging to 7 classes.
Using 143 files for training.
Found 178 files belonging to 7 classes.
Using 35 files for validation.
```

In [81]:
```
categories = train_data.class_names
plt.figure(figsize=(10, 10))
for images, labels in train_data.take(1):
    for i in range(9):
        ax = plt.subplot(3, 3, i + 1)
        plt.imshow(images[i].numpy().astype("uint8"))
        plt.title(categories[labels[i]])
        plt.axis("off")
plt.show()

data_augmentation = Sequential([
    layers.experimental.preprocessing.RandomFlip("horizontal"),
    layers.experimental.preprocessing.RandomRotation(0.2),
    layers.experimental.preprocessing.RandomZoom(0.2),
])
augmented_train_data = train_data.map(lambda x, y: (data_augmentation(x), y))
```

500 Note

50 Note

20 Note

In [82]:
```
# Step 4: Load pretrained ResNet50 model
resnet_model = ResNet50(
    include_top=False,
    weights="imagenet",
    input_shape=(224,224,3),
    pooling='avg',
    classes=7,
)
resnet_model.summary()
```

```
Model: "resnet50"

__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 input_13 (InputLayer)          [(None, 224, 224, 3)]  0         []

 conv1_pad (ZeroPadding2D)      (None, 230, 230, 3)  0           ['input_13[0][0]']

 conv1_conv (Conv2D)            (None, 112, 112, 64)  9472       ['conv1_pad[0][0]']

 conv1_bn (BatchNormalizati     (None, 112, 112, 64)  256        ['conv1_conv[0][0]']
 on)

 conv1_relu (Activation)        (None, 112, 112, 64)  0          ['conv1_bn[0][0]']

 pool1_pad (ZeroPadding2D)      (None, 114, 114, 64)  0          ['conv1_relu[0][0]']

 pool1_pool (MaxPooling2D)      (None, 56, 56, 64)   0           ['pool1_pad[0][0]']

 conv2_block1_1_conv (Conv2     (None, 56, 56, 64)   4160        ['pool1_pool[0][0]']
 D)

 conv2_block1_1_bn (BatchNo     (None, 56, 56, 64)   256         ['conv2_block1_1_conv[0][0]']
 rmalization)

 conv2_block1_1_relu (Activ     (None, 56, 56, 64)   0           ['conv2_block1_1_bn[0][0]']
 ation)
 conv2_block1_2_conv (Conv2  (None, 56, 56, 64)           36928     ['conv2_block1_1_relu[0][0]']
 D)

 conv2_block1_2_bn (BatchNo  (None, 56, 56, 64)           256       ['conv2_block1_2_conv[0][0]']
 rmalization)

 conv2_block1_2_relu (Activ  (None, 56, 56, 64)           0         ['conv2_block1_2_bn[0][0]']
 ation)

 conv2_block1_0_conv (Conv2  (None, 56, 56, 256)          16640     ['pool1_pool[0][0]']
 D)

 conv2_block1_3_conv (Conv2  (None, 56, 56, 256)          16640     ['conv2_block1_2_relu[0][0]']
 D)

 conv2_block1_0_bn (BatchNo  (None, 56, 56, 256)          1024      ['conv2_block1_0_conv[0][0]']
 rmalization)

 conv2_block1_3_bn (BatchNo  (None, 56, 56, 256)          1024      ['conv2_block1_3_conv[0][0]']
 rmalization)

 conv2_block1_add (Add)      (None, 56, 56, 256)          0         ['conv2_block1_0_bn[0][0]',
                                                                     'conv2_block1_3_bn[0][0]']

 conv2_block1_out (Activati  (None, 56, 56, 256)          0         ['conv2_block1_add[0][0]']
 on)

 conv2_block2_1_conv (Conv2  (None, 56, 56, 64)           16448     ['conv2_block1_out[0][0]']
 D)

 conv2_block2_1_bn (BatchNo  (None, 56, 56, 64)           256       ['conv2_block2_1_conv[0][0]']
 rmalization)

 conv2_block2_1_relu (Activ  (None, 56, 56, 64)           0         ['conv2_block2_1_bn[0][0]']
 ation)

 conv2_block2_2_conv (Conv2  (None, 56, 56, 64)           36928     ['conv2_block2_1_relu[0][0]']
                    D)

