Dataset Link: https://www.kaggle.com/datasets/kukuroo3/body-performance-data

Step - 0:

The main problem that we are trying to solve using the above dataset is to predict the performance of the athelete's body based on different attributes like age, height, weight and different body excercies like broad jump, sit ups etc.,

Step - 1.1: Dataset

The dataset is picked from Kaggle public datasets. And it is related to korean sport atheltes body performance. The dataset has many versions and there is definitely a possibility of change as the dataset is updated regularly. And it has protected features as well.

Step - 1.2: Machine Learning Metrics

Some of the machine learning metrics that could be used to evaluate the machine learning model that is used to solve this problem are **Precision, Recall, Fairness, Accuracy, F1 score**.

Step - 1.3: Business Metrics

1. One business metric would be customer experience as based on our machine learning model prediction people can engage more to understand about their body performance which is very crucial now a days.
2. Second possible business metric would be revenue. By using our machine learning model as central focus we can build an mobile application that is easily accessible which can lead to profits. Basically this model and application can be used in different sports for measuring body performance.

Step - 1.4: Software Metrics

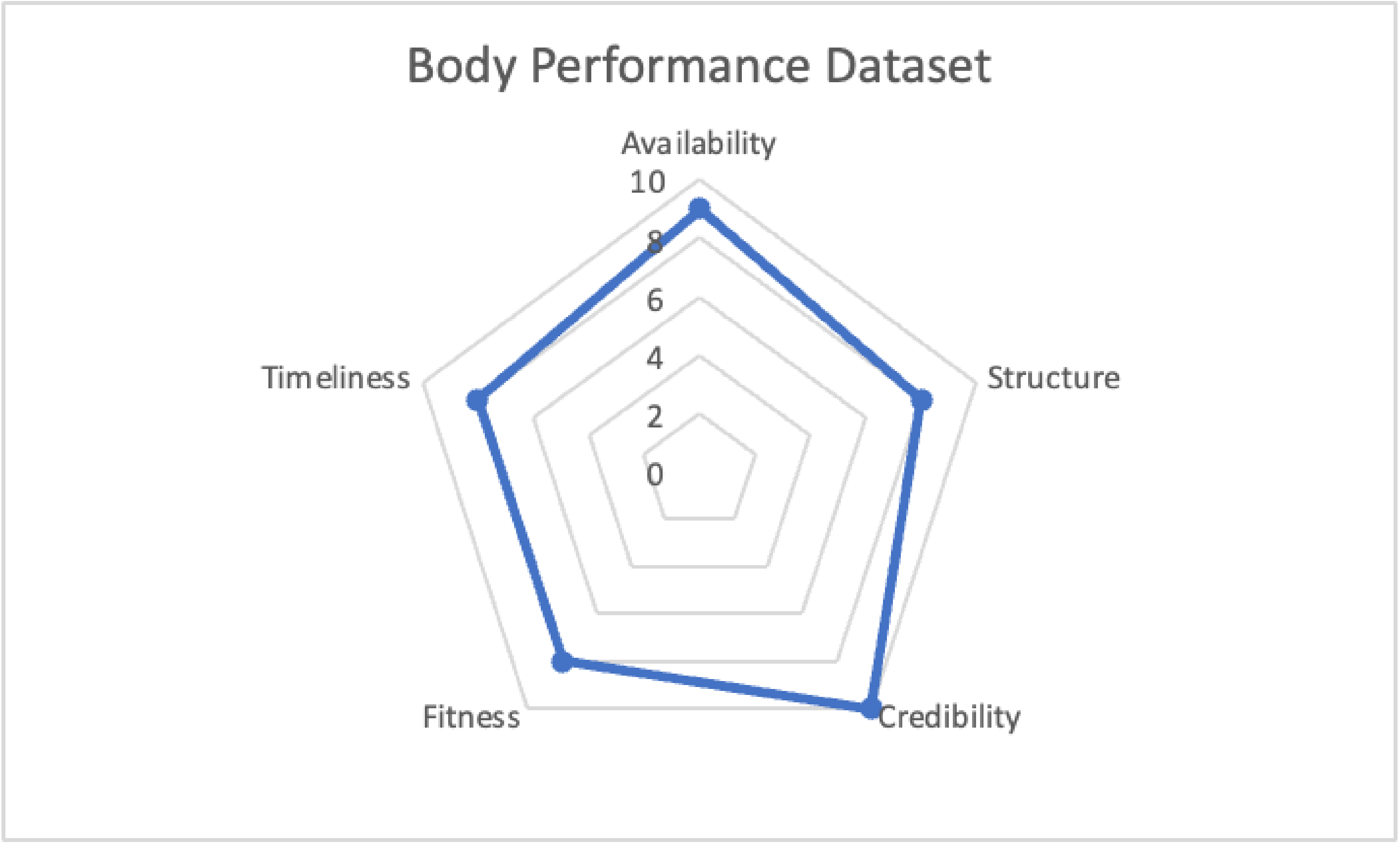
Some of the software metrics that could be used to analyse the model are Throughput, scalability, availablity, latency. As we will be using tensorflow extended which can though of as a cloud based machine learing deployment of the model. So we can have better throughput, and availability. And we can scale the model very quickly by just changing the few parameters

Step - 2.1: Dataset Objective

The main objective of the dataset is to measure the performance of the human body based on different features like age, height, weight etc.,

The main features that made me select this particular dataset are firstly age, height, weight as these are important factors that contribute to the human body performance. Generally, the initial hypothesis is that the performance of the body decreases with increase in age and weight. But there could be other factors that can be considered like the individual excercise habits. The dataset contains this key information as well like situp count, gripforce, broad jump etc., These features combinely made me select this dataset.

Step - 2.2: Quality of Dataset Using Radar Chart



Availability: The availability of the data is marked as 9 because the dataset was update recently and there is a possibility of updating it more data frequently.

Timeliness: The timeliness is also marked as 9 becuase of the fact that data is arrving regualy on time.

Structure: The structure of the dataset is also good as the data is clear and understandable. Also it is easy to understand each and every data point just based on the feature name.

Fitness: The fitness is also good enough as most of the features are relavant enough to predict the target variable.

Credibility: credibility is also marked well as the dataset was taken from credible korean sports foundation to measure the body performance of the player.

```
import pandas as pd
import numpy as np
import sklearn
from matplotlib import pyplot as plt
import seaborn as sns
import datetime
from sklearn.metrics import max_error, mean_absolute_error, r2_score
```

```
pip install neptune-client
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-whe
Requirement already satisfied: neptune-client in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: PyJWT in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: click>=7.0 in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: GitPython>=2.0.8 in /usr/local/lib/python3.7/dist
Requirement already satisfied: swagger-spec-validator>=2.7.4 in /usr/local/lib/p
Requirement already satisfied: Pillow>=1.1.6 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.7/dist-pack
Requirement already satisfied: psutil in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: pandas in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: requests>=2.20.0 in /usr/local/lib/python3.7/dist
Requirement already satisfied: bravado in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: packaging in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: jsonschema<4.0.0 in /usr/local/lib/python3.7/dist
Requirement already satisfied: boto3>=1.16.0 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: future>=0.17.1 in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: oauthlib>=2.1.0 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: requests-oauthlib>=1.0.0 in /usr/local/lib/python
Requirement already satisfied: websocket-client!=1.0.0,>=0.35.0 in /usr/local/li
Requirement already satisfied: botocore<1.28.0,>=1.27.46 in /usr/local/lib/pytho
Requirement already satisfied: s3transfer<0.7.0,>=0.6.0 in /usr/local/lib/python
Requirement already satisfied: jmespath<2.0.0,>=0.7.1 in /usr/local/lib/python3.
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /usr/local/lib/pyt
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/pyth
Requirement already satisfied: gitdb<5,>=4.0.1 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: smmap<6,>=3.0.1 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: attrs>=17.4.0 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: importlib-metadata in /usr/local/lib/python3.7/di
Requirement already satisfied: pyrsistent>=0.14.0 in /usr/local/lib/python3.7/di
Requirement already satisfied: setuptools in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.7/di
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/python3.7/dis
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: pyyaml in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: simplejson in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: msgpack in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: bravado-core>=5.16.1 in /usr/local/lib/python3.7/
Requirement already satisfied: monotonic in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: pytz in /usr/local/lib/python3.7/dist-packages (f
Requirement already satisfied: jsonref in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: strict-rfc3339 in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: jsonpointer>1.13 in /usr/local/lib/python3.7/dist
Requirement already satisfied: rfc3987 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: webcolors in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.7/dist-pa
```

```
pip install scikit-learn neptune-client neptune-sklearn
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-whe
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: neptune-client in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: neptune-sklearn in /usr/local/lib/python3.7/dist-
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.7/
Requirement already satisfied: scipy>=1.1.0 in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: numpy>=1.14.6 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: swagger-spec-validator>=2.7.4 in /usr/local/lib/p
Requirement already satisfied: urllib3 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: psutil in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: websocket-client!=1.0.0,>=0.35.0 in /usr/local/li
Requirement already satisfied: pandas in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.7/dist-pack
Requirement already satisfied: click>=7.0 in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: future>=0.17.1 in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: packaging in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: requests>=2.20.0 in /usr/local/lib/python3.7/dist
Requirement already satisfied: PyJWT in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: bravado in /usr/local/lib/python3.7/dist-packages
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Requirement already satisfied: oauthlib>=2.1.0 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: jsonschema<4.0.0 in /usr/local/lib/python3.7/dist
Requirement already satisfied: boto3>=1.16.0 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: Pillow>=1.1.6 in /usr/local/lib/python3.7/dist-pa
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Requirement already satisfied: botocore<1.28.0,>=1.27.46 in /usr/local/lib/pytho
Requirement already satisfied: python-dateutil<3.0.0,>=2.1 in /usr/local/lib/pyt
Requirement already satisfied: gitdb<5,>=4.0.1 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/pyth
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Requirement already satisfied: pyyaml in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: yellowbrick>=1.3 in /usr/local/lib/python3.7/dist
Requirement already satisfied: scikit-plot>=0.3.7 in /usr/local/lib/python3.7/di
Requirement already satisfied: matplotlib>=1.4.0 in /usr/local/lib/python3.7/dis
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.7/dis
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/
Requirement already satisfied: monotonic in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: bravado-core>=5.16.1 in /usr/local/lib/python3.7/
Requirement already satisfied: simplejson in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: msgpack in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: pytz in /usr/local/lib/python3.7/dist-packages (f
Requirement already satisfied: jsonref in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: rfc3987 in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: strict-rfc3339 in /usr/local/lib/python3.7/dist-p
Requirement already satisfied: jsonpointer>1.13 in /usr/local/lib/python3.7/dist
Requirement already satisfied: webcolors in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packag
```

```
import neptune.new as neptune
from neptune.new.types import File

run = neptune.init(
    project="saivikaschinthirla/5901-Project",
    api_token="eyJhcGlfYWRkcmVzcyI6Imh0dHBzOi8vYXBwLm5lcHR1bmUuYWkiLCJhcGlfdXJsIjo
)
```

```
https://app.neptune.ai/saivikaschinthirla/5901-Project/e/PROJ-3
Info (NVML): Driver Not Loaded. GPU usage metrics may not be reported. For more
Remember to stop your run once you’ve finished logging your metadata (https://dc
```

```
train_data = pd.read_csv("bodyPerformance.csv")
```

```
train_data.shape
```

```
(13393, 12)
```

```
train_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13393 entries, 0 to 13392
Data columns (total 12 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   age                      13393 non-null  int64  
 1   gender                   13393 non-null  object 
 2   height_cm                13393 non-null  float64
 3   weight_kg                13393 non-null  float64
 4   body_fat_percent         13393 non-null  float64
 5   diastolic                13393 non-null  float64
 6   systolic                 13393 non-null  float64
 7   gripForce                13393 non-null  float64
 8   sit_and_bend_forward_cm  13393 non-null  float64
 9   sit-ups_counts           13393 non-null  float64
 10  broad_jump_cm            13393 non-null  float64
 11  class                    13393 non-null  object 
```

```
dtypes: float64(9), int64(1), object(2)
memory usage: 1.2+ MB
```

Step - 2.2: Dataset Pushed to GIT Using GIT LFS:

GIT LINK FOR DATASET: https://github.com/VikCodes7/SalaryDataset.git

Step - 3: Features and Target Variables

Features: In the selected dataset the features are age, gender, height_cm, weight_kg, body_fat_percent, diastolic, systolic, gripForce, sit_and_bend_forward_cm, sit-ups_counts, broad_jump_cm

Target Variable: In the selected dataset the target variable is class which represents various body performance classess. In this it is represented using Class A, B, C and D. After analysing the dataset changed the clases to just A and C.

```
train_data.head(10)
```

	age	gender	height_cm	weight_kg	body_fat_percent	diastolic	systolic	grip
0	27	M	172.3	75.24	21.3	80.0	130.0	
1	25	M	165.0	55.80	15.7	77.0	126.0	
2	31	M	179.6	78.00	20.1	92.0	152.0	
3	32	M	174.5	71.10	18.4	76.0	147.0	
4	28	M	173.8	67.70	17.1	70.0	127.0	
5	36	F	165.4	55.40	22.0	64.0	119.0	
6	42	F	164.5	63.70	32.2	72.0	135.0	
7	33	M	174.9	77.20	36.9	84.0	137.0	
8	54	M	166.8	67.50	27.6	85.0	165.0	
9	28	M	185.0	84.60	14.4	81.0	156.0	

```
train_data.isnull().sum()
```

```
age                         0
gender                      0
```

```
height_cm                  0
weight_kg                  0
body_fat_percent           0
diastolic                  0
systolic                   0
gripForce                  0
sit_and_bend_forward_cm    0
sit-ups_counts             0
broad_jump_cm              0
class                      0
dtype: int64
```

```
# target_variable = train_data["class"]
train_data['performance_class'] = train_data['class']
train_data = train_data.drop(columns=['class'])
train_data.performance_class = train_data.performance_class.map( {'A':0 , 'C':1} )
target_variable = train_data["performance_class"]
train_data = train_data.drop(columns=["performance_class"])
```

```
train_data.head()
```

	age	gender	height_cm	weight_kg	body_fat_percent	diastolic	systolic	grip
0	27	M	172.3	75.24	21.3	80.0	130.0	
1	25	M	165.0	55.80	15.7	77.0	126.0	
2	31	M	179.6	78.00	20.1	92.0	152.0	
3	32	M	174.5	71.10	18.4	76.0	147.0	
4	28	M	173.8	67.70	17.1	70.0	127.0	

```
numerics = ['int16', 'int32', 'int64', 'float16', 'float32', 'float64']
categorical_columns = list(train_data.select_dtypes(exclude=numerics).columns)
print(categorical_columns)
```

```
['gender']
```

```
from sklearn.preprocessing import LabelEncoder, StandardScaler

def one_hot_encoding_column(df, one_hot_categ):
    for col in one_hot_categ:
        tmp = pd.get_dummies(df[col], prefix = col)
        df = pd.concat([df, tmp], axis = 1)
    df = df.drop(columns = one_hot_categ)
```

```
train_data_new = one_hot_encoding_column(train_data, categorical_columns)
```

Step - 5: Protected Features:

In the current dataset the protected features are age, and gender.

