Import

In [201…

```
import random

import numpy as np
import pandas as pd

from PIL import Image

import torch
from torch import nn
from torchvision.datasets import ImageFolder
from torch.utils.data import DataLoader
from torcheval.metrics.functional import multiclass_f1_score

import torchvision.transforms as tfs
from torchvision.models import vit_b_16, ViT_B_16_Weights, regnet, efficientnet_
    ResNet50_Weights, convnext_base, ConvNeXt_Base_Weights, regnet_x_16gf, RegNe
from torchvision.utils import make_grid

import lightning.pytorch as pl
from lightning.pytorch.loggers import TensorBoardLogger, WandbLogger

from transformers import ViTFeatureExtractor
from transformers import ViTForImageClassification, ViTImageProcessor
from transformers import TrainingArguments
from transformers import Trainer

from sklearn.metrics import confusion_matrix

import wandb
from tqdm.auto import tqdm

import seaborn as sns
import matplotlib.pyplot as plt

from datasets import load_dataset

from evaluate import load

import csv
import os
```

Constants

Dataset is available at the link:
https://drive.google.com/file/d/1ImAdVuWzqT5OT40qBxV1tVSoFDEAeeKy/view?usp=sharing

In [2]:

```
TRAIN = 'D:/woodhack/train/'
VAL = 'D:/woodhack/val/'
TEST = 'D:/woodhack/test/'
LEARNING_RATE = 3e-4
```

```
BATCH_SIZE = 16
IMG_SIZE = 256
device = "cuda" if torch.cuda.is_available() else "cpu"
```

In [6]:
```
pl.seed_everything(42)
```

```
Global seed set to 42
```

Out[6]: 42

ViT

Data

Overview

Load train and val datasets from disk

In [3]:
```
train_ds = load_dataset("imagefolder", data_dir=TRAIN)
train_ds
```

Resolving data files: 528/528 [00:00<00:00, 42376.44it/s]

100%

```
Found cached dataset imagefolder (C:/Users/melik/.cache/huggingface/datasets/imagefolder/default-fa8f3fe944beb9c6/0.0.0/37fbb85cc714a338bea574ac6c7d0b5be5aff46c1862c1989b20e0771199e93f)
```

100% 1/1 [00:00<00:00, 60.07it/s]

Out[3]:
```
DatasetDict({
    train: Dataset({
        features: ['image', 'label'],
        num_rows: 528
    })
})
```

In [4]:
```
val_ds = load_dataset("imagefolder", data_dir=VAL)
val_ds
```

Resolving data files: 50/50 [00:00<00:00, 4471.16it/s]

100%

```
Found cached dataset imagefolder (C:/Users/melik/.cache/huggingface/datasets/imagefolder/default-52cbcd16184219aa/0.0.0/37fbb85cc714a338bea574ac6c7d0b5be5aff46c1862c1989b20e0771199e93f)
```

100% 1/1 [00:00<00:00, 69.13it/s]

Out[4]:
```
DatasetDict({
    train: Dataset({
        features: ['image', 'label'],
        num_rows: 50
    })
})
```

