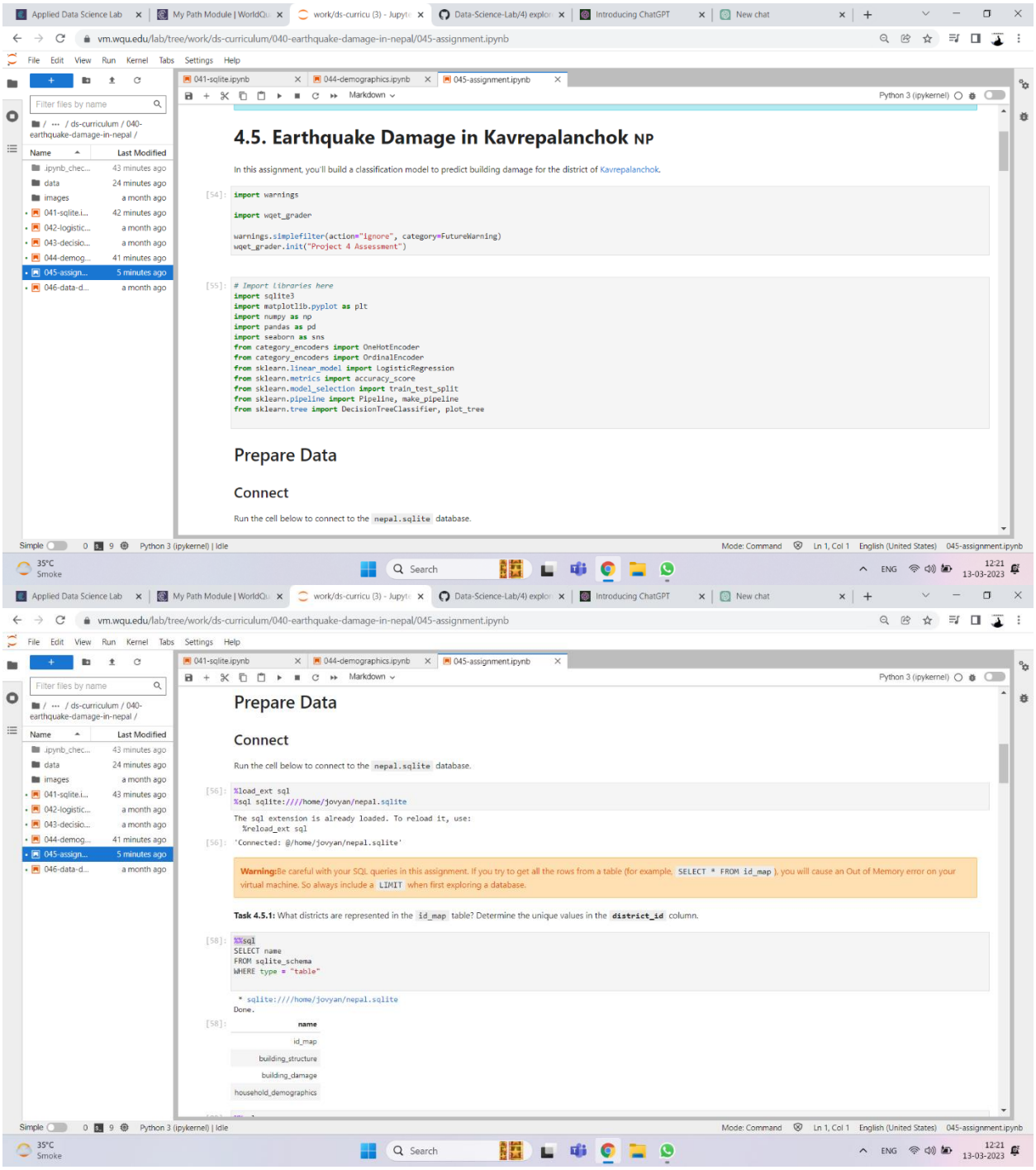
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4.5. Earthquake Damage in Kavrepalanchok NP
In this assignment, you'll build a classification model to predict building damage for the district of Kavrepalanchok.
[54]:
import warnings
import wget_grader
warnings.simplefilter(action="ignore", category=FutureWarning)
wget_grader.init("Project 4 Assessment")
[55]:
# Import libraries here
import sqlite3
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import seaborn as sns
from category_encoders import OneHotEncoder
from category_encoders import OrdinalEncoder
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline, make_pipeline
from sklearn.tree import DecisionTreeClassifier, plot_tree
Prepare Data
Connect
Run the cell below to connect to the nepal.sqlite database.
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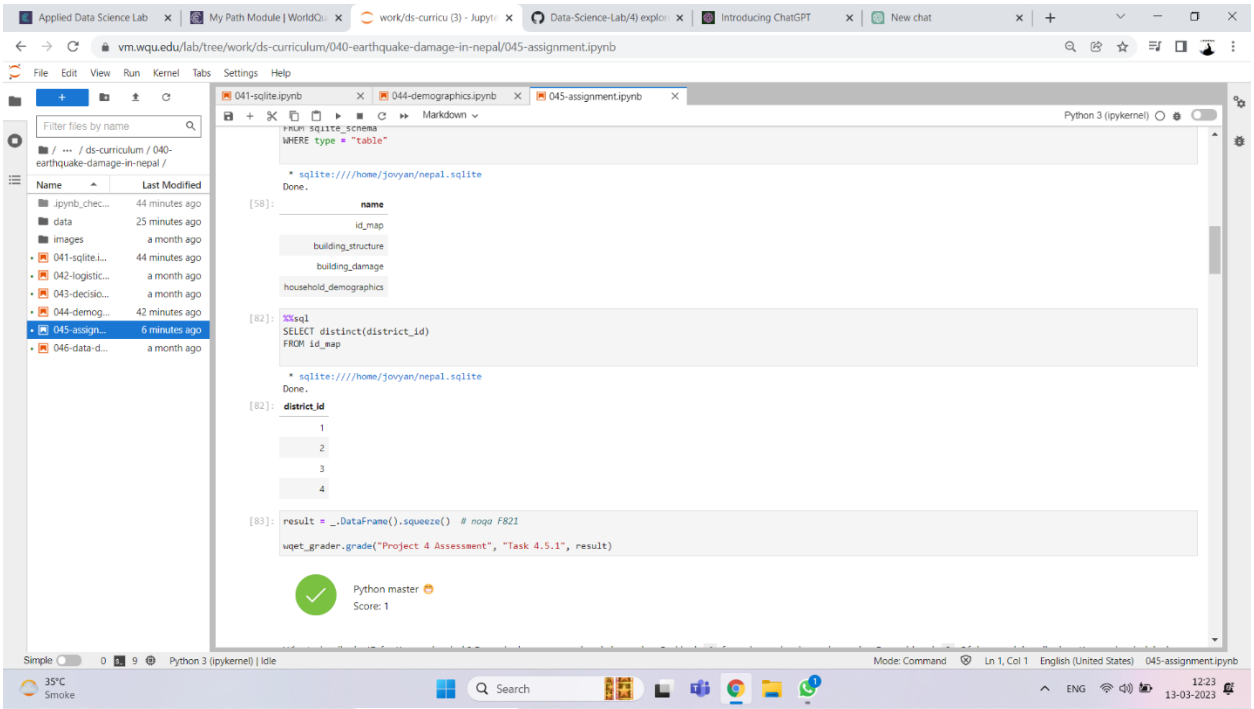
Prepare Data
Connect
Run the cell below to connect to the nepal.sqlite database.
[56]:
%load_ext sql
%sql sqlite:////home/jovyan/nepal.sqlite
The sql extension is already loaded. To reload it, use:
%reload_ext sql
[56]:
'Connected: @/home/jovyan/nepal.sqlite'
Warning: Be careful with your SQL queries in this assignment. If you try to get all the rows from a table (for example, SELECT * FROM id_map), you will cause an Out of Memory error on your virtual machine. So always include a LIMIT when first exploring a database.
Task 4.5.1: What districts are represented in the id_map table? Determine the unique values in the district_id column.
[58]:
%%sql
SELECT name
FROM sqlite_schema
WHERE type = "table"
* sqlite:////home/jovyan/nepal.sqlite
Done.
[58]:
name
id_map
building_structure
building_damage
household_demographics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045-assign... 6 minutes ago
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WHERE type = "table"
* sqlite:////home/jovyan/nepal.sqlite
Done.
[58]:
name
id_map
building_structure
building_damage
household_demographics
[82]:
%%sql
SELECT distinct(district_id)
FROM id_map
* sqlite:////home/jovyan/nepal.sqlite
Done.
[82]:
district_id
1
2
3
4
[83]:
result = _.DataFrame().squeeze() # noqa F821
wqet_grader.grade("Project 4 Assessment", "Task 4.5.1", result)
Python master
Score: 1
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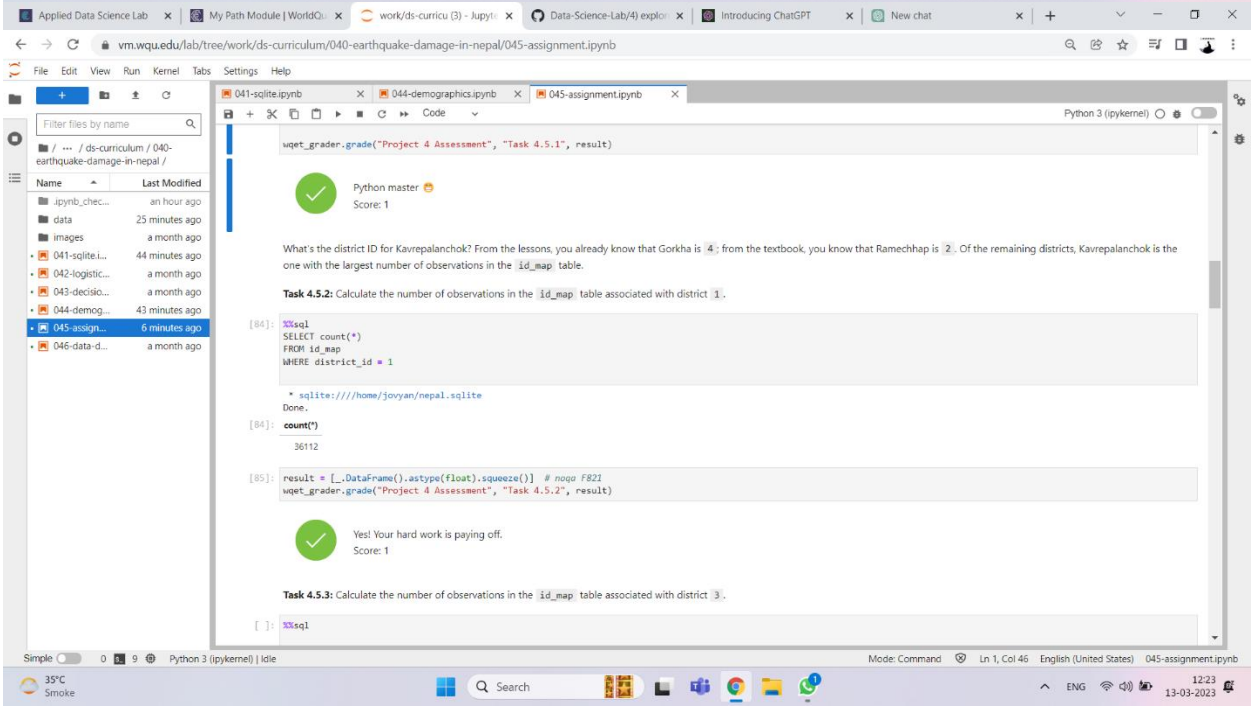
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wqet_grader.grade("Project 4 Assessment", "Task 4.5.1", result)
Python master
Score: 1
What's the district ID for Kavrepalanchok? From the lessons, you already know that Gorkha is 4 from the textbook, you know that Ramechhap is 2. Of the remaining districts, Kavrepalanchok is the one with the largest number of observations in the id_map table.
Task 4.5.2: Calculate the number of observations in the id_map table associated with district 1.
[84]:
%%sql
SELECT count(*)
