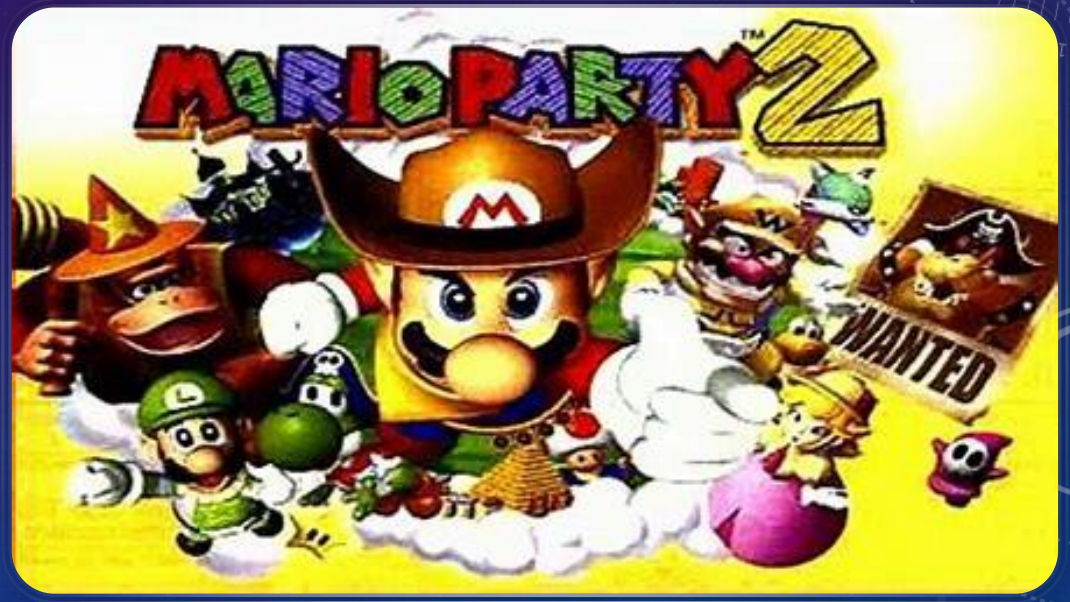
RECOMMENDATION SYSTEM FOR VIDEO GAMES

BY DEVESH GOKALGANDHI

THANKS TO SPRINGBOARD MENTOR: NADAV RINDLER

THE PROBLEM



- Currently, there are approximately 2.2 billion gamers, worldwide (a third of the people on the planet are gamers).
- Once we finish the thrill and enjoyment of one game, we want to jump into the next one.
- But how do we decide what to play next?
- How can we find the games that are most like the games we previously enjoyed?

WHO MIGHT CARE?

GAMERS!!!

SOLUTION: A RECOMMENDATION SYSTEM!

HOW EXACTLY WILL THE SYSTEM RECOMMEND GAMES?

Content Based Filtering

- Analyzes the descriptions and metadata of the games ONLY.
- Combination of features into a “bag of words”, as input into TF-IDF.
- Recommend list of games that are most like their respective game.
- Evaluated using premade GiantBomb list of similar games, to their respective game

Collaborative Based Filtering

- Filter games that a user might like based on the ratings of similar users, who enjoyed the same games as the user.
- Use clustering and matrix factorization algorithms to predict ratings for unrated games
- Evaluated using error metrics: RMSE and MAE

THE DATASET

•Game review data extracted from one of the largest gaming databases, GiantBomb, through their API.

•In total, 24023 game reviews were extracted, in which 6561 users reviewed 4223 games, ranging from July 2008 to September 2019.

WHAT FEATURES WILL BE IMPORTANT TO EACH FILTERING METHOD?