Step - 6: Model Building

```
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(train_data_new, target_variabl
```

```
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.ensemble import RandomForestClassifier, GradientBoostingClassifier
from pprint import pprint
from sklearn.metrics import accuracy_score

classifiers = [RandomForestClassifier(), LogisticRegression(), GradientBoostingCla
```

```
scaler = StandardScaler()

for classifier in classifiers:
  clf = classifier
  print("Using {} classifier".format(clf))
  X_train_std = scaler.fit_transform(x_train)
  clf.fit(X_train_std, y_train)
  X_test_std = scaler.fit_transform(x_test)
  y_pred = clf.predict(X_test_std)
  print("{0:.1%} accuracy on test set.".format(accuracy_score(y_test, y_pred)))
```

```
Using RandomForestClassifier() classifier
87.2% accuracy on test set.
Using LogisticRegression() classifier
83.4% accuracy on test set.
Using GradientBoostingClassifier() classifier
86.6% accuracy on test set.
Using DecisionTreeClassifier() classifier
81.4% accuracy on test set.
Using KNeighborsClassifier() classifier
81.9% accuracy on test set.
```

Step - 7: Reason for RandomForest Model Selection

As we know that for a given machine learning model it is difficult to say that this particular model will solve the problem. So in order to overcome this I have used a few classifier models and recursively trained the models on the dataset to know which model performs well on this particular dataset. After training and generating accuracies above I can see that RandomForestClassifier outperformed other models. So going forward We will be picking this model for our dataset.

```
from sklearn.feature_selection import RFE

rf = RandomForestClassifier(random_state=0)
rf.fit(scaler.fit_transform(x_train), y_train)
acc = accuracy_score(y_test, rf.predict(scaler.fit_transform(x_test)))

#Applying RFE to select features of most importance
rfe = RFE(estimator=RandomForestClassifier(), n_features_to_select=10, step=2,verb
rfe.fit(x_train, y_train)
mask = rfe.support_
reduced_X = train_data_new.loc[:, mask]
print(reduced_X.columns)
```

```
Fitting estimator with 12 features.
Index(['age', 'height_cm', 'weight_kg', 'body_fat_percent', 'diastolic',
       'systolic', 'gripForce', 'sit_and_bend_forward_cm', 'sit-ups_counts',
       'broad_jump_cm'],
      dtype='object')
```

```
pprint(dict(zip(x_train.columns, rf.feature_importances_.round(2))))

print("{0:.1%} accuracy on test set.".format(acc))
```

```
{'age': 0.09,
 'body_fat_percent': 0.07,
 'broad_jump_cm': 0.08,
 'diastolic': 0.04,
 'gender_F': 0.02,
 'gender_M': 0.01,
 'gripForce': 0.08,
 'height_cm': 0.05,
 'sit-ups_counts': 0.16,
 'sit_and_bend_forward_cm': 0.31,
 'systolic': 0.04,
 'weight_kg': 0.07}
87.4% accuracy on test set.
```

Step- 4: Features with most predictive value

After selecting RandomForestClassifier as our model. I have used RecursiveFeartureElimination(RFE) method to know the most important features of the current dataset. And can see that **'sit and bend forward_cm'** and **'sit-ups counts'** features are the most important features with most predictive value.

Step - 8: Machine Learning Metrics

As mentioned earlier some of the machine learning metrics that we use are accuracy which is displayed above and for our model it is just above 81%. And for other metrics like precision, recall etc., below are the numbers generated.

```
from sklearn.metrics import classification_report,f1_score
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.78      0.89      0.83      1335
           1       0.88      0.74      0.80      1344

    accuracy                           0.82      2679
   macro avg       0.83      0.82      0.82      2679
weighted avg       0.83      0.82      0.82      2679
```

```
print(f1_score(y_test, y_pred))
```

```
0.8043478260869565
```

```
acc = accuracy_score(y_test, y_pred)
print("{0:.1%} accuracy on test set before error analysis.".format(acc))
```

```
81.9% accuracy on test set.
```

Step - 9: Error Analysis

From the initial metrics we can see that recall for both the prediction classes is 89 for class A and 74 for class C. And after doing some exploration on the data found that height is in cm and weight is in KGS. so changed the metric of height by dividing by 100. Next, after looking at the wrongly identified samples and analysing distribution graphs of age, diastolic, body_fat columns I can see that most of the data in the distribution is below or above some range. And based on that necesasry new columns of data is created and retrained the model. Then the accuracy of the model got increased by few points of percentage. And also recall percentage for both the classes got increased.

```
train_data_new['height_cm'] = train_data_new['height_cm'] / 100
```

```
results = rf.predict(scaler.fit_transform(x_test))
print(results)

```

```
[0 0 0 ... 0 0 1]
```

```
wronglyPredictedSamples = x_test[results != y_test]
```

```
wronglyPredictedSamples.head()
```

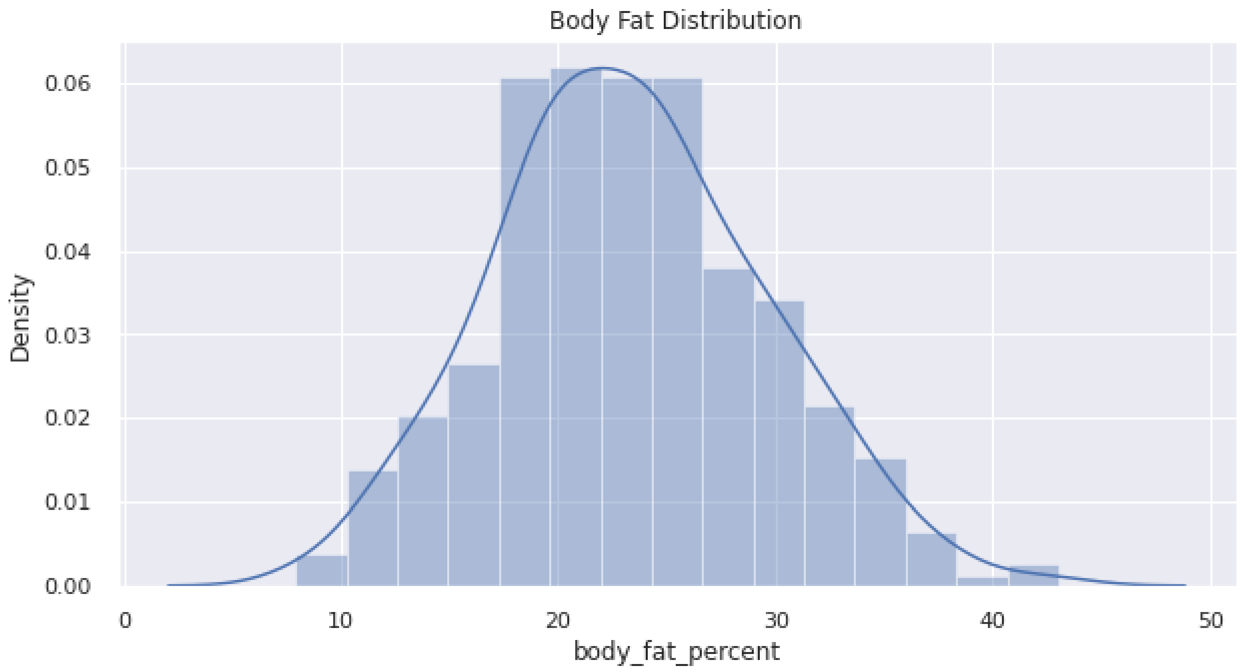
	age	height_cm	weight_kg	body_fat_percent	diastolic	systolic	gripForc
6939	22	170.0	66.6	25.5	56.0	129.0	28.
12440	42	170.6	63.8	16.3	72.0	120.0	61.
10855	50	163.6	63.0	30.4	71.0	136.0	28.
4602	48	174.3	74.3	23.0	73.0	126.0	44.
2908	58	168.4	69.7	25.7	81.0	134.0	37.

```
sns.set()
plt.figure(figsize=(10, 5))
plt.title('Age Distribution')
sns.distplot(wronglyPredictedSamples['age'])
plt.show()
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/distributions.py:2619: FutureWarn
  warnings.warn(msg, FutureWarning)
```

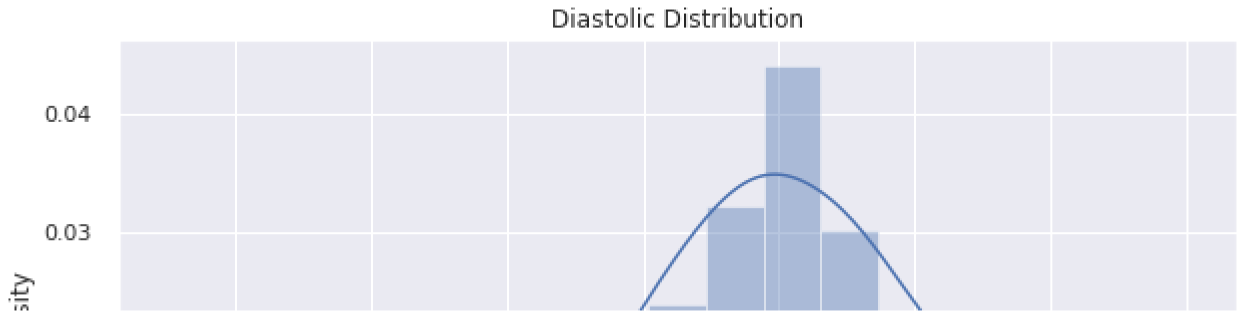
```
sns.set()
plt.figure(figsize=(10, 5))
plt.title('Body Fat Distribution')
sns.distplot(wronglyPredictedSamples['body_fat_percent'])
plt.show()
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/distributions.py:2619: FutureWarn
  warnings.warn(msg, FutureWarning)
```



```
sns.set()
plt.figure(figsize=(10, 5))
plt.title('Diastolic Distribution')
sns.distplot(wronglyPredictedSamples['diastolic'])
plt.show()
```

```
/usr/local/lib/python3.7/dist-packages/seaborn/distributions.py:2619: FutureWarn
  warnings.warn(msg, FutureWarning)
```



```
def create_age_groups(df, age_limit=30):
  df['AgeGroup'] = np.where(df['age'] < age_limit, 0, 1)
  return df
```

```
def create_body_fat_groups(df, age_limit=26):
  df['BodyFatGroup'] = np.where(df['body_fat_percent'] < age_limit, 0, 1)
  return df


def create_diastolic_groups(df, diastolic_limit=72):
  df['DiastolicGroup'] = np.where(df['diastolic'] < diastolic_limit, 0, 1)
  return df
```

```
train_data_error_analysis = create_age_groups(train_data_new)
train_data_error_analysis = create_body_fat_groups(train_data_error_analysis)
train_data_error_analysis = create_diastolic_groups(train_data_error_analysis)
```

```
x_train_new, x_test_new, y_train_new, y_test_new = train_test_split(train_data_err
```

```
parameters = {'n_estimators': 70,
              'max_depth': 7,
              'min_samples_split': 3}
```

```
clf = RandomForestClassifier(**parameters)
clf.fit(scaler.fit_transform(x_train_new), y_train_new)
acc = accuracy_score(y_test_new, clf.predict(scaler.fit_transform(x_test_new)))
print("{0:.1%} accuracy on test set after performing error analysis.".format(acc))
```

```
86.0% accuracy on test set after performing error analysis.
```

```
run['parameters'] = parameters
y_pred = clf.predict(scaler.fit_transform(x_test_new))

run['scores/max_error'] = max_error(y_test_new, y_pred)
run['scores/mean_absolute_error'] = mean_absolute_error(y_test_new, y_pred)
run['scores/r2_score'] = r2_score(y_test_new, y_pred)
```

```
run["train/accuracy"].log(acc)
run["test/mean_absolute_error"].log(mean_absolute_error(y_test_new, y_pred))
run["test/max_error"].log(max_error(y_test_new, y_pred))
```

```
import neptune.new.integrations.sklearn as npt_utils

run["cls_summary"] = npt_utils.create_classifier_summary(
    clf, x_train_new, x_test_new, y_train_new, y_test_new
)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
```

```
run["confusion-matrix"] = npt_utils.create_confusion_matrix_chart(clf, x_train_new
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
```

```
run["visuals/classification_report"] = \
    npt_utils.create_classification_report_chart(
    clf, x_train_new, x_test_new, y_train_new, y_test_new)

```

```
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
/usr/local/lib/python3.7/dist-packages/sklearn/base.py:444: UserWarning: X has f
  f"X has feature names, but {self.__class__.__name__} was fitted without"
```

Metrics After Error Analysis

```
print(classification_report(y_test_new, clf.predict(scaler.fit_transform(x_test_ne
```

```
              precision    recall  f1-score   support

           0       0.82      0.93      0.87      2005
           1       0.92      0.79      0.85      2013

    accuracy                           0.86      4018
   macro avg       0.87      0.86      0.86      4018
weighted avg       0.87      0.86      0.86      4018
```

```
print(f1_score(y_test_new, clf.predict(scaler.fit_transform(x_test_new))))
```

```
0.8498402555910542
```

```
print(accuracy_score(y_test_new, clf.predict(scaler.fit_transform(x_test_new))))
```

```
0.8596316575410652
```

Step - 10: Model Fairness Evaluation

We are doing the fairness evaluation based on protected variable gender which has two values male and female. As we can see from below model is approximately just above 82% accurate for both males and females. The main reason behind this can be involvment of other features of the dataset as well. Based on the below observation we can say that our model is not biased towards male or female as accuracies are almost similar.

```
male_dataset = x_test_new[x_test_new['gender_M'] == 1]
female_dataset = x_test_new[x_test_new['gender_F'] == 1]

males_test = y_test_new[x_test_new['gender_M'] == 1]
females_test = y_test_new[x_test_new['gender_F'] == 1]
```

```
male_predictions = clf.predict(scaler.fit_transform(male_dataset))
print("{0:.1%} accuracy on males test set.".format(accuracy_score(males_test, male
female_predictions = clf.predict(scaler.fit_transform(female_dataset))
print("{0:.1%} accuracy on females test set.".format(accuracy_score(females_test,
```

```
82.2% accuracy on males test set.
82.0% accuracy on females test set.
```

```
train_data_error_analysis.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13393 entries, 0 to 13392
Data columns (total 15 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   age                      13393 non-null  int64  
 1   height_cm                13393 non-null  float64
 2   weight_kg                13393 non-null  float64
 3   body_fat_percent         13393 non-null  float64
 4   diastolic                13393 non-null  float64
 5   systolic                 13393 non-null  float64
 6   gripForce                13393 non-null  float64
 7   sit_and_bend_forward_cm  13393 non-null  float64
 8   sit-ups_counts           13393 non-null  float64
 9   broad_jump_cm            13393 non-null  float64
 10  gender_F                 13393 non-null  uint8  
 11  gender_M                 13393 non-null  uint8  
 12  AgeGroup                 13393 non-null  int64  
 13  BodyFatGroup             13393 non-null  int64  
 14  DiastolicGroup           13393 non-null  int64  
dtypes: float64(9), int64(4), uint8(2)
memory usage: 1.4 MB
Warning: string series 'monitoring/stdout' value was longer than 1000 characters
```

```
train_data_error_analysis = train_data_error_analysis.astype({"age":'float', "gend
```

```
train_data_error_analysis.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13393 entries, 0 to 13392
Data columns (total 15 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   age                      13393 non-null  float64
 1   height_cm                13393 non-null  float64
 2   weight_kg                13393 non-null  float64
 3   body_fat_percent         13393 non-null  float64
 4   diastolic                13393 non-null  float64
 5   systolic                 13393 non-null  float64
 6   gripForce                13393 non-null  float64
 7   sit_and_bend_forward_cm  13393 non-null  float64
 8   sit-ups_counts           13393 non-null  float64
 9   broad_jump_cm            13393 non-null  float64
 10  gender_F                 13393 non-null  float64
 11  gender_M                 13393 non-null  float64
 12  AgeGroup                 13393 non-null  float64
 13  BodyFatGroup             13393 non-null  float64
 14  DiastolicGroup           13393 non-null  float64
dtypes: float64(15)
memory usage: 1.5 MB
```

