DATE
23/12/2024

MOVIELENS ANALYTICS PIPELINE

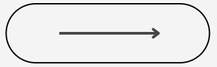
Navadeep Vedantham
navadeep_vedantham@apple.com

Approach for the Problem

The approach involves designing and implementing a robust data pipeline using Apache Spark for the MovieLens dataset to extract meaningful insights through data integration, aggregation, and visualisation.

Key Steps:

1. Data Loading: Loading raw datasets from CSV files into Spark DataFrames.
2. Data Cleaning and Transformation: Cleaning null values, formatting timestamps, and restructuring genres into separate rows.
3. Data Integration: Joining datasets based on movieId and userId to create a unified dataset.
4. Statistical Computation: Calculating metrics such as average ratings, rating counts, and variance.
5. Data Aggregation: Summarizing data based on genres, years, and user activity.
6. Anomaly Detection: Identifying movies with unusually high rating variances.
7. Reporting and Visualization: Generating insights and visualizing trends.
8. Data Persistence: Storing processed and aggregated data in Google Cloud Storage (GCS).



WHY THIS APPROACH?

- Scalability: Apache Spark ensures efficient processing of large datasets.
- Flexibility: Modular design allows custom transformations and aggregations.
- Cloud Integration: GCS provides reliable storage and easy access for output datasets.
- Actionable Insights: Generates reports and visualizations for decision-making.

TECHNOLOGIES USED AND WHY

- Apache Spark (Scala):
- Why: Fast in-memory processing and rich API for data transformations and analytics.
- Google Cloud Storage (GCS):
- Why: Reliable, scalable cloud storage for output datasets in various formats.
- Spark SQL & DataFrame API:
- Why: Simplifies data querying and processing.
- Local Environment with Spark:
- Why: Easy to configure for development and testing.

DETAILED PIPELINE WORKFLOW

Step 1: Environment Setup

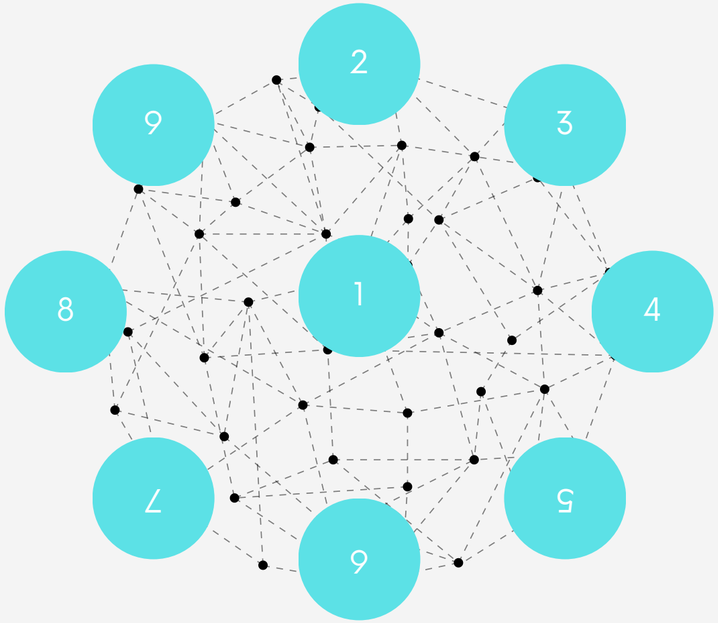
- Configured Spark session for local execution and GCS integration.

Step 2: Data Loading

- Loaded datasets into DataFrames from:
  - Ratings.csv
  - Movies.csv
  - Tags.csv
  - Links.csv

Step 3: Data Cleaning and Transformation

- Ratings Dataset:
  - Converted timestamps to date format.
  - Dropped null values.
- Movies Dataset:
  - Split genres into multiple rows.
  - Removed nulls.
- Tags Dataset:
  - Cleaned and removed null values.



