```
import pandas as pd
```

```
df = pd.read_excel("TCM.xlsx")
```

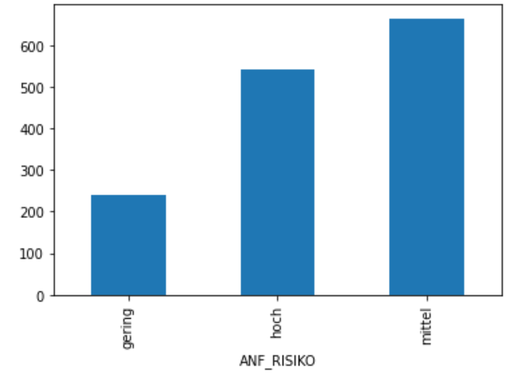
```
/usr/local/lib/python3.8/dist-packages/openpyxl/styles/stylesheet.py:226: UserWarning: Workbook contains no default sty
  warn("Workbook contains no default style, apply openpyxl's default")
```

```
df = df[["ANF_BESCHREIBUNG", "ANF_RISIKO"]]
#df['ANF_RISIKO'] = df['ANF_RISIKO'].replace("gering", 3)
#df['ANF_RISIKO'] = df['ANF_RISIKO'].replace("mittel", 2)
#df['ANF_RISIKO'] = df['ANF_RISIKO'].replace("hoch", 1)
df.head()
```

	ANF_BESCHREIBUNG	ANF_RISIKO
0	In der Formularansicht können über den Befehl ...	mittel
1	Testfälle können innerhalb des Systemordners "...	hoch
2	Beim Start des TestCaseManagers wird versucht,...	hoch
3	Testfälle können innerhalb des Systemordners "...	hoch
4	Der Ablauf für die Erstellung einer Kopie eine...	hoch

```
df.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f60ca7f0730>
```



```
pip install transformers
```

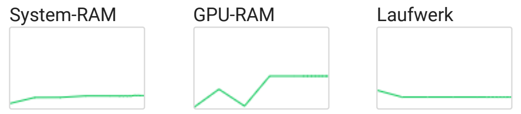
```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Requirement already satisfied: transformers in /usr/local/lib/python3.8/dist-packages (4.25.1)
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.8/dist-packages (from transformers) (1.21.6)
Requirement already satisfied: huggingface-hub<1.0,>=0.10.0 in /usr/local/lib/python3.8/dist-packages (from transformer
Requirement already satisfied: regex!=2019.12.17 in /usr/local/lib/python3.8/dist-packages (from transformers) (2022.6.
Requirement already satisfied: filelock in /usr/local/lib/python3.8/dist-packages (from transformers) (3.9.0)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.8/dist-packages (from transformers) (21.3)
```

Ressourcen ✕

Sie haben Colab Pro abonniert. Weitere Informationen.
Verfügbar: 98.24 Recheneinheiten
Nutzungsrate: ca. 1.96 pro Stunde
Sie haben 1 aktive Sitzung. Sitzungen verwalten

Sie möchten mehr Arbeitsspeicher und Speicherplatz?
Upgrade auf Colab Pro+ ausführen