FROM id_map
WHERE district_id = 1
* sqlite:////home/jovyan/nepal.sqlite
Done.
[84]:
count(*)
36112
[85]:
result = [_.DataFrame().astype(float).squeeze()] # noqa F821
wqet_grader.grade("Project 4 Assessment", "Task 4.5.2", result)
Yes! Your hard work is paying off.
Score: 1
Task 4.5.3: Calculate the number of observations in the id_map table associated with district 3.
[ ]:
%%sql
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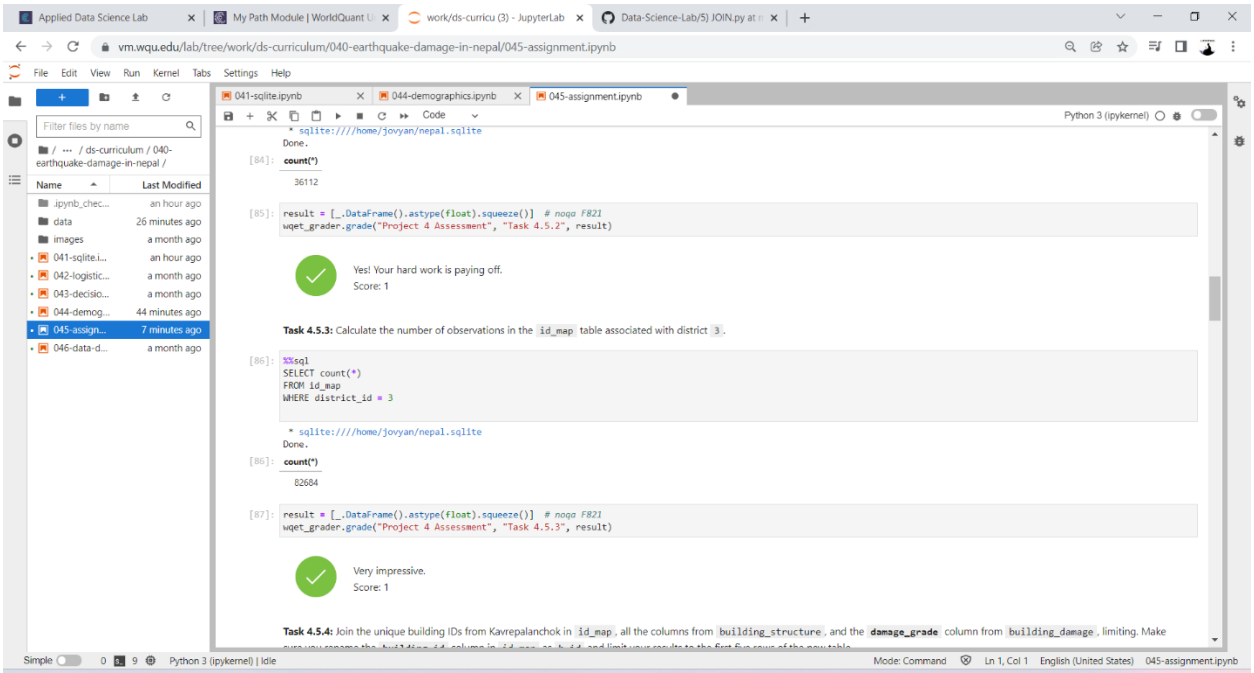
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* sqlite:////home/jovyan/nepal.sqlite
Done.
[84]:
count(*)
36112
[85]:
result = [_.DataFrame().astype(float).squeeze()] # noqa F821
wqet_grader.grade("Project 4 Assessment", "Task 4.5.2", result)
Yes! Your hard work is paying off.
Score: 1
Task 4.5.3: Calculate the number of observations in the id_map table associated with district 3.
[86]:
%%sql
SELECT count(*)
FROM id_map
WHERE district_id = 3
* sqlite:////home/jovyan/nepal.sqlite
Done.
[86]:
count(*)
82684
[87]:
result = [_.DataFrame().astype(float).squeeze()] # noqa F821
wqet_grader.grade("Project 4 Assessment", "Task 4.5.3", result)
Very impressive.
Score: 1
Task 4.5.4: Join the unique building IDs from Kavrepalanchok in id_map, all the columns from building_structure, and the damage_grade column from building_damage, limiting. Make
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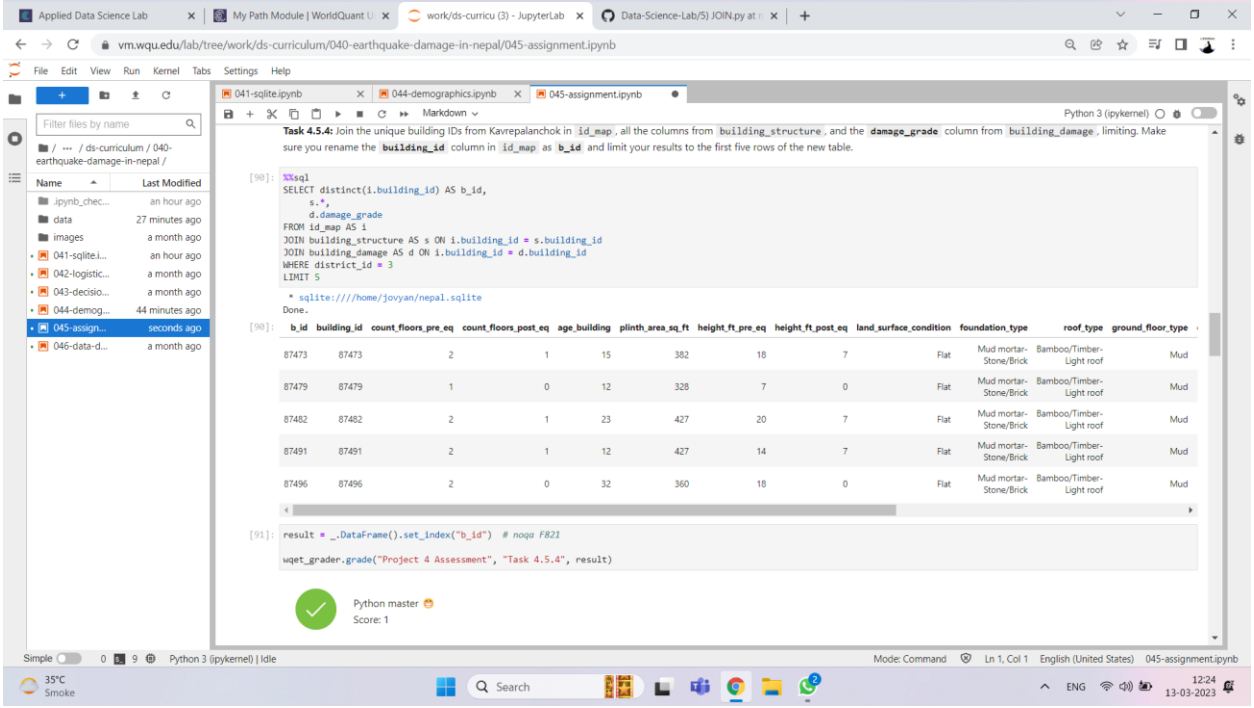
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Task 4.5.4: Join the unique building IDs from Kavrepalanchok in id_map, all the columns from building_structure, and the damage_grade column from building_damage, limiting. Make sure you rename the building_id column in id_map as b_id and limit your results to the first five rows of the new table.
[90]:
%%sql
SELECT distinct(i.building_id) AS b_id,
s.*,
d.damage_grade
FROM id_map AS i
JOIN building_structure AS s ON i.building_id = s.building_id
JOIN building_damage AS d ON i.building_id = d.building_id
WHERE district_id = 3
LIMIT 5
* sqlite:////home/jovyan/nepal.sqlite
Done.
[90]:
b_id building_id count_floors_pre_eq count_floors_post_eq age_building plinth_area_sq_ft height_ft_pre_eq height_ft_post_eq land_surface_condition foundation_type roof_type ground_floor_type
87473 87473 2 1 15 382 18 7 Flat Mud mortar-Stone/Brick Bamboo/Timber-Light roof Mud
87479 87479 1 0 12 328 7 0 Flat Mud mortar-Stone/Brick Bamboo/Timber-Light roof Mud
87482 87482 2 1 23 427 20 7 Flat Mud mortar-Stone/Brick Bamboo/Timber-Light roof Mud
87491 87491 2 1 12 427 14 7 Flat Mud mortar-Stone/Brick Bamboo/Timber-Light roof Mud
87496 87496 2 0 32 360 18 0 Flat Mud mortar-Stone/Brick Bamboo/Timber-Light roof Mud
[91]:
result = _.DataFrame().set_index("b_id") # noqa F821
wqet_grader.grade("Project 4 Assessment", "Task 4.5.4", result)
Python master
Score: 1
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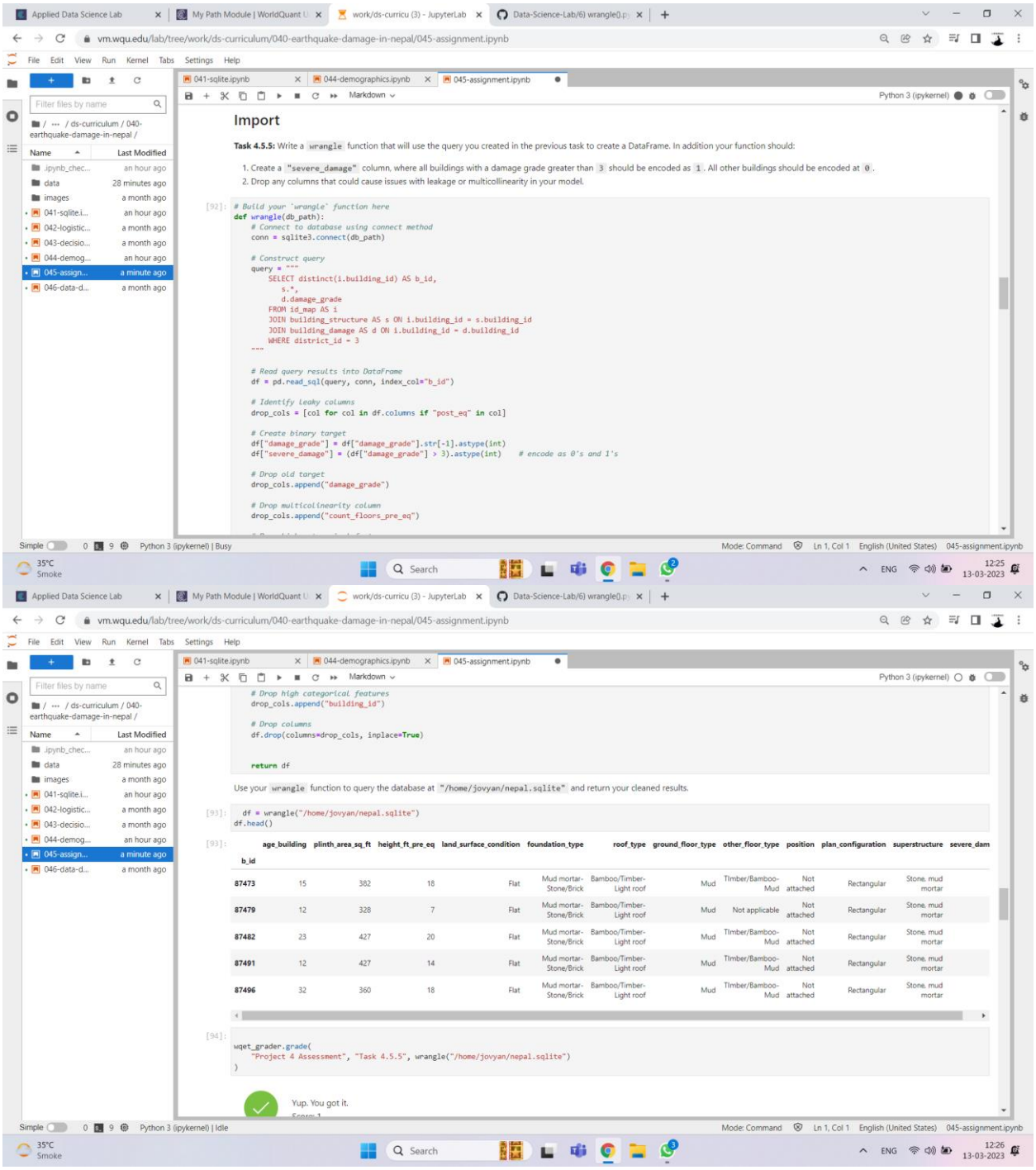
