



COVID-19 ETL Data Pipeline with Dagster, Spark, and Plotly

A Data Engineering Project in "Fundamental Data Engineering" Course - AIDE Institute

Thang Bui Q.

[AIDE] FDE02 - Student
Faculty of Mathematics and Computer Science
University of Science (VNUHCM-US)

April 16, 2023

1. Overview of Datapipeline
2. Collecting data and project goal
3. Setup data pipeline with Spark
4. Data mining on data warehouse and hosting Plotly

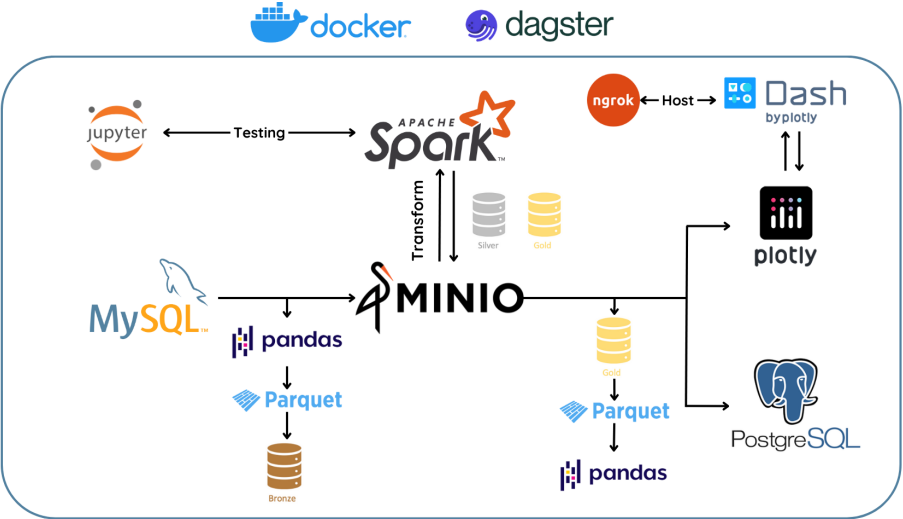
Before the report



With sincere thanks...

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Data Flow Diagram



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Collecting data

- Time-series data (date-by-date), clean above 80%.
- Git-repo: <https://github.com/CSSEGISandData/COVID-19>

Province/State ▼	Country/Region ▼	Lat ▼	Long ▼	Date ▼	Confirmed ▼	Deaths ▼	Recovered ▼	Active ▼	WHO Region ▼
Alberta	Canada	53.93	-116.58	2020-07-14	8912	163	0	8749	Americas
Alberta	Canada	53.93	-116.58	2020-07-15	8994	163	0	8831	Americas
Alberta	Canada	53.93	-116.58	2020-07-16	9114	165	0	8949	Americas
Alberta	Canada	53.93	-116.58	2020-07-17	9219	167	0	9052	Americas
Alberta	Canada	53.93	-116.58	2020-07-18	9219	167	0	9052	Americas
Alberta	Canada	53.93	-116.58	2020-07-19	9219	167	0	9052	Americas
Alberta	Canada	53.93	-116.58	2020-07-20	9587	170	0	9417	Americas
Alberta	Canada	53.93	-116.58	2020-07-21	9728	172	0	9556	Americas
Alberta	Canada	53.93	-116.58	2020-07-22	9728	172	0	9556	Americas
Alberta	Canada	53.93	-116.58	2020-07-23	9975	176	0	9799	Americas
Alberta	Canada	53.93	-116.58	2020-07-24	10086	178	0	9908	Americas
Alberta	Canada	53.93	-116.58	2020-07-25	10086	178	0	9908	Americas
Alberta	Canada	53.93	-116.58	2020-07-26	10086	178	0	9908	Americas
Alberta	Canada	53.93	-116.58	2020-07-27	10390	186	0	10204	Americas
	Afghanistan	33.94	67.71	2020-01-22	0	0	0	0	Eastern Mediterranean
	Albania	41.15	20.17	2020-01-22	0	0	0	0	Europe
	Algeria	28.03	1.66	2020-01-22	0	0	0	0	Africa
	Andorra	42.51	1.52	2020-01-22	0	0	0	0	Europe
	Angola	-11.2	17.87	2020-01-22	0	0	0	0	Africa
	Antigua and Barbuda	17.06	-61.8	2020-01-22	0	0	0	0	Americas
	Argentina	-38.42	-63.62	2020-01-22	0	0	0	0	Americas
	Armenia	40.07	45.04	2020-01-22	0	0	0	0	Europe
	Austria	47.52	14.55	2020-01-22	0	0	0	0	Europe
	Azerbaijan	40.14	47.58	2020-01-22	0	0	0	0	Europe

