Hands-on Lab: Extract, Transfrom and Load GDP Data

Estimated Effort: 60 mins

Introduction

In this practice project, you will put the skills acquired through the course to use and create a complete ETL pipeline for accessing data from a website and processing it to meet the requirements.

Project Scenario:

An international firm that is looking to expand its business in different countries across the world has recruited you. You have been hired as a junior Data Engineer and are tasked with creating an automated script that can extract the list of all countries in order of their GDPs in billion USDs (rounded to 2 decimal places), as logged by the International Monetary Fund (IMF). Since IMF releases this evaluation twice a year, this code will be used by the organization to extract the information as it is updated.

The required data seems to be available on the URL mentioned below:

URL

```
'https://web.archive.org/web/20230902185326/https://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29'
```

Copied!

The required information needs to be made accessible as a `CSV` file `Countries_by_GDP.csv` as well as a table `Countries_by_GDP` in a database file `World_Economies.db` with attributes `Country` and `GDP_USD_billion`.

Your boss wants you to demonstrate the success of this code by running a query on the database table to display only the entries with more than a 100 billion USD economy. Also, you should log in a file with the entire process of execution named `etl_project_log.txt`.

You must create a Python code 'etl_project_gdp.py' that performs all the required tasks.

Objectives

You have to complete the following tasks for this project

1. Write a data extraction function to retrieve the relevant information from the required URL.
2. Transform the available GDP information into 'Billion USD' from 'Million USD'.
3. Load the transformed information to the required CSV file and as a database file.
4. Run the required query on the database.
5. Log the progress of the code with appropriate timestamps.

Initial setup

Before you start building the code, you need to install the required libraries for it.

The libraries needed for the code are as follows:

1. `requests` - The library used for accessing the information from the URL.
2. `bs4` - The library containing the `BeautifulSoup` function used for webscraping.
3. `pandas` - The library used for processing the extracted data, storing it to required formats and communicating with the databases.
4. `sqlite3` - The library required to create a database server connection.
5. `numpy` - The library required for the mathematical rounding operation as required in the objectives.
6. `datetime` - The library containing the function `datetime` used for extracting the timestamp for logging purposes.

As discussed before, use the following command format in a terminal window to install the libraries.

```
python3.11 -m pip install <library_name>
```

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While `requests`, `sqlite3`, and `datetime` come bundled with `python`, the other libraries will have to be installed.

▾ Installing Libraries

```
python3.11 -m pip install pandas
python3.11 -m pip install numpy
python3.11 -m pip install bs4
```

Copied! Executed!

Once the required libraries are installed, create a file `etl_project_gdp.py` in the path `\home\project\`.

Code structure

The code should be created in an organized manner such that you can perform each task with a dedicated function. For reference, you can copy paste the structure as shown below to `etl_project_gdp.py`.

```
# Code for ETL operations on Country-GDP data

# Importing the required libraries

def extract(url, table_attribs):
    ''' This function extracts the required
    information from the website and saves it to a dataframe. The
    function returns the dataframe for further processing. '''

    return df

def transform(df):
    ''' This function converts the GDP information from Currency
    format to float value, transforms the information of GDP from
    USD (Millions) to USD (Billions) rounding to 2 decimal places.
    The function returns the transformed dataframe.'''

    return df

def load_to_csv(df, csv_path):
    ''' This function saves the final dataframe as a `CSV` file
    in the provided path. Function returns nothing.'''

def load_to_db(df, sql_connection, table_name):
    ''' This function saves the final dataframe as a database table
    with the provided name. Function returns nothing.'''

def run_query(query_statement, sql_connection):
    ''' This function runs the stated query on the database table and
    prints the output on the terminal. Function returns nothing. '''

def log_progress(message):
    ''' This function logs the mentioned message at a given stage of the code execution to a log file. Function returns nothing'''

''' Here, you define the required entities and call the relevant
functions in the correct order to complete the project. Note that this
portion is not inside any function.'''
```

Copied!

Preliminary: Importing libraries and defining known values

As per the requirement, write the commands in `etl_project_gdp.py` at the position specified in the code structure, to import the relevant libraries.

▸ Click here for solution

Further, you need to initialize all the known entities. These are mentioned below:

1. URL:

```
'https://web.archive.org/web/20230902185326/https://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29'
```

Copied!