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Import
Task 4.5.5: Write a wrangle function that will use the query you created in the previous task to create a DataFrame. In addition your function should:
1. Create a "severe_damage" column, where all buildings with a damage grade greater than 3 should be encoded as 1. All other buildings should be encoded at 0.
2. Drop any columns that could cause issues with leakage or multicollinearity in your model.
[92]:
# Build your `wrangle` function here
def wrangle(db_path):
# Connect to database using connect method
conn = sqlite3.connect(db_path)
# Construct query
query = """
SELECT distinct(i.building_id) AS b_id,
s.*,
d.damage_grade
FROM id_map AS i
JOIN building_structure AS s ON i.building_id = s.building_id
JOIN building_damage AS d ON i.building_id = d.building_id
WHERE district_id = 3
"""
# Read query results into DataFrame
df = pd.read_sql(query, conn, index_col="b_id")
# Identify leaky columns
drop_cols = [col for col in df.columns if "post_eq" in col]
# Create binary target
df["damage_grade"] = df["damage_grade"].str[-1].astype(int)
df["severe_damage"] = (df["damage_grade"] > 3).astype(int) # encode as 0's and 1's
# Drop old target
drop_cols.append("damage_grade")
# Drop multicolinearity column
drop_cols.append("count_floors_pre_eq")
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# Drop high categorical features
drop_cols.append("building_id")
# Drop columns
df.drop(columns=drop_cols, inplace=True)
return df
Use your wrangle function to query the database at "/home/jovyan/nepal.sqlite" and return your cleaned results.
[93]:
df = wrangle("/home/jovyan/nepal.sqlite")
df.head()
[93]:
b_id | age_building | plinth_area_sq_ft | height_ft_pre_eq | land_surface_condition | foundation_type | roof_type | ground_floor_type | other_floor_type | position | plan_configuration | superstructure | severe_dam
87473 | 15 | 382 | 18 | Flat | Mud mortar-Stone/Brick | Bamboo/Timber-Light roof | Mud | TImber/Bamboo-Mud | Not attached | Rectangular | Stone, mud mortar
87479 | 12 | 328 | 7 | Flat | Mud mortar-Stone/Brick | Bamboo/Timber-Light roof | Mud | Not applicable | Not attached | Rectangular | Stone, mud mortar
87482 | 23 | 427 | 20 | Flat | Mud mortar-Stone/Brick | Bamboo/Timber-Light roof | Mud | TImber/Bamboo-Mud | Not attached | Rectangular | Stone, mud mortar
87491 | 12 | 427 | 14 | Flat | Mud mortar-Stone/Brick | Bamboo/Timber-Light roof | Mud | TImber/Bamboo-Mud | Not attached | Rectangular | Stone, mud mortar
87496 | 32 | 360 | 18 | Flat | Mud mortar-Stone/Brick | Bamboo/Timber-Light roof | Mud | TImber/Bamboo-Mud | Not attached | Rectangular | Stone, mud mortar
[94]:
wqet_grader.grade(
"Project 4 Assessment", "Task 4.5.5", wrangle("/home/jovyan/nepal.sqlite")
)
Yup. You got it.
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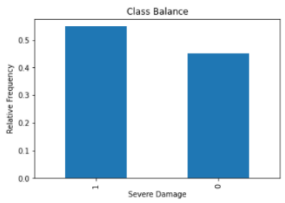
Explore