Explore Dataset



covid19_cases_position.csv

RAW Lat/Long wise no. of cases

covid19_country_wise.csv

RAW country level no. of cases

covid19_time_series.csv

RAW Date wise no. of cases

covid19_worldometer.csv

RAW Worldometers data (has Continent info)

Project Goal (WHO Spreadmap)

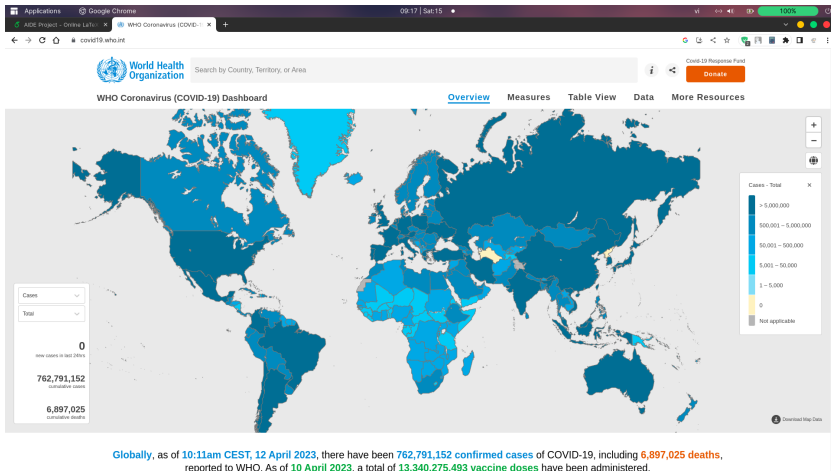


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We need to initialize the schemas for the RAW data in MySQL with the 4 tables (as 4 csv files). Then, we need to create clean tables with aggregated and filtered data for silver layer from 4 assets. And create two tables at last in gold layer:

1. **covid19_daily_stats**
2. **covid19_continent_stats**

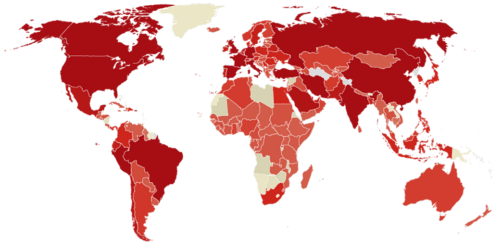
Sample SQL Script For MySQL Schemas

```
-- Doing the same things with 3 others
DROP TABLE IF EXISTS covid19_time_series;
CREATE TABLE covid19_time_series (
  `date`          date,
  country_region  varchar(64),
  confirmed       int4,
  deaths          int4,
  recovered       int4,
  active          int4,
  new_cases       int4,
  new_deaths      int4,
  new_recovered   int4,
  who_region      varchar(64),
  CONSTRAINT PK_covid19_timeseries PRIMARY KEY (`date`, `country_region`)
);
LOAD DATA LOCAL INFILE '/tmp/covid19-clean/covid19_time_series.csv'
INTO TABLE covid19_time_series FIELDS TERMINATED BY ',' LINES TERMINATED BY '\n'
IGNORE 1 ROWS;
```



This asset will provide **daily** statistics for each country, including confirmed cases, deaths, and recoveries (**with latitude and longitude**). It will join data from the covid19_cases_position and covid19_time_series tables.

