

Task2_ML_RafEngelen

November 10, 2023

1 Report task 2: Benchmarking two ML algorithms

1.1 Introduction

The purpose of this report is to compare some techniques to create Machine Learning models.

In this file you will find some code written in comments. This is code that is only necessary to run on Streamlit. The version on Streamlit will have that code not in comments.

Streamlit link: <https://rafengelenaitask2.streamlit.app>

1.2 The Dataset

I have chosen the following dataset for this task: <https://archive.ics.uci.edu/dataset/101/tic+tac+toe+endgame>.

The data contains no headers, this is why i create them myself. The data can be used for supervised machine learning. The data is labeled, the column “x has won” contains the labels in which the data is catecorized.

```
[368]: import pandas as pd
feature_cols=[
    "top-left", "top-middle", "top-right",
    "middle-left", "middle-middel", "middle-right",
    "bottom-left", "bottom-middle", "bottom-right"
]
tictactoe_df = pd.read_csv("data/tic-tac-toe.data",
                           sep=',',
                           header=None,
                           names=feature_cols+["x has won"])

print(tictactoe_df)
```

	top-left	top-middle	top-right	middle-left	middle-middel	middle-right	\
0	x	x	x	x	o	o	
1	x	x	x	x	o	o	
2	x	x	x	x	o	o	
3	x	x	x	x	o	o	
4	x	x	x	x	o	o	
..	
953	o	x	x	x	o	o	

```

954      o      x      o      x      x      o
955      o      x      o      x      o      x
956      o      x      o      o      x      x
957      o      o      x      x      x      o

```

```

      bottom-left bottom-middle bottom-right x has won
0          x          o          o positive
1          o          x          o positive
2          o          o          x positive
3          o          b          b positive
4          b          o          b positive
..         ...         ...         ...         ...
953         o          x          x negative
954         x          o          x negative
955         x          o          x negative
956         x          o          x negative
957         o          x          x negative

```

[958 rows x 10 columns]

1.2.1 Exploratory Data Analysis

First we research the data out of the dataset. By using the describe function we get some interesting information about the data. We see the amount of values in each column, how many unique values there are in each column, which value is the most frequent value and how many times that value is in that column.

We can also find out how many null values there are in each column by using the isna function. We see that the data does not have any null values.

```
[369]: print(tictactoe_df.describe(), "\n\n", tictactoe_df.isna().sum(), sep="")
```

```

      top-left top-middle top-right middle-left middle-middel middle-right \
count      958      958      958      958      958      958
unique       3       3       3       3       3       3
top          x       x       x       x       x       x
freq      418      378      418      378      458      378

```

```

      bottom-left bottom-middle bottom-right x has won
count      958      958      958      958
unique       3       3       3       2
top          x       x       x positive
freq      418      378      418      626

```

```

top-left      0
top-middle    0
top-right     0
middle-left   0
middle-middel 0

```

```

middle-right      0
bottom-left       0
bottom-middle     0
bottom-right      0
x has won         0
dtype: int64

```

1.2.2 Splitting the data

We need 2 sets of data, one to train the model and the other to test the model.

```

[370]: from sklearn.model_selection import train_test_split

X = tictactoe_df[feature_cols] # Features
y = tictactoe_df[['x has won']] # target variable

# Split dataset into training set and test set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3) # 70%
                                     ↪ training and 30% test

```

encoding Because the data in the features are strings, I need to encode the data. This encoding is necessary because Scikit requires the values to be floats. This encoding gives a numeric value the different string categories. This can be done in different ways. 2 of the most often used encoding methods are Label Encoding and One Hot Encoding.

Label encoding gives each categorical value of a feature a numerical value. If there are 3 different categorical values, these will be encoded to [1,2,3]. This encoding method is requires not much computational power. But it will create an order in the data.

One Hot Encoding will generate a new column for each categorical value in a feature. In each column there will be 2 possible values, 0 and 1. 0 means the item does not have the specific value of that column. 1 means the item does have the specific value of that column. This will create more variables and it requires a lot more computational power.