 conv2_block2_2_bn (BatchNo  (None, 56, 56, 64)           256       ['conv2_block2_2_conv[0][0]']
 rmalization)

 conv2_block2_2_relu (Activ  (None, 56, 56, 64)           0         ['conv2_block2_2_bn[0][0]']
 ation)

 conv2_block2_3_conv (Conv2  (None, 56, 56, 256)          16640     ['conv2_block2_2_relu[0][0]']
 D)

 conv2_block2_3_bn (BatchNo  (None, 56, 56, 256)          1024      ['conv2_block2_3_conv[0][0]']
 rmalization)

 conv2_block2_add (Add)      (None, 56, 56, 256)          0         ['conv2_block1_out[0][0]',
                                                                     'conv2_block2_3_bn[0][0]']

 conv2_block2_out (Activati  (None, 56, 56, 256)          0         ['conv2_block2_add[0][0]']
 on)

 conv2_block3_1_conv (Conv2  (None, 56, 56, 64)           16448     ['conv2_block2_out[0][0]']
 D)

 conv2_block3_1_bn (BatchNo  (None, 56, 56, 64)           256       ['conv2_block3_1_conv[0][0]']
 rmalization)

 conv2_block3_1_relu (Activ  (None, 56, 56, 64)           0         ['conv2_block3_1_bn[0][0]']
 ation)

 conv2_block3_2_conv (Conv2  (None, 56, 56, 64)           36928     ['conv2_block3_1_relu[0][0]']
 D)

 conv2_block3_2_bn (BatchNo  (None, 56, 56, 64)           256       ['conv2_block3_2_conv[0][0]']
 rmalization)

 conv2_block3_2_relu (Activ  (None, 56, 56, 64)           0         ['conv2_block3_2_bn[0][0]']
 ation)
 conv2_block3_3_conv (Conv2  (None, 56, 56, 256)          16640     ['conv2_block3_2_relu[0][0]']
 D)

 conv2_block3_3_bn (BatchNo  (None, 56, 56, 256)          1024      ['conv2_block3_3_conv[0][0]']
 rmalization)

 conv2_block3_add (Add)      (None, 56, 56, 256)          0         ['conv2_block2_out[0][0]',
                                                                     'conv2_block3_3_bn[0][0]']

 conv2_block3_out (Activati  (None, 56, 56, 256)          0         ['conv2_block3_add[0][0]']
 on)

 conv3_block1_1_conv (Conv2  (None, 28, 28, 128)          32896     ['conv2_block3_out[0][0]']
 D)

 conv3_block1_1_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block1_1_conv[0][0]']
 rmalization)

 conv3_block1_1_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block1_1_bn[0][0]']
 ation)

 conv3_block1_2_conv (Conv2  (None, 28, 28, 128)          147584    ['conv3_block1_1_relu[0][0]']
 D)

 conv3_block1_2_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block1_2_conv[0][0]']
 rmalization)

 conv3_block1_2_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block1_2_bn[0][0]']
 ation)

 conv3_block1_0_conv (Conv2  (None, 28, 28, 512)          131584    ['conv2_block3_out[0][0]']
 D)

 conv3_block1_3_conv (Conv2  (None, 28, 28, 512)          66048     ['conv3_block1_2_relu[0][0]']
 D)

 conv3_block1_0_bn (BatchNo  (None, 28, 28, 512)          2048      ['conv3_block1_0_conv[0][0]']
 rmalization)
 conv3_block1_3_bn (BatchNo  (None, 28, 28, 512)          2048      ['conv3_block1_3_conv[0][0]']
 rmalization)

 conv3_block1_add (Add)      (None, 28, 28, 512)          0         ['conv3_block1_0_bn[0][0]',
                                                                     'conv3_block1_3_bn[0][0]']

 conv3_block1_out (Activati  (None, 28, 28, 512)          0         ['conv3_block1_add[0][0]']
 on)

 conv3_block2_1_conv (Conv2  (None, 28, 28, 128)          65664     ['conv3_block1_out[0][0]']
 D)

 conv3_block2_1_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block2_1_conv[0][0]']
 rmalization)

 conv3_block2_1_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block2_1_bn[0][0]']
 ation)

 conv3_block2_2_conv (Conv2  (None, 28, 28, 128)          147584    ['conv3_block2_1_relu[0][0]']
 D)