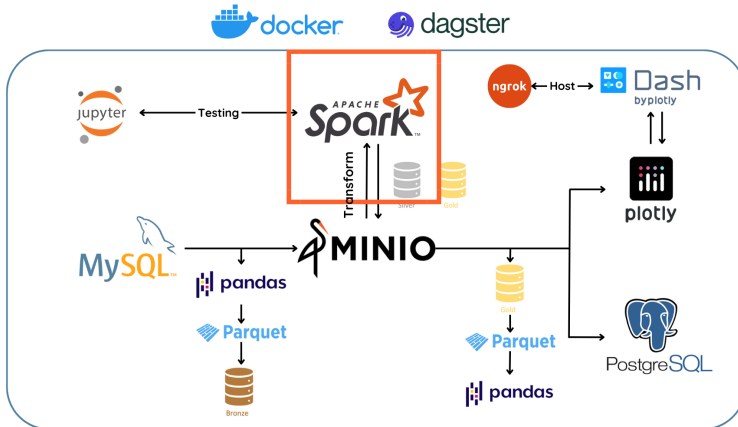
Concepts of covid19_continent_stats



This asset will provide statistics **by continent**, including **total** confirmed cases, deaths, and recoveries. It will join data from the covid19_country_wise and covid19_worldometer tables.

Review Data Flow Diagram

- What's handle the output of Spark DataFrame and Spark (with spark-master and 2 spark-workers with 2 CORES CPU 4GB RAM)?



Design IO Manager for Spark

```
) tree
.
├── Dockerfile
├── etl_pipeline
│   ├── assets
│   │   ├── bronze_layer.py
│   │   ├── gold_layer.py
│   │   ├── silver_layer.py
│   │   └── warehouse_layer.py
│   ├── __init__.py
│   └── resources
│       ├── minio_io_manager.py
│       ├── mysql_io_manager.py
│       ├── psql_io_manager.py
│       └── spark_io_manager.py
├── etl_pipeline_tests
│   ├── __init__.py
│   └── test_assets.py
├── pyproject.toml
├── README.md
├── requirements.txt
├── setup.cfg
├── setup.py
└── spark-defaults.conf

4 directories, 18 files
```

Connecting MinIO to it and handling the output of a Pandas DataFrame, **spark_io_manager** use the Hadoop S3A connector to read and write data to **MinIO**. The IO Manager use the Spark DataFrame APIs in Spark to manipulate and transform the data as needed, and then convert it to a Pandas DataFrame using the **spark.sql(sql_stm).toPandas()** method.

Install right Python and Java version for etl-pipeline

Spark need Python \leq **3.9.16** and Java **17** to work right. Don't forget to add `dagster-spark==0.18.6` and `pyspark==3.3.2` in your **requirements.txt**.

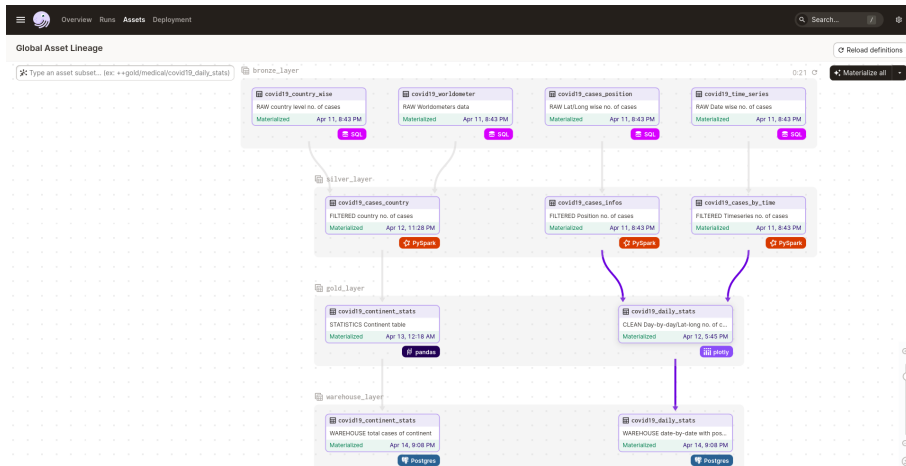
```
FROM python:3.9.16-slim
SHELL ["/bin/bash", "-o", "pipefail", "-c"]
USER root
RUN apt-get update --yes && \
    apt-get install --yes --no-install-recommends \
    "openjdk-17-jre-headless" \
    ca-certificates-java && \
    apt-get clean && rm -rf /var/lib/apt/lists/* \
    pip install --upgrade pip && pip install -r requirements.txt
```