Content-Based

- Genres
- Themes
- Concepts
- Game Descriptions
- Platforms
- Publishers
- Developers

Collaborative-Based

- Username
- Game name
- User rating for game, on a scale of 0-5

		Items					
		1	*2*	...	*i*	...	*m*
Users	*1*	5	3		1	2	
	2		2				4
	:			5			
	u	3	4		2	1	
	:					4	
	n			3	2		

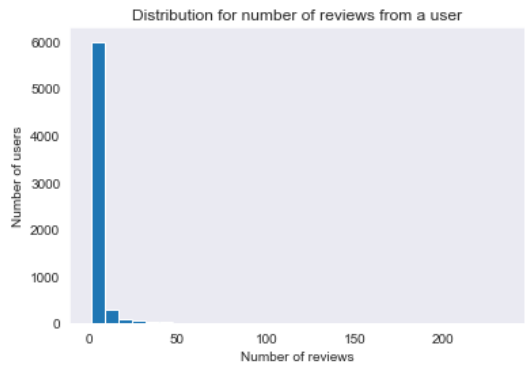
DATA EXPLORATION

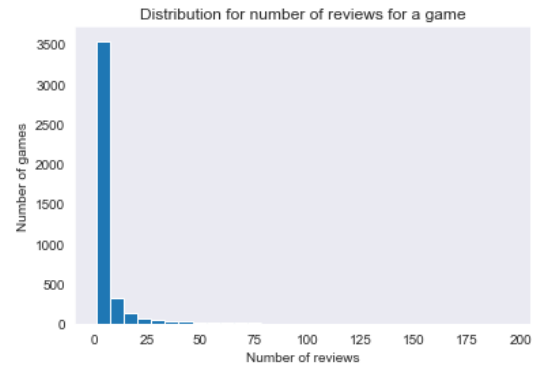
1. Ratings and Reviews
2. Genres, Themes, and Concepts
3. Characters and Franchises
4. Platforms, Publishers, and Developers
5. Term Frequency

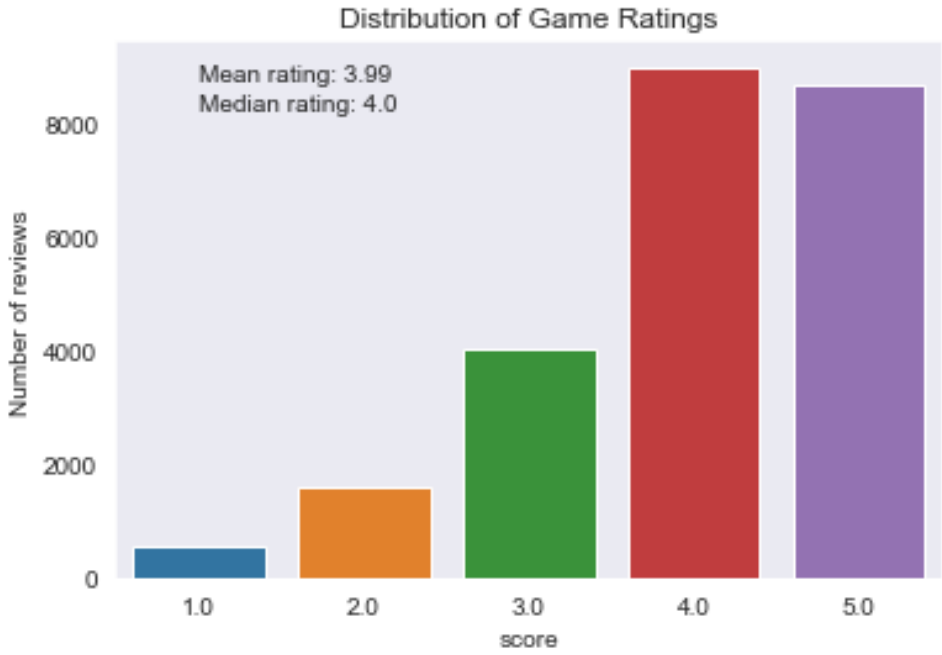
RATINGS ARE HEAVILY SKEWED TO THE POSITIVE SIDE