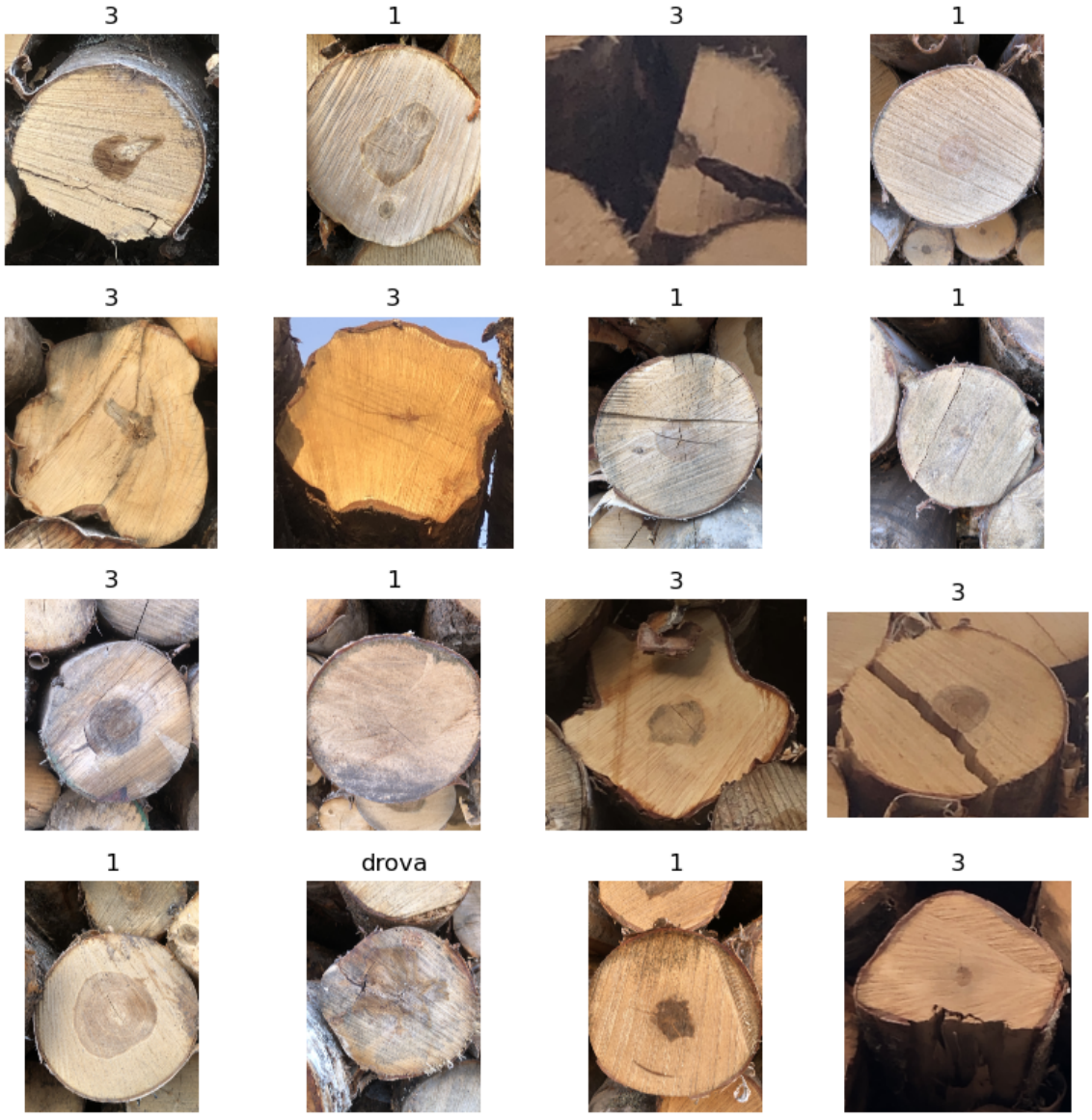
Look at the examples

In [6]:
```
def show_image_grid(dataset, split, grid_size=(4,4)):
    # Select random images from the given split
    indices = random.sample(range(len(dataset[split])), grid_size[0]*grid_size[1
    images = [dataset[split][i]["image"] for i in indices]
    labels = [dataset[split][i]["label"] for i in indices]

    # Display the images in a grid
    fig, axes = plt.subplots(nrows=grid_size[0], ncols=grid_size[1], figsize=(8,
    for i, ax in enumerate(axes.flat):
        ax.imshow(images[i])
        ax.axis('off')
        ax.set_title(dataset["train"].features["label"].int2str(labels[i]))

    plt.tight_layout()
    plt.show()

show_image_grid(train_ds, 'train')
```