(GPU) des Google Compute Engine-Back-Ends in Python 3
Ressourcen werden seit 18:45 angezeigt



```
Requirement already satisfied: pyyaml>=5.1 in /usr/local/lib/python3.8/dist-packages (from transformers) (6.0)
Requirement already satisfied: tqdm>=4.27 in /usr/local/lib/python3.8/dist-packages (from transformers) (4.64.1)
Requirement already satisfied: requests in /usr/local/lib/python3.8/dist-packages (from transformers) (2.25.1)
Requirement already satisfied: tokenizers!=0.11.3,<0.14,>=0.11.1 in /usr/local/lib/python3.8/dist-packages (from transf
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.8/dist-packages (from huggingface-h
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python3.8/dist-packages (from packaging>=20.0
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.8/dist-packages (from requests->transformers) (2.
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.8/dist-packages (from requests->transfor
Requirement already satisfied: chardet<5,>=3.0.2 in /usr/local/lib/python3.8/dist-packages (from requests->transformers
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.8/dist-packages (from requests->transformer
```

```python
from transformers import BertTokenizer

tokenizer = BertTokenizer.from_pretrained('bert-base-german-cased')

example_text = 'Ich werde heute lange schlafen'
bert_input = tokenizer(example_text,padding='max_length', max_length = 10,
                       truncation=True, return_tensors="pt")


print(bert_input['input_ids'])
print(bert_input['token_type_ids'])
print(bert_input['attention_mask'])
```

```
tensor([[    3,  1671,  1631,  1138,  2197, 21872,     4,     0,     0,     0]])
tensor([[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]])
tensor([[1, 1, 1, 1, 1, 1, 1, 0, 0, 0]])
```

```python
example_text = tokenizer.decode(bert_input.input_ids[0])

print(example_text)
```

```
[CLS] Ich werde heute lange schlafen [SEP] [PAD] [PAD] [PAD]
```

```python
import torch
import numpy as np
from transformers import BertTokenizer

tokenizer = BertTokenizer.from_pretrained('bert-base-german-cased')
labels = {'gering':3,
          'mittel':2,
          'hoch':1
          }

class Dataset(torch.utils.data.Dataset):

    def __init__(self, df):

        self.labels = [labels[label] for label in df['ANF_RISIKO']]
        self.texts = [tokenizer(text,
                               padding='max_length', max_length = 512, truncation=True,
                                return_tensors="pt") for text in df['ANF_BESCHREIBUNG']]

    def classes(self):
        return self.labels

    def __len__(self):
        return len(self.labels)

    def get_batch_labels(self, idx):
        # Fetch a batch of labels
        return np.array(self.labels[idx])

    def get_batch_texts(self, idx):
        # Fetch a batch of inputs
        return self.texts[idx]

    def __getitem__(self, idx):

        batch_texts = self.get_batch_texts(idx)
        batch_y = self.get_batch_labels(idx)

        return batch_texts, batch_y
```

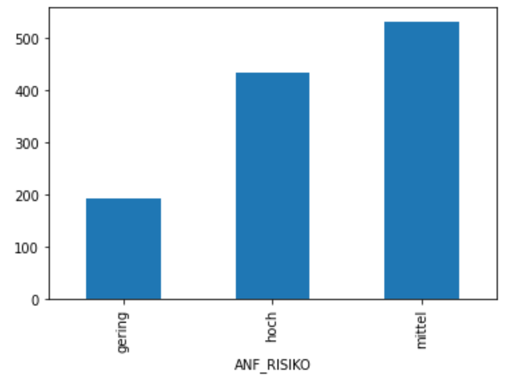
```
np.random.seed(1234)
df_train, df_val, df_test = np.split(df.sample(frac=1, random_state=42),
                                     [int(.8*len(df)), int(.9*len(df))])

print(len(df_train), len(df_val), len(df_test))
```

```
1156 145 145
```

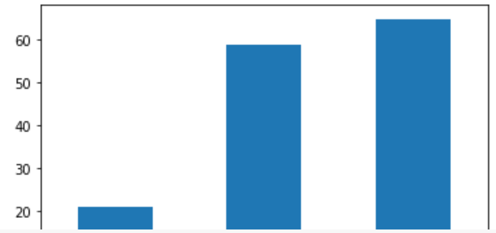
```
df_train.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5ff1de9760>
```



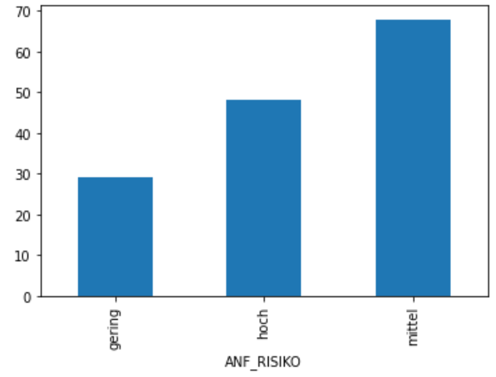
```
df_test.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5ff1bdcbe0>
```



```
df_val.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f606a528cd0>
```



```
df_train
```

	ANF_BESCHREIBUNG	ANF_RISIKO
413	Für das Verschieben von Testfallzuordnungen in...	gering
316	Mit dem Typ „Resultat" können Filterkriterien ...	mittel
554	In der Toolbar von Formularansichten gibt es i...	gering
65	Ein in der Resultatshistorie ausgewähltes TF-R...	mittel
1380	Für Anforderungen gibt es unterschiedliche Sym...	mittel
...	...	...
517	Bei Testfällen ohne Resultat wird immer das (n...	gering
1069	Für die Zuordnung eines PTARs zu einem Testfal...	hoch
476	Für das Löschen von Versionen gibt es die folg...	mittel
157	Das Layout einer Komponente kann im Register „...	mittel
16	Das Layout einer Komponente kann im Register „...	mittel