Task 4.5.6: Are the classes in this dataset balanced? Create a bar chart with the normalized value counts from the `"severe_damage"` column. Be sure to label the x-axis `"Severe Damage"` and the y-axis `"Relative Frequency"`. Use the title `"Kavrepalanchok, Class Balance"`.

[95]:
```
# Plot value counts of "severe_damage"
df["severe_damage"].value_counts(normalize=True).plot(
    kind="bar", xlabel="Severe Damage", ylabel="Relative Frequency", title="Class Balance"
);
# Don't delete the code below 👇
plt.savefig("images/4-5-6.png", dpi=150)
```



[96]:
```
with open("images/4-5-6.png", "rb") as file:
    wqet_grader.grade("Project 4 Assessment", "Task 4.5.6", file)
```

Excellent work.
Score: 1

Task 4.5.7: Is there a relationship between the footprint size of a building and the damage it sustained in the earthquake? Use seaborn to create a boxplot that shows the distributions of the

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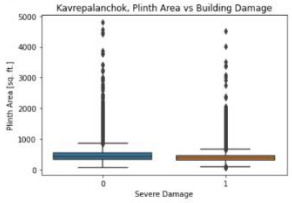
Task 4.5.7: Is there a relationship between the footprint size of a building and the damage it sustained in the earthquake? Use seaborn to create a boxplot that shows the distributions of the `"plinth_area_sq_ft"` column for both groups in the `"severe_damage"` column. Label your x-axis `"Severe Damage"` and y-axis `"Plinth Area [sq. ft.]"`. Use the title `"Kavrepalanchok, Plinth Area vs Building Damage"`.

[97]:
```
sns.boxplot(x="severe_damage", y="plinth_area_sq_ft", data=df)
plt.xlabel("Severe Damage")
plt.ylabel("Plinth Area [sq. ft.]")
plt.title("Kavrepalanchok, Plinth Area vs Building Damage");
# Don't delete the code below 👇
plt.savefig("images/4-5-7.png", dpi=150)
```



[98]:
```
with open("images/4-5-7.png", "rb") as file:
    wqet_grader.grade("Project 4 Assessment", "Task 4.5.7", file)
```

Python master
Score: 1

Task 4.5.8: Are buildings with certain roof types more likely to suffer severe damage? Create a pivot table of `df` where the index is `"roof_type"` and the values come from the `"severe_damage"` column, aggregated by the mean.