DETAILED PIPELINE WORKFLOW

Step 4: Data Integration

- Joined ratings, movies, tags, and links using common keys (e.g., movieId).

Step 5: Statistical Computation

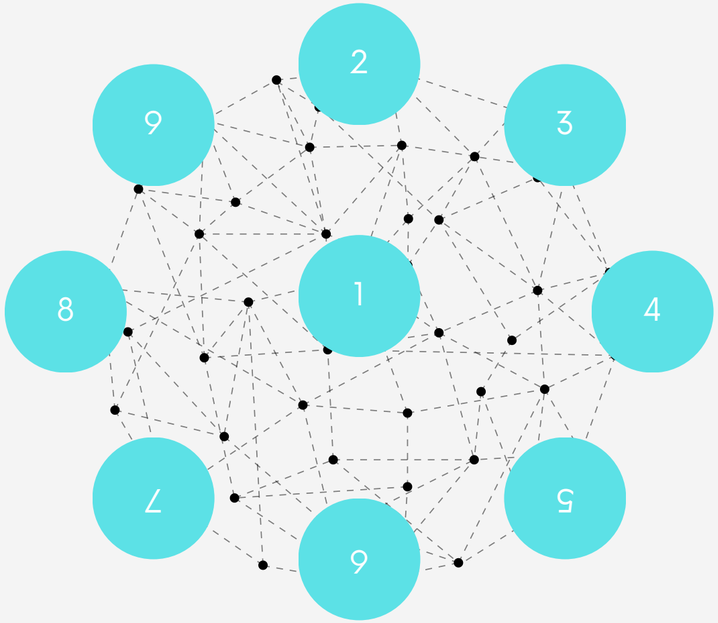
- Metrics calculated:
  - Average Ratings
  - Rating Count
  - Rating Variance

Step 6: Data Aggregation

- Aggregated data based on:
  - Genres: Calculated average and total ratings.
  - Years: Yearly average ratings.
  - Users: Total ratings and average ratings per user.

Step 7: Anomaly Detection

- Identified movies with high rating variance (e.g., stddev > 2.5).



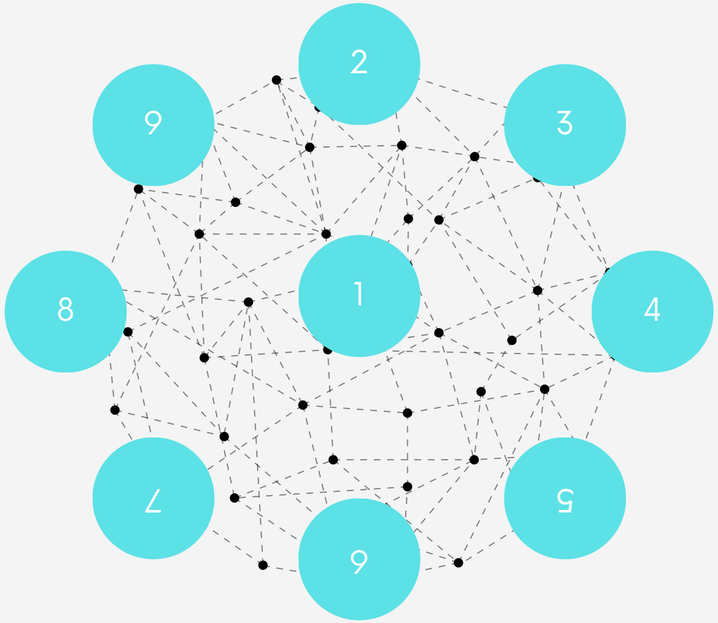
DETAILED PIPELINE WORKFLOW

Step 8: Reporting and Visualisation

- Generated insights for:
  - Top-rated movies.
  - Popular genres.
  - Most active users.
  - Yearly trends.
- Visualizations included:
  - Average ratings per year.
  - Rolling averages for ratings over time.

Step 9: Data Persistence

- Stored output datasets in GCS in Parquet and JSON formats.