Preprocess

Prepare datasets for input to model

In [7]:
```
def transform(examples):
    inputs = image_processor([img.convert("RGB") for img in examples["image"]],
    if 'label' in examples.keys():
        inputs["labels"] = examples["label"]
    return inputs
```

In [11]:
```
prepared_train_ds = train_ds.with_transform(transform)
prepared_train_ds
```

Out[11]:
```
DatasetDict({
    train: Dataset({
        features: ['image', 'label'],
        num_rows: 528
    })
})
```

In [13]:
```
prepared_val_ds = val_ds.with_transform(transform)
prepared_val_ds
```

Out[13]:
```
DatasetDict({
    train: Dataset({
        features: ['image', 'label'],
        num_rows: 50
    })
})
```

In [14]:
```
def collate_fn(batch):
    # print(batch)
    return {
        'pixel_values': torch.stack([x['pixel_values'] for x in batch]),
        'labels': torch.tensor([x['labels'] for x in batch])
    }
```

Metrics

Load metrics and write function to compute them

In [15]:
```
# load the accuracy and f1 metrics from the evaluate module
accuracy = load("accuracy")
f1 = load("f1")

def compute_metrics(eval_pred):
    # compute the accuracy and f1 scores & return them
    accuracy_score = accuracy.compute(predictions=np.argmax(eval_pred.predictior
    f1_score = f1.compute(predictions=np.argmax(eval_pred.predictions, axis=1),
    return {**accuracy_score, **f1_score}
```

Training

Model

Download pretrained ViT and modify it for custom dataset

In [ ]:
```
# the model name
model_name = "google/vit-base-patch16-224"
# load the image processor
image_processor = ViTImageProcessor.from_pretrained(model_name)
# loading the pre-trained model
model = ViTForImageClassification.from_pretrained(model_name)
model.classifier = nn.Linear(in_features=768, out_features=3, bias=True)
model.num_labels = 3
None
```

In [ ]:
```
# the model name
model_name = "google/vit-base-patch16-224"
# load the image processor
image_processor = ViTImageProcessor.from_pretrained(model_name)
# loading the pre-trained model
model = ViTForImageClassification.from_pretrained(model_name)
model.classifier = nn.Linear(in_features=768, out_features=3, bias=True)
model.num_labels = 3
```

Train

In [40]:
```
training_args = TrainingArguments(
    output_dir="./vit-wood-classification",
    per_device_train_batch_size=8,
    evaluation_strategy="steps",
    num_train_epochs=1,
    eval_steps=11,
    save_steps=11,
    logging_steps=1,
    save_total_limit=2,
    remove_unused_columns=False,
    push_to_hub=False,
    report_to='wandb',
    load_best_model_at_end=True,
)
```

```
PyTorch: setting up devices
```

In [41]:
```
trainer = Trainer(
    model=model,
    args=training_args,
    data_collator=collate_fn,
    compute_metrics=compute_metrics,
    train_dataset=prepared_train_ds["train"],
    eval_dataset=prepared_val_ds["train"],
    tokenizer=image_processor,
)
```

In [42]:
```
train_results = trainer.train()
```

```
C:\Users\melik\anaconda3\lib\site-packages\transformers\optimization.py:306: Fu
tureWarning: This implementation of AdamW is deprecated and will be removed in
a future version. Use the PyTorch implementation torch.optim.AdamW instead, or
set `no_deprecation_warning=True` to disable this warning
  warnings.warn(
***** Running training *****
  Num examples = 528
  Num Epochs = 1
  Instantaneous batch size per device = 8
  Total train batch size (w. parallel, distributed & accumulation) = 8
  Gradient Accumulation steps = 1
  Total optimization steps = 66
  Number of trainable parameters = 85800963
Automatic Weights & Biases logging enabled, to disable set os.environ["WANDB_DI
SABLED"] = "true"
```

[66/66 20:30, Epoch 1/1]