 conv3_block2_2_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block2_2_conv[0][0]']
 rmalization)

 conv3_block2_2_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block2_2_bn[0][0]']
 ation)

 conv3_block2_3_conv (Conv2  (None, 28, 28, 512)          66048     ['conv3_block2_2_relu[0][0]']
 D)

 conv3_block2_3_bn (BatchNo  (None, 28, 28, 512)          2048      ['conv3_block2_3_conv[0][0]']
 rmalization)

 conv3_block2_add (Add)      (None, 28, 28, 512)          0         ['conv3_block1_out[0][0]',
                                                                     'conv3_block2_3_bn[0][0]']

 conv3_block2_out (Activati  (None, 28, 28, 512)          0         ['conv3_block2_add[0][0]']
 on)

 conv3_block3_1_conv (Conv2  (None, 28, 28, 128)          65664     ['conv3_block2_out[0][0]']
 D)

 conv3_block3_1_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block3_1_conv[0][0]']
 rmalization)

 conv3_block3_1_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block3_1_bn[0][0]']
 ation)

 conv3_block3_2_conv (Conv2  (None, 28, 28, 128)          147584    ['conv3_block3_1_relu[0][0]']
 D)

 conv3_block3_2_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block3_2_conv[0][0]']
 rmalization)

 conv3_block3_2_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block3_2_bn[0][0]']
 ation)

 conv3_block3_3_conv (Conv2  (None, 28, 28, 512)          66048     ['conv3_block3_2_relu[0][0]']
 D)

 conv3_block3_3_bn (BatchNo  (None, 28, 28, 512)          2048      ['conv3_block3_3_conv[0][0]']
 rmalization)

 conv3_block3_add (Add)      (None, 28, 28, 512)          0         ['conv3_block2_out[0][0]',
                                                                     'conv3_block3_3_bn[0][0]']

 conv3_block3_out (Activati  (None, 28, 28, 512)          0         ['conv3_block3_add[0][0]']
 on)

 conv3_block4_1_conv (Conv2  (None, 28, 28, 128)          65664     ['conv3_block3_out[0][0]']
 D)

 conv3_block4_1_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block4_1_conv[0][0]']
 rmalization)
 conv3_block4_1_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block4_1_bn[0][0]']
 ation)

 conv3_block4_2_conv (Conv2  (None, 28, 28, 128)          147584    ['conv3_block4_1_relu[0][0]']
 D)

 conv3_block4_2_bn (BatchNo  (None, 28, 28, 128)          512       ['conv3_block4_2_conv[0][0]']
 rmalization)

 conv3_block4_2_relu (Activ  (None, 28, 28, 128)          0         ['conv3_block4_2_bn[0][0]']
 ation)

 conv3_block4_3_conv (Conv2  (None, 28, 28, 512)          66048     ['conv3_block4_2_relu[0][0]']
 D)

 conv3_block4_3_bn (BatchNo  (None, 28, 28, 512)          2048      ['conv3_block4_3_conv[0][0]']
 rmalization)

 conv3_block4_add (Add)      (None, 28, 28, 512)          0         ['conv3_block3_out[0][0]',
                                                                     'conv3_block4_3_bn[0][0]']

 conv3_block4_out (Activati  (None, 28, 28, 512)          0         ['conv3_block4_add[0][0]']
 on)

 conv4_block1_1_conv (Conv2  (None, 14, 14, 256)          131328    ['conv3_block4_out[0][0]']
 D)

 conv4_block1_1_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block1_1_conv[0][0]']
 rmalization)

 conv4_block1_1_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block1_1_bn[0][0]']
 ation)

 conv4_block1_2_conv (Conv2  (None, 14, 14, 256)          590080    ['conv4_block1_1_relu[0][0]']
 D)

 conv4_block1_2_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block1_2_conv[0][0]']
 rmalization)
 conv4_block1_2_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block1_2_bn[0][0]']
 ation)

 conv4_block1_0_conv (Conv2  (None, 14, 14, 1024)         525312    ['conv3_block4_out[0][0]']
 D)

 conv4_block1_3_conv (Conv2  (None, 14, 14, 1024)         263168    ['conv4_block1_2_relu[0][0]']
 D)

 conv4_block1_0_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block1_0_conv[0][0]']
 rmalization)

 conv4_block1_3_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block1_3_conv[0][0]']
 rmalization)

