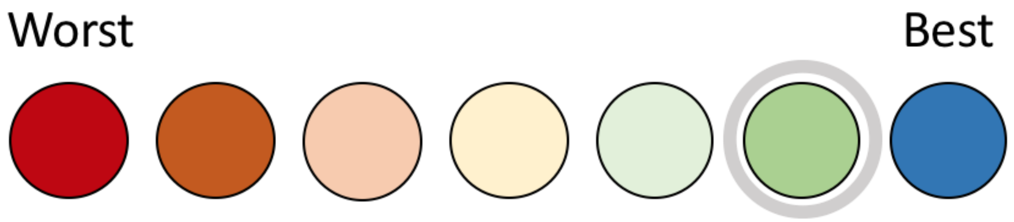
# Introduction to the Million Songs Dataset

BUILDING RECOMMENDATION ENGINES WITH PYSPARK

**Jamen Long**
Data Scientist at Nike

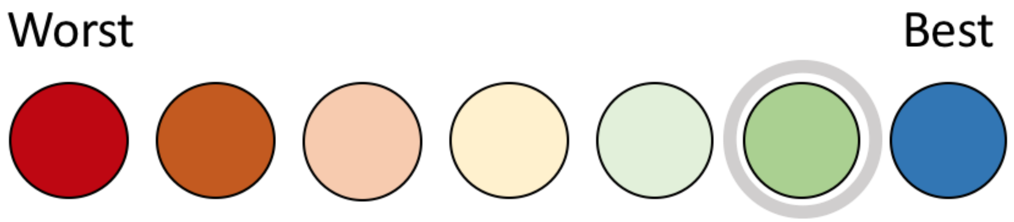
# Explicit vs implicit

Explicit Ratings

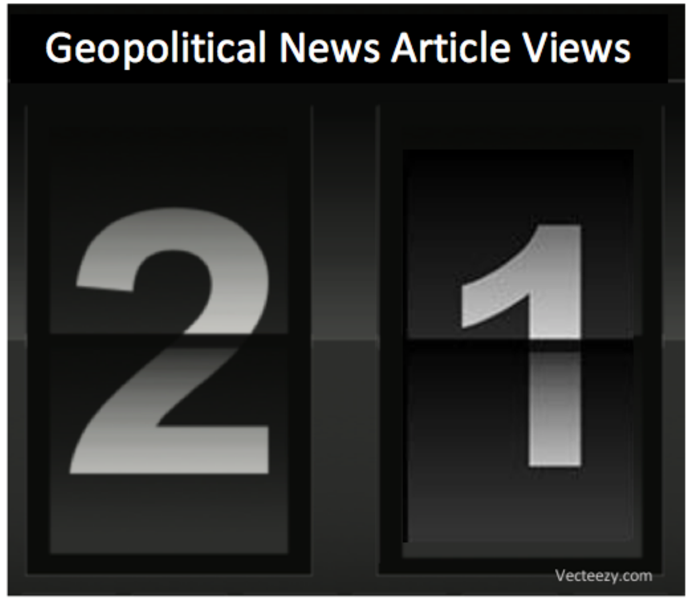
# Explicit vs implicit (cont.)