2. table_attribs: The attributes or column names for the dataframe stored as a list. Since the data available in the website is in USD Millions, the attributes should initially be 'Country' and 'GDP_USD_millions'. This will be modified in the transform function later.

3. db_name: As mentioned in the Project scenario, 'World_Economies.db'

4. table_name: As mentioned in the Project scenario, 'Countries_by_GDP'

5. csv_path: As mentioned in the Project scenario, 'Countries_by_GDP.csv'

You should log the initialization process

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Task 1: Extracting information

Extraction of information from a web page is done using the web scraping process. For this, you'll have to analyze the link and come up with the strategy of how to get the required information. The following points are worth observing for this task.

1. Inspect the URL and note the position of the table. Note that even the images with captions in them are stored in tabular format. Hence, in the given webpage, our table is at the third position, or index 2. Among this, we require the entries under 'Country/Territory' and 'IMF -> Estimate'.

2. Note that there are a few entries in which the IMF estimate is shown to be '—'. Also, there is an entry at the top named 'World', which we do not require. Segregate this entry from the others because this entry does not have a hyperlink and all others in the table do. So you can take advantage of that and access only the rows for which the entry under 'Country/Terriroty' has a hyperlink associated with it.

Note that '—' is a special character and not a general hyphen, '-'. Copy the character from the instructions here to use in the code.

Assuming the function gets the URL and the table_attribs parameters as arguments, complete the function `extract()` in the code following the steps below.

1. Extract the web page as text.
   ▸ Click here for hint
2. Parse the text into an `HTML` object.
   ▸ Click here for hint
3. Create an empty pandas DataFrame named `df` with columns as the table_attribs.
   ▸ Click here for hint
4. Extract all 'tbody' attributes of the HTML object and then extract all the rows of the index 2 table using the 'tr' attribute.
   ▸ Click here for hint
5. Check the contents of each row, having attribute ‘td’, for the following conditions.
   a. The row should not be empty.
   b. The first column should contain a hyperlink.
   c. The third column should not be '—'.
   ▸ Click here for hint
6. Store all entries matching the conditions in step 5 to a dictionary with keys the same as entries of table_attribs. Append all these dictionaries one by one to the dataframe.
   ▸ Click here for hint

▸ Click here for solution

Task 2: Transform information

The transform function needs to modify the ‘GDP_USD_millions’. You need to cover the following points as a part of the transformation process.

1. Convert the contents of the 'GDP_USD_millions' column of `df` dataframe from currency format to floating numbers.
   ▸ Click here for hint
2. Divide all these values by 1000 and round it to 2 decimal places.
   ▸ Click here for hint
3. Modify the name of the column from 'GDP_USD_millions' to 'GDP_USD_billions'.
   ▸ Click here for hint

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Task 3: Loading information

Loading process for this project is two fold.

1. You have to save the transformed dataframe to a CSV file. For this, pass the dataframe `df` and the CSV file path to the function `load_to_csv()` and add the required statements there.

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2. You have to save the transformed dataframe as a table in the database. This needs to be implemented in the function `load_to_db()`, which accepts the dataframe `df`, the connection object to the SQL database `conn`, and the table name variable `table_name` to be used.

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Task 4: Querying the database table

Assuming that the appropriate query was initiated and the query statement has been passed to the function `run_query()`, along with the SQL connection object `sql_connection` and the table name variable `table_name`, this function should run the query statement on the table and retrieve the output as a filtered dataframe. This dataframe can then be simply printed.

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Task 5: Logging progress

Logging needs to be done using the `log_progress()` funciton. This function will be called multiple times throughout the execution of this code and will be asked to add a log entry in a .txt file, `etl_project_log.txt`. The entry is supposed to be in the following format:

> '<Time_stamp> : <message_text>'

Here, message text is passed to the function as an argument. Each entry must be in a separate line.

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Function calls

Now, you have to set up the sequence of function calls for your assigned tasks. Follow the sequence below.

Task	Log message on completion
Declaring known values	Preliminaries complete. Initiating ETL process.
Call extract() function	Data extraction complete. Initiating Transformation process.