 conv4_block1_add (Add)      (None, 14, 14, 1024)         0         ['conv4_block1_0_bn[0][0]',
                                                                     'conv4_block1_3_bn[0][0]']

 conv4_block1_out (Activati  (None, 14, 14, 1024)         0         ['conv4_block1_add[0][0]']
 on)

 conv4_block2_1_conv (Conv2  (None, 14, 14, 256)          262400    ['conv4_block1_out[0][0]']
 D)

 conv4_block2_1_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block2_1_conv[0][0]']
 rmalization)

 conv4_block2_1_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block2_1_bn[0][0]']
 ation)

 conv4_block2_2_conv (Conv2  (None, 14, 14, 256)          590080    ['conv4_block2_1_relu[0][0]']
 D)

 conv4_block2_2_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block2_2_conv[0][0]']
 rmalization)

 conv4_block2_2_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block2_2_bn[0][0]']
 ation)

 conv4_block2_3_conv (Conv2  (None, 14, 14, 1024)         263168    ['conv4_block2_2_relu[0][0]']
 D)

 conv4_block2_3_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block2_3_conv[0][0]']
 rmalization)

 conv4_block2_add (Add)      (None, 14, 14, 1024)         0         ['conv4_block1_out[0][0]',
                                                                     'conv4_block2_3_bn[0][0]']

 conv4_block2_out (Activati  (None, 14, 14, 1024)         0         ['conv4_block2_add[0][0]']
 on)

 conv4_block3_1_conv (Conv2  (None, 14, 14, 256)          262400    ['conv4_block2_out[0][0]']
 D)

 conv4_block3_1_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block3_1_conv[0][0]']
 rmalization)

 conv4_block3_1_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block3_1_bn[0][0]']
 ation)

 conv4_block3_2_conv (Conv2  (None, 14, 14, 256)          590080    ['conv4_block3_1_relu[0][0]']
 D)

 conv4_block3_2_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block3_2_conv[0][0]']
 rmalization)

 conv4_block3_2_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block3_2_bn[0][0]']
 ation)

 conv4_block3_3_conv (Conv2  (None, 14, 14, 1024)         263168    ['conv4_block3_2_relu[0][0]']
 D)

 conv4_block3_3_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block3_3_conv[0][0]']
 rmalization)
 conv4_block3_add (Add)      (None, 14, 14, 1024)         0         ['conv4_block2_out[0][0]',
                                                                     'conv4_block3_3_bn[0][0]']

 conv4_block3_out (Activati  (None, 14, 14, 1024)         0         ['conv4_block3_add[0][0]']
 on)

 conv4_block4_1_conv (Conv2  (None, 14, 14, 256)          262400    ['conv4_block3_out[0][0]']
 D)

 conv4_block4_1_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block4_1_conv[0][0]']
 rmalization)

 conv4_block4_1_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block4_1_bn[0][0]']
 ation)

 conv4_block4_2_conv (Conv2  (None, 14, 14, 256)          590080    ['conv4_block4_1_relu[0][0]']
 D)

 conv4_block4_2_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block4_2_conv[0][0]']
 rmalization)

 conv4_block4_2_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block4_2_bn[0][0]']
 ation)

 conv4_block4_3_conv (Conv2  (None, 14, 14, 1024)         263168    ['conv4_block4_2_relu[0][0]']
 D)

 conv4_block4_3_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block4_3_conv[0][0]']
 rmalization)

 conv4_block4_add (Add)      (None, 14, 14, 1024)         0         ['conv4_block3_out[0][0]',
                                                                     'conv4_block4_3_bn[0][0]']

 conv4_block4_out (Activati  (None, 14, 14, 1024)         0         ['conv4_block4_add[0][0]']
 on)

 conv4_block5_1_conv (Conv2  (None, 14, 14, 256)          262400    ['conv4_block4_out[0][0]']
 D)
 conv4_block5_1_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block5_1_conv[0][0]']
 rmalization)

 conv4_block5_1_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block5_1_bn[0][0]']
 ation)

 conv4_block5_2_conv (Conv2  (None, 14, 14, 256)          590080    ['conv4_block5_1_relu[0][0]']
 D)

 conv4_block5_2_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block5_2_conv[0][0]']
 rmalization)

 conv4_block5_2_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block5_2_bn[0][0]']
 ation)