## Explicit Ratings


## Implicit Ratings


= Low Confidence Rating

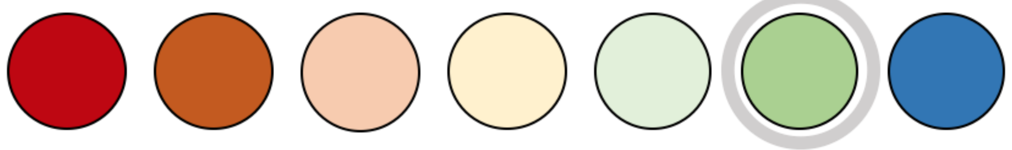



= High Confidence Rating

# Implicit refresher II

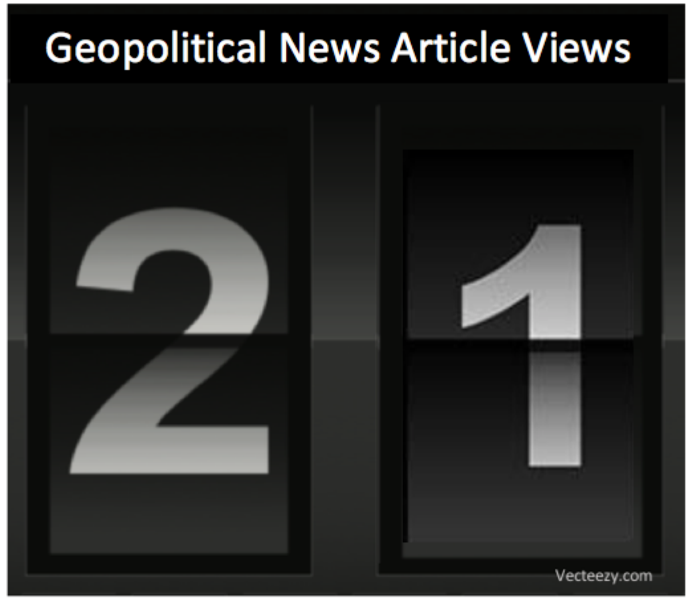
## Explicit Ratings


Worst Best



## Implicit Ratings


= Low Confidence Rating




= High Confidence Rating

# Introduction to the Million Songs Dataset

Thierry Bertin-Mahieux, Daniel P.W. Ellis, Brian Whitman, and Paul Lamere. The Million Song Dataset. In Proceedings of the 12th International Society for Music Information Retrieval Conference (SIMIR 20122), 2011.

# Add zeros sample

```
ratings.show()
```

```
+------+------+---------+
|userId|songId|num_plays|
+------+------+---------+
|    10|    22|        5|
|    38|    99|        1|
|    38|    77|        3|
|    42|    99|        1|
+------+------+---------+
```

# Cross join intro

```
users = ratings.select("userId").distinct()
users.show()
```

```
+------+
|userId|
+------+
|    10|
|    38|
|    42|
+------+
```

```
songs = ratings.select("songId").distinct()
songs.show()
```

```
+------+
|songId|
+------+
|    22|
|    77|
|    99|
+------+
```

# Cross join output

```
cross_join = users.crossJoin(songs)
cross_join.show()
```

```
+------+------+
|userId|songId|
+------+------+
|    10|    22|
|    10|    77|
|    10|    99|
|    38|    22|
|    38|    77|
|    38|    99|
|    42|    22|
|    42|    77|
|    42|    99|
+------+------+
```

# Joining back original ratings data

```
cross_join = users.crossJoin(songs)
                  .join(ratings, ["userId", "songId"], "left")
cross_join.show()
```

```
+------+------+---------+
|userId|songId|num_plays|
+------+------+---------+
|    10|    22|        5|
|    10|    77|     null|
|    10|    99|     null|
|    38|    22|     null|
|    38|    77|        3|
|    38|    99|        1|
|    42|    22|     null|
|    42|    77|     null|
|    42|    99|        1|
+------+------+---------+
```

# Filling in with zero

```
cross_join = users.crossJoin(songs)
                  .join(ratings, ["userId", "songId"], "left").fillna(0)
cross_join.show()
```

```
+------+------+---------+
|userId|songId|num_plays|
+------+------+---------+
|    10|    22|        5|
|    10|    77|        0|
|    10|    99|        0|
|    38|    22|        0|
|    38|    77|        3|
|    38|    99|        1|
|    42|    22|        0|
|    42|    77|        0|
|    42|    99|        1|
+------+------+---------+
```

# Add zeros function

```
def add_zeros(df):
    # Extracts distinct users
    users = df.select("userId").distinct()

    # Extracts distinct songs
    songs = df.select("songId").distinct()

    # Joins users and songs, fills blanks with 0
    cross_join = users.crossJoin(items) \
                .join(df, ["userId", "songId"], "left").fillna(0)

    return cross_join
```

# Let's practice!

BUILDING RECOMMENDATION ENGINES WITH PYSPARK

# Evaluating implicit ratings models

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# Why RMSE worked before

| userId | movieId | rating | explicit rating prediction |
|---|---|---|---|
| 1 | 2112 | 5 | 4.88 |
| 1 | 303 | 3.5 | 3.96 |
| 2 | 5 | 3 | 2.78 |
| 2 | 77 | 2 | 2.89 |
| 3 | 913 | 1.5 | 2.11 |
| 3 | 44 | 4 | 3.56 |
| 3 | 6 | 4.5 | 4.67 |

Predictions reflect actual ratings.
RMSE makes sense here.

# Why RMSE doesn't work now

| userId | movieId | num_plays | implicit rating prediction |
|---|---|---|---|
| 1 | 2112 | 16 | 1.755 |
| 1 | 303 | 3 | .88 |
| 2 | 5 | 1 | .01 |
| 2 | 77 | 2 | .5 |
| 3 | 913 | 1 | .08 |
| 3 | 44 | 21 | 1.98 |
| 3 | 6 | 4 | .98 |

Different metrics.
RMSE doesn't make sense here.