Step - 11: Building pipeline using TFX

```
try:
  import colab
  !pip install --upgrade pip
except:
  pass
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-whe
Requirement already satisfied: pip in /usr/local/lib/python3.7/dist-packages (21
Collecting pip
  Downloading pip-22.2.2-py3-none-any.whl (2.0 MB)
     |████████████████████████████████| 2.0 MB 5.5 MB/s
Installing collected packages: pip
  Attempting uninstall: pip
    Found existing installation: pip 21.1.3
    Uninstalling pip-21.1.3:
      Successfully uninstalled pip-21.1.3
Successfully installed pip-22.2.2
```

```
pip install tfx
```

```
    Found existing installation: cloudpickle 1.3.0
    Uninstalling cloudpickle-1.3.0:
      Successfully uninstalled cloudpickle-1.3.0
  Attempting uninstall: attrs
    Found existing installation: attrs 22.1.0
    Uninstalling attrs-22.1.0:
      Successfully uninstalled attrs-22.1.0
  Attempting uninstall: ipython
    Found existing installation: ipython 5.5.0
    Uninstalling ipython-5.5.0:
      Successfully uninstalled ipython-5.5.0
  Attempting uninstall: google-resumable-media
    Found existing installation: google-resumable-media 0.4.1
    Uninstalling google-resumable-media-0.4.1:

      Successfully uninstalled google-resumable-media-0.4.1
  Attempting uninstall: google-auth-httplib2
    Found existing installation: google-auth-httplib2 0.0.4
    Uninstalling google-auth-httplib2-0.0.4:
      Successfully uninstalled google-auth-httplib2-0.0.4
  Attempting uninstall: google-api-core
    Found existing installation: google-api-core 1.31.6
    Uninstalling google-api-core-1.31.6:
      Successfully uninstalled google-api-core-1.31.6
  Attempting uninstall: tensorboard
    Found existing installation: tensorboard 2.8.0
    Uninstalling tensorboard-2.8.0:
      Successfully uninstalled tensorboard-2.8.0
  Attempting uninstall: google-cloud-core
    Found existing installation: google-cloud-core 1.0.3
    Uninstalling google-cloud-core-1.0.3:
      Successfully uninstalled google-cloud-core-1.0.3
  Attempting uninstall: tensorflow
```

```
      Found existing installation: tensorflow 2.8.2+zzzcolab20220719082949
      Uninstalling tensorflow-2.8.2+zzzcolab20220719082949:
        Successfully uninstalled tensorflow-2.8.2+zzzcolab20220719082949
    Attempting uninstall: google-cloud-storage
      Found existing installation: google-cloud-storage 1.18.1
      Uninstalling google-cloud-storage-1.18.1:
        Successfully uninstalled google-cloud-storage-1.18.1
    Attempting uninstall: google-cloud-language
      Found existing installation: google-cloud-language 1.2.0
      Uninstalling google-cloud-language-1.2.0:
        Successfully uninstalled google-cloud-language-1.2.0
    Attempting uninstall: google-cloud-bigquery-storage
      Found existing installation: google-cloud-bigquery-storage 1.1.2
      Uninstalling google-cloud-bigquery-storage-1.1.2:
        Successfully uninstalled google-cloud-bigquery-storage-1.1.2
    Attempting uninstall: google-cloud-bigquery
      Found existing installation: google-cloud-bigquery 1.21.0
      Uninstalling google-cloud-bigquery-1.21.0:
        Successfully uninstalled google-cloud-bigquery-1.21.0
ERROR: pip's dependency resolver does not currently take into account all the pa
pandas-gbq 0.13.3 requires google-cloud-bigquery[bqstorage,pandas]<2.0.0dev,>=1.
jupyter-console 5.2.0 requires prompt-toolkit<2.0.0,>=1.0.0, but you have prompt
gym 0.17.3 requires cloudpickle<1.7.0,>=1.2.0, but you have cloudpickle 2.1.0 wh
google-colab 1.0.0 requires ipython~=5.5.0, but you have ipython 7.34.0 which is
Successfully installed apache-beam-2.40.0 attrs-20.3.0 cloudpickle-2.1.0 dill-0.
WARNING: Running pip as the 'root' user can result in broken permissions and con
```

```python
import os
from absl import logging
import urllib.request
import tempfile
import pandas as pd
logging.set_verbosity(logging.INFO)  # Set default logging level.

import tensorflow as tf
%tensorflow_version 2.9.1
print('TensorFlow version: {}'.format(tf.__version__))
from tfx import v1 as tfx
print('TFX version: {}'.format(tfx.__version__))
```

```
Colab only includes TensorFlow 2.x; %tensorflow_version has no effect.
TensorFlow version: 2.9.1
INFO:absl:tensorflow_io is not available: No module named 'tensorflow_io'
INFO:absl:tensorflow_ranking is not available: No module named 'tensorflow_ranki
INFO:absl:tensorflow_text is not available: No module named 'tensorflow_text'
INFO:absl:tensorflow_decision_forests is not available: No module named 'tensorf
INFO:absl:struct2tensor is not available: No module named 'struct2tensor'
INFO:absl:tensorflow_text is not available: No module named 'tensorflow_text'
TFX version: 1.9.1
```

```python
PIPELINE_NAME = "performance_prediction_pipeline"


```

```
# PIPELINE_ROOT for output directory to store artifacts generated from the pipelin
# 3 => CODE HERE #
PIPELINE_ROOT=os.path.join('pipelines', PIPELINE_NAME)

# METADATA_PATH for storing meta data
# 4 => CODE HERE #
METADATA_PATH=os.path.join('metdata', PIPELINE_NAME, 'metadata.db')

# SERVING_MODEL_DIR to deploy your model
# 5 => CODE HERE #
SERVING_MODEL_DIR=os.path.join('serving_model', PIPELINE_NAME)
```

```
data = pd.read_csv('bodyPerformance.csv')
data['performance_class'] = data['class']
data = data.drop(columns=['class'])
data.performance_class = data.performance_class.map( {'A':0 , 'C':1} )

train_data_pipeline = one_hot_encoding_column(data, categorical_columns)

train_data_pipeline = create_age_groups(train_data_pipeline)
train_data_pipeline = create_body_fat_groups(train_data_pipeline)
train_data_pipeline = create_diastolic_groups(train_data_pipeline)
```

```
train_data_pipeline = train_data_pipeline.astype({"age":'float', "gender_F":'float
```

```
DATA_ROOT = tempfile.mkdtemp(prefix='tfx-data')
# Create a temporary directory.

# read your CSV file. Convert column Species from categorical string to int values
# _data_filepath should point to your converted CSV file
# 6 => CODE HERE #
_data_filepath = os.path.join(DATA_ROOT, "data.csv")
train_data_pipeline.to_csv(_data_filepath)
```

```
columns_list = list(data.columns)
print(columns_list)
```

```
['age', 'gender', 'height_cm', 'weight_kg', 'body_fat_percent', 'diastolic', 'sy
```

```
!head {_data_filepath}
```

```
,age,height_cm,weight_kg,body_fat_percent,diastolic,systolic,gripForce,sit_and_b
0,27.0,172.3,75.24,21.3,80.0,130.0,54.9,18.4,60.0,217.0,1,0.0,1.0,0.0,0.0,1.0
1,25.0,165.0,55.8,15.7,77.0,126.0,36.4,16.3,53.0,229.0,0,0.0,1.0,0.0,0.0,1.0
2,31.0,179.6,78.0,20.1,92.0,152.0,44.8,12.0,49.0,181.0,1,0.0,1.0,1.0,0.0,1.0
3,32.0,174.5,71.1,18.4,76.0,147.0,41.4,15.2,53.0,219.0,0,0.0,1.0,1.0,0.0,1.0
4,28.0,173.8,67.7,17.1,70.0,127.0,43.5,27.1,45.0,217.0,0,0.0,1.0,0.0,0.0,0.0
5,36.0,165.4,55.4,22.0,64.0,119.0,23.8,21.0,27.0,153.0,0,1.0,0.0,1.0,0.0,0.0
6,42.0,164.5,63.7,32.2,72.0,135.0,22.7,0.8,18.0,146.0,1,1.0,0.0,1.0,1.0,1.0
```

```
7,33.0,174.9,77.2,36.9,84.0,137.0,45.9,12.3,42.0,234.0,0,0.0,1.0,1.0,1.0,1.0
8,54.0,166.8,67.5,27.6,85.0,165.0,40.4,18.6,34.0,148.0,1,0.0,1.0,1.0,1.0,1.0
```

```
_trainer_module_file = 'performance_trainer.py'
```

```
!pip install tensorflow_decision_forests
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-whe
Collecting tensorflow_decision_forests
  Downloading tensorflow_decision_forests-0.2.7-cp37-cp37m-manylinux_2_17_x86_64
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 16.0/16.0 MB 36.5 MB/s eta 0:00:0(
Requirement already satisfied: absl-py in /usr/local/lib/python3.7/dist-packages
Collecting wurlitzer
  Downloading wurlitzer-3.0.2-py3-none-any.whl (7.3 kB)
Requirement already satisfied: tensorflow~=2.9.1 in /usr/local/lib/python3.7/dis
Requirement already satisfied: wheel in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-packages (
Requirement already satisfied: pandas in /usr/local/lib/python3.7/dist-packages
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (fr
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.7/dist
Requirement already satisfied: tensorboard<2.10,>=2.9 in /usr/local/lib/python3.
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.7/dist
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.7/d
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in /usr/local/lib/python3.7/d
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: setuptools in /usr/local/lib/python3.7/dist-packa
Requirement already satisfied: h5py>=2.9.0 in /usr/local/lib/python3.7/dist-pack
Requirement already satisfied: tensorflow-estimator<2.10.0,>=2.9.0rc0 in /usr/lc
Requirement already satisfied: packaging in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.7/d
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/loca
Requirement already satisfied: keras-preprocessing>=1.1.1 in /usr/local/lib/pyth
Requirement already satisfied: protobuf<3.20,>=3.9.2 in /usr/local/lib/python3.7
Requirement already satisfied: keras<2.10.0,>=2.9.0rc0 in /usr/local/lib/python3
Requirement already satisfied: flatbuffers<2,>=1.12 in /usr/local/lib/python3.7/
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.7/dis
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.7/dis
Requirement already satisfied: pytz>=2017.3 in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.
Requirement already satisfied: cached-property in /usr/local/lib/python3.7/dist-
Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in /usr/loc
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.7/dist-
Requirement already satisfied: google-auth<3,>=1.6.3 in /usr/local/lib/python3.7
Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.7/d
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in /usr/local/lib/p
Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in /usr/local/li
Requirement already satisfied: pyparsing>=2.0.2 in /usr/local/lib/python3.7/dist
Requirement already satisfied: cachetools<5.0,>=2.0.0 in /usr/local/lib/python3.
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.7/dist-pa
Requirement already satisfied: pyasn1-modules>=0.2.1 in /usr/local/lib/python3.7
Requirement already satisfied: requests-oauthlib>=0.7.0 in /usr/local/lib/python
Requirement already satisfied: importlib-metadata>=4.4 in /usr/local/lib/python3
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.7/dist-pac
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.7/di
Requirement already satisfied: charset-normalizer<3,>=2 in /usr/local/lib/python
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.7
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packag
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in /usr/local/lib/python3.7/
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.7/dist-
Installing collected packages: wurlitzer, tensorflow_decision_forests
Successfully installed tensorflow_decision_forests-0.2.7 wurlitzer-3.0.2
WARNING: Running pip as the 'root' user can result in broken permissions and con
```

age height_cm weight_kg body fat_% diastolic systolic gripForce sit and bend forward_cm sit-ups counts broad jump_cm gender_F gender_M

```
%%writefile {_trainer_module_file}

from typing import List
from absl import logging
import tensorflow as tf
from tensorflow import keras
from tensorflow_transform.tf_metadata import schema_utils
import tensorflow_decision_forests as tfdf


from tfx import v1 as tfx
from tfx_bsl.public import tfxio
from tensorflow_metadata.proto.v0 import schema_pb2

# define the list of features in _FEATURE_KEYS variable
# 8 => CODE HERE #
_FEATURE_KEYS = ['age', 'height_cm', 'weight_kg', 'body_fat_percent', 'diastolic',



# define your target variable _LABEL_KEY
# 9 => CODE HERE #
_LABEL_KEY = 'performance_class'

_TRAIN_BATCH_SIZE = 20
_EVAL_BATCH_SIZE = 10

# Since we're not generating or creating a schema, we will instead create
# a feature spec.  Since there are a fairly small number of features this is
# manageable for this dataset.
_FEATURE_SPEC = {
    **{
        feature: tf.io.FixedLenFeature(shape=[1], dtype=tf.float32)
           for feature in _FEATURE_KEYS
       },
    _LABEL_KEY: tf.io.FixedLenFeature(shape=[1], dtype=tf.int64)
}


def _input_fn(file_pattern: List[str],
              data_accessor: tfx.components.DataAccessor,
              schema: schema_pb2.Schema,
              batch_size: int = 200) -> tf.data.Dataset:
  """Generates features and label for training.

  Args:
    file_pattern: List of paths or patterns of input tfrecord files.
    data_accessor: DataAccessor for converting input to RecordBatch.
    schema: schema of the input data.
    batch_size: representing the number of consecutive elements of returned
      dataset to combine in a single batch

  Returns:
    A dataset that contains (features, indices) tuple where features is a
      dictionary of Tensors, and indices is a single Tensor of label indices.
  """
  return data_accessor.tf_dataset_factory(
      file_pattern,
      tfxio.TensorFlowDatasetOptions(
          batch_size=batch_size, label_key=_LABEL_KEY, num_epochs=100),
      schema=schema)


def _build_keras_model() -> tf.keras.Model:
  """Creates a DNN Keras model for classifying penguin data.

  Returns:
    A Keras Model.
  """
  # The model below is built with Functional API, please refer to
  # https://www.tensorflow.org/guide/keras/overview for all API options.
  # inputs = [keras.layers.Input(shape=(1,), name=f) for f in _FEATURE_KEYS]
  # d = keras.layers.concatenate(inputs)
  # # compelete your model architecture here
  # # 10 => CODE HERE #
  # d = keras.layers.Dense(8, activation='relu')(d)
  # d = keras.layers.Dense(8, activation='relu')(d)
  # d = keras.layers.Dense(8, activation='relu')(d)
  # outputs = keras.layers.Dense(3)(d)

  # model = keras.Model(inputs=inputs, outputs=outputs)
  # model.compile(
  #     optimizer=keras.optimizers.Adam(1e-2),
  #     loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
  #     metrics=[keras.metrics.SparseCategoricalAccuracy()])

  # model.summary(print_fn=logging.info)
  model = tfdf.keras.RandomForestModel(check_dataset=False)
  # model.compile(metrics=[keras.metrics.Accuracy()])
  # model.build((1, 6))
  # print(model.summary())

  return model


# TFX Trainer will call this function.
def run_fn(fn_args: tfx.components.FnArgs):
  """Train the model based on given args.

  Args:
    fn_args: Holds args used to train the model as name/value pairs.
  """

  # This schema is usually either an output of SchemaGen or a manually-curated
  # version provided by pipeline author. A schema can also derived from TFT
  # graph if a Transform component is used. In the case when either is missing,
  # `schema_from_feature_spec` could be used to generate schema from very simple
  # feature_spec, but the schema returned would be very primitive.
  schema = schema_utils.schema_from_feature_spec(_FEATURE_SPEC)

  train_dataset = _input_fn(
      fn_args.train_files,
      fn_args.data_accessor,
      schema,
      batch_size=_TRAIN_BATCH_SIZE)
  eval_dataset = _input_fn(
      fn_args.eval_files,
      fn_args.data_accessor,
      schema,
      batch_size=_EVAL_BATCH_SIZE)

  model = _build_keras_model()
  model.fit(
      train_dataset,
      steps_per_epoch=100,
      validation_data=eval_dataset,
      validation_steps=5)

  # The result of the training should be saved in `fn_args.serving_model_dir`
  # directory.
  model.save(fn_args.serving_model_dir, save_format='tf')
```

```
Writing performance_trainer.py
```

```
import tensorflow_model_analysis as tfma