 conv4_block5_3_conv (Conv2  (None, 14, 14, 1024)         263168    ['conv4_block5_2_relu[0][0]']
 D)

 conv4_block5_3_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block5_3_conv[0][0]']
 rmalization)

 conv4_block5_add (Add)      (None, 14, 14, 1024)         0         ['conv4_block4_out[0][0]',
                                                                     'conv4_block5_3_bn[0][0]']

 conv4_block5_out (Activati  (None, 14, 14, 1024)         0         ['conv4_block5_add[0][0]']
 on)

 conv4_block6_1_conv (Conv2  (None, 14, 14, 256)          262400    ['conv4_block5_out[0][0]']
 D)

 conv4_block6_1_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block6_1_conv[0][0]']
 rmalization)

 conv4_block6_1_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block6_1_bn[0][0]']
 ation)

 conv4_block6_2_conv (Conv2  (None, 14, 14, 256)          590080    ['conv4_block6_1_relu[0][0]']
 D)

 conv4_block6_2_bn (BatchNo  (None, 14, 14, 256)          1024      ['conv4_block6_2_conv[0][0]']
 rmalization)

 conv4_block6_2_relu (Activ  (None, 14, 14, 256)          0         ['conv4_block6_2_bn[0][0]']
 ation)

 conv4_block6_3_conv (Conv2  (None, 14, 14, 1024)         263168    ['conv4_block6_2_relu[0][0]']
 D)

 conv4_block6_3_bn (BatchNo  (None, 14, 14, 1024)         4096      ['conv4_block6_3_conv[0][0]']
 rmalization)

 conv4_block6_add (Add)      (None, 14, 14, 1024)         0         ['conv4_block5_out[0][0]',
                                                                     'conv4_block6_3_bn[0][0]']

 conv4_block6_out (Activati  (None, 14, 14, 1024)         0         ['conv4_block6_add[0][0]']
 on)

 conv5_block1_1_conv (Conv2  (None, 7, 7, 512)            524800    ['conv4_block6_out[0][0]']
 D)

 conv5_block1_1_bn (BatchNo  (None, 7, 7, 512)            2048      ['conv5_block1_1_conv[0][0]']
 rmalization)

 conv5_block1_1_relu (Activ  (None, 7, 7, 512)            0         ['conv5_block1_1_bn[0][0]']
 ation)

 conv5_block1_2_conv (Conv2  (None, 7, 7, 512)            2359808   ['conv5_block1_1_relu[0][0]']
 D)

 conv5_block1_2_bn (BatchNo  (None, 7, 7, 512)            2048      ['conv5_block1_2_conv[0][0]']
 rmalization)

 conv5_block1_2_relu (Activ  (None, 7, 7, 512)            0         ['conv5_block1_2_bn[0][0]']
 ation)
 conv5_block1_0_conv (Conv2  (None, 7, 7, 2048)           2099200   ['conv4_block6_out[0][0]']
 D)

 conv5_block1_3_conv (Conv2  (None, 7, 7, 2048)           1050624   ['conv5_block1_2_relu[0][0]']
 D)

 conv5_block1_0_bn (BatchNo  (None, 7, 7, 2048)           8192      ['conv5_block1_0_conv[0][0]']
 rmalization)

 conv5_block1_3_bn (BatchNo  (None, 7, 7, 2048)           8192      ['conv5_block1_3_conv[0][0]']
 rmalization)

 conv5_block1_add (Add)      (None, 7, 7, 2048)           0         ['conv5_block1_0_bn[0][0]',
                                                                     'conv5_block1_3_bn[0][0]']

 conv5_block1_out (Activati  (None, 7, 7, 2048)           0         ['conv5_block1_add[0][0]']
 on)

 conv5_block2_1_conv (Conv2  (None, 7, 7, 512)            1049088   ['conv5_block1_out[0][0]']
 D)

 conv5_block2_1_bn (BatchNo  (None, 7, 7, 512)            2048      ['conv5_block2_1_conv[0][0]']
 rmalization)

 conv5_block2_1_relu (Activ  (None, 7, 7, 512)            0         ['conv5_block2_1_bn[0][0]']
 ation)

 conv5_block2_2_conv (Conv2  (None, 7, 7, 512)            2359808   ['conv5_block2_1_relu[0][0]']
 D)