# (ROEM) Rank Ordering Error Metric

$$\mathrm{ROEM} = \frac{\sum_{u,i} r^t_{u,i}\,\mathrm{rank}_{u,i}}{\sum_{u,i} r^t_{u,i}}$$

# ROEM bad predictions

```
bad_prediction.show()
```

```
+-------+------+-----+--------+--------+
|userId |songId|plays|badPreds|percRank|
+-------+------+-----+--------+--------+
|    111|    22|    3|  0.0001|   1.000|
|    111|     9|    0|   0.999|   0.000|
|    111|   321|    0|    0.08|   0.500|
|    222|    84|    0|0.000003|   1.000|
|    222|   821|    2|    0.88|   0.000|
|    222|    91|    2|    0.73|   0.500|
|    333|  2112|    0|    0.90|   0.000|
|    333|    42|    2|    0.80|   0.500|
|    333|     6|    0|    0.01|   1.000|
+-------+------+-----+--------+--------+
```

# ROEM: PercRank * plays

```
bp = bad_predictions.withColumn("np*rank", col("badPreds")*col("percRank"))
bp.show()
```

```
+-------+------+---------+--------+--------+-------+
|userId |songId|num_plays|badPreds|percRank|np*rank|
+-------+------+---------+--------+--------+-------+
|    111|    22|        3|  0.0001|   1.000|   3.00|
|    111|     9|        0|   0.999|   0.000|   0.00|
|    111|   321|        0|    0.08|   0.500|   0.00|
|    222|    84|        0|0.000003|   1.000|   0.00|
|    222|   821|        2|    0.88|   0.000|   0.00|
|    222|    91|        2|    0.73|   0.500|   1.00|
|    333|  2112|        0|    0.90|   0.000|   0.00|
|    333|    42|        2|    0.80|   0.500|   1.00|
|    333|     6|        0|    0.01|   1.000|   0.00|
+-------+------+---------+--------+--------+-------+
```

# ROEM: bad predictions

```
+-------+------+---------+--------+-------+-------+
|userId |songId|num_plays|badPreds|percRank|np*rank|
+-------+------+---------+--------+-------+-------+
|    111|    22|        3|  0.0001|   1.000|   3.00|
|    111|     9|        0|   0.999|   0.000|   0.00|
|    111|   321|        0|    0.08|   0.500|   0.00|
|    222|    84|        0|0.000003|   1.000|   0.00|
|    222|   821|        2|    0.88|   0.000|   0.00|
|    222|    91|        2|    0.73|   0.500|   1.00|
|    333|  2112|        0|    0.90|   0.000|   0.00|
|    333|    42|        2|    0.80|   0.500|   1.00|
|    333|     6|        0|    0.01|   1.000|   0.00|
+-------+------+---------+--------+-------+-------+
```

```
numerator = bp.groupBy().sum("np*rank").collect()[0][0]
denominator = bp.groupBy().sum("num_plays").collect()[0][0]
print ("ROEM: "), numerator * 1.0/ denominator
```

```
ROEM: 5.0 / 9 = 0.556
```

# Good predictions

```
gp = good_predictions.withColumn("np*rank", col("goodPreds")*col("percRank"))
gp.show()
```

```
+-------+------+---------+---------+--------+-------+
|userId |songId|num_plays|goodPreds|percRank|np*rank|
+-------+------+---------+---------+--------+-------+
|    111|    22|        3|      1.1|   0.000|  0.000|
|    111|    77|        0|     0.01|   0.500|  0.000|
|    111|    99|        0|    0.008|   1.000|  0.000|
|    222|    22|        0|   0.0003|   1.000|  0.000|
|    222|    77|        2|      1.5|   0.000|  0.000|
|    222|    99|        2|      1.4|   0.500|  1.000|
|    333|    22|        0|     0.90|   0.500|  0.000|
|    333|    77|        2|      1.6|   0.000|  0.000|
|    333|    99|        0|     0.01|   1.000|  0.000|
+-------+------+---------+---------+--------+-------+
```