Our data is not nominal ["o", "x", "b"], there is no certain order. This hints that One Hot Encoding will be better for this dataset. That is why I will use One Hot Encoding.

```

[371]: import category_encoders as ce

# label encoding
# ce_ord = ce.OrdinalEncoder(cols = feature_cols)
# X_train_cat = ce_ord.fit_transform(X_train)
# X_test_cat = ce_ord.fit_transform(X_test)

# hot encoding
ce_oh = ce.OneHotEncoder(cols = feature_cols)
X_train_cat_oh = ce_oh.fit_transform(X_train)
X_test_cat_oh = ce_oh.fit_transform(X_test)

```

```
print(X_train_cat_oh)
```

	top-left_1	top-left_2	top-left_3	top-middle_1	top-middle_2	\
216	1	0	0	1	0	
410	0	1	0	1	0	
609	0	0	1	0	1	
692	1	0	0	1	0	
179	1	0	0	1	0	
..	
635	1	0	0	0	0	
467	0	1	0	0	1	
689	1	0	0	1	0	
866	0	1	0	0	1	
308	0	1	0	0	0	

	top-middle_3	top-right_1	top-right_2	top-right_3	middle-left_1	...	\
216	0	1	0	0	1	...	
410	0	1	0	0	0	...	
609	0	0	1	0	0	...	
692	0	0	1	0	0	...	
179	0	0	1	0	1	...	
..	
635	1	0	1	0	0	...	
467	0	0	1	0	0	...	
689	0	0	0	1	1	...	
866	0	0	0	1	1	...	
308	1	0	0	1	0	...	

	middle-right_3	bottom-left_1	bottom-left_2	bottom-left_3	\
216	0	1	0	0	
410	0	1	0	0	
609	0	1	0	0	
692	0	1	0	0	
179	0	0	1	0	
..	
635	0	1	0	0	
467	0	0	0	1	
689	0	0	1	0	
866	0	0	0	1	
308	0	0	1	0	

	bottom-middle_1	bottom-middle_2	bottom-middle_3	bottom-right_1	\
216	1	0	0	1	
410	0	1	0	0	
609	0	1	0	0	
692	0	0	1	1	
179	1	0	0	1	
..	

635	1	0	0	1
467	0	1	0	1
689	1	0	0	1
866	0	1	0	0
308	1	0	0	1

	bottom-right_2	bottom-right_3
216	0	0
410	1	0
609	0	1
692	0	0
179	0	0
..
635	0	0
467	0	0
689	0	0
866	0	1
308	0	0

[670 rows x 27 columns]

1.3 Baseline (Decision Tree)

For the baseline model, I have chosen decision tree.

The basic idea behind a decision tree is to recursively split the dataset into subsets based on the values of different features. Each internal node in the tree represents a decision based on a specific feature, and each leaf node represents the predicted outcome. In each internal node, it will review a specific feature and makes a decision based on that feature.

The technique is popular due to it's simplicity and it's visual nature. They can however be prone to overfitting. Because the nodes in the tree works exactly for the train data set, it is most likely overfitted.

First we need to import some modules.

```
[372]: from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import confusion_matrix, accuracy_score
from io import StringIO
from IPython.display import Image
from sklearn.tree import export_graphviz
import pydotplus
```

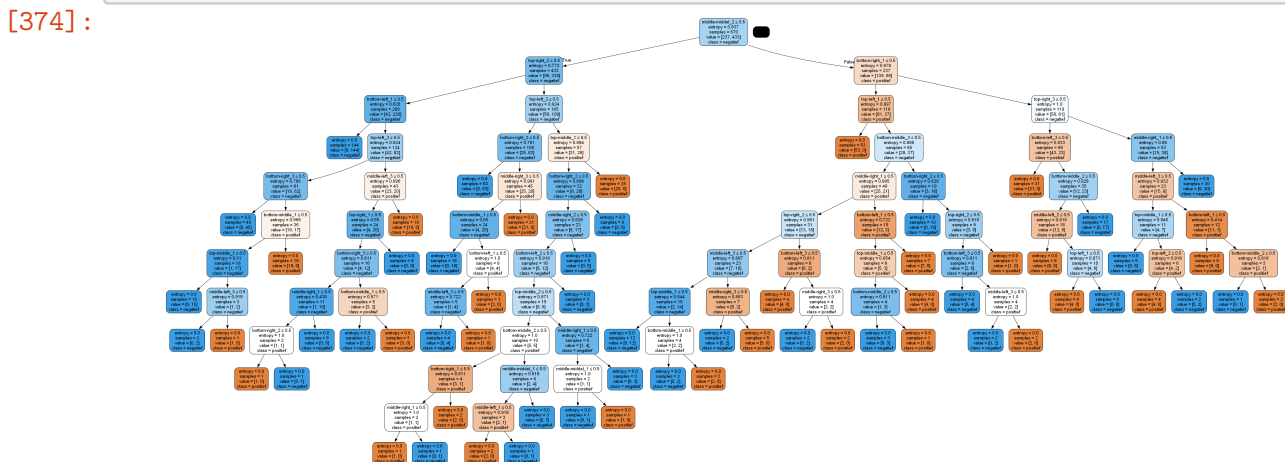
create model (kies entropy of gini zoek op wat het verschil is tussen de 2)

```
[373]: clf_baseline = DecisionTreeClassifier(criterion = "entropy")
clf_baseline = clf_baseline.fit(X_train_cat_oh, y_train)
```