```

```
def _create_pipeline(pipeline_name: str, pipeline_root: str, data_root: str,
                     module_file: str, serving_model_dir: str,
                     metadata_path: str) -> tfx.dsl.Pipeline:
  """Creates a three component penguin pipeline with TFX."""
  # Brings data into the pipeline.
  example_gen = tfx.components.CsvExampleGen(input_base=data_root)

  # Uses user-provided Python function that trains a model.
  trainer = tfx.components.Trainer(
      module_file=module_file,
      examples=example_gen.outputs['examples'],
      train_args=tfx.proto.TrainArgs(num_steps=100),
      eval_args=tfx.proto.EvalArgs(num_steps=5))

  model_resolver = tfx.dsl.Resolver(
      strategy_class=tfx.dsl.experimental.LatestBlessedModelStrategy,
      model=tfx.dsl.Channel(type=tfx.types.standard_artifacts.Model),
      model_blessing=tfx.dsl.Channel(
          type=tfx.types.standard_artifacts.ModelBlessing)).with_id(
              'latest_blessed_model_resolver')

  eval_config = tfma.EvalConfig(
      model_specs=[tfma.ModelSpec(label_key='performance_class')],
      slicing_specs=[
          # An empty slice spec means the overall slice, i.e. the whole dataset.
          tfma.SlicingSpec(),
          # Calculate metrics for each penguin species.
          tfma.SlicingSpec(feature_keys=['performance_class']),
          ],
      metrics_specs=[
          tfma.MetricsSpec(per_slice_thresholds={
              'accuracy':
                  tfma.PerSliceMetricThresholds(thresholds=[
                      tfma.PerSliceMetricThreshold(
                          slicing_specs=[tfma.SlicingSpec()],
                          threshold=tfma.MetricThreshold(
                              value_threshold=tfma.GenericValueThreshold(
                                   lower_bound={'value': 0.4}),
                              # Change threshold will be ignored if there is no
                              # baseline model resolved from MLMD (first run).
                              change_threshold=tfma.GenericChangeThreshold(
                                  direction=tfma.MetricDirection.HIGHER_IS_BETTER,
                                  absolute={'value': -1e-10}))
                       )]),
          })],
      )

  # Pushes the model to a filesystem destination.
  pusher = tfx.components.Pusher(
      model=trainer.outputs['model'],
      push_destination=tfx.proto.PushDestination(
          filesystem=tfx.proto.PushDestination.Filesystem(
              base_directory=serving_model_dir)))

  evaluator = tfx.components.Evaluator(
      examples=example_gen.outputs['examples'],
      model=trainer.outputs['model'],
      baseline_model=model_resolver.outputs['model'],
      eval_config=eval_config)

  # Following three components will be included in the pipeline.
  components = [
      example_gen,
      trainer,
      model_resolver,
      evaluator,
      pusher,
  ]

  return tfx.dsl.Pipeline(
      pipeline_name=pipeline_name,
      pipeline_root=pipeline_root,
      metadata_connection_config=tfx.orchestration.metadata
      .sqlite_metadata_connection_config(metadata_path),
      components=components)
```

```
tfx.orchestration.LocalDagRunner().run(
  _create_pipeline(
      pipeline_name=PIPELINE_NAME,
      pipeline_root=PIPELINE_ROOT,
      data_root=DATA_ROOT,
      module_file=_trainer_module_file,
      serving_model_dir=SERVING_MODEL_DIR,
      metadata_path=METADATA_PATH))
```

```
INFO:absl:Generating ephemeral wheel package for '/content/performance_trainer.p
INFO:absl:User module package has hash fingerprint version d343dfe4385c900dcf26b
INFO:absl:Executing: ['/usr/bin/python3', '/tmp/tmpsj8yjsca/_tfx_generated_setup
INFO:absl:Successfully built user code wheel distribution at 'pipelines/performa
INFO:absl:Full user module path is 'performance_trainer@pipelines/performance_pr
Warning: string series 'monitoring/stderr' value was longer than 1000 characters
INFO:absl:Using deployment config:
 executor_specs {
  key: "CsvExampleGen"
  value {
    beam_executable_spec {
      python_executor_spec {
        class_path: "tfx.components.example_gen.csv_example_gen.executor.Executo
      }
    }
  }
}
executor_specs {
  key: "Evaluator"
  value {
    beam_executable_spec {
      python_executor_spec {
        class_path: "tfx.components.evaluator.executor.Executor"
      }
    }
  }
}
executor_specs {
  key: "Pusher"
  value {
    python_class_executable_spec {
      class_path: "tfx.components.pusher.executor.Executor"
    }
  }
}
executor_specs {
  key: "Trainer"
  value {
    python_class_executable_spec {
      class_path: "tfx.components.trainer.executor.GenericExecutor"
    }
  }
}
custom_driver_specs {
  key: "CsvExampleGen"
  value {
    python_class_executable_spec {
      class_path: "tfx.components.example_gen.driver.FileBasedDriver"
    }
  }
}
metadata_connection_config {
  database_connection_config {
    sqlite {
      filename_uri: "metdata/performance_prediction_pipeline/metadata.db"
      connection_mode: READWRITE_OPENCREATE
    }
  }
}

INFO:absl:Using connection config:
 sqlite {
  filename_uri: "metdata/performance_prediction_pipeline/metadata.db"
  connection_mode: READWRITE_OPENCREATE
}

INFO:absl:Component CsvExampleGen is running.
INFO:absl:Running launcher for node_info {
  type {
    name: "tfx.components.example_gen.csv_example_gen.component.CsvExampleGen"
  }
  id: "CsvExampleGen"
}
contexts {
  contexts {
    type {
      name: "pipeline"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline"
      }
    }
  }
  contexts {
    type {
      name: "pipeline_run"
    }
    name {
      field_value {
        string_value: "2022-08-07T21:46:12.448311"
      }
    }
  }
  contexts {
    type {
      name: "node"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline.CsvExampleGen"
      }
    }
  }
}
outputs {
  outputs {
    key: "examples"
    value {
      artifact_spec {
        type {
          name: "Examples"
          properties {
          properties {
            key: "span"
            value: INT
          }
          properties {
            key: "split_names"
            value: STRING
          }
          properties {
            key: "version"
            value: INT
          }
          base_type: DATASET
        }
      }
    }
  }
}
parameters {
  parameters {
    key: "input_base"
    value {
      field_value {
        string_value: "/tmp/tfx-datakdf18wgu"
      }
    }
  }
  parameters {
    key: "input_config"
    value {
      field_value {
        string_value: "{\n  \"splits\": [\n    {\n      \"name\": \"single_split
      }
    }
  }
  parameters {
    key: "output_config"
    value {
      field_value {
        string_value: "{\n  \"split_config\": {\n    \"splits\": [\n      {\n
      }
    }
  }
  parameters {
    key: "output_data_format"
    value {
      field_value {
        int_value: 6
      }
    }
  }
  parameters {
    key: "output_file_format"
    value {
      field_value {
        int_value: 5
      }
    }
  }
}
downstream_nodes: "Evaluator"
downstream_nodes: "Trainer"
execution_options {
  caching_options {
  }
}

INFO:absl:MetadataStore with DB connection initialized
INFO:absl:select span and version = (0, None)
INFO:absl:latest span and version = (0, None)
INFO:absl:MetadataStore with DB connection initialized
INFO:absl:Going to run a new execution 1
INFO:absl:Going to run a new execution: ExecutionInfo(execution_id=1, input_dict
custom_properties {
  key: "input_fingerprint"
  value {
    string_value: "split:single_split,num_files:1,total_bytes:1072224,xor_checks
  }
}
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Cs
  }
}
custom_properties {
  key: "span"
  value {
    int_value: 0
  }
}
name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:CsvExampleGen:
, artifact_type: name: "Examples"
properties {
  key: "span"
  value: INT
}
properties {
  key: "split_names"
  value: STRING
}
properties {
  key: "version"
  value: INT
}
base_type: DATASET
)]}), exec_properties={'input_config': '{\n  "splits": [\n    {\n      "name": "
  type {
    name: "tfx.components.example_gen.csv_example_gen.component.CsvExampleGen"
  }
  id: "CsvExampleGen"
}
contexts {
  contexts {
    type {
      name: "pipeline"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline"
      }
    }
  }
  contexts {
    type {
      name: "pipeline_run"
    }
    name {
      field_value {
        string_value: "2022-08-07T21:46:12.448311"
      }
    }
  }
  contexts {
    type {
      name: "node"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline.CsvExampleGen"
      }
    }
  }
}
outputs {
  outputs {
    key: "examples"
    value {
      artifact_spec {
        type {
          name: "Examples"
          properties {
            key: "span"
            value: INT
          }
          properties {
            key: "split_names"
            value: STRING
          }
          properties {
            key: "version"
            value: INT
          }
          base_type: DATASET
        }
      }
    }
  }
}
parameters {
  parameters {
    key: "input_base"
    value {
      field_value {
        string_value: "/tmp/tfx-datakdf18wgu"
      }
    }
  }
  parameters {
    key: "input_config"
    value {
      field_value {
        string_value: "{\n  \"splits\": [\n    {\n      \"name\": \"single_split
      }
    }
  }
  parameters {
    key: "output_config"
    value {
      field_value {
        string_value: "{\n  \"split_config\": {\n    \"splits\": [\n      {\n
      }
    }
  }
  parameters {
    key: "output_data_format"
    value {
      field_value {
        int_value: 6
      }
    }
  }
  parameters {
    key: "output_file_format"
    value {
      field_value {
        int_value: 5
      }
    }
  }
}
downstream_nodes: "Evaluator"
downstream_nodes: "Trainer"
execution_options {
  caching_options {
  }
}
, pipeline_info=id: "performance_prediction_pipeline"
, pipeline_run_id='2022-08-07T21:46:12.448311')
INFO:absl:Generating examples.
WARNING:apache_beam.runners.interactive.interactive_environment:Dependencies req
INFO:absl:Processing input csv data /tmp/tfx-datakdf18wgu/* to TFExample.
WARNING:apache_beam.io.tfrecordio:Couldn't find python-snappy so the implementat
INFO:absl:Examples generated.
INFO:absl:Value type <class 'NoneType'> of key version in exec_properties is not
INFO:absl:Value type <class 'list'> of key _beam_pipeline_args in exec_propertie
INFO:absl:Cleaning up stateless execution info.
```

```
INFO:absl:Cleaning up stateless execution info.
INFO:absl:Execution 1 succeeded.
INFO:absl:Cleaning up stateful execution info.
INFO:absl:Publishing output artifacts defaultdict(<class 'list'>, {'examples': [
custom_properties {
  key: "input_fingerprint"
  value {
    string_value: "split:single_split,num_files:1,total_bytes:1072224,xor_checks
  }
}
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Cs
  }
}
custom_properties {
  key: "span"
  value {
    int_value: 0
  }
}
custom_properties {
  key: "tfx_version"
  value {
    string_value: "1.9.1"
  }
}
name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:CsvExampleGen:
, artifact_type: name: "Examples"
properties {
  key: "span"
  value: INT
}
properties {
  key: "split_names"
  value: STRING
}
properties {
  key: "version"
  value: INT
}
base_type: DATASET
)]}) for execution 1
INFO:absl:MetadataStore with DB connection initialized
INFO:absl:Component CsvExampleGen is finished.
INFO:absl:Component latest_blessed_model_resolver is running.
INFO:absl:Running launcher for node_info {
  type {
    name: "tfx.dsl.components.common.resolver.Resolver"
  }
  id: "latest_blessed_model_resolver"
}
contexts {
  contexts {
    type {
      name: "pipeline"
```

```
          }
          name {
            field_value {
              string_value: "performance_prediction_pipeline"
            }
          }
        }
        contexts {
          type {
            name: "pipeline_run"
          }
          name {
            field_value {
              string_value: "2022-08-07T21:46:12.448311"
            }
          }
        }
        contexts {
          type {
            name: "node"
          }
          name {
            field_value {
              string_value: "performance_prediction_pipeline.latest_blessed_model_resc
            }
          }
        }
      }
      inputs {
        inputs {
          key: "model"
          value {
            channels {
              context_queries {
                type {
                  name: "pipeline"
                }
                name {
                  field_value {
                    string_value: "performance_prediction_pipeline"
                  }
                }
              }
              artifact_query {
                type {
                  name: "Model"
                  base_type: MODEL
                }
              }
            }
          }
        }
        inputs {
          key: "model_blessing"
          value {
            channels {
              context_queries {
```

```
          type {
            name: "pipeline"
          }
          name {
            field_value {
              string_value: "performance_prediction_pipeline"
            }
          }
        }
        artifact_query {
          type {
            name: "ModelBlessing"
          }
        }
      }
    }
  }
  resolver_config {
    resolver_steps {
      class_path: "tfx.dsl.input_resolution.strategies.latest_blessed_model_stra
      config_json: "{}"
      input_keys: "model"
      input_keys: "model_blessing"
    }
  }
}
downstream_nodes: "Evaluator"
execution_options {
  caching_options {
  }
}

INFO:absl:Running as an resolver node.
INFO:absl:MetadataStore with DB connection initialized
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
INFO:absl:Component latest_blessed_model_resolver is finished.
INFO:absl:Component Trainer is running.
INFO:absl:Running launcher for node_info {
  type {
    name: "tfx.components.trainer.component.Trainer"
    base_type: TRAIN
  }
  id: "Trainer"
}
contexts {
  contexts {
    type {
      name: "pipeline"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline"
      }
    }
  }
```

```
        contexts {
          type {
            name: "pipeline_run"
          }
          name {
            field_value {
              string_value: "2022-08-07T21:46:12.448311"
            }
          }
        }
        contexts {
          type {
            name: "node"
          }
          name {
            field_value {
              string_value: "performance_prediction_pipeline.Trainer"
            }
          }
        }
      }
      inputs {
        inputs {
          key: "examples"
          value {
            channels {
              producer_node_query {
                id: "CsvExampleGen"
              }
              context_queries {
                type {
                  name: "pipeline"
                }
                name {
                  field_value {
                    string_value: "performance_prediction_pipeline"
                  }
                }
              }
              context_queries {
                type {
                  name: "pipeline_run"
                }
                name {
                  field_value {
                    string_value: "2022-08-07T21:46:12.448311"
                  }
                }
              }
              context_queries {
                type {
                  name: "node"
                }
                name {
                  field_value {
                    string_value: "performance_prediction_pipeline.CsvExampleGen"
                }
              }
              artifact_query {
                type {
                  name: "Examples"
                  base_type: DATASET
                }
              }
              output_key: "examples"
            }
            min_count: 1
          }
        }
      }
      outputs {
        outputs {
          key: "model"
          value {
            artifact_spec {
              type {
                name: "Model"
                base_type: MODEL
              }
            }
          }
        }
        outputs {
          key: "model_run"
          value {
            artifact_spec {
              type {
                name: "ModelRun"
              }
            }
          }
        }
      }
      parameters {
        parameters {
          key: "custom_config"
          value {
            field_value {
              string_value: "null"
            }
          }
        }
        parameters {
          key: "eval_args"
          value {
            field_value {
              string_value: "{\n  \"num_steps\": 5\n}"
            }
          }
        }
        parameters {
          key: "module_path"
```

```
    value {
      field_value {
        string_value: "performance_trainer@pipelines/performance_prediction_pipe
      }
    }
  }
  parameters {
    key: "train_args"
    value {
      field_value {
        string_value: "{\n  \"num_steps\": 100\n}"
      }
    }
  }
}
upstream_nodes: "CsvExampleGen"
downstream_nodes: "Evaluator"
downstream_nodes: "Pusher"
execution_options {
  caching_options {
  }
}

INFO:absl:MetadataStore with DB connection initialized
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ArtifactQuery.property_predicate is not supported.
INFO:absl:MetadataStore with DB connection initialized
INFO:absl:Going to run a new execution 3
INFO:absl:Going to run a new execution: ExecutionInfo(execution_id=3, input_dict
type_id: 15
uri: "pipelines/performance_prediction_pipeline/CsvExampleGen/examples/1"
properties {
  key: "split_names"
  value {
    string_value: "[\"train\", \"eval\"]"
  }
}
custom_properties {
  key: "file_format"
  value {
    string_value: "tfrecords_gzip"
  }
}
custom_properties {
  key: "input_fingerprint"
  value {
    string_value: "split:single_split,num_files:1,total_bytes:1072224,xor_checks
  }
}
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Cs
  }
}
```

```
      ,
      custom_properties {
        key: "payload_format"
        value {
          string_value: "FORMAT_TF_EXAMPLE"
        }
      }
      custom_properties {
        key: "span"
        value {
          int_value: 0
        }
      }
      custom_properties {
        key: "tfx_version"
        value {
          string_value: "1.9.1"
        }
      }
      state: LIVE
      name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:CsvExampleGen:
      create_time_since_epoch: 1659908779968
      last_update_time_since_epoch: 1659908779968
      , artifact_type: id: 15
      name: "Examples"
      properties {
        key: "span"
        value: INT
      }
      properties {
        key: "split_names"
        value: STRING
      }
      properties {
        key: "version"
        value: INT
      }
      base_type: DATASET
      )]}, output_dict=defaultdict(<class 'list'>, {'model': [Artifact(artifact: uri:
      custom_properties {
        key: "name"
        value {
          string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Tr
        }
      }
      name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Trainer:model:
      , artifact_type: name: "Model"
      base_type: MODEL
      )], 'model_run': [Artifact(artifact: uri: "pipelines/performance_prediction_pipe
      custom_properties {
        key: "name"
        value {