 conv5_block2_2_bn (BatchNo  (None, 7, 7, 512)            2048      ['conv5_block2_2_conv[0][0]']
 rmalization)

 conv5_block2_2_relu (Activ  (None, 7, 7, 512)            0         ['conv5_block2_2_bn[0][0]']
 ation)

 conv5_block2_3_conv (Conv2  (None, 7, 7, 2048)           1050624   ['conv5_block2_2_relu[0][0]']
 D)
 conv5_block2_3_bn (BatchNo  (None, 7, 7, 2048)           8192      ['conv5_block2_3_conv[0][0]']
 rmalization)

 conv5_block2_add (Add)      (None, 7, 7, 2048)           0         ['conv5_block1_out[0][0]',
                                                                     'conv5_block2_3_bn[0][0]']

 conv5_block2_out (Activati  (None, 7, 7, 2048)           0         ['conv5_block2_add[0][0]']
 on)

 conv5_block3_1_conv (Conv2  (None, 7, 7, 512)            1049088   ['conv5_block2_out[0][0]']
 D)

 conv5_block3_1_bn (BatchNo  (None, 7, 7, 512)            2048      ['conv5_block3_1_conv[0][0]']
 rmalization)

 conv5_block3_1_relu (Activ  (None, 7, 7, 512)            0         ['conv5_block3_1_bn[0][0]']
 ation)

 conv5_block3_2_conv (Conv2  (None, 7, 7, 512)            2359808   ['conv5_block3_1_relu[0][0]']
 D)

 conv5_block3_2_bn (BatchNo  (None, 7, 7, 512)            2048      ['conv5_block3_2_conv[0][0]']
 rmalization)

 conv5_block3_2_relu (Activ  (None, 7, 7, 512)            0         ['conv5_block3_2_bn[0][0]']
 ation)

 conv5_block3_3_conv (Conv2  (None, 7, 7, 2048)           1050624   ['conv5_block3_2_relu[0][0]']
 D)

 conv5_block3_3_bn (BatchNo  (None, 7, 7, 2048)           8192      ['conv5_block3_3_conv[0][0]']
 rmalization)

 conv5_block3_add (Add)      (None, 7, 7, 2048)           0         ['conv5_block2_out[0][0]',
                                                                     'conv5_block3_3_bn[0][0]']

 conv5_block3_out (Activati  (None, 7, 7, 2048)           0         ['conv5_block3_add[0][0]']
 on)

 avg_pool (GlobalAveragePoo  (None, 2048)                 0         ['conv5_block3_out[0][0]']
 ling2D)

==================================================================================================
Total params: 23587712 (89.98 MB)
Trainable params: 23534592 (89.78 MB)
Non-trainable params: 53120 (207.50 KB)
__________________________________________________________________________________________________
```

In [83]:
```
features_list = []
labels_list = []

for images, labels in augmented_train_data:
    preprocessed_images = preprocess_input(images)

    features = resnet_model.predict(preprocessed_images)

    features_list.append(features)
    labels_list.append(labels.numpy())
features_array = np.concatenate(features_list, axis=0)
labels_array = np.concatenate(labels_list, axis=0)

print("Shape of features array:", features_array.shape)
print("Shape of labels array:", labels_array.shape)
```