INSIGHTS AND REPORTS

1. Top Movies: Identified top-rated movies with more than 50 ratings.
2. Genre Trends: Highlighted popular genres based on ratings.
3. Yearly Trends: Displayed yearly average ratings and rolling averages.
4. User Activity: Analyzed rating patterns and average ratings by users.

OUTPUT AND VISUALISATION

Output and Visualisation

Data Saved in GCS:

a. Aggregated metrics (e.g., genre stats, top movies).
b. Visualisations of trends.

Figures and Reports:

a. Null checks and integrated data visualisations.
b. Genre-wise aggregations.
c. Yearly rating averages.

CODE HIGHLIGHTS

1. Loading Datasets

```
private def loadDataset(filePath: String, datasetName: String): DataFrame = {
  println(s"Loading $datasetName dataset from: $filePath")
  val df = spark.read.option("header", "true").csv(filePath)
  df.show(5, truncate = false)
  df.printSchema()
  println(s"$datasetName dataset count: ${df.count()}")
  df
}
```

2. Data Integration

```
private def integrateData(ratings: DataFrame, movies: DataFrame, tags:
DataFrame, links: DataFrame): DataFrame = {
  println("Integrating datasets...")
  val combinedDF = ratings.join(movies, "movieId")
  val taggedDF = combinedDF.join(tags, Seq("movieId", "userId"), "left")
  taggedDF.join(links, Seq("movieId"), "left")
}
```

3. Statistical Computations:

```
private def calculateMovieStats(data: DataFrame): DataFrame = {
  data.groupBy("movieId", "title", "genre")
    .agg(
      avg("rating").alias("averageRating"),
      count("rating").alias("ratingCount"),
      variance("rating").alias("ratingVariance")
    )
}
```