          string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Tr
        }
      }
      name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Trainer:model_
      , artifact_type: name: "ModelRun"
```

```
)]}), exec_properties={'module_path': 'performance_trainer@pipelines/performance
  type {
    name: "tfx.components.trainer.component.Trainer"
    base_type: TRAIN
  }
  id: "Trainer"
}
contexts {
  contexts {
    type {
      name: "pipeline"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline"
      }
    }
  }
  contexts {
    type {
      name: "pipeline_run"
    }
    name {
      field_value {
        string_value: "2022-08-07T21:46:12.448311"
      }
    }
  }
  contexts {
    type {
      name: "node"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline.Trainer"
      }
    }
  }
}
inputs {
  inputs {
    key: "examples"
    value {
      channels {
        producer_node_query {
          id: "CsvExampleGen"
        }
        context_queries {
          type {
            name: "pipeline"
          }
          name {
            field_value {
              string_value: "performance_prediction_pipeline"
            }
          }
        }
```

```
            context_queries {
              type {
                name: "pipeline_run"
              }
              name {
                field_value {
                  string_value: "2022-08-07T21:46:12.448311"
                }
              }
            }
            context_queries {
              type {
                name: "node"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline.CsvExampleGen"
                }
              }
            }
            artifact_query {
              type {
                name: "Examples"
                base_type: DATASET
              }
            }
            output_key: "examples"
          }
          min_count: 1
        }
      }
    }
    outputs {
      outputs {
        key: "model"
        value {
          artifact_spec {
            type {
              name: "Model"
              base_type: MODEL
            }
          }
        }
      }
      outputs {
        key: "model_run"
        value {
          artifact_spec {
            type {
              name: "ModelRun"
            }
          }
        }
      }
    }
    parameters {
```

```
    parameters {
      key: "custom_config"
      value {
        field_value {
          string_value: "null"
        }
      }
    }
    parameters {
      key: "eval_args"
      value {
        field_value {
          string_value: "{\n  \"num_steps\": 5\n}"
        }
      }
    }
    parameters {
      key: "module_path"
      value {
        field_value {
          string_value: "performance_trainer@pipelines/performance_prediction_pipe
        }
      }
    }
    parameters {
      key: "train_args"
      value {
        field_value {
          string_value: "{\n  \"num_steps\": 100\n}"
        }
      }
    }
  }
  upstream_nodes: "CsvExampleGen"
  downstream_nodes: "Evaluator"
  downstream_nodes: "Pusher"
  execution_options {
    caching_options {
    }
  }
  , pipeline_info=id: "performance_prediction_pipeline"
  , pipeline_run_id='2022-08-07T21:46:12.448311')
  INFO:absl:Train on the 'train' split when train_args.splits is not set.
  INFO:absl:Evaluate on the 'eval' split when eval_args.splits is not set.
  INFO:absl:udf_utils.get_fn {'module_path': 'performance_trainer@pipelines/perfor
  INFO:absl:Installing 'pipelines/performance_prediction_pipeline/_wheels/tfx_user
  INFO:absl:Executing: ['/usr/bin/python3', '-m', 'pip', 'install', '--target', '/
  INFO:absl:Successfully installed 'pipelines/performance_prediction_pipeline/_whe
  INFO:absl:Training model.
  INFO:absl:Feature AgeGroup has a shape dim {
    size: 1
  }
  . Setting to DenseTensor.
  INFO:absl:Feature BodyFatGroup has a shape dim {
    size: 1
  }
  . Setting to DenseTensor.
```

```
INFO:absl:Feature DiastolicGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature age has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature body_fat_percent has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature broad_jump_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature diastolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_F has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_M has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gripForce has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature height_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature performance_class has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit-ups_counts has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit_and_bend_forward_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature systolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature weight_kg has a shape dim {
  size: 1
}
. Setting to DenseTensor.
```

```
INFO:absl:Feature AgeGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature BodyFatGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature DiastolicGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature age has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature body_fat_percent has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature broad_jump_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature diastolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_F has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_M has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gripForce has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature height_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature performance_class has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit-ups_counts has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit_and_bend_forward_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature systolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature weight_kg has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature AgeGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature BodyFatGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature DiastolicGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature age has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature body_fat_percent has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature broad_jump_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature diastolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_F has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_M has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gripForce has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature height_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature performance_class has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit-ups_counts has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit_and_bend_forward_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature systolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature weight_kg has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature AgeGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature BodyFatGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature DiastolicGroup has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature age has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature body_fat_percent has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature broad_jump_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature diastolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_F has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gender_M has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature gripForce has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature height_cm has a shape dim {
  size: 1
```

```
}
. Setting to DenseTensor.
INFO:absl:Feature performance_class has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit-ups_counts has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature sit_and_bend_forward_cm has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature systolic has a shape dim {
  size: 1
}
. Setting to DenseTensor.
INFO:absl:Feature weight_kg has a shape dim {
  size: 1
}
. Setting to DenseTensor.
Use /tmp/tmpsaun8ou4 as temporary training directory
INFO:absl:Use /tmp/tmpsaun8ou4 as temporary training directory
Warning: The steps_per_epoch argument is deprecated. Instead, feed a finite data
WARNING:absl:The steps_per_epoch argument is deprecated. Instead, feed a finite 
Reading training dataset...
INFO:absl:Reading training dataset...
Warning: You are using non-distributed training with steps_per_epoch. This solut
WARNING:absl:You are using non-distributed training with steps_per_epoch. This s
Training dataset read in 0:00:05.922474. Found 2000 examples.
INFO:absl:Training dataset read in 0:00:05.922474. Found 2000 examples.
Reading validation dataset...
INFO:absl:Reading validation dataset...
Warning: You are using non-distributed validation with steps_per_epoch. This sol
WARNING:absl:You are using non-distributed validation with steps_per_epoch. This
Num validation examples: tf.Tensor(50, shape=(), dtype=int32)
INFO:absl:Num validation examples: tf.Tensor(50, shape=(), dtype=int32)
Validation dataset read in 0:00:00.843543. Found 50 examples.
INFO:absl:Validation dataset read in 0:00:00.843543. Found 50 examples.
Training model...
INFO:absl:Training model...
Model trained in 0:00:01.314439
INFO:absl:Model trained in 0:00:01.314439
Compiling model...
INFO:absl:Compiling model...
WARNING:tensorflow:AutoGraph could not transform <function simple_ml_inference_c
Please report this to the TensorFlow team. When filing the bug, set the verbosit
Cause: could not get source code
To silence this warning, decorate the function with @tf.autograph.experimental.d
WARNING: AutoGraph could not transform <function simple_ml_inference_op_with_han
Please report this to the TensorFlow team. When filing the bug, set the verbosit
Cause: could not get source code
To silence this warning, decorate the function with @tf.autograph.experimental.d
Model compiled.
INFO:absl:Model compiled.
```

```
WARNING:absl:Function `_wrapped_model` contains input name(s) AgeGroup, BodyFatG
WARNING:absl:Found untraced functions such as call_get_leaves while saving (show
INFO:absl:Training complete. Model written to pipelines/performance_prediction_p
INFO:absl:Cleaning up stateless execution info.
INFO:absl:Execution 3 succeeded.
INFO:absl:Cleaning up stateful execution info.
INFO:absl:Publishing output artifacts defaultdict(<class 'list'>, {'model': [Art
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Tr
  }
}
custom_properties {
  key: "tfx_version"
  value {
    string_value: "1.9.1"
  }
}
name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Trainer:model:
, artifact_type: name: "Model"
base_type: MODEL
)], 'model_run': [Artifact(artifact: uri: "pipelines/performance_prediction_pipe
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Tr
  }
}
custom_properties {
  key: "tfx_version"
  value {
    string_value: "1.9.1"
  }
}
name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Trainer:model_
, artifact_type: name: "ModelRun"
)]}) for execution 3
INFO:absl:MetadataStore with DB connection initialized
INFO:absl:Component Trainer is finished.
INFO:absl:Component Evaluator is running.
INFO:absl:Running launcher for node_info {
  type {
    name: "tfx.components.evaluator.component.Evaluator"
    base_type: EVALUATE
  }
  id: "Evaluator"
}
contexts {
  contexts {
    type {
      name: "pipeline"
    }
    name {
      field_value {
        string_value: "performance_prediction_pipeline"
      }
```

```
          }
        }
        contexts {
          type {
            name: "pipeline_run"
          }
          name {
            field_value {
              string_value: "2022-08-07T21:46:12.448311"
            }
          }
        }
        contexts {
          type {
            name: "node"
          }
          name {
            field_value {
              string_value: "performance_prediction_pipeline.Evaluator"
            }
          }
        }
      }
      inputs {
        inputs {
          key: "baseline_model"
          value {
            channels {
              producer_node_query {
                id: "latest_blessed_model_resolver"
              }
              context_queries {
                type {
                  name: "pipeline"
                }
                name {
                  field_value {
                    string_value: "performance_prediction_pipeline"
                  }
                }
              }
              context_queries {
                type {
                  name: "pipeline_run"
                }
                name {
                  field_value {
                    string_value: "2022-08-07T21:46:12.448311"
                  }
                }
              }
              context_queries {
                type {
                  name: "node"
                }
                name {
```

```
                field_value {
                  string_value: "performance_prediction_pipeline.latest_blessed_mode
                }
              }
            }
            artifact_query {
              type {
                name: "Model"
                base_type: MODEL
              }
            }
            output_key: "model"
          }
        }
      }
      inputs {
        key: "examples"
        value {
          channels {
            producer_node_query {
              id: "CsvExampleGen"
            }
            context_queries {
              type {
                name: "pipeline"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline"
                }
              }
            }
            context_queries {
              type {
                name: "pipeline_run"
              }
              name {
                field_value {
                  string_value: "2022-08-07T21:46:12.448311"
                }
              }
            }
            context_queries {
              type {
                name: "node"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline.CsvExampleGen"
                }
              }
            }
            artifact_query {
              type {
                name: "Examples"
                base_type: DATASET
              }
            }
            output_key: "examples"
          }
          min_count: 1
        }
      }
      inputs {
        key: "model"
        value {
          channels {
            producer_node_query {
              id: "Trainer"
            }
            context_queries {
              type {
                name: "pipeline"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline"
                }
              }
            }
            context_queries {
              type {
                name: "pipeline_run"
              }
              name {
                field_value {
                  string_value: "2022-08-07T21:46:12.448311"
                }
              }
            }
            context_queries {
              type {
                name: "node"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline.Trainer"
                }
              }
            }
            artifact_query {
              type {
                name: "Model"
                base_type: MODEL
              }
            }
            output_key: "model"
          }
        }
      }
    }
    outputs {
      outputs {
        key: "blessing"
        value {
          artifact_spec {
            type {
              name: "ModelBlessing"
            }
          }
        }
      }
      outputs {
        key: "evaluation"
        value {
          artifact_spec {
            type {
              name: "ModelEvaluation"
            }
          }
        }
      }
    }
    parameters {
      parameters {
        key: "eval_config"
        value {
          field_value {
            string_value: "{\n  \"metrics_specs\": [\n    {\n      \"per_slice_thres
          }
        }
      }
      parameters {
        key: "example_splits"
        value {
          field_value {
            string_value: "null"
          }
        }
      }
      parameters {
        key: "fairness_indicator_thresholds"
        value {
          field_value {
            string_value: "null"
          }
        }
      }
    }
    upstream_nodes: "CsvExampleGen"
    upstream_nodes: "Trainer"
    upstream_nodes: "latest_blessed_model_resolver"
    execution_options {
      caching_options {
      }
    }

    INFO:absl:MetadataStore with DB connection initialized
    WARNING:absl:ContextQuery.property_predicate is not supported.
    WARNING:absl:ContextQuery.property predicate is not supported.
```

```
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ArtifactQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ContextQuery.property_predicate is not supported.
WARNING:absl:ArtifactQuery.property_predicate is not supported.
INFO:absl:MetadataStore with DB connection initialized
INFO:absl:Going to run a new execution 4
INFO:absl:Going to run a new execution: ExecutionInfo(execution_id=4, input_dict
type_id: 18
uri: "pipelines/performance_prediction_pipeline/Trainer/model/3"
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Tr
  }
}
custom_properties {
  key: "tfx_version"
  value {
    string_value: "1.9.1"
  }
}
state: LIVE
name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Trainer:model:
create_time_since_epoch: 1659908798482
last_update_time_since_epoch: 1659908798482
, artifact_type: id: 18
name: "Model"
base_type: MODEL
)], 'baseline_model': [], 'examples': [Artifact(artifact: id: 1
type_id: 15
uri: "pipelines/performance_prediction_pipeline/CsvExampleGen/examples/1"
properties {
  key: "split_names"
  value {
    string_value: "[\"train\", \"eval\"]"
  }
}
custom_properties {
  key: "file_format"
  value {
    string_value: "tfrecords_gzip"
  }
}
custom_properties {
  key: "input_fingerprint"
  value {
    string_value: "split:single_split,num_files:1,total_bytes:1072224,xor_checks
  }
}
custom_properties {
  key: "name"
```

```
        value {
          string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Cs
        }
      }
      custom_properties {
        key: "payload_format"
        value {
          string_value: "FORMAT_TF_EXAMPLE"
        }
      }
      custom_properties {
        key: "span"
        value {
          int_value: 0
        }
      }
      custom_properties {
        key: "tfx_version"
        value {
          string_value: "1.9.1"
        }
      }
      state: LIVE
      name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:CsvExampleGen:
      create_time_since_epoch: 1659908779968
      last_update_time_since_epoch: 1659908779968
      , artifact_type: id: 15
      name: "Examples"
      properties {
        key: "span"
        value: INT
      }
      properties {
        key: "split_names"
        value: STRING
      }
      properties {
        key: "version"
        value: INT
      }
      base_type: DATASET
      )]}, output_dict=defaultdict(<class 'list'>, {'evaluation': [Artifact(artifact:
      custom_properties {
        key: "name"
        value {
          string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Ev
        }
      }
      name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Evaluator:eval
      , artifact_type: name: "ModelEvaluation"