Step	Training Loss	Validation Loss	Accuracy	F1
11	0.139900	0.297837	0.900000	0.625000
22	0.518600	0.278983	0.920000	0.852174
33	0.158400	0.191067	0.960000	0.912593
44	0.049200	0.111700	0.980000	0.944974
55	0.013900	0.109532	0.980000	0.985790
66	0.809500	0.111577	0.960000	0.930427

```
***** Running Evaluation *****
  Num examples = 50
  Batch size = 8
Saving model checkpoint to ./vit-wood-classification\checkpoint-11
Configuration saved in ./vit-wood-classification\checkpoint-11\config.json
Model weights saved in ./vit-wood-classification\checkpoint-11\pytorch_model.bi
n
Image processor saved in ./vit-wood-classification\checkpoint-11\preprocessor_c
onfig.json
***** Running Evaluation *****
  Num examples = 50
  Batch size = 8
Saving model checkpoint to ./vit-wood-classification\checkpoint-22
Configuration saved in ./vit-wood-classification\checkpoint-22\config.json
Model weights saved in ./vit-wood-classification\checkpoint-22\pytorch_model.bi
n
Image processor saved in ./vit-wood-classification\checkpoint-22\preprocessor_c
onfig.json
***** Running Evaluation *****
  Num examples = 50
  Batch size = 8
Saving model checkpoint to ./vit-wood-classification\checkpoint-33
Configuration saved in ./vit-wood-classification\checkpoint-33\config.json
Model weights saved in ./vit-wood-classification\checkpoint-33\pytorch_model.bi
n
Image processor saved in ./vit-wood-classification\checkpoint-33\preprocessor_c
onfig.json
Deleting older checkpoint [vit-wood-classification\checkpoint-11] due to args.s
ave_total_limit
***** Running Evaluation *****
  Num examples = 50
  Batch size = 8
Saving model checkpoint to ./vit-wood-classification\checkpoint-44
Configuration saved in ./vit-wood-classification\checkpoint-44\config.json
Model weights saved in ./vit-wood-classification\checkpoint-44\pytorch_model.bi
n
Image processor saved in ./vit-wood-classification\checkpoint-44\preprocessor_c
onfig.json
Deleting older checkpoint [vit-wood-classification\checkpoint-22] due to args.s
ave_total_limit
***** Running Evaluation *****
  Num examples = 50
  Batch size = 8
Saving model checkpoint to ./vit-wood-classification\checkpoint-55
Configuration saved in ./vit-wood-classification\checkpoint-55\config.json
Model weights saved in ./vit-wood-classification\checkpoint-55\pytorch_model.bi
n
Image processor saved in ./vit-wood-classification\checkpoint-55\preprocessor_c
onfig.json
Deleting older checkpoint [vit-wood-classification\checkpoint-33] due to args.s
ave_total_limit
***** Running Evaluation *****
  Num examples = 50
  Batch size = 8
Saving model checkpoint to ./vit-wood-classification\checkpoint-66
Configuration saved in ./vit-wood-classification\checkpoint-66\config.json
Model weights saved in ./vit-wood-classification\checkpoint-66\pytorch_model.bi
n
Image processor saved in ./vit-wood-classification\checkpoint-66\preprocessor_c
onfig.json
```

```
Deleting older checkpoint [vit-wood-classification\checkpoint-44] due to args.save_total_limit


Training completed. Do not forget to share your model on huggingface.co/models =)


Loading best model from ./vit-wood-classification\checkpoint-55 (score: 0.10953225940465927).
```