Sample Asset Code Using Spark IO Manager

```
@asset(  
    ins = {"table" : AssetIn(key_prefix = ["bronze"])},  
    key_prefix=["silver"],  
    io_manager_key="spark_io_manager",  
    compute_kind="PySpark"  
)  
def sample_asset(context, pandas_data: pd.DataFrame) -> Output[pd.DataFrame]:  
    spark = connect()  
    spark_data = spark.createDataFrame(pandas_data)  
    spark_data.createOrReplaceTempView("data")  
    sql_stm = "SELECT * FROM data;"  
    sparkDF = spark.sql(sql_stm)  
    pd_data = sparkDF.toPandas()  
    return Output(pd_data)
```

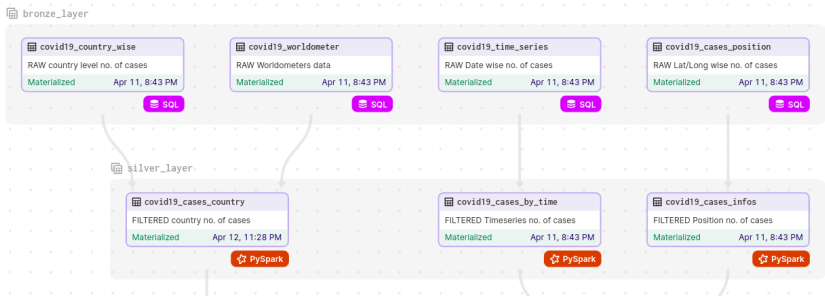
Dagster Dagit - ETL

- Full view of COVID-19 Data Lineage (EXTRACT - TRANSFORM - LOAD)



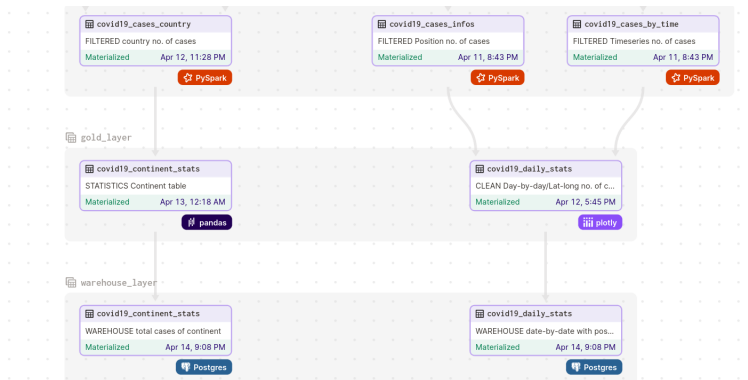
Extract - Transform

- Extract data from MYSQL Database.
- Transform by SPARK and load them into SILVER layer.



Transform - Load

- Transform by SPARK and load them into GOLD layer.
- Host Plotly by Dash, also load data into PostgreSQL Database.