Here we can draw the decision tree that our model has created.

```
[374]: dot_data = StringIO()
export_graphviz(clf_baseline,
               out_file = dot_data,
               filled = True,
               rounded = True,
               special_characters = True,
               feature_names = X_train_cat_oh.columns,
               class_names=['positief', 'negatief'])

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
tree_image = Image(graph.create_png(), width=2000)
tree_image
```



Now I can use the model to predict the results for the test dataset.

```
[375]: y_pred_baseline = clf_baseline.predict(X_test_cat_oh)
```

Because I want to collect information about the model. I want to show the confusion matrix and calculate the accuracy. We want this for the models we will after the baseline model as well, so we will create a function that prints the information we want to see.

First we create and print the confusion matrix. Because the diagonal from the upper left has all the correct predictions, we can easily sum these up to get the amount of correct predictions. We can also calculate the total amount of predictions we have made. At last we can also calculate the accuracy.

```
[376]: import streamlit as st
def print_confusion(actual, prediction):

    confusion = confusion_matrix(actual, prediction, labels = ["positive",
↪ "negative"])
    print(f"Confusion matrix: \n{confusion}")
    st.write(f"Confusion matrix: \n{confusion}")
```

```

# Good predictions:
correct_predictions = confusion.diagonal().sum()
print(f"Amount of correct predictions: {correct_predictions}")
st.write(f"Amount of correct predictions: {correct_predictions}")

# Accuracy:
print(f"Accuracy: {accuracy_score(actual, prediction)}")
st.write(f"Accuracy: {accuracy_score(actual, prediction)}")
# Ook mogelijk voor accuracy: print(f"Accuracy: {metrics.
↪accuracy_score(y_test, y_pred)}")

```

Now we can use this function with out the outcomes of the test dataset and the predictions my model has made.

```
[377]: print_confusion(y_test, y_pred_baseline)
```

```

Confusion matrix:
[[131  62]
 [ 47  48]]
Amount of correct predictions: 179
Accuracy: 0.6215277777777778

```

1.4 Gaussian Naive Bayes

It is an extension of Naive Bayes and uses the Bayes theorem. Naive comes from the fact that the technique sees the features as completely independant. This will cause some error in the model but is overall not a big error. The independance of features makes sure that the technique is simple and powerful.

```
[378]: from sklearn.naive_bayes import GaussianNB, CategoricalNB
```

```

clf_gnb= GaussianNB().fit(X_train_cat_oh, y_train)
y_pred_gnb = clf_gnb.predict(X_test_cat_oh)
print_confusion(y_test, y_pred_gnb)

```

```

Confusion matrix:
[[137  56]
 [ 60  35]]
Amount of correct predictions: 172
Accuracy: 0.5972222222222222

```

```

c:\Users\rafen\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\utils\validation.py:1183: DataConversionWarning: A column-
vector y was passed when a 1d array was expected. Please change the shape of y
to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)

```

1.5 Multi-layer Perceptron (Neural network)

The Multilayer Perceptron is a neural network where the mapping between inputs and output is non-linear. It has multiple input layers, output layers and also some hidden layers. Each layer is composed of interconnected nodes, referred to as neurons. In the input layer, each node represents a feature of the input data. The hidden layers, placed between the input and output layers, contain nodes that transform the input data through weighted connections and activation functions. The output layer produces the final predictions or classifications based on the transformed information from the hidden layers.

```
[379]: from sklearn.neural_network import MLPClassifier
```

```
clf_mlp = MLPClassifier().fit(X_train_cat_oh, y_train)
y_pred_mlp = clf_mlp.predict(X_test_cat_oh)
print_confusion(y_test, y_pred_mlp)
```

```
c:\Users\rafen\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\neural_network\_multilayer_perceptron.py:1102:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples, ), for example using
ravel().
```

```
y = column_or_1d(y, warn=True)
```

```
Confusion matrix:
```

```
[[ 90 103]
```

```
 [ 41  54]]
```

```
Amount of correct predictions: 144
```

```
Accuracy: 0.5
```

```
c:\Users\rafen\AppData\Local\Programs\Python\Python311\Lib\site-
packages\sklearn\neural_network\_multilayer_perceptron.py:691:
```

```
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (200) reached and
the optimization hasn't converged yet.
```

```
warnings.warn(
```