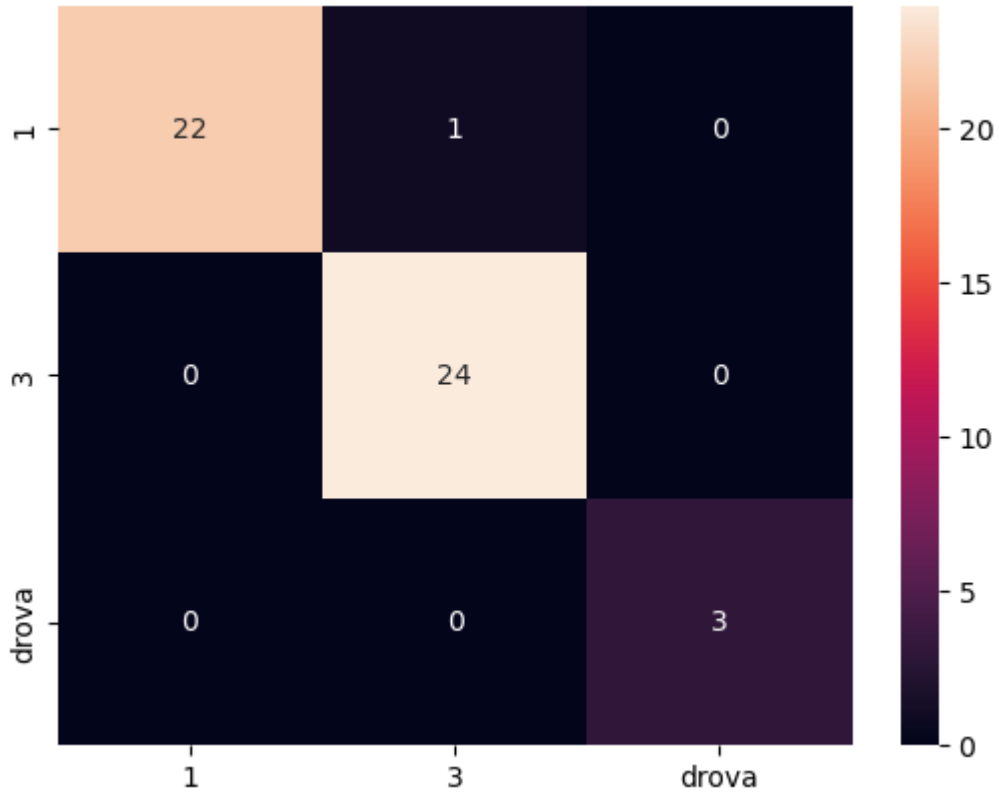
Confusion matrix

In [210…
```
labels = train_ds['train'].features['label'].names
id2label = {i: c for i, c in enumerate(labels)}
id2label
```

Out[210]:
```
{0: '1', 1: '3', 2: 'drova'}
```

In [211…
```
y_true = []
y_pred = []
for i in range(len(prepared_val_ds['train'])):
    pixel_values = prepared_val_ds['train'][i]['pixel_values']
    label = prepared_val_ds['train'][i]['labels']
    pred = model(pixel_values.unsqueeze(0)).logits.argmax().item()
    y_true.append(id2label[label])
    y_pred.append(id2label[pred])
```

In [214…
```
df = pd.DataFrame(confusion_matrix(y_true, y_pred),
                  index = [i for i in labels],
                  columns = [i for i in labels])
sns.heatmap(df, annot=True)
None
```



The only mistake made by neural network

In [218…

```
for i in range(len(prepared_val_ds['train'])):
    pixel_values = prepared_val_ds['train'][i]['pixel_values']
    label = prepared_val_ds['train'][i]['labels']
    pred = model(pixel_values.unsqueeze(0)).logits.argmax().item()
    if label != pred:
        print(i)
        break
```

4

In [228…

```
plt.imshow(val_ds['train'][4]['image'])
plt.axis('off')
None
```

Predict

Image classification on test dataset without labels

In [55]:
```
test_dataset = load_dataset("imagefolder", data_dir=TEST)
prepared_test_dataset = test_dataset.with_transform(transform)
prepared_test_dataset
```

Resolving data files: 100% 249/249 [00:00<00:00, 6606.25it/s]

```
Found cached dataset imagefolder (C:/Users/melik/.cache/huggingface/datasets/imagefolder/default-7593e68df80c91ee/0.0.0/37fbb85cc714a338bea574ac6c7d0b5be5aff46c1862c1989b20e0771199e93f)
```