# ROEM: good predictions

```
+--------+------+---------+---------+--------+-------+
|userId  |songId|num_plays|goodPreds|percRank|np*rank|
+--------+------+---------+---------+--------+-------+
|     111|    22|        3|      1.1|   0.000|  0.000|
|     111|    77|        0|     0.01|   0.500|  0.000|
|     111|    99|        0|    0.008|   1.000|  0.000|
|     222|    22|        0|   0.0003|   1.000|  0.000|
|     222|    77|        2|      1.5|   0.000|  0.000|
|     222|    99|        2|      1.4|   0.500|  1.000|
|     333|    22|        0|     0.90|   0.500|  0.000|
|     333|    77|        2|      1.6|   0.000|  0.000|
|     333|    99|        0|     0.01|   1.000|  0.000|
+--------+------+---------+---------+--------+-------+
```

```
numerator = gp.groupBy().sum("np*rank").collect()[0][0]
denominator = gp.groupBy().sum("num_plays").collect()[0][0]
print ("ROEM: "), numerator * 1.0/ denominator
```

```
ROEM: 1.0 / 9 = 0.1111
```

# ROEM: link to function on GitHub

```
+-------+------+---------+---------+--------+-------+
|userId |songId|num_plays|goodPreds|percRank|np*rank|
+-------+------+---------+---------+--------+-------+
|    111|    22|        3|      1.1|   0.000|  0.000|
|    111|    77|        0|     0.01|   0.500|  0.000|
|    111|    99|        0|    0.008|   1.000|  0.000|
|    222|    22|        0|   0.0003|   1.000|  0.000|
|    222|    77|        2|      1.5|   0.000|  0.000|
|    222|    99|        2|      1.4|   0.500|  1.000|
|    333|    22|        0|     0.90|   0.500|  0.000|
|    333|    77|        2|      1.6|   0.000|  0.000|
|    333|    99|        0|     0.01|   1.000|  0.000|
+-------+------+---------+---------+--------+-------+
```

```
numerator = gp.groupBy().sum("np*rank").collect()[0][0]
denominator = gp.groupBy().sum("num_plays").collect()[0][0]
print ("ROEM: "), numerator * 1.0/ denominator
```

```
ROEM: 1.0 / 9 = 0.1111
```

# Building several ROEM models

```
(train, test) = implicit_ratings.randomSplit([.8, .2])
# Empty list to be filled with models
model_list = []

# Complete each of the hyperparameter value lists
ranks = [10, 20, 30, 40]
maxIters = [10, 20, 30, 40]
regParams = [.05, .1, .15]
alphas = [20, 40, 60, 80]

# For loop will automatically create and store ALS models
for r in ranks:
    for mi in maxIters:
        for rp in regParams:
            for a in alphas:
                model_list.append(ALS(userCol= "userId", itemCol= "songId",
                ratingCol= "num_plays", rank = r, maxIter = mi, regParam = rp,
                alpha = a, coldStartStrategy="drop",nonnegative = True,
                implicitPrefs = True))
```

# Error output

```
for model in model_list:
    # Fits each model to the training data
    trained_model = model.fit(train)

    # Generates test predictions
    predictions = trained_model.transform(test)

    # Evaluates each model's performance
    ROEM(predictions)
```

# Let's practice!

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# Overview of binary, implicit ratings

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# Binary ratings

```
binary_movie_ratings.show()
```

```
+------+-------+-------------+
|userId|movieId|binary_rating|
+------+-------+-------------+
|    26|    474|            0|
|    26|   2529|            1|
|    26|     26|            0|
|    26|   1950|            0|
|    26|   4823|            1|
|    26|  72011|            1|
|    26| 142507|            0|
|    38|   1325|            0|
|    38|   6011|            1|
+------+-------+-------------+
```

# Class imbalance

```
getSparsity(binary_ratings)
```

```
Sparsity: .993
```

# Item weighting

- **Item Weighting:** Movies with more user views = higher weight

# Item weighting and user weighting

- **Item Weighting:** Movies with more user views = higher weight
- **User Weighting:** Users that have seen more movies will have lower weights applied to unseen movies

# Let's practice!

BUILDING RECOMMENDATION ENGINES WITH PYSPARK

# Course recap

BUILDING RECOMMENDATION ENGINES WITH PYSPARK

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# Course summary

## Three types of data

- Explicit Ratings
- Implicit Ratings using user behavior counts
- Implicit Ratings using binary user behavior

# Things to bear in mind

- The more data the better

# Things to bear in mind (cont.)

- The more data the better
- The best model evaluation is whether actual users take your recommendations

# Resources

- McKinsey&Company: "How Retailers Can Keep Up With Consumers"
- ALS Data Preparation: Wide to Long Function
- Hu, Koren, Volinsky: "Collaborative Filtering for Implicit Feedback Datasets"
- GitHub Repo: Cross Validation With Implicit Ratings in Pyspark
- Pan, Zhou, Cao, Liu, Lukose, Scholz, Yang: "One Class Collaborative Filtering"

# Let's practice!

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