      )], 'blessing': [Artifact(artifact: uri: "pipelines/performance_prediction_pipel
      custom_properties {
        key: "name"
        value {
          string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Ev
        }
      }
```

```
        name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Evaluator:bles
        , artifact_type: name: "ModelBlessing"
        )]}), exec_properties={'example_splits': 'null', 'fairness_indicator_thresholds'
          type {
            name: "tfx.components.evaluator.component.Evaluator"
            base_type: EVALUATE
          }
          id: "Evaluator"
        }
        contexts {
          contexts {
            type {
              name: "pipeline"
            }
            name {
              field_value {
                string_value: "performance_prediction_pipeline"
              }
            }
          }
          contexts {
            type {
              name: "pipeline_run"
            }
            name {
              field_value {
                string_value: "2022-08-07T21:46:12.448311"
              }
            }
          }
          contexts {
            type {
              name: "node"
            }
            name {
              field_value {
                string_value: "performance_prediction_pipeline.Evaluator"
              }
            }
          }
        }
        inputs {
          inputs {
            key: "baseline_model"
            value {
              channels {
                producer_node_query {
                  id: "latest_blessed_model_resolver"
                }
                context_queries {
                  type {
                    name: "pipeline"
                  }
                  name {
                    field_value {
                      string_value: "performance_prediction_pipeline"
                    }
                  }
                }
                context_queries {
                  type {
                    name: "pipeline_run"
                  }
                  name {
                    field_value {
                      string_value: "2022-08-07T21:46:12.448311"
                    }
                  }
                }
                context_queries {
                  type {
                    name: "node"
                  }
                  name {
                    field_value {
                      string_value: "performance_prediction_pipeline.latest_blessed_mode
                    }
                  }
                }
                artifact_query {
                  type {
                    name: "Model"
                    base_type: MODEL
                  }
                }
                output_key: "model"
              }
            }
          }
          inputs {
            key: "examples"
            value {
              channels {
                producer_node_query {
                  id: "CsvExampleGen"
                }
                context_queries {
                  type {
                    name: "pipeline"
                  }
                  name {
                    field_value {
                      string_value: "performance_prediction_pipeline"
                    }
                  }
                }
                context_queries {
                  type {
                    name: "pipeline_run"
                  }
                  name {
                    field_value {
                      string_value: "2022-08-07T21:46:12.448311"
                    }
                  }
                }
                context_queries {
                  type {
                    name: "node"
                  }
                  name {
                    field_value {
                      string_value: "performance_prediction_pipeline.CsvExampleGen"
                    }
                  }
                }
                artifact_query {
                  type {
                    name: "Examples"
                    base_type: DATASET
                  }
                }
                output_key: "examples"
              }
              min_count: 1
            }
          }
          inputs {
            key: "model"
            value {
              channels {
                producer_node_query {
                  id: "Trainer"
                }
                context_queries {
                  type {
                    name: "pipeline"
                  }
                  name {
                    field_value {
                      string_value: "performance_prediction_pipeline"
                    }
                  }
                }
                context_queries {
                  type {
                    name: "pipeline_run"
                  }
                  name {
                    field_value {
                      string_value: "2022-08-07T21:46:12.448311"
                    }
                  }
                }
                context_queries {
                  type {
                    name: "node"
                  }
                  name {
                    field_value {
                      string_value: "performance_prediction_pipeline.Trainer"
                    }
                  }
                }
                artifact_query {
                  type {
                    name: "Model"
                    base_type: MODEL
                  }
                }
                output_key: "model"
              }
            }
          }
        }
        outputs {
          outputs {
            key: "blessing"
            value {
              artifact_spec {
                type {
                  name: "ModelBlessing"
                }
              }
            }
          }
          outputs {
            key: "evaluation"
            value {
              artifact_spec {
                type {
                  name: "ModelEvaluation"
                }
              }
            }
          }
        }
        parameters {
          parameters {
            key: "eval_config"
            value {
              field_value {
                string_value: "{\n  \"metrics_specs\": [\n    {\n      \"per_slice_thres
              }
            }
          }
          parameters {
            key: "example_splits"
            value {
              field_value {
                string_value: "null"
              }
            }
          }
          parameters {
            key: "fairness_indicator_thresholds"
```

```
        value {
          field_value {
            string_value: "null"
          }
        }
      }
    }
    upstream_nodes: "CsvExampleGen"
    upstream_nodes: "Trainer"
    upstream_nodes: "latest_blessed_model_resolver"
    execution_options {
      caching_options {
      }
    }
    , pipeline_info=id: "performance_prediction_pipeline"
    , pipeline_run_id='2022-08-07T21:46:12.448311')
    INFO:absl:udf_utils.get_fn {'example_splits': 'null', 'fairness_indicator_thresh
    INFO:absl:Request was made to ignore the baseline ModelSpec and any change thres
    model_specs {
      label_key: "performance_class"
    }
    slicing_specs {
    }
    slicing_specs {
      feature_keys: "performance_class"
    }
    metrics_specs {
      per_slice_thresholds {
        key: "accuracy"
        value {
          thresholds {
            slicing_specs {
            }
            threshold {
              value_threshold {
                lower_bound {
                  value: 0.4
                }
              }
            }
          }
        }
      }
    }

    INFO:absl:Using pipelines/performance_prediction_pipeline/Trainer/model/3/Format
    INFO:absl:The 'example_splits' parameter is not set, using 'eval' split.
    INFO:absl:Evaluating model.
    INFO:absl:udf_utils.get_fn {'example_splits': 'null', 'fairness_indicator_thresh
    INFO:absl:Request was made to ignore the baseline ModelSpec and any change thres
    model_specs {
      label_key: "performance_class"
    }
    slicing_specs {
    }
    slicing_specs {
      feature_keys: "performance_class"
```

```
  feature_keys: "performance_class"
}
metrics_specs {
  model_names: ""
  per_slice_thresholds {
    key: "accuracy"
    value {
      thresholds {
        slicing_specs {
        }
        threshold {
          value_threshold {
            lower_bound {
              value: 0.4
            }
          }
        }
      }
    }
  }
}

INFO:absl:Request was made to ignore the baseline ModelSpec and any change thres
model_specs {
  label_key: "performance_class"
}
slicing_specs {
}
slicing_specs {
  feature_keys: "performance_class"
}
metrics_specs {
  model_names: ""
  per_slice_thresholds {
    key: "accuracy"
    value {
      thresholds {
        slicing_specs {
        }
        threshold {
          value_threshold {
            lower_bound {
              value: 0.4
            }
          }
        }
      }
    }
  }
}

INFO:absl:Request was made to ignore the baseline ModelSpec and any change thres
model_specs {
  label_key: "performance_class"
}
slicing_specs {
}
```

```
slicing_specs {
  feature_keys: "performance_class"
}
metrics_specs {
  model_names: ""
  per_slice_thresholds {
    key: "accuracy"
    value {
      thresholds {
        slicing_specs {
        }
        threshold {
          value_threshold {
            lower_bound {
              value: 0.4
            }
          }
        }
      }
    }
  }
}

INFO:absl:Evaluation complete. Results written to pipelines/performance_predicti
INFO:absl:Checking validation results.
WARNING:tensorflow:From /usr/local/lib/python3.7/dist-packages/tensorflow_model_
Instructions for updating:
Use eager execution and:
`tf.data.TFRecordDataset(path)`
INFO:absl:Blessing result False written to pipelines/performance_prediction_pipe
INFO:absl:Cleaning up stateless execution info.
INFO:absl:Execution 4 succeeded.
INFO:absl:Cleaning up stateful execution info.
INFO:absl:Publishing output artifacts defaultdict(<class 'list'>, {'evaluation':
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Ev
  }
}
custom_properties {
  key: "tfx_version"
  value {
    string_value: "1.9.1"
  }
}
name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Evaluator:eval
, artifact_type: name: "ModelEvaluation"
)], 'blessing': [Artifact(artifact: uri: "pipelines/performance_prediction_pipel
custom_properties {
  key: "name"
  value {
    string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Ev
  }
}
custom_properties {
  key: "tfx_version"
```

```
      key: "tfx_version"
      value {
        string_value: "1.9.1"
      }
    }
    name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Evaluator:bles
    , artifact_type: name: "ModelBlessing"
    )]}) for execution 4
    INFO:absl:MetadataStore with DB connection initialized
    INFO:absl:Component Evaluator is finished.
    INFO:absl:Component Pusher is running.
    INFO:absl:Running launcher for node_info {
      type {
        name: "tfx.components.pusher.component.Pusher"
        base_type: DEPLOY
      }
      id: "Pusher"
    }
    contexts {
      contexts {
        type {
          name: "pipeline"
        }
        name {
          field_value {
            string_value: "performance_prediction_pipeline"
          }
        }
      }
      contexts {
        type {
          name: "pipeline_run"
        }
        name {
          field_value {
            string_value: "2022-08-07T21:46:12.448311"
          }
        }
      }
      contexts {
        type {
          name: "node"
        }
        name {
          field_value {
            string_value: "performance_prediction_pipeline.Pusher"
          }
        }
      }
    }
    inputs {
      inputs {
        key: "model"
        value {
          channels {
            producer_node_query {
              id: "Trainer"
            }
            context_queries {
              type {
                name: "pipeline"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline"
                }
              }
            }
            context_queries {
              type {
                name: "pipeline_run"
              }
              name {
                field_value {
                  string_value: "2022-08-07T21:46:12.448311"
                }
              }
            }
            context_queries {
              type {
                name: "node"
              }
              name {
                field_value {
                  string_value: "performance_prediction_pipeline.Trainer"
                }
              }
            }
            artifact_query {
              type {
                name: "Model"
                base_type: MODEL
              }
            }
            output_key: "model"
          }
        }
      }
    }
    outputs {
      outputs {
        key: "pushed_model"
        value {
          artifact_spec {
            type {
              name: "PushedModel"
              base_type: MODEL
            }
          }
        }
      }
    }
    parameters {
```

```
    parameters {
      key: "custom_config"
      value {
        field_value {
          string_value: "null"
        }
      }
    }
    parameters {
      key: "push_destination"
      value {
        field_value {
          string_value: "{\n  \"filesystem\": {\n    \"base_directory\": \"serving
        }
      }
    }
  }
  upstream_nodes: "Trainer"
  execution_options {
    caching_options {
    }
  }

  INFO:absl:MetadataStore with DB connection initialized
  WARNING:absl:ContextQuery.property_predicate is not supported.
  WARNING:absl:ContextQuery.property_predicate is not supported.
  WARNING:absl:ContextQuery.property_predicate is not supported.
  WARNING:absl:ArtifactQuery.property_predicate is not supported.
  INFO:absl:MetadataStore with DB connection initialized
  INFO:absl:Going to run a new execution 5
  INFO:absl:Going to run a new execution: ExecutionInfo(execution_id=5, input_dict
  type_id: 18
  uri: "pipelines/performance_prediction_pipeline/Trainer/model/3"
  custom_properties {
    key: "name"
    value {
      string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Tr
    }
  }
  custom_properties {
    key: "tfx_version"
    value {
      string_value: "1.9.1"
    }
  }
  state: LIVE
  name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Trainer:model:
  create_time_since_epoch: 1659908798482
  last_update_time_since_epoch: 1659908798482
  , artifact_type: id: 18
  name: "Model"
  base_type: MODEL
  )]}, output_dict=defaultdict(<class 'list'>, {'pushed_model': [Artifact(artifact
  custom_properties {
    key: "name"
    value {
      string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Pu
    }
  }
  name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Pusher:pushed_
  , artifact_type: name: "PushedModel"
  base_type: MODEL
  )]}), exec_properties={'push_destination': '{\n  "filesystem": {\n    "base_dire
    type {
      name: "tfx.components.pusher.component.Pusher"
      base_type: DEPLOY
    }
    id: "Pusher"
  }
  contexts {
    contexts {
      type {
        name: "pipeline"
      }
      name {
        field_value {
          string_value: "performance_prediction_pipeline"
        }
      }
    }
    contexts {
      type {
        name: "pipeline_run"
      }
      name {
        field_value {
          string_value: "2022-08-07T21:46:12.448311"
        }
      }
    }
    contexts {
      type {
        name: "node"
      }
      name {
        field_value {
          string_value: "performance_prediction_pipeline.Pusher"
        }
      }
    }
  }
  inputs {
    inputs {
      key: "model"
      value {
        channels {
          producer_node_query {
            id: "Trainer"
          }
          context_queries {
            type {
              name: "pipeline"
            }
            name {
              field_value {
                string_value: "performance_prediction_pipeline"
              }
            }
          }
          context_queries {
            type {
              name: "pipeline_run"
            }
            name {
              field_value {
                string_value: "2022-08-07T21:46:12.448311"
              }
            }
          }
          context_queries {
            type {
              name: "node"
            }
            name {
              field_value {
                string_value: "performance_prediction_pipeline.Trainer"
              }
            }
          }
          artifact_query {
            type {
              name: "Model"
              base_type: MODEL
            }
          }
          output_key: "model"
        }
      }
    }
  }
  outputs {
    outputs {
      key: "pushed_model"
      value {
        artifact_spec {
          type {
            name: "PushedModel"
            base_type: MODEL
          }
        }
      }
    }
  }
  parameters {
    parameters {
      key: "custom_config"
      value {
        field_value {
          string_value: "null"
        }
      }
    }
    parameters {
      key: "push_destination"
      value {
        field_value {
          string_value: "{\n  \"filesystem\": {\n    \"base_directory\": \"serving
        }
      }
    }
  }
  upstream_nodes: "Trainer"
  execution_options {
    caching_options {
    }
  }
  , pipeline_info=id: "performance_prediction_pipeline"
  , pipeline_run_id='2022-08-07T21:46:12.448311')
  WARNING:absl:Pusher is going to push the model without validation. Consider usin
  INFO:absl:Model version: 1659908808
  INFO:absl:Model written to serving path serving_model/performance_prediction_pip
  INFO:absl:Model pushed to pipelines/performance_prediction_pipeline/Pusher/pushe
  INFO:absl:Cleaning up stateless execution info.
  INFO:absl:Execution 5 succeeded.
  INFO:absl:Cleaning up stateful execution info.
  INFO:absl:Publishing output artifacts defaultdict(<class 'list'>, {'pushed_model
  custom_properties {
    key: "name"
    value {
      string_value: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Pu
    }
  }
  custom_properties {
    key: "tfx_version"
    value {
      string_value: "1.9.1"
    }
  }
  name: "performance_prediction_pipeline:2022-08-07T21:46:12.448311:Pusher:pushed_
  , artifact_type: name: "PushedModel"
  base_type: MODEL
  )]}) for execution 5
  INFO:absl:MetadataStore with DB connection initialized
  INFO:absl:Component Pusher is finished.
```

```
! find {'serving_model'}
```

```
serving_model
serving_model/performance_prediction_pipeline
serving_model/performance_prediction_pipeline/1659908808
serving_model/performance_prediction_pipeline/1659908808/variables
serving_model/performance_prediction_pipeline/1659908808/variables/variables.ind
serving_model/performance_prediction_pipeline/1659908808/variables/variables.dat
serving_model/performance_prediction_pipeline/1659908808/saved_model.pb
serving_model/performance_prediction_pipeline/1659908808/keras_metadata.pb
serving_model/performance_prediction_pipeline/1659908808/assets
serving_model/performance_prediction_pipeline/1659908808/assets/ce938c33b7084919
serving_model/performance_prediction_pipeline/1659908808/assets/ce938c33b7084919
serving_model/performance_prediction_pipeline/1659908808/assets/ce938c33b7084919
serving_model/performance_prediction_pipeline/1659908808/assets/ce938c33b7084919
serving_model/performance_prediction_pipeline/1659908808/assets/ce938c33b7084919
```