100% 1/1 [00:00<00:00, 19.30it/s]

Out[55]:
```
DatasetDict({
    train: Dataset({
        features: ['image'],
        num_rows: 249
    })
})
```

In [95]:
```
idx2label = {i: label for i, label in enumerate(train_ds['train'].features['labe
idx2label[2] = 0
```

In [156…
```
idx2label
```

Out[156]:
```
{0: '1', 1: '3', 2: 0}
```

In [149…
```
preds = []
for file in tqdm(sorted(os.listdir(TEST), key=lambda x: int(x[:x.find('.')]))):
    image = Image.open(TEST + file)
```

```
    image = image_processor(image, return_tensors="pt")
    pred = model(image['pixel_values']).logits
    preds.append(idx2label[pred.argmax().item()])
```

100% 249/249 [03:49<00:00, 1.03it/s]

In [150…
```
with open('submission.csv','w', newline='\n') as csvfile:
    writer = csv.writer(csvfile, delimiter=',',
                        quotechar='|', quoting=csv.QUOTE_MINIMAL)
    writer.writerow(['id', 'class'])
    for i, pred in enumerate(preds, start=1):
        writer.writerow([i, pred])
```

Timing of image classification on 1 image

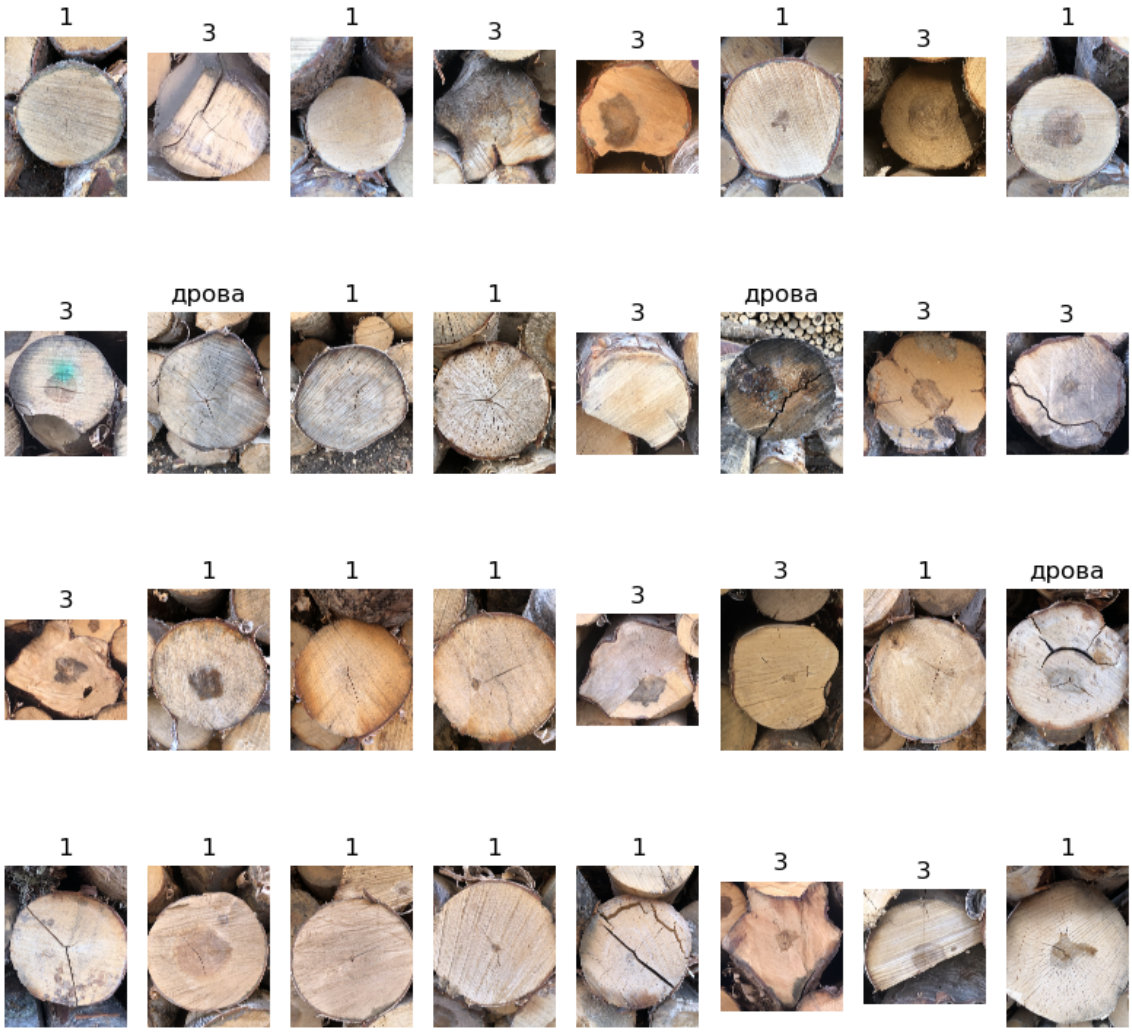
In [54]:
```
%%timeit
model(prepared_test_dataset['train'][0]['pixel_values'].unsqueeze(0))
```

```
1.23 s ± 167 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

Examples

In [169…
```
sorted_files = [TEST + file_name for file_name in sorted(os.listdir(TEST), key=l
fig, axes = plt.subplots(nrows=4, ncols=8, figsize=(8,8))
for i, ax in enumerate(axes.flat):
    img = Image.open(sorted_files[i])
    ax.imshow(img)
    ax.axis('off')
    ax.set_title('дрова' if preds[i] == 0 else preds[i])