Task	Log message on completion
Call transform() function	Data transformation complete. Initiating loading process.
Call load_to_csv()	Data saved to CSV file.
Initiate SQLite3 connection	SQL Connection initiated.
Call load_to_db()	Data loaded to Database as table. Running the query.
Call run_query() *	Process Complete.
Close SQLite3 connection	-

Note: The query statement to be executed here is

```
f"SELECT * from {table_name} WHERE GDP_USD_billions >= 100"
```

▸ Click here for solution

Code Execution and expected output

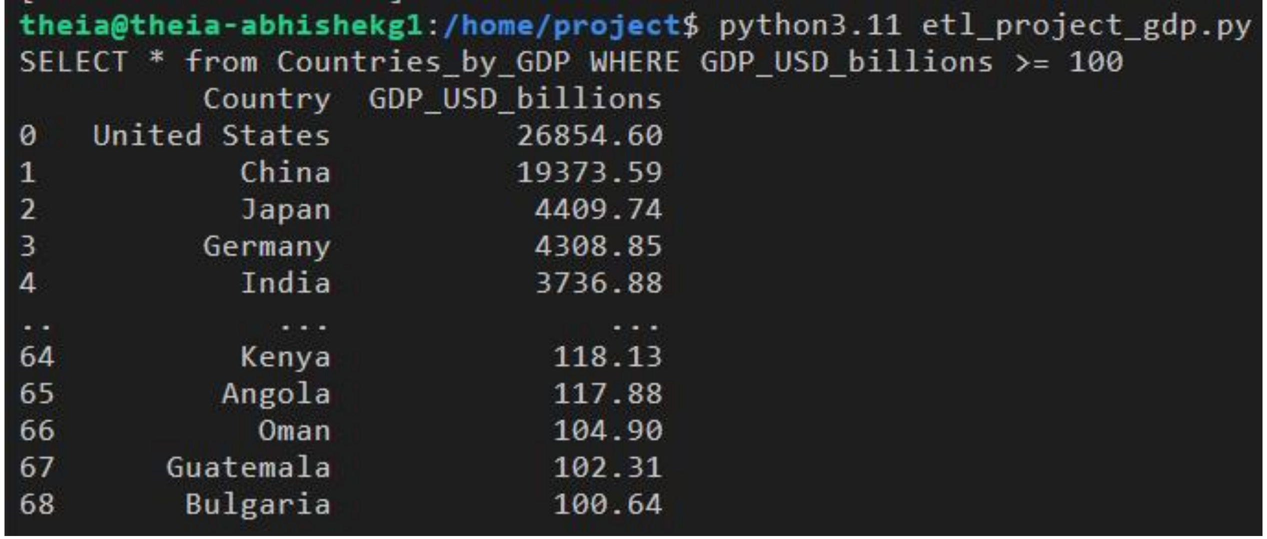
Once the code is complete, execute it through the terminal using the following command:

```
python3.11 etl_project_gdp.py
```

Copied! Executed!