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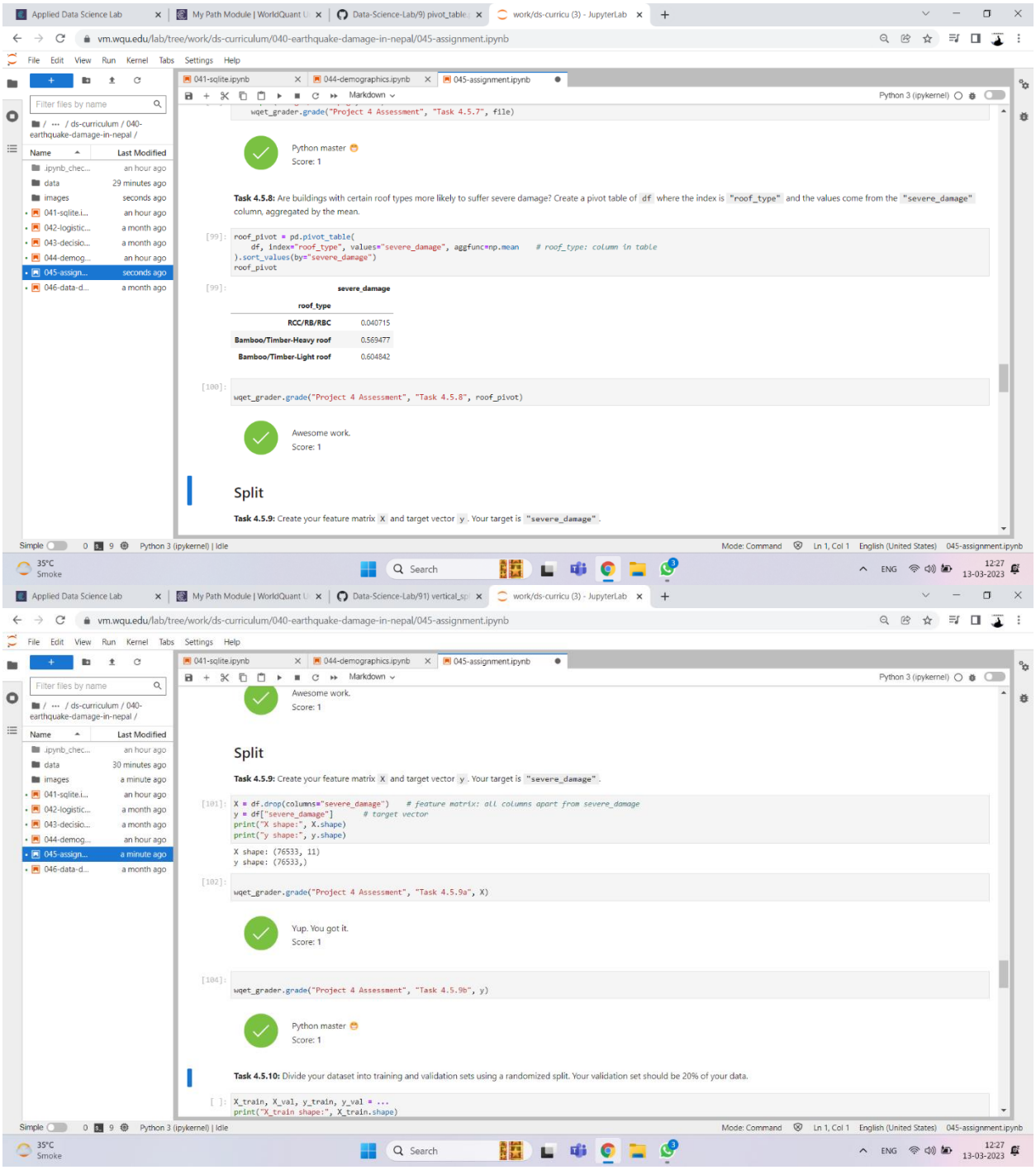
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Data-Science-Lab/9) pivot_table(
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wget_grader.grade("Project 4 Assessment", "Task 4.5.7", file)
Python master
Score: 1
Task 4.5.8: Are buildings with certain roof types more likely to suffer severe damage? Create a pivot table of df where the index is "roof_type" and the values come from the "severe_damage" column, aggregated by the mean.
[99]:
roof_pivot = pd.pivot_table(
df, index="roof_type", values="severe_damage", aggfunc=np.mean # roof_type: column in table
).sort_values(by="severe_damage")
roof_pivot
[99]:
severe_damage
roof_type
RCC/RB/RBC 0.040715
Bamboo/Timber-Heavy roof 0.569477
Bamboo/Timber-Light roof 0.604842
[100]:
wget_grader.grade("Project 4 Assessment", "Task 4.5.8", roof_pivot)
Awesome work.
Score: 1
Split
Task 4.5.9: Create your feature matrix X and target vector y. Your target is "severe_damage".
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Python 3 (ipykernel)
Awesome work.
Score: 1
Split
Task 4.5.9: Create your feature matrix X and target vector y. Your target is "severe_damage".
[101]:
X = df.drop(columns="severe_damage") # feature matrix: all columns apart from severe_damage
y = df["severe_damage"] # target vector
print("X shape:", X.shape)
print("y shape:", y.shape)
X shape: (76533, 11)
y shape: (76533,)
[102]:
wget_grader.grade("Project 4 Assessment", "Task 4.5.9a", X)
Yup. You got it.
Score: 1
[104]:
wget_grader.grade("Project 4 Assessment", "Task 4.5.9b", y)
Python master
Score: 1
Task 4.5.10: Divide your dataset into training and validation sets using a randomized split. Your validation set should be 20% of your data.
[ ]:
X_train, X_val, y_train, y_val = ...
print("X_train shape:", X_train.shape)
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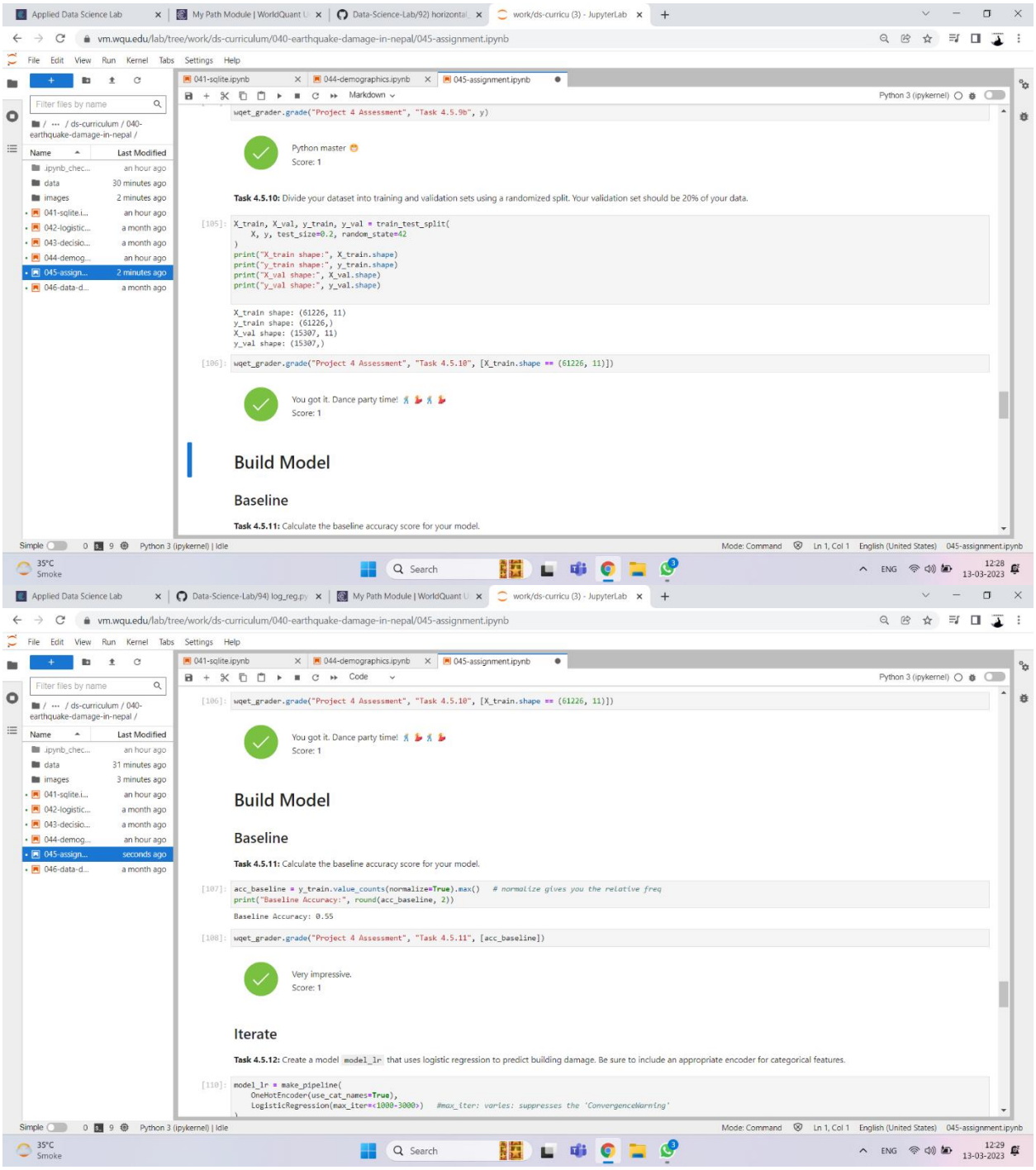
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wqet_grader.grade("Project 4 Assessment", "Task 4.5.9b", y)
Python master
Score: 1
Task 4.5.10: Divide your dataset into training and validation sets using a randomized split. Your validation set should be 20% of your data.
[105]:
X_train, X_val, y_train, y_val = train_test_split(
X, y, test_size=0.2, random_state=42
)
print("X_train shape:", X_train.shape)
print("y_train shape:", y_train.shape)
print("X_val shape:", X_val.shape)
print("y_val shape:", y_val.shape)
X_train shape: (61226, 11)
y_train shape: (61226,)
X_val shape: (15307, 11)
y_val shape: (15307,)
[106]:
wqet_grader.grade("Project 4 Assessment", "Task 4.5.10", [X_train.shape == (61226, 11)])
You got it. Dance party time!
Score: 1
Build Model
Baseline
Task 4.5.11: Calculate the baseline accuracy score for your model.
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[106]:
wqet_grader.grade("Project 4 Assessment", "Task 4.5.10", [X_train.shape == (61226, 11)])
You got it. Dance party time!
Score: 1
Build Model
Baseline
Task 4.5.11: Calculate the baseline accuracy score for your model.
[107]:
acc_baseline = y_train.value_counts(normalize=True).max() # normalize gives you the relative freq
print("Baseline Accuracy:", round(acc_baseline, 2))