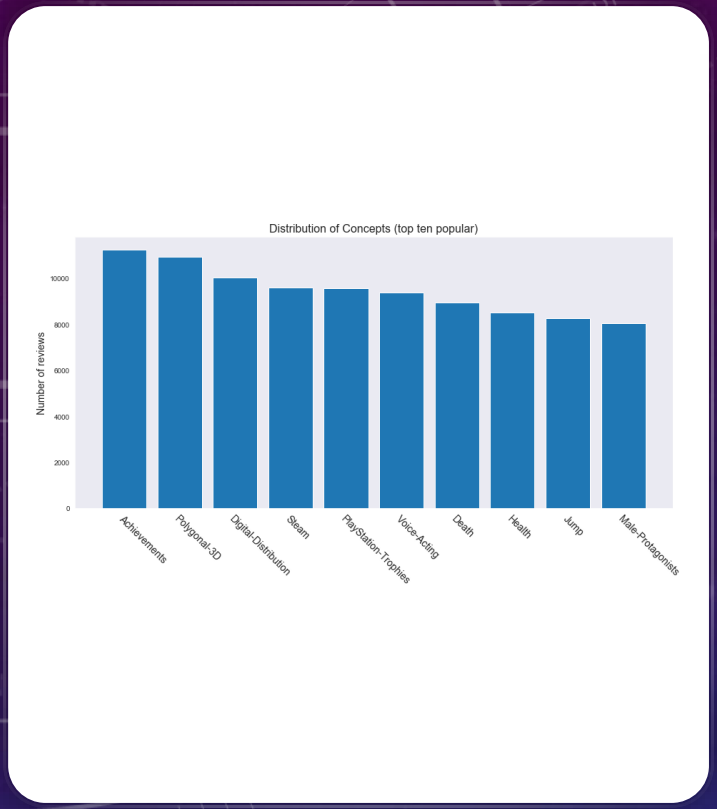
- Ratings are heavily skewed towards positive ratings,
- Many users have only reviewed one game.
- Many games have only been reviewed upon by one user.

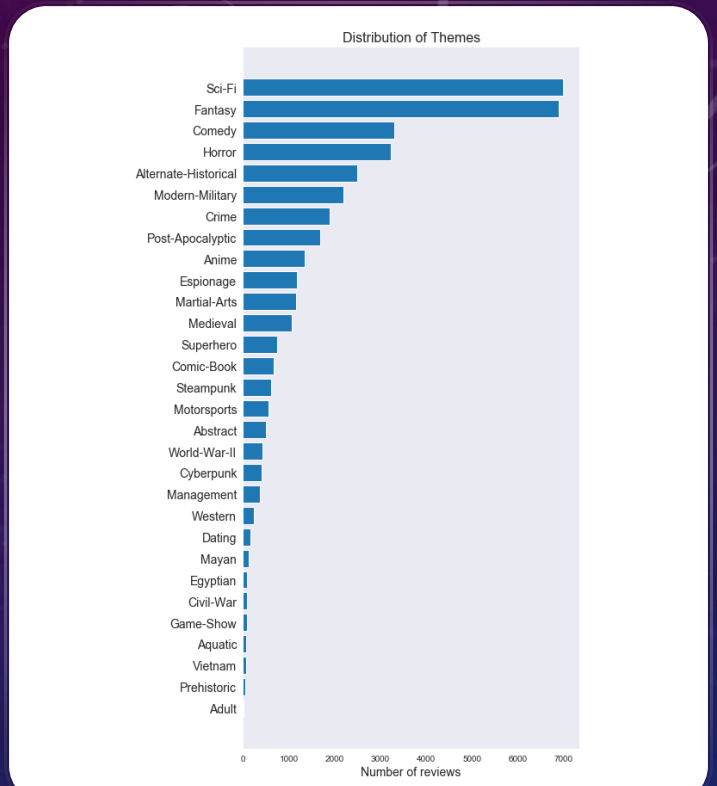
This will affect the collaborative-based filtering system, by overpredicting for lower rated games.