Benchmark sparkSQL on gold layer

GOLD: Covid19_daily_stats

CLEAN Day-by-day/Lat-long no. of cases

```
▷ %timeit -r 4
  sql_stm1 = """
  -- 1
  SELECT
    t.`date`,
    t.country_region,
    t.confirmed,
    t.deaths,
    t.recovered
  FROM covid19_time_series AS t
  JOIN covid19_cases_position AS c
  ON t.country_region = c.country_region
  JOIN covid19_country_wise AS w
  ON t.country_region = w.country_region
  WHERE t.confirmed > 0 OR t.deaths > 0 OR t.recovered > 0;
  """
  spark.sql(sql_stm1).toPandas()
```

[7]

... 1.07 s ± 252 ms per loop (mean ± std. dev. of 4 runs, 1 loop each)

Benchmark sparkSQL on gold layer

GOLD: Covid19_continent_stats

STATISTICS Continent table

```
▷ ~  
%%timeit -r 4  
sql_stm2 = """  
-- 1  
SELECT  
    w.continent AS Continent,  
    SUM(cw.confirmed) AS TotalCases,  
    SUM(cw.deaths) AS TotalDeaths,  
    SUM(cw.recovered) AS TotalRecovered  
FROM covid19_worldometer AS w  
JOIN covid19_cases_position AS c  
ON w.country_region = c.country_region  
JOIN covid19_country_wise AS cw  
ON w.country_region = cw.country_region  
GROUP BY  
    w.continent;  
"""  
spark.sql(sql_stm2).toPandas()
```

[12]

... 735 ms ± 240 ms per loop (mean ± std. dev. of 4 runs, 1 loop each)

Test Spark SQL Result

```
covid19_daily_stats = spark.sql(sql_stm1)
covid19_daily_stats.show()
```

[13]

date	country_region	confirmed	deaths	recovered
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28
2020-01-22	China	548	17	28

only showing top 20 rows

```
covid19_continent_stats = spark.sql(sql_stm2)
covid19_continent_stats.show()
```

[7]

Continent	TotalCases	TotalDeaths	TotalRecovered
Europe	4860471	476988	2430932
Africa	828239	17759	487793
Australia/Oceania	124070	1358	76031
North America	2049543	157599	428613
South America	3780484	135506	2714173
Asia	3799878	85740	2722251



It seems like you're planning to plot some data using Plotly and host it with Dash. But you're not ready yet? Why not? What do you even have to plot? First, you should focus on getting into the nitty-gritty of data mining and really enjoy it before trying to plot something. So, take a deep dive into the `covid19_daily_stats`, get mining and dig up some golden insights before trying to plot anything!

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First look at gold_layer (using J-Lab as testing)

```
spark_covid19_daily_stats = spark.read.parquet("s3a://warehouse/gold/medical/covid19_daily_stats.pq")
spark_covid19_continent_stats = spark.read.parquet("s3a://warehouse/gold/medical/covid19_continent_stats.pq")
df1 = pd.DataFrame(spark_covid19_daily_stats.toPandas())
df2 = pd.DataFrame(spark_covid19_continent_stats.toPandas())
```

[3]

...

	date	country_region	confirmed	deaths	recovered	active	latitude	longitude	who_region
0	2020-07-27	Russia	816680	13334	602249	201097	61.5240	105.3190	Europe
1	2020-07-26	Russia	811073	13249	599172	198652	61.5240	105.3190	Europe
2	2020-07-25	Russia	805332	13172	596064	196096	61.5240	105.3190	Europe
3	2020-07-24	Russia	799499	13026	587728	198745	61.5240	105.3190	Europe
4	2020-07-23	Russia	793720	12873	579295	201552	61.5240	105.3190	Europe
...
49063	2020-01-26	Netherlands	0	0	0	0	18.0425	-63.0548	Europe
49064	2020-01-25	Netherlands	0	0	0	0	18.0425	-63.0548	Europe
49065	2020-01-24	Netherlands	0	0	0	0	18.0425	-63.0548	Europe
49066	2020-01-23	Netherlands	0	0	0	0	18.0425	-63.0548	Europe
49067	2020-01-22	Netherlands	0	0	0	0	18.0425	-63.0548	Europe