plt.tight_layout()
plt.show()
```



CNN

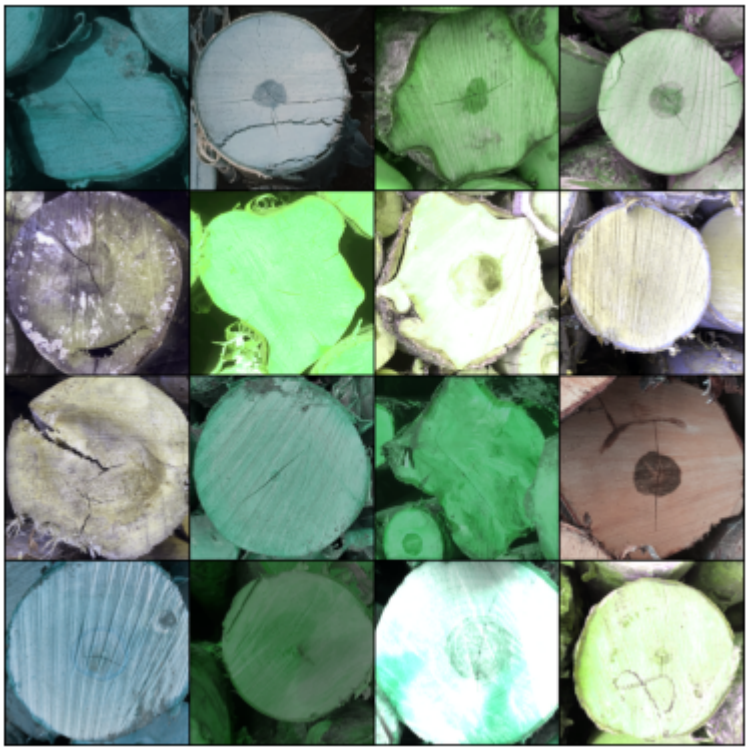
In [8]:
```
transforms = tfs.Compose([
    tfs.Resize(224),
    tfs.CenterCrop(224),
    tfs.ColorJitter(brightness=0.5, hue=0.5),
    tfs.ToTensor()])
```

In [9]:
```
dataset = ImageFolder(root=ROOT, transform=transforms)
idx = list(range(len(dataset)))
np.random.shuffle(idx)
```

In [10]:
```
train_idx = idx[:-50]
val_idx = idx[-50:]
train_ds = torch.utils.data.Subset(dataset, train_idx)
val_ds = torch.utils.data.Subset(dataset, val_idx)
train_dl = torch.utils.data.DataLoader(
    train_ds, batch_size=BATCH_SIZE,
    shuffle=True)
val_dl = torch.utils.data.DataLoader(
    val_ds, batch_size=BATCH_SIZE,
    shuffle=False)
```

In [172…
```
images, labels = next(iter(train_dl))
plt.imshow(make_grid(images, nrow=4).permute(2, 1, 0))
```