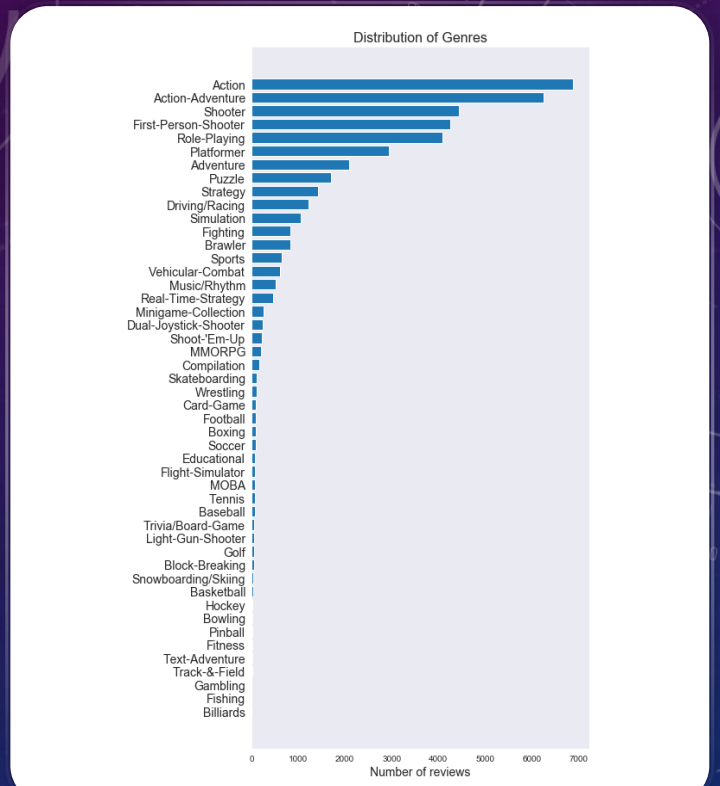












Distribution of games by Concept (right), Theme (middle), and Genre (right).

ACTION AND ACTION ADVENTURE GENRES DOMINATE

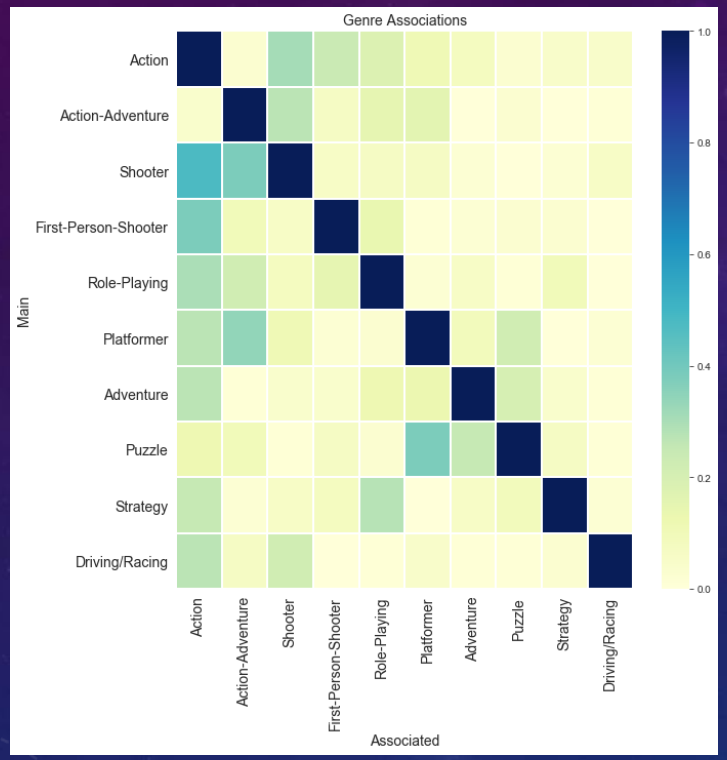
SCI-FI AND FANTASY THEMES DOMINATE

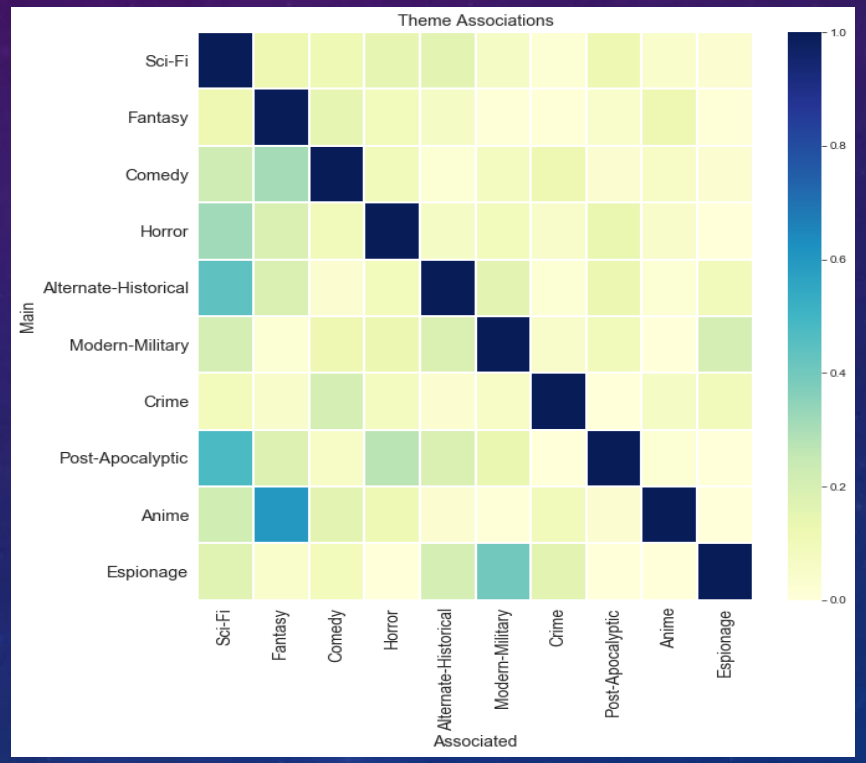
ACHIEVEMENTS AND POLYGONAL 3D* CONCEPTS DOMINATE