1.6 Compare models

```
[380]: print("Decision Tree:")
print_confusion(y_test, y_pred_baseline)
print("\nGaussian Naive Bayes")
print_confusion(y_test, y_pred_gnb)
print("\nMulti-layer Perceptron")
print_confusion(y_test, y_pred_mlp)
```

```
Decision Tree:
```

```
Confusion matrix:
```

```
[[131  62]
```

```
 [ 47  48]]
```

```
Amount of correct predictions: 179
```

```
Accuracy: 0.6215277777777778
```


Gaussian Naive Bayes

Confusion matrix:

```
[[137  56]
```

```
 [ 60  35]]
```

Amount of correct predictions: 172

Accuracy: 0.5972222222222222

Multi-layer Perceptron

Confusion matrix:

```
[[ 90 103]
```

```
 [ 41  54]]
```

Amount of correct predictions: 144

Accuracy: 0.5

I have tried the previous code a few times and these were the results:

Comparison 1

```
Decision Tree:
Confusion matrix:
[[107  77]
 [ 75  29]]
Amount of correct predictions: 136
Accuracy: 0.4722222222222222
```

```
Gaussian Naive Bayes
Confusion matrix:
[[94 90]
 [80 24]]
Amount of correct predictions: 118
Accuracy: 0.4097222222222222
```

```
Multi-layer Perceptron
Confusion matrix:
[[ 59 125]
 [ 41  63]]
Amount of correct predictions: 122
Accuracy: 0.4236111111111111
```

Comparison 2

```
Decision Tree:
Confusion matrix:
[[140  48]
 [ 55  45]]
Amount of correct predictions: 185
Accuracy: 0.6423611111111112
```

```
Gaussian Naive Bayes
Confusion matrix:
[[153  35]
 [ 65  35]]
Amount of correct predictions: 188
Accuracy: 0.6527777777777778
```

```
Multi-layer Perceptron
Confusion matrix:
[[108  80]
 [ 57  43]]
Amount of correct predictions: 151
Accuracy: 0.5243055555555556
```

Comparison 3

```
Decision Tree:  
Confusion matrix:  
[[133  53]  
 [ 54  48]]  
Amount of correct predictions: 181  
Accuracy: 0.6284722222222222
```

```
Gaussian Naive Bayes  
Confusion matrix:  
[[133  53]  
 [ 63  39]]  
Amount of correct predictions: 172  
Accuracy: 0.5972222222222222
```

```
Multi-layer Perceptron  
Confusion matrix:  
[[ 77 109]  
 [ 43  59]]  
Amount of correct predictions: 136  
Accuracy: 0.4722222222222222
```

Comparison 4

```
Decision Tree:
Confusion matrix:
[[132  53]
 [ 42  61]]
Amount of correct predictions: 193
Accuracy: 0.6701388888888888
```

```
Gaussian Naive Bayes
Confusion matrix:
[[151  34]
 [ 66  37]]
Amount of correct predictions: 188
Accuracy: 0.6527777777777778
```

```
Multi-layer Perceptron
Confusion matrix:
[[ 75 110]
 [ 26  77]]
Amount of correct predictions: 152
Accuracy: 0.5277777777777778
```

Comparison 5

```

Decision Tree:
Confusion matrix:
[[132  51]
 [ 45  60]]
Amount of correct predictions: 192
Accuracy: 0.6666666666666666

Gaussian Naive Bayes
Confusion matrix:
[[136  47]
 [ 68  37]]
Amount of correct predictions: 173
Accuracy: 0.6006944444444444

Multi-layer Perceptron
Confusion matrix:
[[87 96]
 [37 68]]
Amount of correct predictions: 155
Accuracy: 0.5381944444444444

```

We can see that all models have a fluctuating accuracy, this of course depends on the training data. The Decision Tree stands out over these experiments as a better option. But of course this sample is too small to make any assumptions.