```
1/1 [==============================] - 1s 1s/step
1/1 [==============================] - 1s 839ms/step
1/1 [==============================] - 1s 815ms/step
1/1 [==============================] - 1s 786ms/step
1/1 [==============================] - 1s 641ms/step
Shape of features array: (143, 2048)
Shape of labels array: (143,)
```

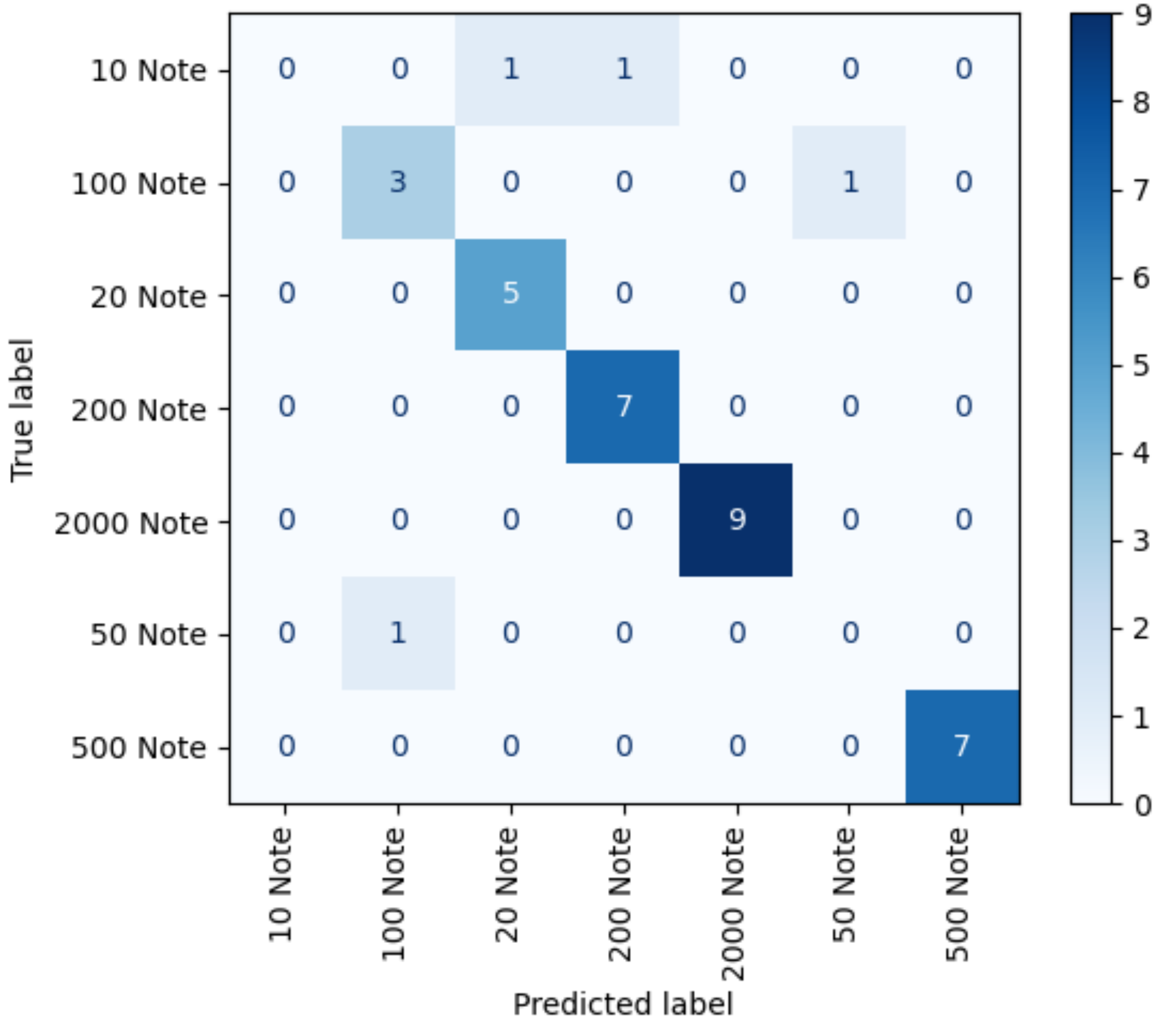
In [84]:
```
test_features_list = []
test_labels_list = []
# Extract features and labels
for images, labels in validation_data:
    # Preprocess images for ResNet50 model
    preprocessed_images = preprocess_input(images)

    # Extract features using the pre-trained ResNet50 model
    features = resnet_model.predict(preprocessed_images)

    # Append features and labels to the lists
    test_features_list.append(features)
    test_labels_list.append(labels.numpy())

# Convert lists to NumPy arrays
test_features_array = np.concatenate(test_features_list, axis=0)
test_labels_array = np.concatenate(test_labels_list, axis=0)

# Display the shapes of the extracted features and labels
print("Shape of features array:", test_features_array.shape)
print("Shape of labels array:", test_labels_array.shape)
```

```
1/1 [==============================] - 1s 818ms/step
1/1 [==============================] - 0s 110ms/step
Shape of features array: (35, 2048)
Shape of labels array: (35,)
```

In [85]:
```
# Define the parameter grid to search
parameter_grid = {
    'C': [0.1, 1, 10, 100],  # You can adjust the range of C values
    'kernel': ['linear', 'rbf', 'poly', 'sigmoid'],  # You can adjust the list of kernel functions
}