We expect the content-based system to hold less weight towards the popular features, as they occur more frequently in the corpus.

* Polygonal 3D refers to 3D rendering of the games, rather than a 2D side scrolling game.

MOST GAMES HAVE HIGHER ASSOCIATION WITH THE ACTION GENRE OR SCI-FI THEME BECAUSE BOTH A MOST POPULAR.

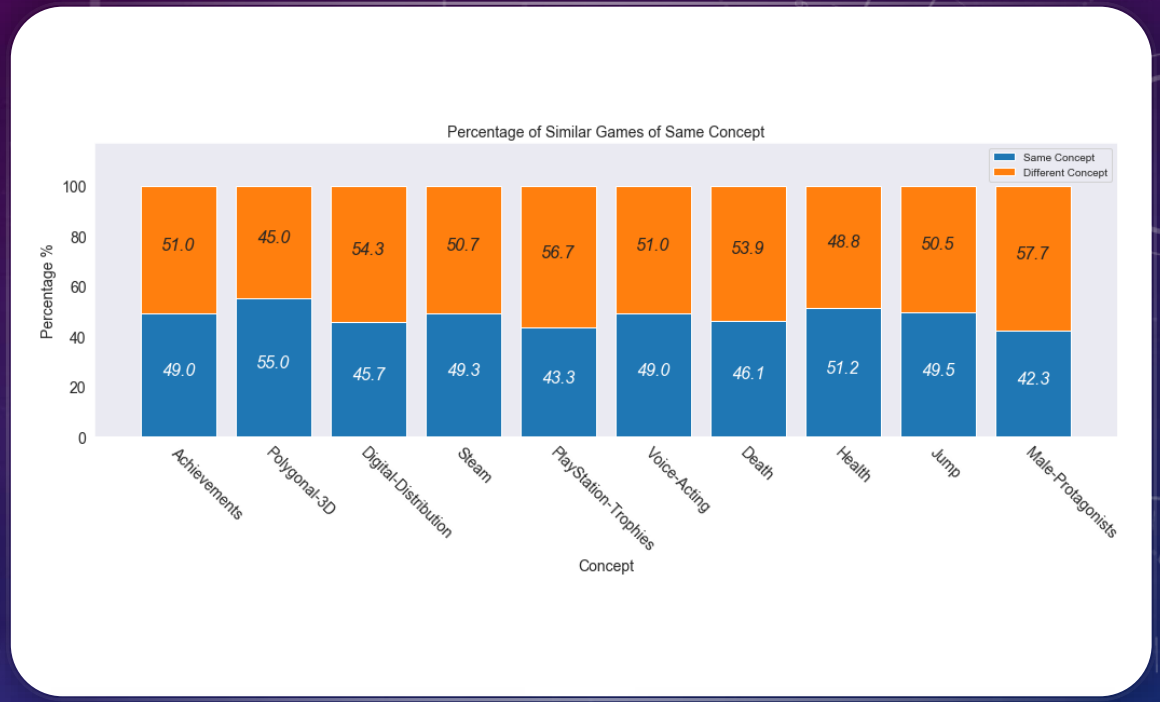