49068 rows x 9 columns

</>

	Continent	TotalCases	TotalDeaths	TotalRecovered
0	Europe	2482951	155775	1605640
1	Africa	828239	17759	487793
2	Australia/Oceania	16949	189	10854
3	North America	768505	59215	428613
4	South America	3780484	135506	2714173
5	Asia	3799878	85740	2722251

Show the continent gradient table of COVID-19

```
▶ covid19_continent_stats.style.background_gradient(cmap="Reds")
```

[10]

...

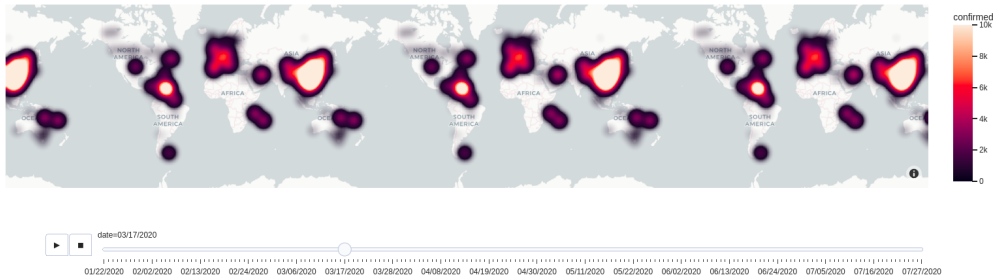
	Continent	TotalCases	TotalDeaths	TotalRecovered
0	Europe	2482951	155775	1605640
1	Africa	828239	17759	487793
2	Australia/Oceania	16949	189	10854
3	North America	768505	59215	428613
4	South America	3780484	135506	2714173
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Plot the spread map of COVID-19

```
import plotly.io as pio
pio.templates.default = "seaborn"
df1['date'] = df1['date'].dt.strftime('%m/%d/%Y')
fig_map = px.density_mapbox(df1, lat='latitude', lon='longitude', z='confirmed', radius=20, zoom=1, hover_data=["country_region", "who_region", "confirmed"],
                           mapbox_style="carto-positron", animation_frame = 'date', range_color= [0, 10000], title='Spread of Covid-19')
fig_map.update_layout(margin={"r":0,"t":30,"l":0,"b":0})
fig_map.show()
```

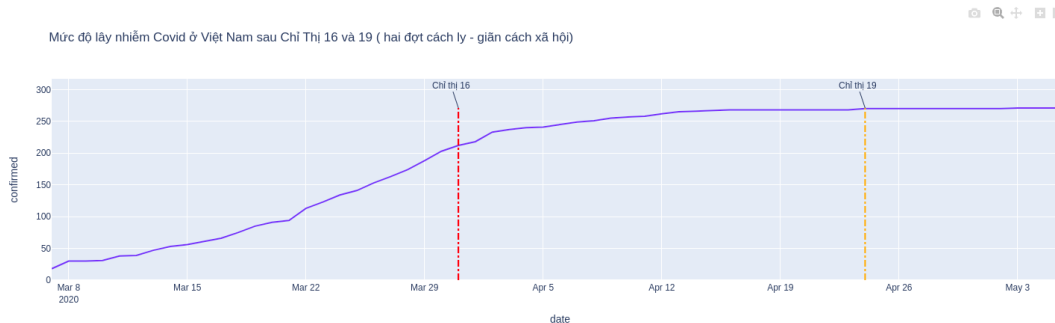
MagicPython

Spread of Covid-19



It's done! But wait...it's timeseries!