Baseline Accuracy: 0.55
[108]:
wqet_grader.grade("Project 4 Assessment", "Task 4.5.11", [acc_baseline])
Very impressive.
Score: 1
Iterate
Task 4.5.12: Create a model model_lr that uses logistic regression to predict building damage. Be sure to include an appropriate encoder for categorical features.
[110]:
model_lr = make_pipeline(
OneHotEncoder(use_cat_names=True),
LogisticRegression(max_iter=<1000-3000>) #max_iter: varies: suppresses the 'ConvergenceWarning'
)
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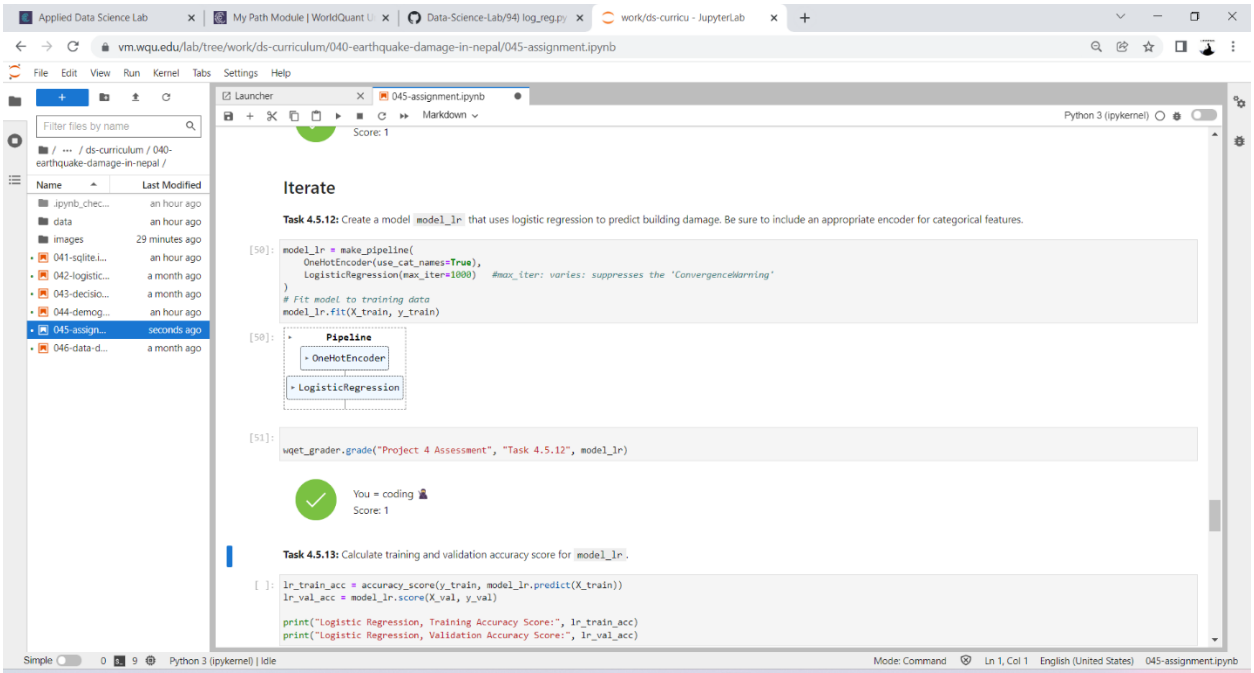
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Score: 1
Iterate
Task 4.5.12: Create a model model_lr that uses logistic regression to predict building damage. Be sure to include an appropriate encoder for categorical features.
[50]:
model_lr = make_pipeline(
OneHotEncoder(use_cat_names=True),
LogisticRegression(max_iter=1000) #max_iter: varies: suppresses the 'ConvergenceWarning'
)
# Fit model to training data
model_lr.fit(X_train, y_train)
[50]:
Pipeline
OneHotEncoder
LogisticRegression
[51]:
wqet_grader.grade("Project 4 Assessment", "Task 4.5.12", model_lr)
You = coding
Score: 1
Task 4.5.13: Calculate training and validation accuracy score for model_lr.
[ ]:
lr_train_acc = accuracy_score(y_train, model_lr.predict(X_train))
lr_val_acc = model_lr.score(X_val, y_val)
print("Logistic Regression, Training Accuracy Score:", lr_train_acc)
print("Logistic Regression, Validation Accuracy Score:", lr_val_acc)
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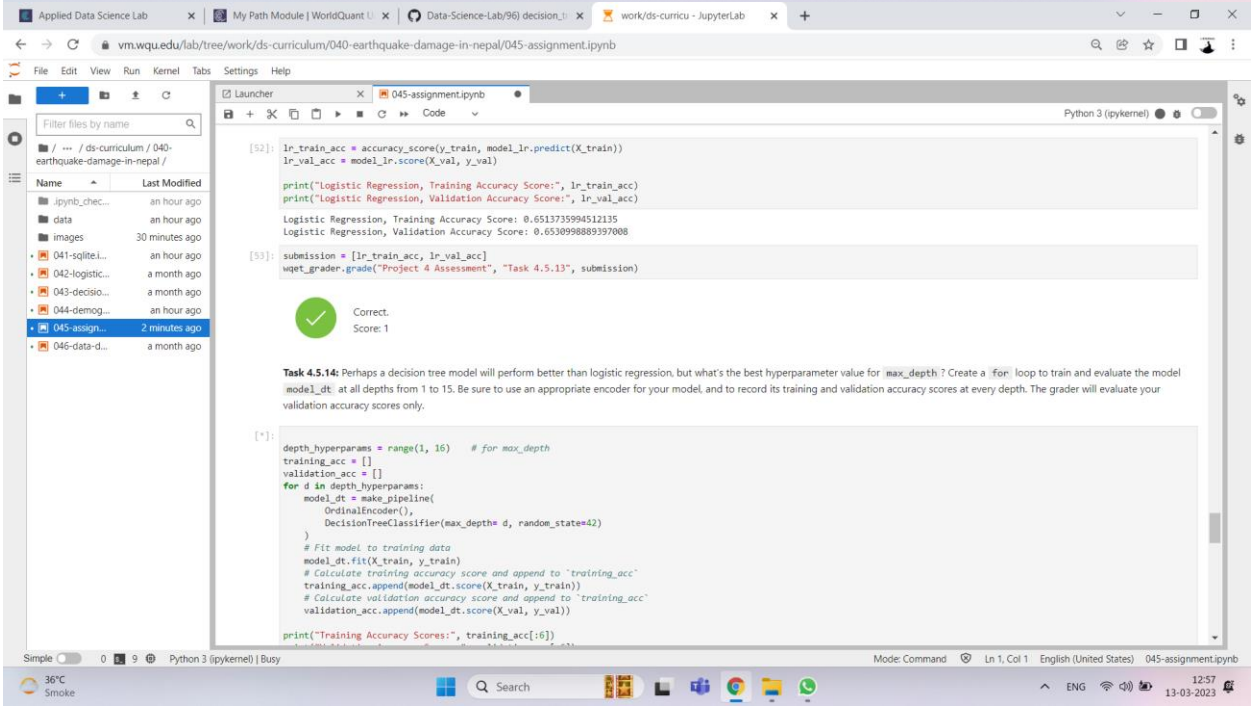
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[52]:
lr_train_acc = accuracy_score(y_train, model_lr.predict(X_train))
lr_val_acc = model_lr.score(X_val, y_val)
print("Logistic Regression, Training Accuracy Score:", lr_train_acc)
print("Logistic Regression, Validation Accuracy Score:", lr_val_acc)
Logistic Regression, Training Accuracy Score: 0.6513735994512135
Logistic Regression, Validation Accuracy Score: 0.6530998889397008
[53]:
submission = [lr_train_acc, lr_val_acc]
wqet_grader.grade("Project 4 Assessment", "Task 4.5.13", submission)
Correct.
Score: 1
Task 4.5.14: Perhaps a decision tree model will perform better than logistic regression, but what's the best hyperparameter value for max_depth? Create a for loop to train and evaluate the model model_dt at all depths from 1 to 15. Be sure to use an appropriate encoder for your model, and to record its training and validation accuracy scores at every depth. The grader will evaluate your validation accuracy scores only.
[*]:
depth_hyperparams = range(1, 16) # for max_depth
training_acc = []
validation_acc = []
for d in depth_hyperparams:
model_dt = make_pipeline(
OrdinalEncoder(),
DecisionTreeClassifier(max_depth= d, random_state=42)
)
# Fit model to training data
model_dt.fit(X_train, y_train)
# Calculate training accuracy score and append to `training_acc`
training_acc.append(model_dt.score(X_train, y_train))
# Calculate validation accuracy score and append to `training_acc`
validation_acc.append(model_dt.score(X_val, y_val))
print("Training Accuracy Scores:", training_acc[:6])
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Markdown | Python 3 (ipykernel)