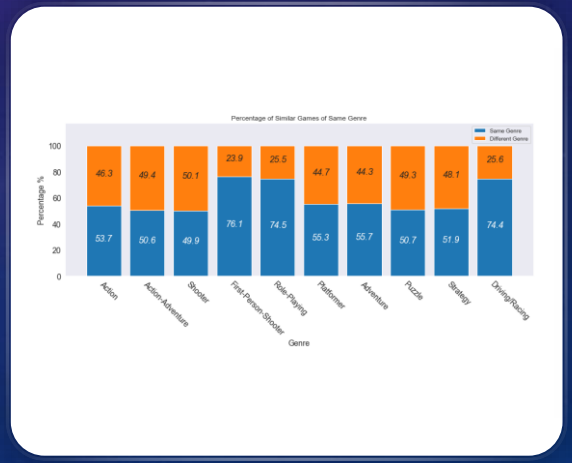


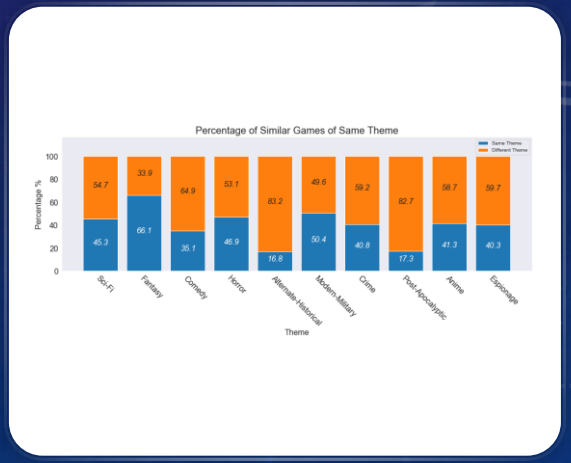
We expect the content-based system to capture these associations to recommend games with the same associations.

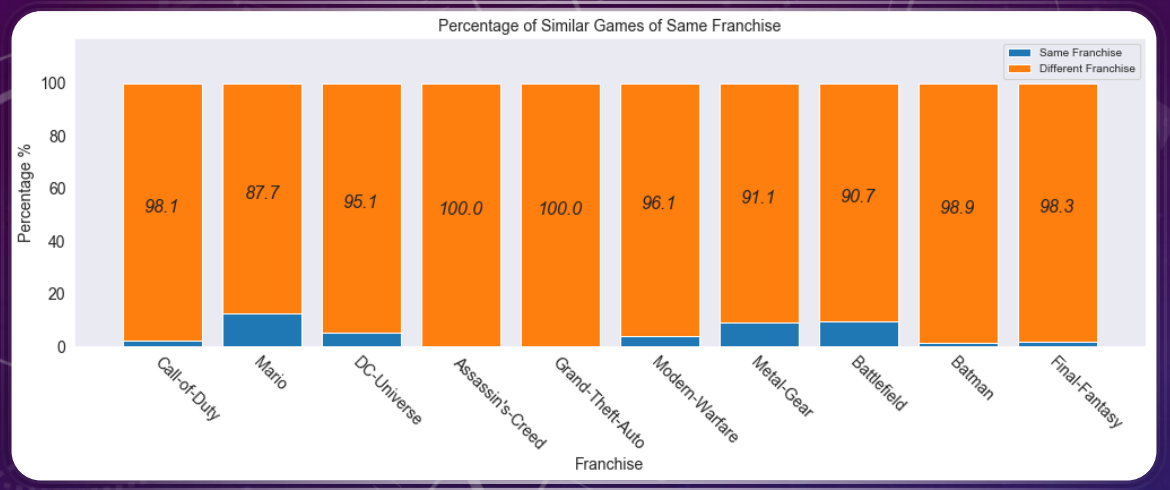
SIMILAR GAMES TEND TO SHARE THE SAME GENRE, THEME, OR CONCEPT AS THEIR RESPECTIVE GAME