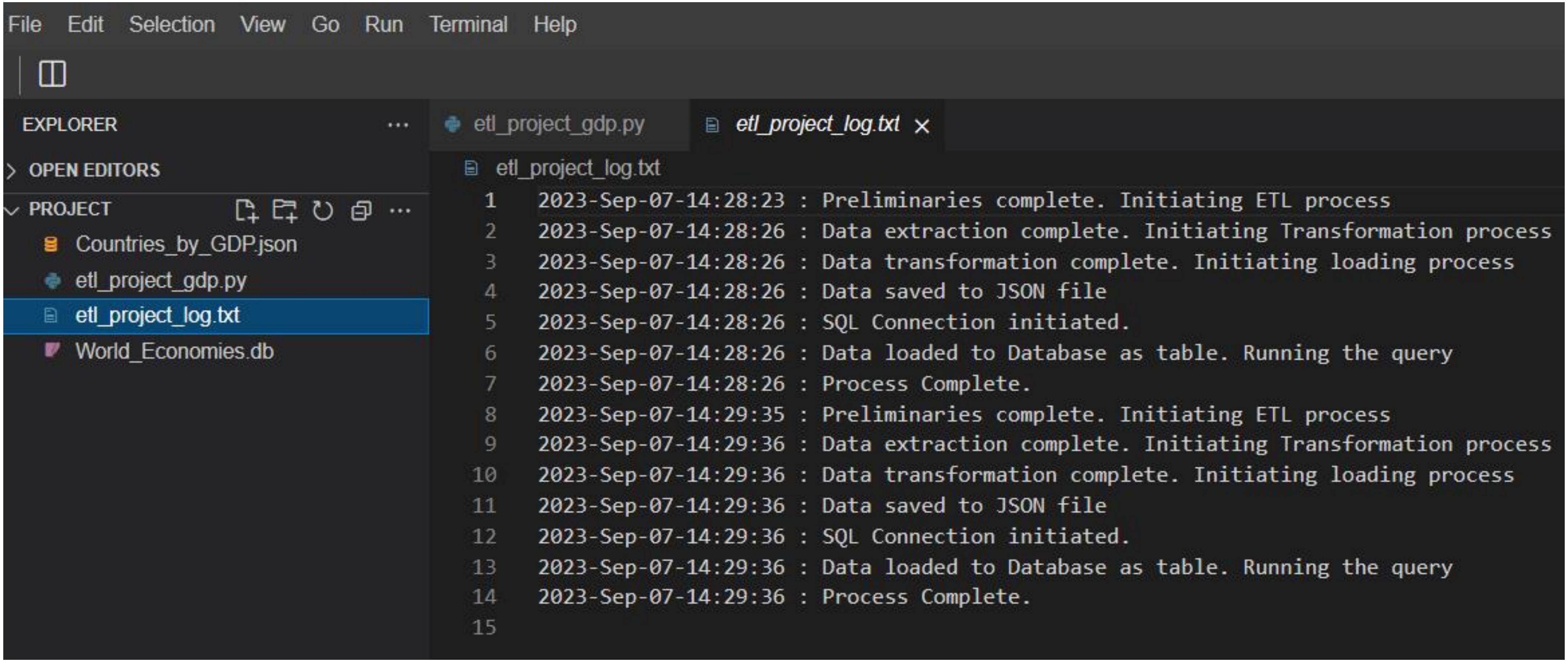
You should be able to make the following observations.

1. Output of the terminal



```
theia@theia-abhishekg1:/home/project$ python3.11 etl_project_gdp.py
SELECT * from Countries_by_GDP WHERE GDP_USD_billions >= 100
          Country  GDP_USD_billions
0   United States          26854.60
1           China          19373.59
2           Japan           4409.74
3         Germany           4308.85
4           India           3736.88
..            ...               ...
64          Kenya            118.13
65         Angola            117.88
66           Oman            104.90
67      Guatemala            102.31
68       Bulgaria            100.64
```

2. Created files and the log contents



```
2023-Sep-07-14:28:23 : Preliminaries complete. Initiating ETL process
2023-Sep-07-14:28:26 : Data extraction complete. Initiating Transformation process
2023-Sep-07-14:28:26 : Data transformation complete. Initiating loading process
2023-Sep-07-14:28:26 : Data saved to JSON file
2023-Sep-07-14:28:26 : SQL Connection initiated.
2023-Sep-07-14:28:26 : Data loaded to Database as table. Running the query
2023-Sep-07-14:28:26 : Process Complete.
2023-Sep-07-14:29:35 : Preliminaries complete. Initiating ETL process
2023-Sep-07-14:29:36 : Data extraction complete. Initiating Transformation process
2023-Sep-07-14:29:36 : Data transformation complete. Initiating loading process
2023-Sep-07-14:29:36 : Data saved to JSON file
2023-Sep-07-14:29:36 : SQL Connection initiated.
2023-Sep-07-14:29:36 : Data loaded to Database as table. Running the query
2023-Sep-07-14:29:36 : Process Complete.
```

Important Note:

> Maintaining consistency of the lab structure, the webpage being accessed is routed through an archive database. Often, in case the archive server is busy, the users may encounter delayed execution and/or an error such as:
> requests.exceptions.ConnectionError: HTTPSConnectionPool(host='web.archive.org', port=443): Max retries exceeded with url.
> In such a situation, try executing the code again. In case the problem persists, you can change the URL to the live version, such as:
> https://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29

Practice project solution

In case you are not able to get the required output from the code or are facing some errors, the final file for `etl_project_gdp.py` is shared below. Please note that this is for your help, and we encourage you to first try to resolve the errors on your own.