1156 rows × 2 columns

```
from torch import nn
from transformers import BertModel

class BertClassifier(nn.Module):

    def __init__(self, dropout=0.5):

        super(BertClassifier, self).__init__()

        self.bert = BertModel.from_pretrained('bert-base-german-cased')
        self.dropout = nn.Dropout(dropout)
        self.linear = nn.Linear(768, 5)
        self.relu = nn.ReLU()

    def forward(self, input_id, mask):

        _, pooled_output = self.bert(input_ids= input_id, attention_mask=mask,return_dict=False)
        dropout_output = self.dropout(pooled_output)
        linear_output = self.linear(dropout_output)
        final_layer = self.relu(linear_output)

        return final_layer
```

```
from torch.optim import Adam
from tqdm import tqdm

def train(model, train_data, val_data, learning_rate, epochs):

    train, val = Dataset(train_data), Dataset(val_data)

    train_dataloader = torch.utils.data.DataLoader(train, batch_size=2, shuffle=True)
    val_dataloader = torch.utils.data.DataLoader(val, batch_size=2)

    use_cuda = torch.cuda.is_available()
    device = torch.device("cuda" if use_cuda else "cpu")

    criterion = nn.CrossEntropyLoss()
    optimizer = Adam(model.parameters(), lr= learning_rate)

    if use_cuda:

            model = model.cuda()
            criterion = criterion.cuda()

    train_loss = []
    train_acc = []
    val_loss = []
    val_acc = []

    for epoch_num in range(epochs):

            total_acc_train = 0
            total_loss_train = 0

            for train_input, train_label in tqdm(train_dataloader):
                train_label = train_label.to(device)
                mask = train_input['attention_mask'].to(device)
                input_id = train_input['input_ids'].squeeze(1).to(device)

                output = model(input_id, mask)

                batch_loss = criterion(output, train_label.long())
                total_loss_train += batch_loss.item()

                acc = (output.argmax(dim=1) == train_label).sum().item()
                total_acc_train += acc

                model.zero_grad()
                batch_loss.backward()
                optimizer.step()

            total_acc_val = 0
            total_loss_val = 0

            with torch.no_grad():

                for val_input, val_label in val_dataloader:

                    val_label = val_label.to(device)
                    mask = val_input['attention_mask'].to(device)
                    input_id = val_input['input_ids'].squeeze(1).to(device)

                    output = model(input_id, mask)

                    batch_loss = criterion(output, val_label.long())
                    total_loss_val += batch_loss.item()

                    acc = (output.argmax(dim=1) == val_label).sum().item()
                    total_acc_val += acc


            train_loss = np.append(train_loss, (total_loss_train / len(train_data)))
            train_acc = np.append(train_acc, (total_acc_train / len(train_data)))
            val_loss = np.append(val_loss, (total_loss_val / len(val_data)))
            val_acc = np.append(val_acc, (total_acc_val / len(val_data)))

    return train_loss, train_acc, val_loss, val_acc
```

```
EPOCHS = 2
model = BertClassifier()
LR = 1e-5

loss_tr, acc_tr, loss_val, acc_val = train(model, df_train, df_val, LR, EPOCHS)
```

```
Some weights of the model checkpoint at bert-base-german-cased were not used when initializing BertModel: ['cls.seq_rel
- This IS expected if you are initializing BertModel from the checkpoint of a model trained on another task or with ano
- This IS NOT expected if you are initializing BertModel from the checkpoint of a model that you expect to be exactly i
100%|██████████| 578/578 [01:59<00:00,  4.85it/s]
100%|██████████| 578/578 [02:02<00:00,  4.72it/s]
```

```
print("loss_tr: ", loss_tr)
print("acc_tr: ", acc_tr)
print("loss_val: ", loss_val)
print("acc_val: ", acc_val)
```

```
loss_tr:  [0.2930658  0.05024045]
acc_tr:  [0.79411765 0.97750865]
loss_val:  [0.13125464 0.09216433]
acc_val:  [0.94482759 0.94482759]
```

```
def evaluate(model, test_data):

    test = Dataset(test_data)

    test_dataloader = torch.utils.data.DataLoader(test, batch_size=1)

    use_cuda = torch.cuda.is_available()
    device = torch.device("cuda" if use_cuda else "cpu")

    if use_cuda:

        model = model.cuda()

    total_acc_test = 0
    zuhochkl = 0
    zuniedrigkl = 0
    richtigkl = 0
    with torch.no_grad():

        for test_input, test_label in test_dataloader:

              test_label = test_label.to(device)
              mask = test_input['attention_mask'].to(device)
              input_id = test_input['input_ids'].squeeze(1).to(device)

              output = model(input_id, mask)

              pred = output.argmax(dim=1)[0].item()
              trcl = test_label[0].item()

              if (pred < trcl):
                  zuhochkl = zuhochkl + 1
              if (pred > trcl):
                  zuniedrigkl = zuniedrigkl + 1
              if (pred == trcl):
                  richtigkl = richtigkl + 1

              acc = (output.argmax(dim=1) == test_label).sum().item()
              total_acc_test += acc

    print(f'Test Accuracy: {total_acc_test / len(test_data): .3f}')

    checksum = zuhochkl + zuniedrigkl + richtigkl
    print("zu hoch klassifiziert: ", zuhochkl)
    print("zu niedrig klassifiziert: ", zuniedrigkl)
    print("richtig klassifiziert: ", richtigkl)
    print("checksum: ", checksum)
    print("meine acc: ", richtigkl/checksum)
```

```
print(df_test.shape)
evaluate(model, df_test)
```