Step - 12: Way to calculate Software and Business Metrics

Way of calculating Business Metrics

As our dataset is about measuring the performance of the body.

1. We can use this to measure the performance of the atheletes. So one business metrics would be athelete engagement which is similar to customer engagement on how frequent the atheletes are using this to measure their performance.
2. Second way of calculating the business metric would be revenue we can typically calculate by making an application and checking the number of downloads or by checking the frequent usage of a website.

Way of calculating Software Metrics

1. As we are building our pipeline using tensorflow extended, which inturn will build and deploy the model to one of the cloud environemnt. So we can measure the scalability as one software metric as cloud environments are easily scalable and can check to how much extent we can scale the resources.
2. Some other software metrics we can calculate is throughput which can be calculated by measuring how much data our model can process at once. And we can calculate the availability based on the cloud environment availability. As we are deploying our model on cloud the availability is dependent on the cloud environment.
3. Next software metric we can calculate is latency where we can measure this based on the time taken by the model to generate the predictions. This sometimes depends on the internet speed. But as we are deploying in cloud we can always improve the performance.

```
from ml_metadata.proto import metadata_store_pb2
# Non-public APIs, just for showcase.
from tfx.orchestration.portable.mlmd import execution_lib

def get_latest_artifacts(metadata, pipeline_name, component_id):
  """Output artifacts of the latest run of the component."""
  context = metadata.store.get_context_by_type_and_name(
      'node', f'{pipeline_name}.{component_id}')
  executions = metadata.store.get_executions_by_context(context.id)
  latest_execution = max(executions,
                         key=lambda e:e.last_update_time_since_epoch)
  return execution_lib.get_artifacts_dict(metadata, latest_execution.id,
                                          [metadata_store_pb2.Event.OUTPUT])
```

```
from tfx.orchestration.metadata import Metadata
from tfx.types import standard_component_specs

metadata_connection_config = tfx.orchestration.metadata.sqlite_metadata_connection
   METADATA_PATH)

with Metadata(metadata_connection_config) as metadata_handler:
  # Find output artifacts from MLMD.
  evaluator_output = get_latest_artifacts(metadata_handler, PIPELINE_NAME,
                                          'Evaluator')
  eval_artifact = evaluator_output[standard_component_specs.EVALUATION_KEY][0]
```

```
INFO:absl:MetadataStore with DB connection initialized
```

```
import tensorflow_model_analysis as tfma

eval_result = tfma.load_eval_result(eval_artifact.uri)
tfma.view.render_slicing_metrics(eval_result, slicing_column='performance_class')
```

Examples (Weighted) Threshold
0

Visualization
Metrics Histogram

```
# command for downloading the saved model in zip format. So that we can dockerize
!zip -r /content/content.zip /content/
```

```
    adding: content/ (stored 0%)
    adding: content/.config/ (stored 0%)
    adding: content/.config/.last_survey_prompt.yaml (stored 0%)
    adding: content/.config/active_config (stored 0%)
    adding: content/.config/gce (stored 0%)
    adding: content/.config/configurations/ (stored 0%)
    adding: content/.config/configurations/config_default (deflated 15%)
    adding: content/.config/logs/ (stored 0%)
    adding: content/.config/logs/2022.08.03/ (stored 0%)
    adding: content/.config/logs/2022.08.03/20.20.58.507230.log (deflated 54%)
    adding: content/.config/logs/2022.08.03/20.20.57.728033.log (deflated 55%)
    adding: content/.config/logs/2022.08.03/20.20.37.810163.log (deflated 54%)
    adding: content/.config/logs/2022.08.03/20.20.11.079200.log (deflated 54%)
    adding: content/.config/logs/2022.08.03/20.19.49.687892.log (deflated 91%)
    adding: content/.config/logs/2022.08.03/20.20.30.273467.log (deflated 86%)
    adding: content/.config/.last_update_check.json (deflated 22%)
    adding: content/.config/config_sentinel (stored 0%)
    adding: content/.config/.last_opt_in_prompt.yaml (stored 0%)
    adding: content/metdata/ (stored 0%)
    adding: content/metdata/performance_prediction_pipeline/ (stored 0%)
    adding: content/metdata/performance_prediction_pipeline/metadata.db (deflated
    adding: content/performance_trainer.py (deflated 58%)
    adding: content/__pycache__/ (stored 0%)
    adding: content/__pycache__/performance_trainer.cpython-37.pyc (deflated 41%)
    adding: content/bodyPerformance.csv (deflated 65%)
    adding: content/serving_model/ (stored 0%)
    adding: content/serving_model/performance_prediction_pipeline/ (stored 0%)
    adding: content/serving_model/performance_prediction_pipeline/1659744840/ (stc
    adding: content/serving_model/performance_prediction_pipeline/1659744840/varia
    adding: content/serving_model/performance_prediction_pipeline/1659744840/varia
    adding: content/serving_model/performance_prediction_pipeline/1659744840/varia
    adding: content/serving_model/performance_prediction_pipeline/1659744840/saved
    adding: content/serving_model/performance_prediction_pipeline/1659744840/keras
    adding: content/serving_model/performance_prediction_pipeline/1659744840/asset
    adding: content/serving_model/performance_prediction_pipeline/1659744840/asset
    adding: content/serving_model/performance_prediction_pipeline/1659744840/asset
    adding: content/serving_model/performance_prediction_pipeline/1659744840/asset
    adding: content/serving_model/performance_prediction_pipeline/1659744840/asset
    adding: content/serving_model/performance_prediction_pipeline/1659744840/asset
    adding: content/serving_model/performance_prediction_pipeline/1659745087/ (stc
    adding: content/serving_model/performance_prediction_pipeline/1659745087/varia
    adding: content/serving_model/performance_prediction_pipeline/1659745087/varia
    adding: content/serving_model/performance_prediction_pipeline/1659745087/varia
    adding: content/serving_model/performance_prediction_pipeline/1659745087/saved
```

```
      adding: content/serving_model/performance_prediction_pipeline/1659745087/keras
      adding: content/serving_model/performance_prediction_pipeline/1659745087/asset
      adding: content/serving_model/performance_prediction_pipeline/1659745087/asset
      adding: content/serving_model/performance_prediction_pipeline/1659745087/asset
      adding: content/serving_model/performance_prediction_pipeline/1659745087/asset
      adding: content/serving_model/performance_prediction_pipeline/1659745087/asset
      adding: content/serving_model/performance_prediction_pipeline/1659745087/asset
      adding: content/serving_model/performance_prediction_pipeline/1659740216/ (stc
      adding: content/serving_model/performance_prediction_pipeline/1659740216/varia
      adding: content/serving_model/performance_prediction_pipeline/1659740216/varia
      adding: content/serving_model/performance_prediction_pipeline/1659740216/varia
      adding: content/serving_model/performance_prediction_pipeline/1659740216/saved
      adding: content/serving_model/performance_prediction_pipeline/1659740216/keras
      adding: content/serving_model/performance_prediction_pipeline/1659740216/asset
```

Step - 13 Interface for Inferance

To provide the user an interface for inferance I have developed a simple frontend using react. From this we will provide a form to the user to enter different details about the parameters to get the performance of the athelete they are looking for.

Steps followed to achieve inferance.

Model deployment:

First downloaded the saved model using above command. Then pushed this to dropbox. Along with the model I have pushed tensorflow_linux_serving.zip file (provided by tensorflow). The reason for pushing this linux file is firstly, I have used tensorflow serving for model prediction which inturn provides differnt API's to get predictions, classify things etc., from the saved tfx pipeline model. secondly, in tfx pipeline I have used tensorflow decision forests as my model and this does not have support for direct docker image of tensorflow serving. So in order to push my saved model to cloud I have used these files and then created a dockerfile and writeen necessary configurations and deployed this in google cloud run.

Link for deployed model:

For frontend model deployment:

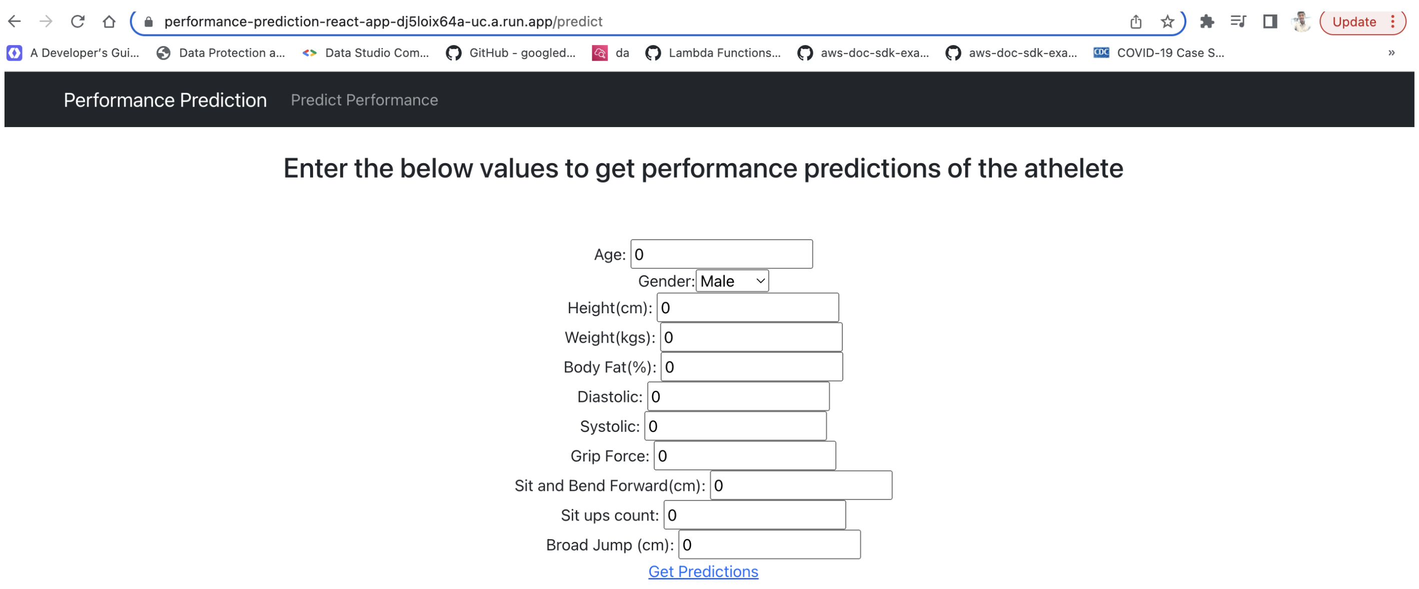
For frontend I have used react and provided a form for the user to enter details and get the prediction. Here becuase our model is deployed in different port we cannot directly access the model API as we will get CORS issue so to resolve this created one mode node js application which will act as a backend and gets the prediciton data from the model and sends to the react application.

Link for frontend application:

---

https://performance-prediction-react-app-dj5loix64a-uc.a.run.app

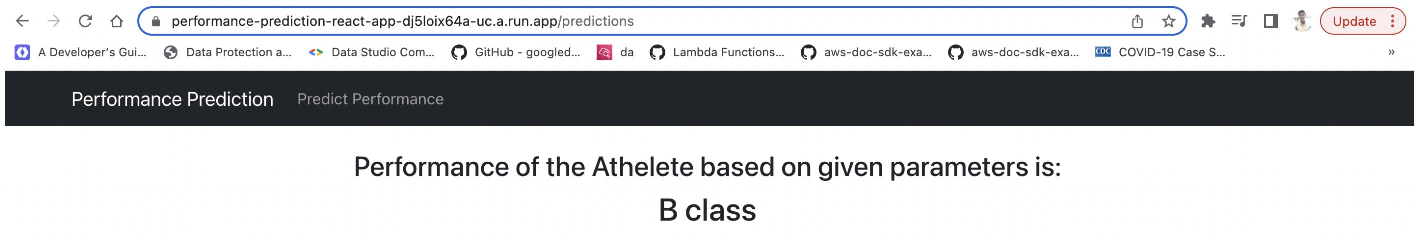
Screenshots:


performance-prediction-react-app-dj5loix64a-uc.a.run.app/predict
Performance Prediction
Predict Performance

Enter the below values to get performance predictions of the athelete

Age:	0
Gender:	Male
Height(cm):	0
Weight(kgs):	0
Body Fat(%):	0
Diastolic:	0
Systolic:	0
Grip Force:	0
Sit and Bend Forward(cm):	0
Sit ups count:	0
Broad Jump (cm):	0

Get Predictions


performance-prediction-react-app-dj5loix64a-uc.a.run.app/predictions
Performance Prediction
Predict Performance

Performance of the Athelete based on given parameters is:

B class

Link for Node Application: https://prediction-node-app-dj5loix64a-uc.a.run.app

Git Lab Link for above code:

https://git.cs.dal.ca/chinthirla/sai_chinthirla_b00911631_csci5901.git

The code is present in Project_code folder.

Step - 14: Deploying model in google cloud using docker

Deployed the model in google cloud run using docker. The dockerfile is present in above git lab link.