4. Reporting and Visualization

```
private def generateReports(data: DataFrame): Unit = {
  println("Generating reports and visualizations...")
  val genreTrends = aggregateByGenre(data)
  genreTrends.show(truncate = false)
  val yearlyRatings = ratingsPerYear(data)
  yearlyRatings.show(truncate = false)
}
```

```
Loading Links dataset from: /Users/navadeep/Downloads/Work/Assignments/Datasets/movieDataset/link.csv
Displaying first 5 rows of Links dataset:
+-------+------+------+
|movieId|imdbId|tmdbId|
+-------+------+------+
|1      |114709|862   |
|2      |113497|8844  |
|3      |113228|15602 |
|4      |114885|31357 |
|5      |113041|11862 |
+-------+------+------+
only showing top 5 rows

Schema of Links dataset:
root
 |-- movieId: string (nullable = true)
 |-- imdbId: string (nullable = true)
 |-- tmdbId: string (nullable = true)

Links dataset count: 27278
```

```
Loading Tags dataset from: /Users/navadeep/Downloads/Work/Assignments/Datasets/movieDataset/tag.csv
Displaying first 5 rows of Tags dataset:
+------+-------+-------------+-------------------+
|userId|movieId|tag          |timestamp          |
+------+-------+-------------+-------------------+
|18    |4141   |Mark Waters  |2009-04-24 18:19:40|
|65    |208    |dark hero    |2013-05-10 01:41:18|
|65    |353    |dark hero    |2013-05-10 01:41:19|
|65    |521    |noir thriller|2013-05-10 01:39:43|
|65    |592    |dark hero    |2013-05-10 01:41:18|
+------+-------+-------------+-------------------+
only showing top 5 rows

Schema of Tags dataset:
root
 |-- userId: string (nullable = true)
 |-- movieId: string (nullable = true)
 |-- tag: string (nullable = true)
 |-- timestamp: string (nullable = true)

Tags dataset count: 465564
Cleaning tags data...
```

```
Loading Movies dataset from: /Users/navadeep/Downloads/Work/Assignments/Datasets/movieDataset/movie.csv
Displaying first 5 rows of Movies dataset:
+-------+----------------------------------+----------------------------------------+
|movieId|title                             |genres                                  |
+-------+----------------------------------+----------------------------------------+
|1      |Toy Story (1995)                  |Adventure|Animation|Children|Comedy|Fantasy|
|2      |Jumanji (1995)                    |Adventure|Children|Fantasy              |
|3      |Grumpier Old Men (1995)           |Comedy|Romance                          |
|4      |Waiting to Exhale (1995)          |Comedy|Drama|Romance                    |
|5      |Father of the Bride Part II (1995)|Comedy                                  |
+-------+----------------------------------+----------------------------------------+
only showing top 5 rows

Schema of Movies dataset:
root
 |-- movieId: string (nullable = true)
 |-- title: string (nullable = true)
 |-- genres: string (nullable = true)

Movies dataset count: 27278
Transforming movies data...
```

```
Loading Ratings dataset from: /Users/navadeep/Downloads/Work/Assignments/Datasets/movieDataset/rating.csv
Displaying first 5 rows of Ratings dataset:
+------+-------+------+-------------------+
|userId|movieId|rating|timestamp          |
+------+-------+------+-------------------+
|1     |2      |3.5   |2005-04-02 23:53:47|
|1     |29     |3.5   |2005-04-02 23:31:16|
|1     |32     |3.5   |2005-04-02 23:33:39|
|1     |47     |3.5   |2005-04-02 23:32:07|
|1     |50     |3.5   |2005-04-02 23:29:40|
+------+-------+------+-------------------+
only showing top 5 rows

Schema of Ratings dataset:
root
 |-- userId: string (nullable = true)
 |-- movieId: string (nullable = true)
 |-- rating: string (nullable = true)
 |-- timestamp: string (nullable = true)

Ratings dataset count: 20000263
Preparing ratings data...
Raw Ratings:
+------+-------+------+-------------------+
|userId|movieId|rating|          timestamp|
+------+-------+------+-------------------+
|     1|      2|   3.5|2005-04-02 23:53:47|
|     1|     29|   3.5|2005-04-02 23:31:16|
|     1|     32|   3.5|2005-04-02 23:33:39|
|     1|     47|   3.5|2005-04-02 23:32:07|
|     1|     50|   3.5|2005-04-02 23:29:40|
+------+-------+------+-------------------+
only showing top 5 rows
```

```
Ratings:+------+-------+------+-------------------+-------------------+
|userId|movieId|rating|          timestamp|         ratingDate|
+------+-------+------+-------------------+-------------------+
|     1|      2|   3.5|2005-04-02 23:53:47|2005-04-02 23:53:47|
|     1|     29|   3.5|2005-04-02 23:31:16|2005-04-02 23:31:16|
|     1|     32|   3.5|2005-04-02 23:33:39|2005-04-02 23:33:39|
|     1|     47|   3.5|2005-04-02 23:32:07|2005-04-02 23:32:07|
|     1|     50|   3.5|2005-04-02 23:29:40|2005-04-02 23:29:40|
+------+-------+------+-------------------+-------------------+
only showing top 5 rows

+-------+---------------+--------------------+---------+
|movieId|          title|              genres|    genre|
+-------+---------------+--------------------+---------+
|      1|Toy Story (1995)|Adventure|Animati...|Adventure|
|      1|Toy Story (1995)|Adventure|Animati...|Animation|
|      1|Toy Story (1995)|Adventure|Animati...| Children|
|      1|Toy Story (1995)|Adventure|Animati...|   Comedy|
|      1|Toy Story (1995)|Adventure|Animati...|  Fantasy|
+-------+---------------+--------------------+---------+
only showing top 5 rows
```

```
+------+-------+-------------+-------------------+
|userId|movieId|          tag|          timestamp|
+------+-------+-------------+-------------------+
|    18|   4141| Mark Waters|2009-04-24 18:19:40|
|    65|    208|    dark hero|2013-05-10 01:41:18|
|    65|    353|    dark hero|2013-05-10 01:41:19|
|    65|    521|noir thriller|2013-05-10 01:39:43|
|    65|    592|    dark hero|2013-05-10 01:41:18|
+------+-------+-------------+-------------------+
only showing top 5 rows

+-------+------+------+
|movieId|imdbId|tmdbId|
+-------+------+------+
|      1|114709|   862|
|      2|113497|  8844|
|      3|113228| 15602|
|      4|114885| 31357|
|      5|113041| 11862|
+-------+------+------+
only showing top 5 rows
```