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Task 4.5.14: Perhaps a decision tree model will perform better than logistic regression, but what's the best hyperparameter value for `max_depth`? Create a `for` loop to train and evaluate the model `model_dt` at all depths from 1 to 15. Be sure to use an appropriate encoder for your model, and to record its training and validation accuracy scores at every depth. The grader will evaluate your validation accuracy scores only.

[54]:
```
depth_hyperparams = range(1, 16)    # for max_depth
training_acc = []
validation_acc = []
for d in depth_hyperparams:
    model_dt = make_pipeline(
        OrdinalEncoder(),
        DecisionTreeClassifier(max_depth= d, random_state=42)
    )
    # Fit model to training data
    model_dt.fit(X_train, y_train)
    # Calculate training accuracy score and append to `training_acc`
    training_acc.append(model_dt.score(X_train, y_train))
    # Calculate validation accuracy score and append to `training_acc`
    validation_acc.append(model_dt.score(X_val, y_val))

print("Training Accuracy Scores:", training_acc[:6])
print("Validation Accuracy Scores:", validation_acc[:6])
```

```
Training Accuracy Scores: [0.6303041191650606, 0.6303041191650606, 0.642292490118577, 0.6535295462711192, 0.6543951915852743, 0.6576617776761506]
Validation Accuracy Scores: [0.6350035931273273, 0.6350035931273273, 0.6453909975828053, 0.6527732410008493, 0.6529039001763899, 0.6584569151368654]
```

[55]:
```
submission = pd.Series(validation_acc, index=depth_hyperparams)

wqet_grader.grade("Project 4 Assessment", "Task 4.5.14", submission)
```

That's the right answer. Keep it up!
Score: 1

Task 4.5.15: Using the values in `training_acc` and `validation_acc`, plot the validation curve for `model_dt`. Label your x-axis `"Max Depth"` and your y-axis `"Accuracy Score"`. Use the title `"Validation Curve, Decision Tree Model"`, and include a legend.

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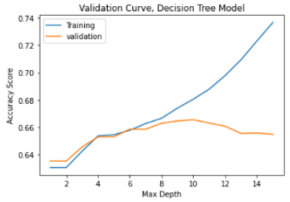
[56]:
```
# Validation curve
plt.plot(depth_hyperparams, training_acc, label="Training")
plt.plot(depth_hyperparams, validation_acc, label="validation")
plt.xlabel("Max Depth")
plt.ylabel("Accuracy Score")
plt.title("Validation Curve, Decision Tree Model")
plt.legend();


# build & fit again
final_model_dt = make_pipeline(
    OrdinalEncoder(),
    DecisionTreeClassifier(max_depth=10, random_state=42)
)

# Don't delete the code below 👇
plt.savefig("images/4-5-15.png", dpi=150)
```



[57]:
```
with open("images/4-5-15.png", "rb") as file:
    wqet_grader.grade("Project 4 Assessment", "Task 4.5.15", file)
```