1.7 Streamlit

I want to use the cache of streamlit. Reason being is that when I press a button, everything is being executed again. This is not good if we want to use the same test and training data for all the techniques and also for performance of the application. That's why everything I have coded above will be removed from the streamlit app and moved to a main function. With this we can use sessions.

```

[381]: st.header('Raf Engelen - r0901812 - 3APP01', divider='gray')
      st.title("Task 2 ML: Benchmarking two ML algorithms")
      option = st.sidebar.selectbox(
          'Choose machine learning model',

```

```

    ('Decision Tree', 'Gaussian Naive Bayes', 'Multi-layer Perceptron')
)
if option == 'Decision Tree':
    st.subheader("Decision Tree")
    print_confusion(y_test, y_pred_baseline)
elif option == 'Gaussian Naive Bayes':
    st.subheader("Gaussian Naive Bayes")
    print_confusion(y_test, y_pred_gnb)
elif option == 'Multi-layer Perceptron':
    st.subheader("Multi-layer Perceptron")
    print_confusion(y_test, y_pred_mlp)

```

Confusion matrix:

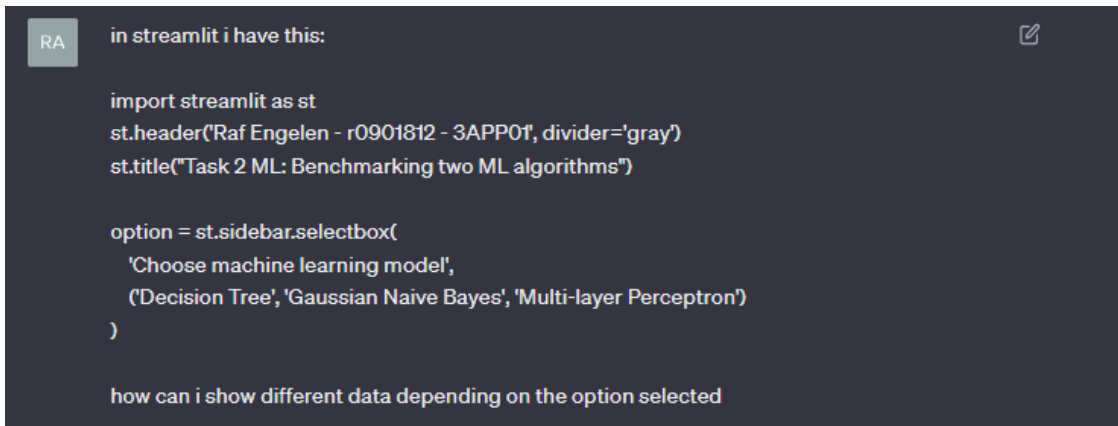
```
[[131  62]
 [ 47  48]]
```

Amount of correct predictions: 179

Accuracy: 0.6215277777777778

1.8 GenAI tools

In this task I have utilised ChatGPT mostly for using streamlit. First, I wanted to have my dropdown to determine what data I should show:



The screenshot shows a Streamlit application window with a dark theme. In the top left corner, there is a small grey box with the letters 'RA'. The main area of the application contains the following Python code:

```

import streamlit as st
st.header('Raf Engelen - r0901812 - 3APP01', divider='gray')
st.title("Task 2 ML: Benchmarking two ML algorithms")

option = st.sidebar.selectbox(
    'Choose machine learning model',
    ('Decision Tree', 'Gaussian Naive Bayes', 'Multi-layer Perceptron')
)

```

Below the code, the text "how can i show different data depending on the option selected" is visible, which appears to be a prompt or a comment related to the task.

```

option = st.sidebar.selectbox(
    'Choose machine learning model',
    ('Decision Tree', 'Gaussian Naive Bayes', 'Multi-layer Perceptron')
)

# Display data based on the selected option
if option == 'Decision Tree':
    st.subheader('Decision Tree Model Information')
    st.write("Accuracy: ", dt_model.score(X, y))
    # Add more information specific to Decision Tree model

elif option == 'Gaussian Naive Bayes':
    st.subheader('Gaussian Naive Bayes Model Information')
    st.write("Accuracy: ", nb_model.score(X, y))
    # Add more information specific to Gaussian Naive Bayes model

elif option == 'Multi-layer Perceptron':
    st.subheader('Multi-layer Perceptron Model Information')
    st.write("Accuracy: ", mlp_model.score(X, y))
    # Add more information specific to Multi-layer Perceptron model

```

In this example, I used three different models (Decision Tree, Gaussian Naive Bayes, and Multi-layer Perceptron) and displayed relevant information based on the selected option. You should replace the model training and data loading with your actual data and models.