Fig.ratings, movies, tags, links

```
Null check in Ratings - Column: movieId - Null Count: 0
Null check in Ratings - Column: userId - Null Count: 0
Null check in Movies - Column: movieId - Null Count: 0
Null check in Tags - Column: movieId - Null Count: 0
Null check in Tags - Column: userId - Null Count: 0
Null check in Links - Column: movieId - Null Count: 0
Integrating datasets...
Full Data:
+-------+------+------+-------------------+-------------------+--------------------+--------------------+-------+----+---------+------+------+
|movieId|userId|rating|          timestamp|         ratingDate|               title|              genres|  genre| tag|timestamp|imdbId|tmdbId|
+-------+------+------+-------------------+-------------------+--------------------+--------------------+-------+----+---------+------+------+
|   1035| 46736|     4|2008-10-03 23:14:18|2008-10-03 23:14:18|Sound of Music, T...|     Musical|Romance| Romance|null|     null| 59742| 15121|
|   1035| 46736|     4|2008-10-03 23:14:18|2008-10-03 23:14:18|Sound of Music, T...|     Musical|Romance| Musical|null|     null| 59742| 15121|
|   1563| 23312|     4|1999-10-16 11:42:02|1999-10-16 11:42:02|Dream With the Fi...|               Drama|   Drama|null|     null|119019| 47686|
|   2505| 11731|   4.5|2013-06-12 15:39:38|2013-06-12 15:39:38|         8MM (1999)|Drama|Mystery|Thr...|Thriller|null|     null|134273|  8224|
|   2505| 11731|   4.5|2013-06-12 15:39:38|2013-06-12 15:39:38|         8MM (1999)|Drama|Mystery|Thr...| Mystery|null|     null|134273|  8224|
+-------+------+------+-------------------+-------------------+--------------------+--------------------+-------+----+---------+------+------+
only showing top 5 rows

Saving data to: gs://task-dataset-bucket/FinalProject/CaseStudy3/movies_stats as parquet
```

Fig. Null checks and Integrated data

```
Generating reports and visualizations...
Aggregate bY Genre+-------+------+------+-------------------+-------------------+--------------------+--------------------+-------+----+---------+------+------+
|movieId|userId|rating|          timestamp|         ratingDate|               title|              genres|  genre| tag|timestamp|imdbId|tmdbId|
+-------+------+------+-------------------+-------------------+--------------------+--------------------+-------+----+---------+------+------+
|   1035| 46736|     4|2008-10-03 23:14:18|2008-10-03 23:14:18|Sound of Music, T...|     Musical|Romance| Romance|null|     null| 59742| 15121|
|   1035| 46736|     4|2008-10-03 23:14:18|2008-10-03 23:14:18|Sound of Music, T...|     Musical|Romance| Musical|null|     null| 59742| 15121|
|   1563| 23312|     4|1999-10-16 11:42:02|1999-10-16 11:42:02|Dream With the Fi...|               Drama|   Drama|null|     null|119019| 47686|
|   2505| 11731|   4.5|2013-06-12 15:39:38|2013-06-12 15:39:38|         8MM (1999)|Drama|Mystery|Thr...|Thriller|null|     null|134273|  8224|
|   2505| 11731|   4.5|2013-06-12 15:39:38|2013-06-12 15:39:38|         8MM (1999)|Drama|Mystery|Thr...| Mystery|null|     null|134273|  8224|
+-------+------+------+-------------------+-------------------+--------------------+--------------------+-------+----+---------+------+------+
only showing top 5 rows
```