```
plt.axis('off')
None
```



In [236…

```
model = regnet_x_16gf(weights=RegNet_X_16GF_Weights)
model.fc = nn.Sequential(
    nn.Linear(2048, 3, bias=True))

# model = resnet50(weights=ResNet50_Weights.IMAGENET1K_V2)
# model.fc = nn.Linear(2048, 3, bias=True)
```

In [237…

```
class CNNClassifier(pl.LightningModule):
    def __init__(self, model):
        super().__init__()
        self.model = model

    def training_step(self, batch, batch_idx):
        # training_step defines the train loop.
        images, labels = batch
        pred = self.model(images)
        loss = nn.CrossEntropyLoss()(pred, labels)
        self.log(name='train_f1', value=multiclass_f1_score(pred, labels, num_cl
        return loss

    def validation_step(self, batch, batch_idx):
        images, labels = batch
        pred = self.model(images)
        self.log(name='val_f1', value=multiclass_f1_score(pred, labels, num_clas

    def test_step(self, batch, batch_idx):
        images = batch
        pred = self.model(images)
        return pred

    def configure_optimizers(self):
        optimizer = torch.optim.AdamW(self.parameters(), lr=LEARNING_RATE)
        return optimizer
```

In [240…

```
cnn_clf = CNNClassifier(model)
# logger = WandbLogger(name="regnet_x_16_gf")

trainer = pl.Trainer(
    max_epochs=1,
    log_every_n_steps=1,
    deterministic=True,
    # logger=logger
)
```

```
GPU available: False, used: False
TPU available: False, using: 0 TPU cores
IPU available: False, using: 0 IPUs
HPU available: False, using: 0 HPUs
```

In [241…

```
trainer.fit(
    model=cnn_clf,
    train_dataloaders=train_dl,
    val_dataloaders=val_dl
)
# wandb.finish()
```

```
  | Name  | Type   | Params
---------------------------------
0 | model | ResNet | 23.5 M
---------------------------------
23.5 M    Trainable params
0         Non-trainable params
23.5 M    Total params
94.057    Total estimated model params size (MB)
Sanity Checking: 0it [00:00, ?it/s]
```

```
C:\Users\melik\anaconda3\lib\site-packages\lightning\pytorch\trainer\connectors
\data_connector.py:432: PossibleUserWarning: The dataloader, train_dataloader,
does not have many workers which may be a bottleneck. Consider increasing the v
alue of the `num_workers` argument` (try 12 which is the number of cpus on this
machine) in the `DataLoader` init to improve performance.
  rank_zero_warn(
Training: 0it [00:00, ?it/s]
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
Validation: 0it [00:00, ?it/s]
WARNING:root:Warning: Some classes do not exist in the target. F1 scores for th
ese classes will be cast to zeros.
`Trainer.fit` stopped: `max_epochs=1` reached.
```

In [223…
```
images, _ = next(iter(val_dl))
```

In [ ]:
```
cnn_clf.eval()
cnn_clf.model.eval()
```

In [243…
```
%%timeit
cnn_clf.model(images[0].unsqueeze(0))
```

```
110 ms ± 2.09 ms per loop (mean ± std. dev. of 7 runs, 10 loops each)
```