I also wanted to show the decision tree on the application. I have asked it using the following prompt but sadly the answers did not work.

RA

i have the following code to show a decision tree:

```
dot_data = StringIO()
export_graphviz(clf_baseline,
                out_file = dot_data,
                filled = True,
                rounded = True,
                special_characters = True,
                feature_names = X_train_cat_oh.columns,
                class_names=['positief', 'negatief']
                )

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
Image(graph.create_png(), width=2000)
```

how can i show this on a streamlit page?

```
# Visualize the Decision Tree
dot_data = StringIO()
export_graphviz(clf_baseline,
                out_file=dot_data,
                filled=True,
                rounded=True,
                special_characters=True,
                feature_names=iris.feature_names,
                class_names=[str(i) for i in iris.target_names]
                )

graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
tree_image = Image(graph.create_png())

# Streamlit app
st.header('Raf Engelen - r0901812 - 3APP01', divider='gray')
st.title("Task 2 ML: Decision Tree Visualization")

# Display the Decision Tree image
st.image(tree_image, caption='Decision Tree', use_column_width=True)
```

In this example, the `st.image` method is used to display the Decision Tree image. Make sure to adjust the feature names and class names according to your data. The `use_column_width=True` parameter ensures that the image is displayed with the width of the column.

Regenerate

The application was rerunning code so the performance was suboptimal. That's why I used the following prompt:

RA

i am creating a streamlit program which trains a machine learning model. I have a button that will toggle the visibility of a dataframe on the webpage. but for some reason the model gets trained again. How can i make it so that the model is only trained at the start and not after a button press



To ensure that your machine learning model is trained only once at the start of your Streamlit app and not retrained upon every button press, you can use Streamlit's caching mechanism. Streamlit provides the `@st.cache` decorator to cache the result of a function based on its inputs. This way, if the inputs to the function haven't changed, Streamlit will use the cached result instead of re-executing the function.

Here's a simple example:

python

Copy code

```
import streamlit as st
import pandas as pd
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

# Function to train the machine learning model
@st.cache(allow_output_mutation=True) # Use allow_output_mutation to allow
def train_model():
    # Load your data (replace this with your data loading code)
    data = pd.read_csv("your_dataset.csv")

    # Preprocess your data and split into features and target
    X = data.drop("target_column", axis=1)
    y = data["target_column"]

    # Split the data into training and testing sets
    X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,

    # Train your machine learning model (replace this with your model training code)
    model = RandomForestClassifier()
    model.fit(X_train, y_train)

    # Evaluate the model
    y_pred = model.predict(X_test)
    accuracy = accuracy_score(y_test, y_pred)

    return model, accuracy
```

Regenerate

```

# Main Streamlit app
st.title("Machine Learning Model Training App")

# Train the model at the start of the app
model, accuracy = train_model()

# Button to toggle visibility of the DataFrame
if st.button("Toggle DataFrame Visibility"):
    # Display the DataFrame (replace this with your DataFrame display code)
    st.dataframe(pd.DataFrame({"Column1": [1, 2, 3], "Column2": [4, 5, 6]}))

# Display model information
st.subheader("Model Information")
st.write(f"Model Accuracy: {accuracy}")

# Additional sections of your Streamlit app...

```

In this example, the `train_model` function is decorated with `@st.cache(allow_output_mutation=True)`, which allows caching of mutable objects like the trained model. The model will be trained only once, and subsequent calls to the function will use the cached result.

Note: Make sure to replace the data loading and model training code with your actual implementation. The provided code is a template for illustration purposes.

1.9 Bronnenlijst:

1.9. Naive Bayes. (z.d.). scikit-learn. https://scikit-learn.org/stable/modules/naive_bayes.html

Dash, S. (2023, 3 november). Decision Trees explained — entropy, information gain, Gini index, CCP pruning. Medium. <https://towardsdatascience.com/decision-trees-explained-entropy-information-gain-gini-index-ccp-pruning-4d78070db36c>

Sethi, A. (2023, 15 juni). One Hot Encoding vs. label encoding using SciKit-Learn. Analytics Vidhya. <https://www.analyticsvidhya.com/blog/2020/03/one-hot-encoding-vs-label-encoding-using-scikit-learn/#:~:text=Label%20encoding%20is%20simpler%20and,lead%20to%20high-dimensional%20data>

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