# Create an SVM classifier
svm_classifier = SVC()

# Create the GridSearchCV object
```

```
grid_search_cv = GridSearchCV(svm_classifier, parameter_grid, cv=5, scoring='accuracy')

# Perform the grid search on your training data
grid_search_cv.fit(features_array, labels_array)

# Print the best hyperparameters and corresponding accuracy
print("Best Hyperparameters:", grid_search_cv.best_params_)
print("Best Accuracy:", grid_search_cv.best_score_)

# Get the best model from the grid search
best_svm_classifier = grid_search_cv.best_estimator_

# Make predictions on the test set using the best model
best_predictions = best_svm_classifier.predict(test_features_array)

# Calculate accuracy and print confusion matrix for the best model
best_accuracy = accuracy_score(test_labels_array, best_predictions)
print(f'Best Model Accuracy: {best_accuracy * 100:.2f}%')

best_confusion_matrix = confusion_matrix(test_labels_array, best_predictions)

plt.figure(figsize=(8, 6))

best_confusion_matrix_display = ConfusionMatrixDisplay(confusion_matrix=best_confusion_matrix, display_labels=cat

best_confusion_matrix_display.plot(cmap=plt.cm.Blues, xticks_rotation=90)

plt.show()
```

```
Best Hyperparameters: {'C': 0.1, 'kernel': 'linear'}
Best Accuracy: 0.8669950738916257
Best Model Accuracy: 88.57%
<Figure size 800x600 with 0 Axes>
```


True label
Predicted label
10 Note
100 Note
20 Note
200 Note
2000 Note
50 Note
500 Note
0 0 1 1 0 0 0
0 3 0 0 0 1 0
0 0 5 0 0 0 0
0 0 0 7 0 0 0
0 0 0 0 9 0 0
0 1 0 0 0 0 0
0 0 0 0 0 0 7
0 1 2 3 4 5 6 7 8 9

```
In [86]: correctly_classified_indices = np.where(test_labels_array == best_predictions)[0]
         num_correctly_classified_images = min(9, len(correctly_classified_indices))

         plt.figure(figsize=(12, 12))
         for i in range(num_correctly_classified_images):
             ax = plt.subplot(3, 3, i + 1)
             index = correctly_classified_indices[i]
             img, actual_label = val_dataset.unbatch().skip(index).take(1).as_numpy_iterator().next()
             img = img.astype("uint8")
             predicted_label = class_names[best_predictions[index]]

             plt.imshow(img)
             plt.title(f'Actual: {class_names[actual_label]}\nPredicted: {predicted_label}')
             plt.axis("off")
         plt.suptitle("Some correctly classified images")
         plt.show()
```

Some correctly classified images

Actual: 100 Note
Predicted: 100 Note

Actual: 20 Note
Predicted: 200 Note

Actual: 200 Note
Predicted: 2000 Note

Actual: 2000 Note
Predicted: 2000 Note

Actual: 500 Note
Predicted: 500 Note

Actual: 500 Note
Predicted: 2000 Note

Actual: 10 Note
Predicted: 100 Note

Actual: 20 Note
Predicted: 500 Note

Actual: 200 Note
Predicted: 100 Note

In [87]:
```
wrongly_classified_indices = np.where(test_labels_array != best_predictions)[0]
num_wrongly_classified_images = min(9, len(wrongly_classified_indices))

plt.figure(figsize=(12, 12))
for i in range(num_wrongly_classified_images):
    ax = plt.subplot(3, 3, i + 1)
    index = wrongly_classified_indices[i]
    img, actual_label = val_dataset.unbatch().skip(index).take(1).as_numpy_iterator().next()
    img = img.astype("uint8")
    predicted_label = class_names[best_predictions[index]]

    plt.imshow(img)
    plt.title(f'Actual: {class_names[actual_label]}\nPredicted: {predicted_label}')
    plt.axis("off")
plt.suptitle("some wronlgy classified images")
plt.show()
```

some wronlgy classified images

Actual: 2000 Note
Predicted: 100 Note

Actual: 50 Note
Predicted: 200 Note

Actual: 2000 Note
Predicted: 20 Note

Actual: 2000 Note
Predicted: 50 Note

```
In [ ]:
```

```
In [ ]:
```

```
In [ ]:
```