Fig. Aggregate by Genre

Data visualisation

```
+------------------+------------------+--------------------+
|genre             |avgGenreRating    |totalRatingsByGenre|
+------------------+------------------+--------------------+
|Crime             |3.678323176438156 |3344526             |
|Romance           |3.545343637579382 |3847993             |
|Thriller          |3.511530456827378 |5392978             |
|Adventure         |3.504920857792138 |4433475             |
|Drama             |3.678117982649218 |8995560             |
|War               |3.8107847596768254|1061841             |
|Documentary       |3.741678966053692 |250690              |
|Fantasy           |3.510150631148478 |2143315             |
|Mystery           |3.668876318486703 |1586892             |
|Musical           |3.5615689542275617|879656              |
|Animation         |3.6215837663516655|1156610             |
|Film-Noir         |3.966126460007793 |220718              |
|(no genres listed)|3.030848329048843 |389                 |
|IMAX              |3.6580310830139138|511083              |
|Horror            |3.282691755347552 |1507559             |
|Western           |3.573077723892207 |427449              |
|Comedy            |3.4298469564432756|7580391             |
|Children          |3.4111114082632055|1682640             |
|Action            |3.447358900144718 |5688312             |
|Sci-Fi            |3.4428975218952584|3206402             |
+------------------+------------------+--------------------+
```

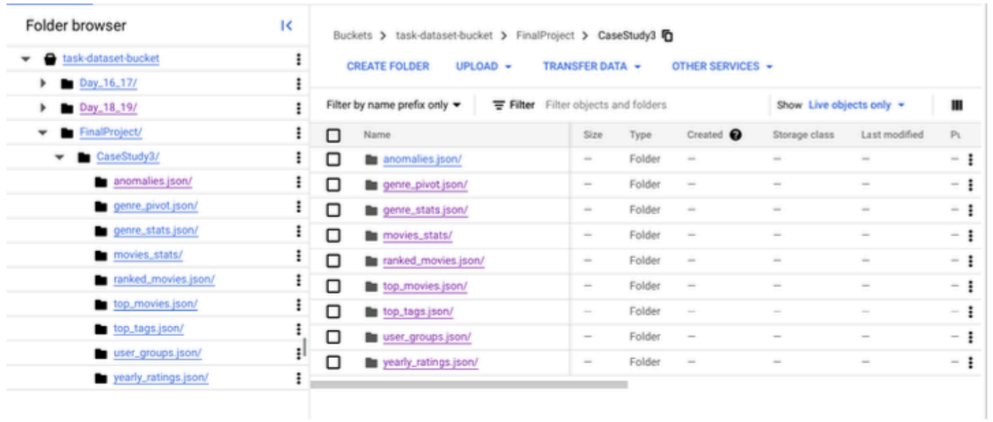
```
+------+-----------+-----------------+
|userId|totalRatings|averageRating    |
+------+-----------+-----------------+
|101205|166         |3.8433734939759034|
|104603|195         |3.6564102564102563|
|121556|193         |3.139896373056995 |
|131450|94          |3.723404255319149 |
|131682|233         |4.180257510729613 |
|133809|781         |3.9622279129321383|
|136186|263         |2.9163498098859315|
|1436  |610         |3.2508196721311475|
|22596 |59          |3.593220338983051 |
|23318 |376         |3.7247340425531914|
|39641 |167         |3.8323353293413174|
|40740 |263         |3.3802281368821294|
|42688 |1045        |4.143540669856459 |
|46870 |70          |3.3142857142857145|
|47880 |852         |3.841549295774648 |
|49755 |456         |3.1359649122807016|
|60733 |232         |2.997844827586207 |
|77930 |752         |3.9202127659574466|
|85022 |187         |3.9331550802139037|
|89517 |86          |3.5232558139534884|
+------+-----------+-----------------+
only showing top 20 rows
```