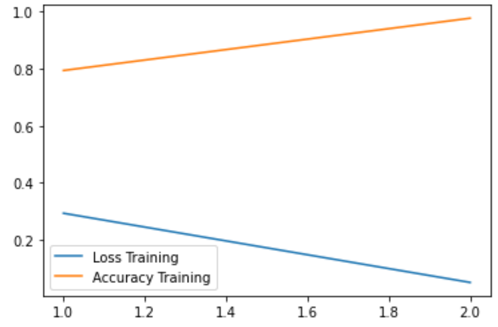
```
(145, 2)
Test Accuracy:  0.952
zu hoch klassifiziert:  2
zu niedrig klassifiziert:  5
richtig klassifiziert:  138
checksum:  145
meine acc:  0.9517241379310345
```

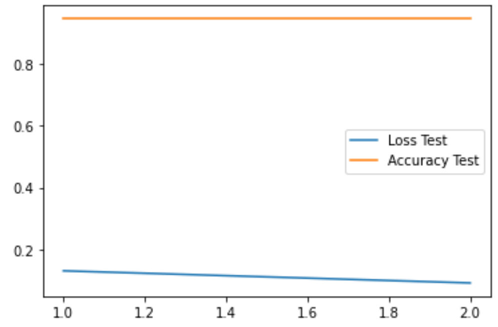
```
p1 = pd.DataFrame({
    'Loss Training': loss_tr,
    'Accuracy Training': acc_tr
    }, index=[1,2])

p2 = pd.DataFrame({
    'Loss Test': loss_val,
    'Accuracy Test': acc_val
    }, index=[1,2])

p1.plot.line()
p2.plot.line()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5fe6da8c10>
```





```
def get_pred(model, test_data):

    test = Dataset(test_data)

    test_dataloader = torch.utils.data.DataLoader(test, batch_size=1)

    use_cuda = torch.cuda.is_available()
    device = torch.device("cuda" if use_cuda else "cpu")

    if use_cuda:

        model = model.cuda()

    with torch.no_grad():

        pred = []

        for test_input, test_label in test_dataloader:

              test_label = test_label.to(device)
              mask = test_input['attention_mask'].to(device)
              input_id = test_input['input_ids'].squeeze(1).to(device)

              output = model(input_id, mask)

              if output.argmax(dim=1)[0].item() == 3:
                pred = np.append(pred, 'gering')
              if output.argmax(dim=1)[0].item() == 2:
                pred = np.append(pred, 'mittel')
              if output.argmax(dim=1)[0].item() == 1:
                pred = np.append(pred, 'hoch')

    test_data['Vorhersage'] = pred
    print(test_data)
```

```
var = pd.DataFrame({'ANF_BESCHREIBUNG': [
    "ich bin ein test text für das tolle modell",
    "ein text mit informationsdialog ist vielleicht richtig",
    "Die Sonne lacht vom Himmel doch die Software stürzt ab"
    ],
    'ANF_RISIKO': ["hoch", "gering", "mittel"]})
var.head()
```

	ANF_BESCHREIBUNG	ANF_RISIKO
0	ich bin ein test text für das tolle modell	hoch
1	ein text mit informationsdialog ist vielleicht...	gering
2	Die Sonne lacht vom Himmel doch die Software s...	mittel

```
get_pred(model, var)
```

```
                                   ANF_BESCHREIBUNG ANF_RISIKO Vorhersage
0         ich bin ein test text für das tolle modell       hoch     gering
```

```
1  ein text mit informationsdialog ist vielleicht...     gering     gering
2  Die Sonne lacht vom Himmel doch die Software s...     mittel     mittel
```

Laufzeittyp ändern

✓ 0 s Abgeschlossen um 18:56