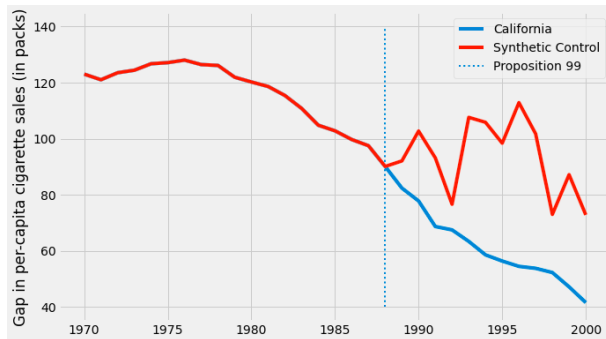
- How does DS do forecasting? Why you must design gold layer like that?
- Example: (Covid19 Confirmed Cases Rate At Vietnam) - data doesn't lie
- 16/CT-TTg about quarantine (src: vncdc.gov.vn): 31-03-2020



Concepts of Synthetic Control

- Given the weights $\mathbf{W} = (w_2, \dots, w_{J+1})$, the synthetic control estimate of Y_{jt}^N is:

$$\hat{Y}_{jt}^N = \sum_{j=2}^{J+1} w_j Y_{jt}$$



Train models by Linear Regression

```
Get data_synth = Filter (date < 2020/4/20, continent == Southeast Asia)
#With sincere thanks: Minh Man Le (HCMUS)
from sklearn.linear_model import LinearRegression
Y = data_synth["Vietnam"].values # Vietnam
X = data_synth.drop(columns="Vietnam").values # other SA countries
weights_lr = (
    LinearRegression(fit_intercept = False)
    .fit(X,Y)
    .coef_
)
```

Fit Weights bằng Linear Regression:

$$||X_1 - X_0 W|| = \left(\sum_{h=1}^k v_h \left(X_{h1} - \sum_{j=2}^{J+1} w_j X_{hj} \right)^2 \right)^{\frac{1}{2}}$$

```
[18] weights_lr = LinearRegression(fit_intercept=False).fit(X,Y).coef_  
... array([-0.10893782,  8.73269379, -1.80399272,  0.02270781, -0.00903101,  
          2.86670085,  3.11041653,  0.20735996,  0.05780642,  0.26259073])
```

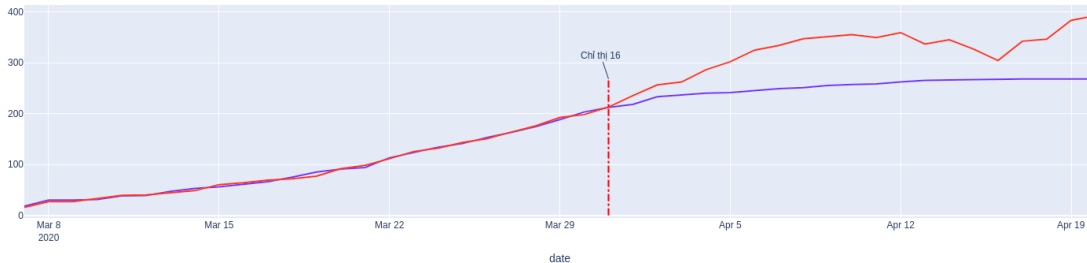
Đường synthetic control của Covid19 (các dữ liệu ước lượng \hat{Y})

$$\hat{Y}_{jt}^N = \sum_{j=2}^{J+1} w_j Y_{jt}$$

```
▷ covid_synth_lr = data_for_synth_line.values.dot(weights_lr)
```