Link for deplpoyed model:

https://performance-prediction-dj5loix64a-uc.a.run.app

You can test the above link using postman and using link like below: https://performance-prediction-dj5loix64a-uc.a.run.app/v1/models/performance_prediction_pipeline:predict

It is a post API call and you can use json body as below.

```
{

 "instances": [{"AgeGroup":[0.0],"BodyFatGroup": [0.0], "DiastolicGroup":[1.0],

                "age": [37.0],

                "body_fat_percent":[30.7],

                "broad_jump_cm":[229.0],

                "diastolic":[70.0],

                "gender_F":[0.0],

               "gender_M":[1.0],

               "gripForce":[40.4],

               "height_cm":[175.0],

               "sit-ups_counts":[53.0],

               "sit_and_bend_forward_cm":[16.3],

               "systolic":[126.0],

               "weight_kg" :[65.8]}]

}
```

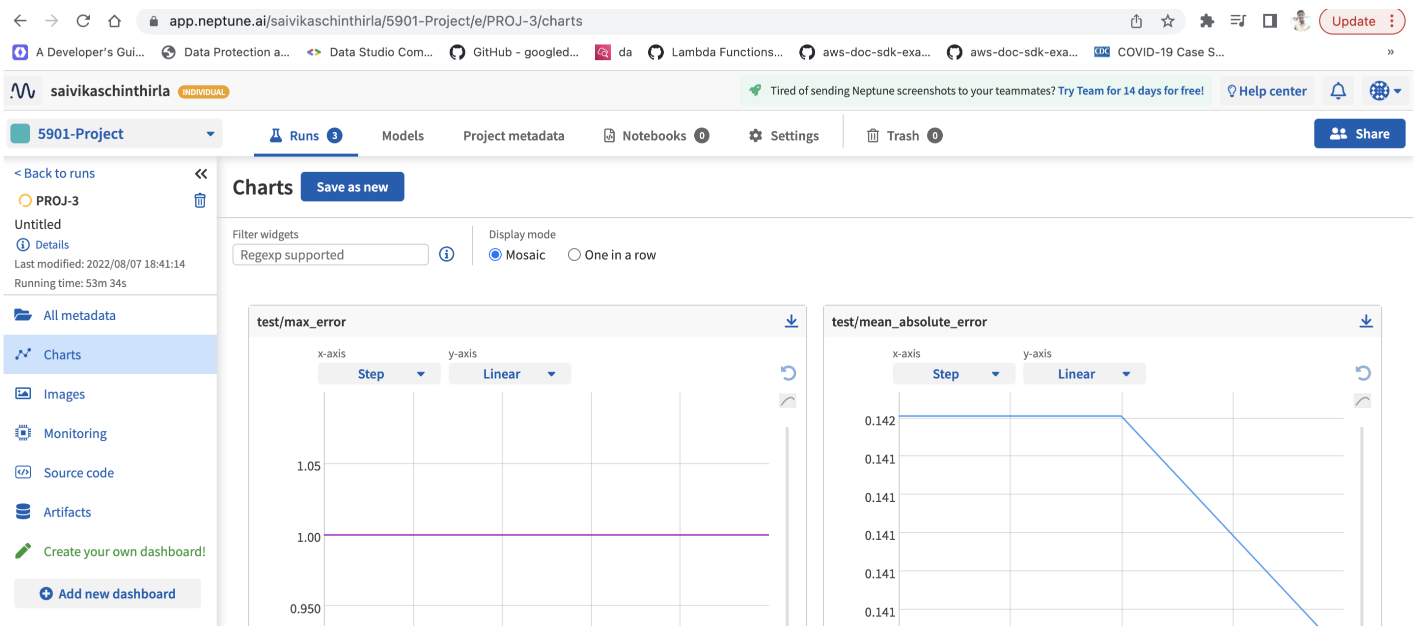
Step - 15: Model maintainance Dashboard

For model maintainance dashboard I have used neptune AI where we can have different things like model meta data, live charts for model performance.

Link for Model Maintainance:

https://app.neptune.ai/saivikaschinthirla/5901-Project/e/PROJ-3/images

Screenshots:



app.neptune.ai/saivikaschinthirla/5901-Project/e/PROJ-3/charts

saivikaschinthirla INDIVIDUAL

5901-Project | Runs 3 | Models | Project metadata | Notebooks 0 | Settings | Trash 0 | Share

< Back to runs

PROJ-3

Untitled

Details

Last modified: 2022/08/07 18:41:14

Running time: 53m 34s

Charts Save as new

Filter widgets: Regexp supported

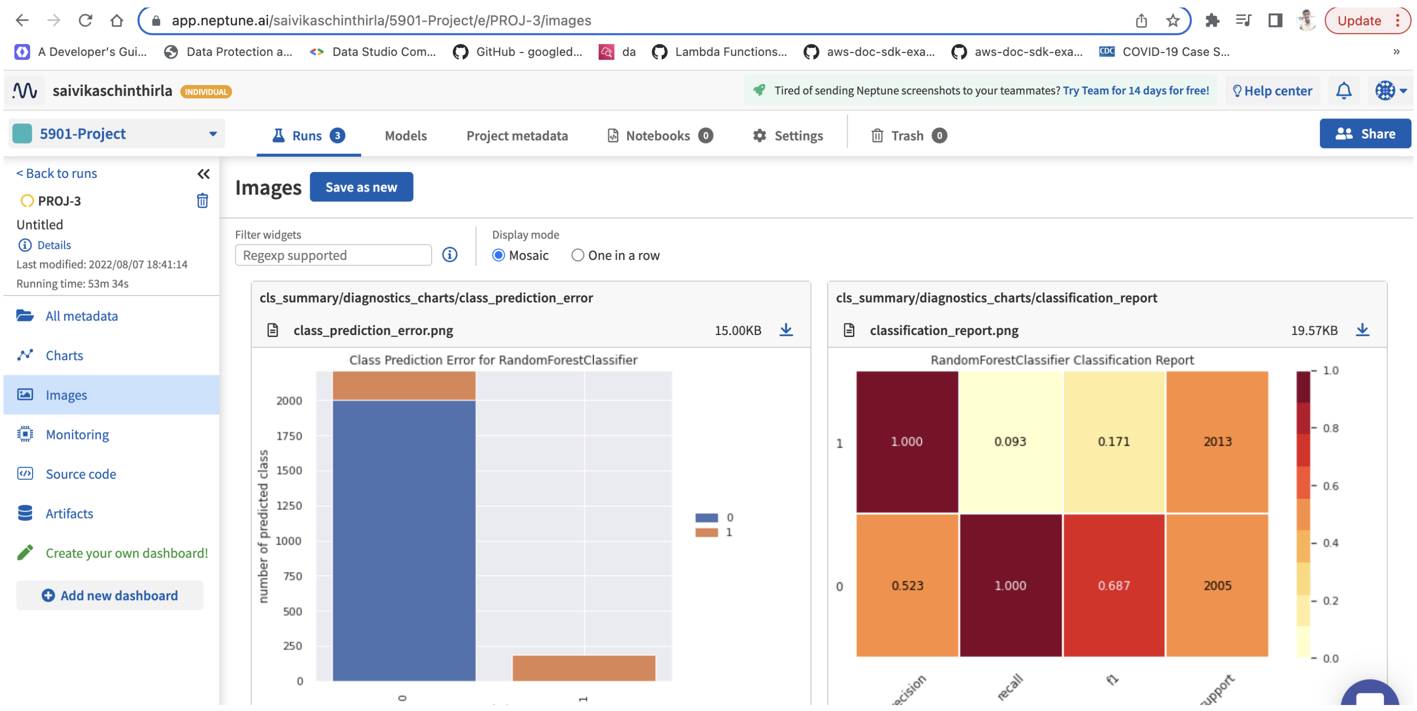
Display mode: [✓ Mosaic] One in a row

test/max_error

x-axis Step y-axis Linear

test/mean_absolute_error

x-axis Step y-axis Linear



app.neptune.ai/saivikaschinthirla/5901-Project/e/PROJ-3/images

saivikaschinthirla INDIVIDUAL

5901-Project | Runs 3 | Models | Project metadata | Notebooks 0 | Settings | Trash 0 | Share

< Back to runs

PROJ-3

Untitled

Details

Last modified: 2022/08/07 18:41:14

Running time: 53m 34s

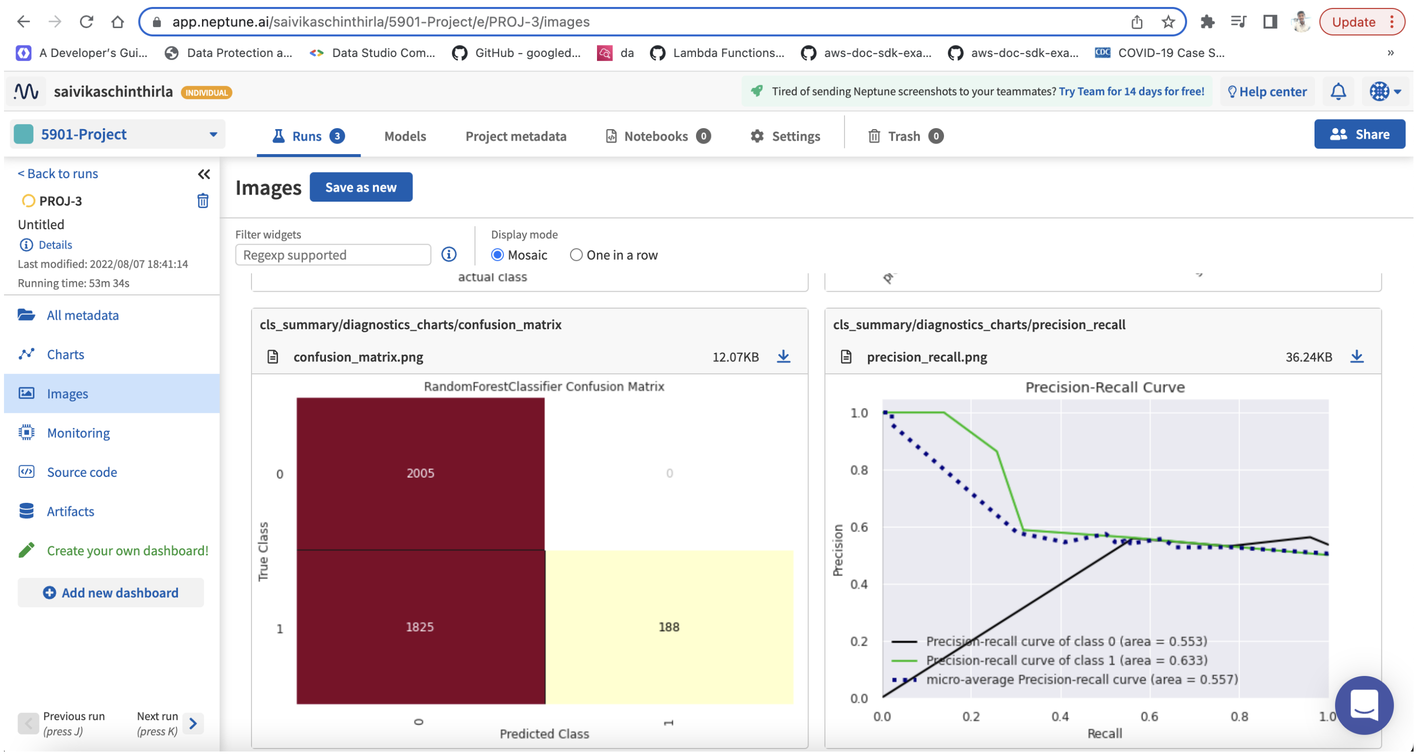
Images Save as new

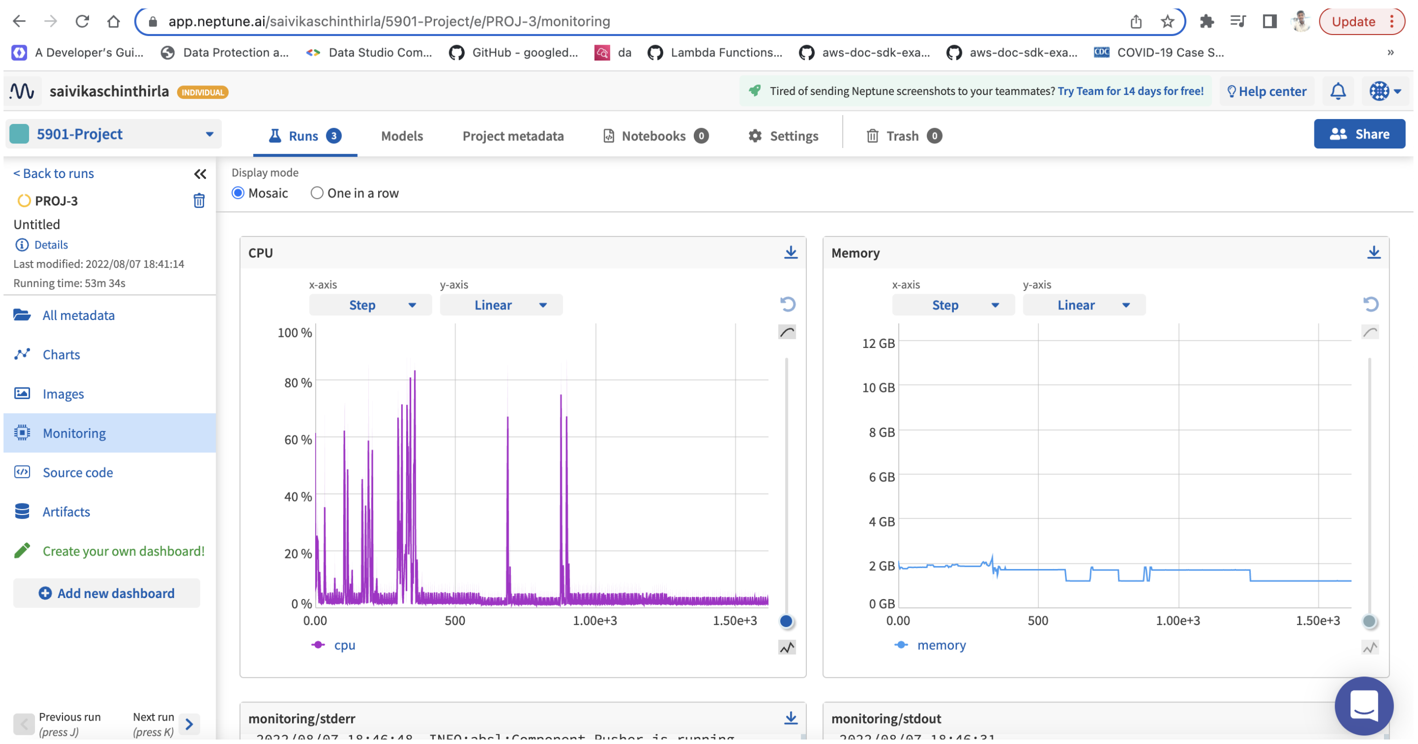
Filter widgets: Regexp supported

Display mode: [✓ Mosaic] One in a row

cls_summary/diagnostics_charts/class_prediction_error — class_prediction_error.png 15.00KB

cls_summary/diagnostics_charts/classification_report — classification_report.png 19.57KB


app.neptune.ai/saivikaschinthirla/5901-Project/e/PROJ-3/images
saivikaschinthirla
5901-Project
Runs 3
Models
Project metadata
Notebooks 0
Settings
Trash 0
Share
< Back to runs
PROJ-3
Untitled
Details
Last modified: 2022/08/07 18:41:14
Running time: 53m 34s
All metadata
Charts
Images
Monitoring
Source code
Artifacts
Create your own dashboard!
Add new dashboard
Images
Save as new
Filter widgets
Regexp supported
Display mode
Mosaic
One in a row
cls_summary/diagnostics_charts/confusion_matrix
confusion_matrix.png 12.07KB
RandomForestClassifier Confusion Matrix
True Class
Predicted Class
2005
0
1825
188
cls_summary/diagnostics_charts/precision_recall
precision_recall.png 36.24KB
Precision-Recall Curve
Precision
Recall
Precision-recall curve of class 0 (area = 0.553)
Precision-recall curve of class 1 (area = 0.633)
micro-average Precision-recall curve (area = 0.557)



```
2022/08/07 18:46:48  INFO:absl:Component Pusher is running
```

```
2022/08/07 18:46:31
```