▾ etl_project_gdp.py

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```
# Code for ETL operations on Country-GDP data

# Importing the required libraries

from bs4 import BeautifulSoup
import requests
import pandas as pd
import numpy as np
import sqlite3
from datetime import datetime

def extract(url, table_attribs):
    ''' The purpose of this function is to extract the required
    information from the website and save it to a dataframe. The
    function returns the dataframe for further processing. '''

    page = requests.get(url).text
    data = BeautifulSoup(page,'html.parser')
    df = pd.DataFrame(columns=table_attribs)
    tables = data.find_all('tbody')
    rows = tables[2].find_all('tr')
    for row in rows:
        col = row.find_all('td')
        if len(col)!=0:
            if col[0].find('a') is not None and '–' not in col[2]:
                data_dict = {"Country": col[0].a.contents[0],
                             "GDP_USD_millions": col[2].contents[0]}
                df1 = pd.DataFrame(data_dict, index=[0])
                df = pd.concat([df,df1], ignore_index=True)
    return df

def transform(df):
    ''' This function converts the GDP information from Currency
    format to float value, transforms the information of GDP from
    USD (Millions) to USD (Billions) rounding to 2 decimal places.
    The function returns the transformed dataframe.'''

    GDP_list = df["GDP_USD_millions"].tolist()
    GDP_list = [float("".join(x.split(','))) for x in GDP_list]
    GDP_list = [np.round(x/1000,2) for x in GDP_list]
    df["GDP_USD_millions"] = GDP_list
    df=df.rename(columns = {"GDP_USD_millions":"GDP_USD_billions"})
    return df

def load_to_csv(df, csv_path):
    ''' This function saves the final dataframe as a `CSV` file
    in the provided path. Function returns nothing.'''

    df.to_csv(csv_path)

def load_to_db(df, sql_connection, table_name):
    ''' This function saves the final dataframe to as a database table
    with the provided name. Function returns nothing.'''

    df.to_sql(table_name, sql_connection, if_exists='replace', index=False)

def run_query(query_statement, sql_connection):
    ''' This function runs the stated query on the database table and
    prints the output on the terminal. Function returns nothing. '''

    print(query_statement)
    query_output = pd.read_sql(query_statement, sql_connection)
    print(query_output)

def log_progress(message):
    ''' This function logs the mentioned message at a given stage of the
    code execution to a log file. Function returns nothing.'''

    timestamp_format = '%Y-%h-%d-%H:%M:%S' # Year-Monthname-Day-Hour-Minute-Second
    now = datetime.now() # get current timestamp
    timestamp = now.strftime(timestamp_format)
    with open("./etl_project_log.txt","a") as f:
        f.write(timestamp + ' : ' + message + '\n')
```

```

''' Here, you define the required entities and call the relevant
functions in the correct order to complete the project. Note that this
portion is not inside any function.'''

url = 'https://web.archive.org/web/20230902185326/https://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29'
table_attribs = ["Country", "GDP_USD_millions"]
db_name = 'World_Economies.db'
table_name = 'Countries_by_GDP'
csv_path = './Countries_by_GDP.csv'

log_progress('Preliminaries complete. Initiating ETL process')

df = extract(url, table_attribs)

log_progress('Data extraction complete. Initiating Transformation process')

df = transform(df)

log_progress('Data transformation complete. Initiating loading process')

load_to_csv(df, csv_path)

log_progress('Data saved to CSV file')

sql_connection = sqlite3.connect('World_Economies.db')

log_progress('SQL Connection initiated.')

load_to_db(df, sql_connection, table_name)

log_progress('Data loaded to Database as table. Running the query')

query_statement = f"SELECT * from {table_name} WHERE GDP_USD_billions >= 100"
run_query(query_statement, sql_connection)

log_progress('Process Complete.')

sql_connection.close()
```

Copied!

Conclusion

Congratulations on completing this project!

In this project, you performed complex Extract, Transform, and Loading operations on real world data. By now, you should be able to:

- Extract relevant information from websites using Webscraping and requests API.
- Transform the data to a required format.
- Load the processed data to a local file or as a database table.
- Query the database table using Python.
- Create detailed logs of all operations conducted.

Author(s)

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Changelog

Date	Version	Changed by	Change Description
2023-09-08	0.1	Abhishek Gagneja	Initial version created
2023-09-12	0.2	Steve Hord	QA pass with edits