Plot the synthetic control line of Vietnam

Mức độ lây nhiễm Covid ở Việt Nam khi có và không có CT16

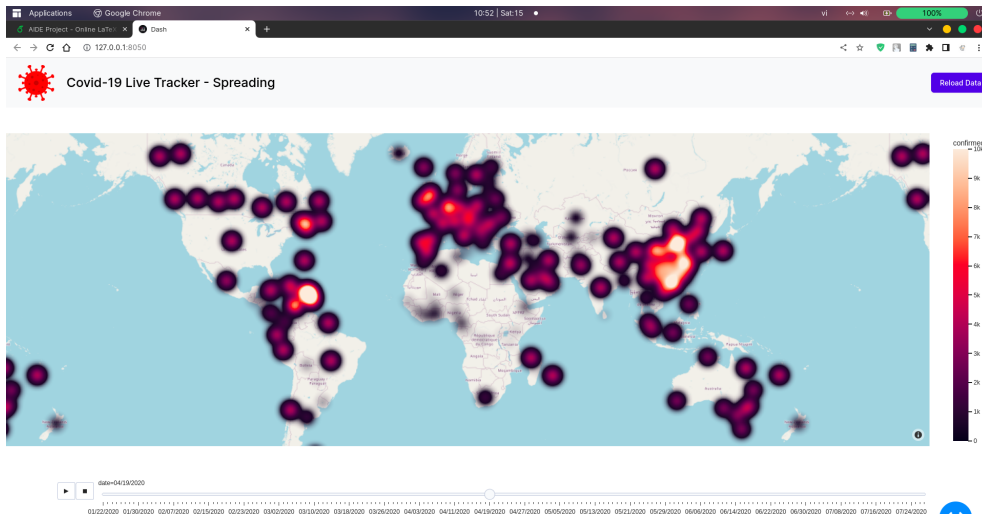


Build Dash App with Plotly

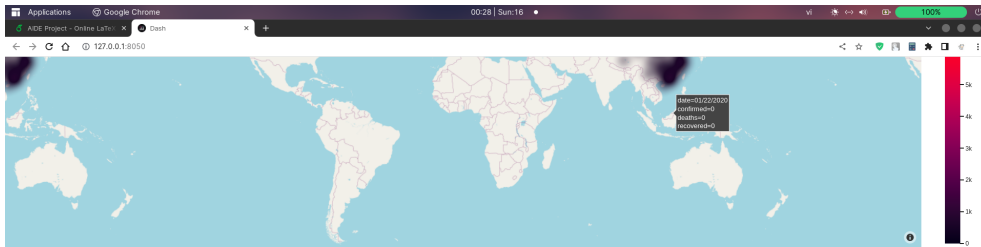
```
%%writefile my_dash_app.py
import dash
import dash_core_components as dcc
import dash_html_components as html
app = dash.Dash(__name__)
#fig_map define
app.layout = html.Div(children=[
    html.Div([
        dcc.Graph(
            id='graph1',
            figure=fig_map
        ),
    ])
])
if __name__ == '__main__':
    app.run_server(debug=True, use_reloader=True)

!python3 ./my_dash_app.py && ngrok http 8050
```

Final Result and Demo



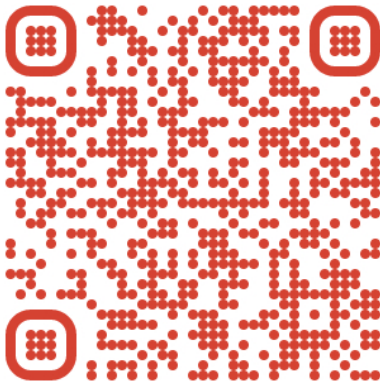
Final Result and Demo






	Continent	TotalCases	TotalDeaths	TotalRecovered
0	Europe	2482951	155775	1605640
1	Africa	828239	17759	487793
2	Australia/Oceania	16949	189	10854
3	North America	768505	59215	428613
4	South America	3780484	135506	2714173
5	Asia	3799878	85740	2722251



- See full source code on my Github Repository at thangbuiq/covid19-etl-pipeline: <https://github.com/thangbuiq/covid19-etl-pipeline>
- Or scan this red-thing:



-  AIDE Institute (2023)
Fundamental of Data Engineering
Slides and Courseworks
-  Ong Xuan Hong (2023)
Medium.com
DataOps 03: Trino + DBT + Spark — Everything Everywhere All at Once
-  Eduardo Sarmento (2020)
Medium.com
How to Create a Simple Dashboard With Plotly

Thanks for listening!