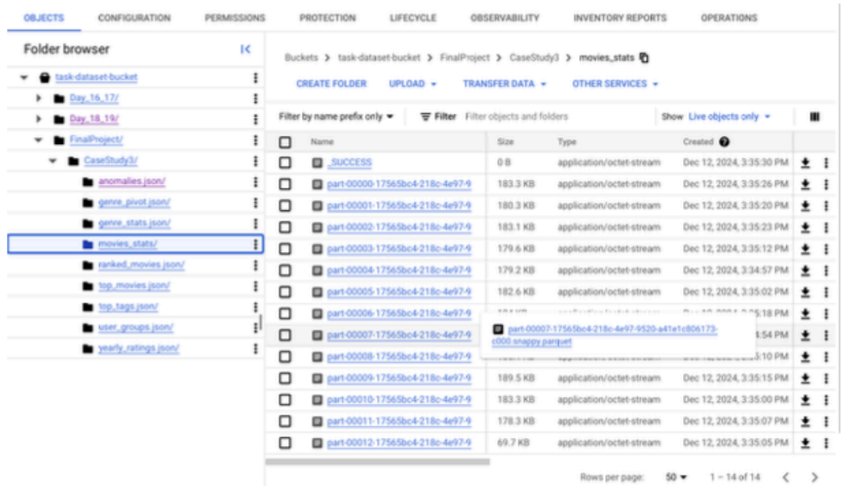
```
+-------+--------------------------------+----------+-----------------+-----------+------------------+
|movieId|title                           |genre     |averageRating    |ratingCount|ratingVariance    |
+-------+--------------------------------+----------+-----------------+-----------+------------------+
|318    |Shawshank Redemption, The (1994)|Drama     |4.448998801985281|64273      |0.5150114835839518|
|318    |Shawshank Redemption, The (1994)|Crime     |4.448998801985281|64273      |0.5150114835839518|
|858    |Godfather, The (1972)           |Drama     |4.363334531942947|41715      |0.7063544653259511|
|858    |Godfather, The (1972)           |Crime     |4.363334531942947|41715      |0.7063544653259511|
|50     |Usual Suspects, The (1995)      |Mystery   |4.334675130851533|47573      |0.5733776150707832|
|50     |Usual Suspects, The (1995)      |Thriller  |4.334675130851533|47573      |0.5733776150707832|
|50     |Usual Suspects, The (1995)      |Crime     |4.334675130851533|47573      |0.5733776150707832|
|527    |Schindler's List (1993)         |Drama     |4.3104387441814405|50485      |0.6829569523376989|
|527    |Schindler's List (1993)         |War       |4.3104387441814405|50485      |0.6829569523376989|
|77658  |Cosmos (1980)                   |Documentary|4.279013539651838|1034       |1.022511707464129 |
+-------+--------------------------------+----------+-----------------+-----------+------------------+
```