You got it. Dance party time! 🕺 🕺 🕺

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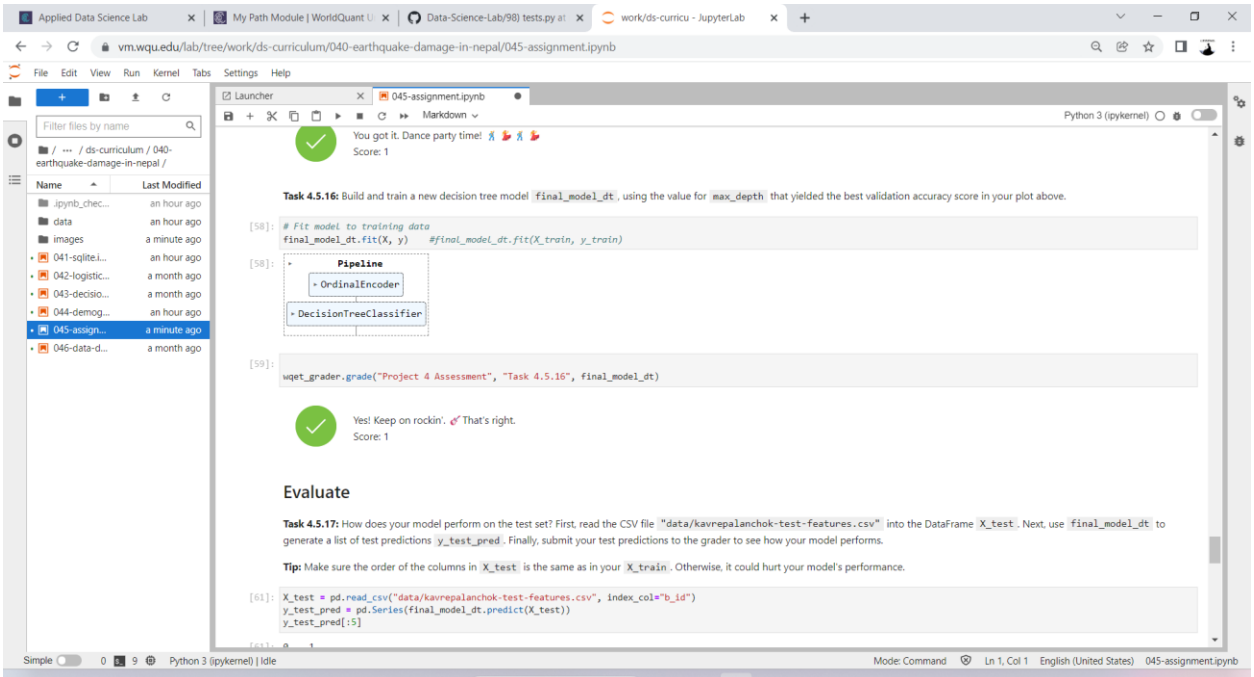
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You got it. Dance party time!
Score: 1
Task 4.5.16: Build and train a new decision tree model final_model_dt, using the value for max_depth that yielded the best validation accuracy score in your plot above.
[58]: # Fit model to training data
final_model_dt.fit(X, y) #final_model_dt.fit(X_train, y_train)
[58]: Pipeline
OrdinalEncoder
DecisionTreeClassifier
[59]: wqet_grader.grade("Project 4 Assessment", "Task 4.5.16", final_model_dt)
Yes! Keep on rockin'. That's right.
Score: 1
Evaluate
Task 4.5.17: How does your model perform on the test set? First, read the CSV file "data/kavrepalanchok-test-features.csv" into the DataFrame X_test. Next, use final_model_dt to generate a list of test predictions y_test_pred. Finally, submit your test predictions to the grader to see how your model performs.
Tip: Make sure the order of the columns in X_test is the same as in your X_train. Otherwise, it could hurt your model's performance.
[61]: X_test = pd.read_csv("data/kavrepalanchok-test-features.csv", index_col="b_id")
y_test_pred = pd.Series(final_model_dt.predict(X_test))
y_test_pred[:5]
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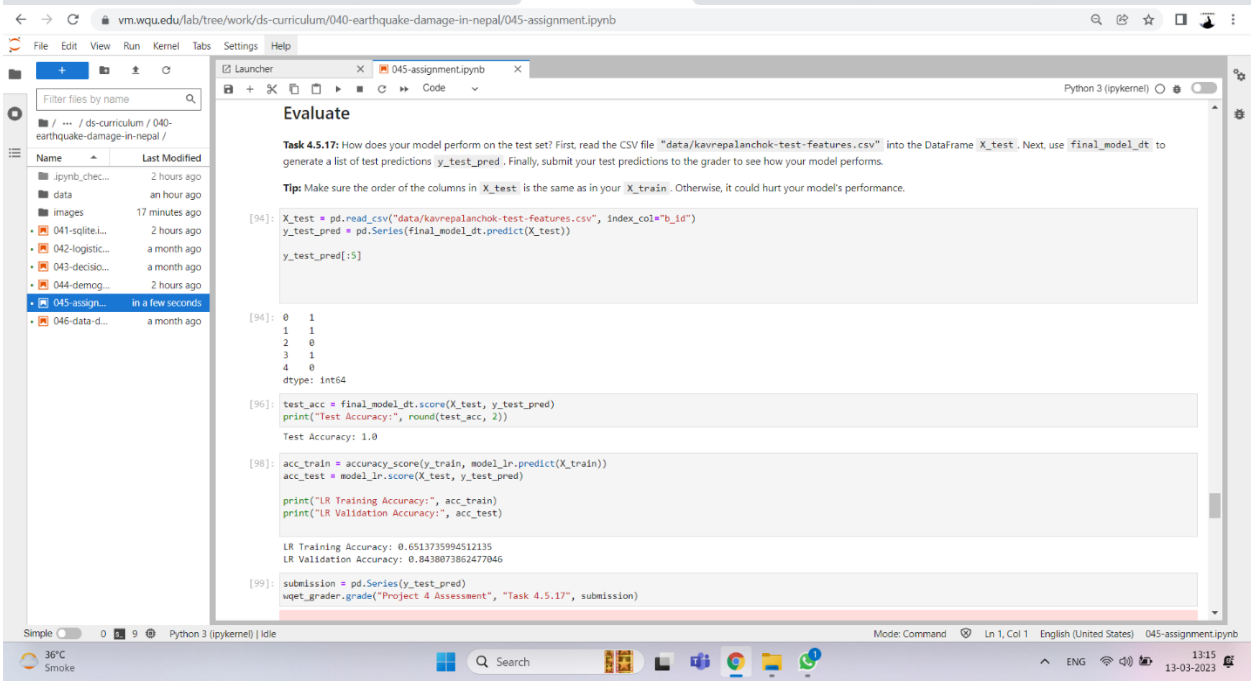
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Evaluate
Task 4.5.17: How does your model perform on the test set? First, read the CSV file "data/kavrepalanchok-test-features.csv" into the DataFrame X_test. Next, use final_model_dt to generate a list of test predictions y_test_pred. Finally, submit your test predictions to the grader to see how your model performs.
Tip: Make sure the order of the columns in X_test is the same as in your X_train. Otherwise, it could hurt your model's performance.
[94]: X_test = pd.read_csv("data/kavrepalanchok-test-features.csv", index_col="b_id")
y_test_pred = pd.Series(final_model_dt.predict(X_test))
y_test_pred[:5]
[94]: 0 1
1 1
2 0
3 1
4 0
dtype: int64
[96]: test_acc = final_model_dt.score(X_test, y_test_pred)
print("Test Accuracy:", round(test_acc, 2))
Test Accuracy: 1.0
[98]: acc_train = accuracy_score(y_train, model_lr.predict(X_train))
acc_test = model_lr.score(X_test, y_test_pred)
print("LR Training Accuracy:", acc_train)
print("LR Validation Accuracy:", acc_test)
LR Training Accuracy: 0.6513735994512135
LR Validation Accuracy: 0.8438073862477046
[99]: submission = pd.Series(y_test_pred)
wqet_grader.grade("Project 4 Assessment", "Task 4.5.17", submission)
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Communicate Results

Task 4.5.18: What are the most important features for `final_model_dt`? Create a Series Gini `feat_imp`, where the index labels are the feature names for your dataset and the values are the feature importances for your model. Be sure that the Series is sorted from smallest to largest feature importance.

[100]:
```
features = X_train.columns
importances = final_model_dt.named_steps["decisiontreeclassifier"].feature_importances_
feat_imp = pd.Series(importances, index=features).sort_values()
feat_imp.head()
```

[100]:
```
plan_configuration       0.004032
position                 0.007129
land_surface_condition   0.008241
ground_floor_type        0.009741
foundation_type          0.010620
dtype: float64
```

[101]:
```
features = model_lr.named_steps["onehotencoder"].get_feature_names()
importances = model_lr.named_steps["logisticregression"].coef_[0]
feat_imp = pd.Series(np.exp(importances), index=features).sort_values()
feat_imp.head()
```

[101]:
```
foundation_type_RC                    0.430515
superstructure_Brick, cement mortar   0.550657
roof_type_RCC/RB/RBC                  0.566908
ground_floor_type_RC                  0.599185
superstructure_RC, non-engineered     0.618918
dtype: float64
```

[102]:
```
wqet_grader.grade("Project 4 Assessment", "Task 4.5.18", feat_imp)
```

```
Exception                                 Traceback (most recent call last)
```

Simple | 0 | 9 | Python 3 (ipykernel) | Idle | Mode: Command | Ln 1, Col 1 | English (United States) | 045-assignment.ipynb

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Markdown | Python 3 (ipykernel)

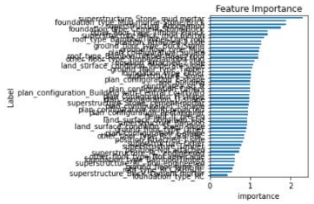
```
    149 # Used only in testing
```

```
Exception: Could not grade submission: Could not verify access to this assessment: Received error from WQET submission API: You have already passed this course!
```

Task 4.5.19: Create a horizontal bar chart of `feat_imp`. Label your x-axis `"Gini Importance"` and your y-axis `"Label"`. Use the title `"Kavrepalanchok Decision Tree, Feature Importance"`.

Do you see any relationship between this plot and the exploratory data analysis you did regarding roof type?

[103]:
```
# Create horizontal bar chart of feature importances
# horizontal bar chart
feat_imp.plot(kind="barh")
plt.xlabel("importance")
plt.ylabel("Label")
plt.title("Feature Importance");
# Don't delete the code below 👇
plt.tight_layout()
plt.savefig("images/4-5-19.png", dpi=150)
```



[104]:
```
with open("images/4-5-19.png", "rb") as file:
    wqet_grader.grade("Project 4 Assessment", "Task 4.5.19", file)
```

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