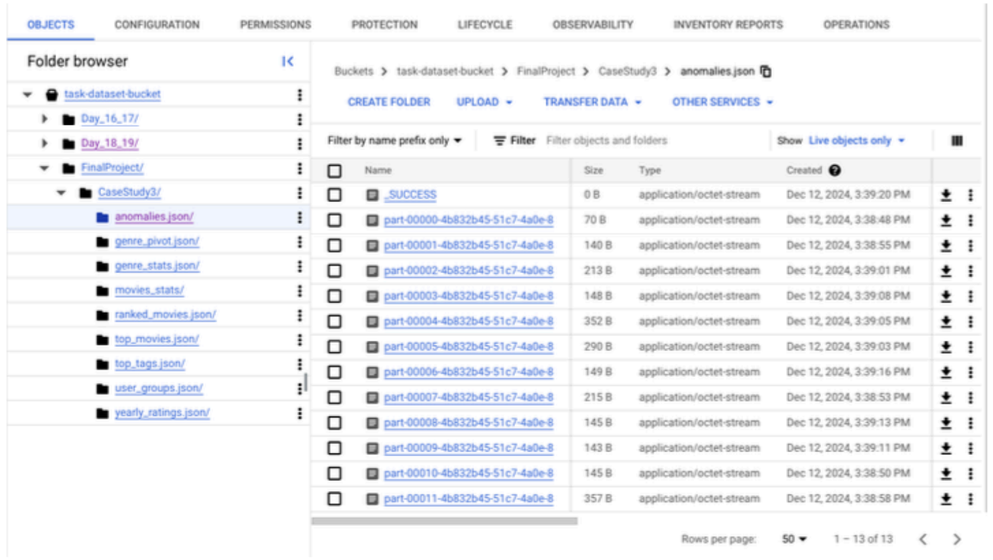
```
+----+------------------+
|year|yearlyAverage     |
+----+------------------+
|2003|3.485253490840837 |
|2007|3.4785849349864235|
|2015|3.52402006158835  |
|2006|3.468486949207258 |
|2013|3.6607698061081626|
|1997|3.6043686609177428|
|2014|3.6209940750533343|
|2004|3.4380688007194675|
|1996|3.5614778965200102|
|1998|3.5261758778350414|
|2012|3.6308968552591345|
|2009|3.528494320853906 |
|2001|3.5474717613541142|
|2005|3.436573723100307 |
|2000|3.582719338481802 |
|2010|3.562078686833833 |
|2011|3.5897459515607797|
|2008|3.5474812625608765|
|1999|3.611680198668057 |
|2002|3.501837202738953 |
+----+------------------+
only showing top 20 rows
```

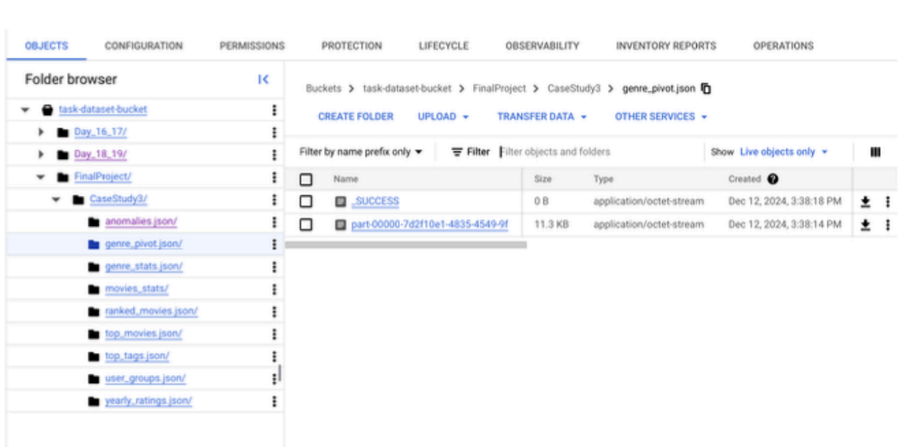
```
+----+------------------+
|year|rollingAverage    |
+----+------------------+
|1995|3.7               |
|1996|3.5614778965200102|
|1997|3.6043686609177428|
|1998|3.5261758778350414|
|1999|3.611680198668057 |
|2000|3.582719338481802 |
|2001|3.5474717613541142|
|2002|3.501837202738953 |
|2003|3.485253490840837 |
|2004|3.4380688007194675|
|2005|3.436573723100307 |
|2006|3.468486949207258 |
|2007|3.4785849349864235|
|2008|3.5474812625608765|
|2009|3.528494320853906 |
|2010|3.562078686833833 |
|2011|3.5897459515607797|
|2012|3.6308968552591345|
|2013|3.6607698061081626|
|2014|3.6209940750533343|
+----+------------------+
only showing top 20 rows

Reports and visualizations generated successfully!
Data Pipeline Execution Completed Successfully!
```

Google cloud storage









Thank You