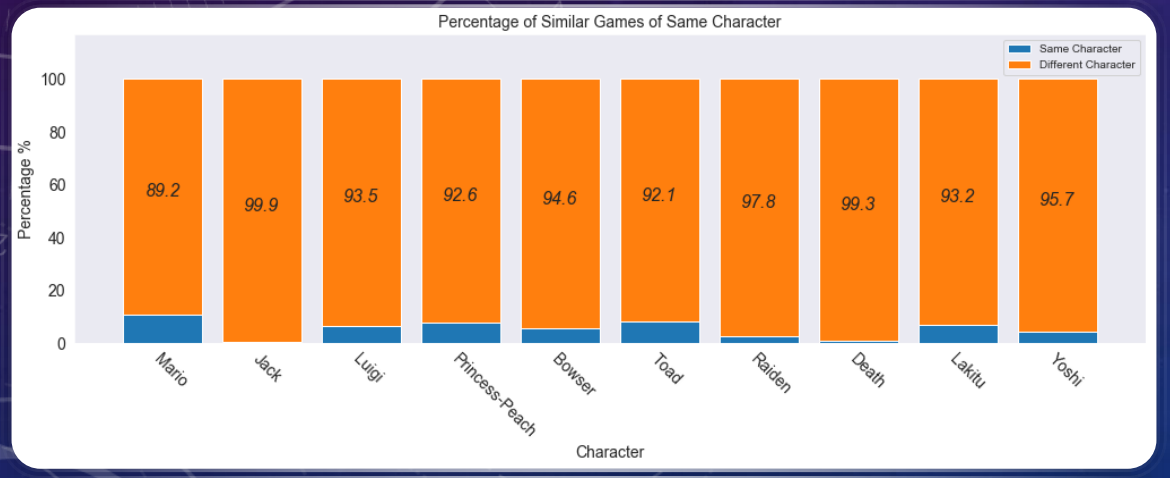
These features will be important for the content-based system to recommend games that are within the target similar games list.





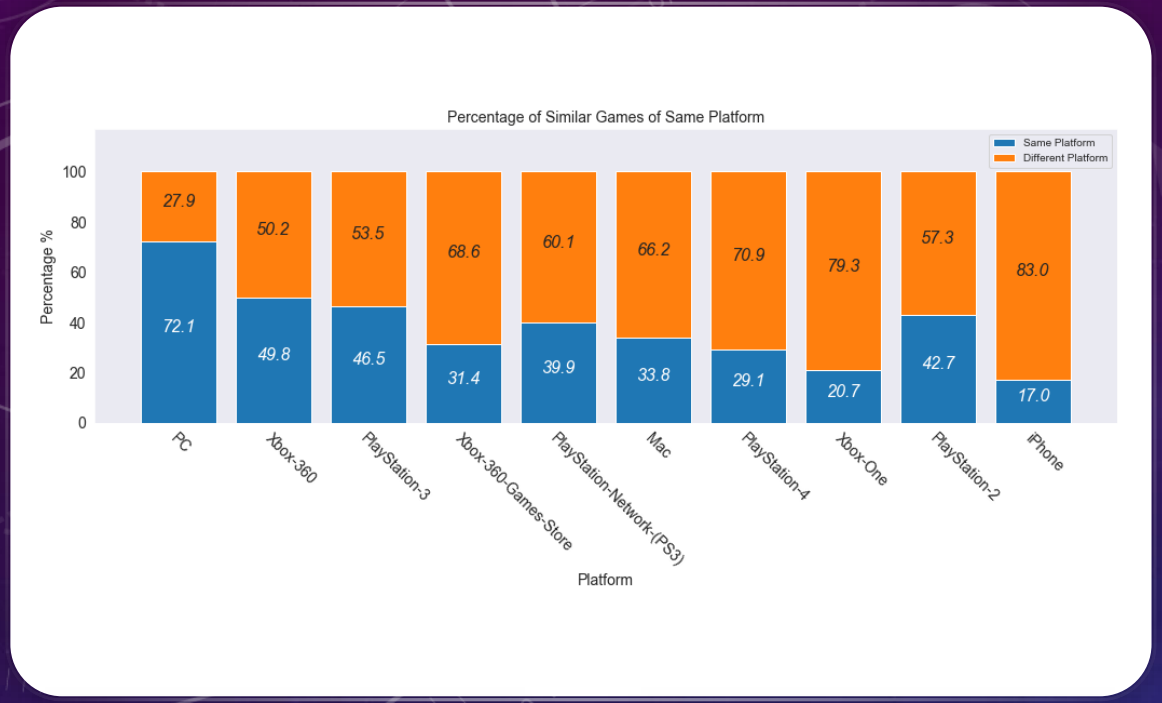


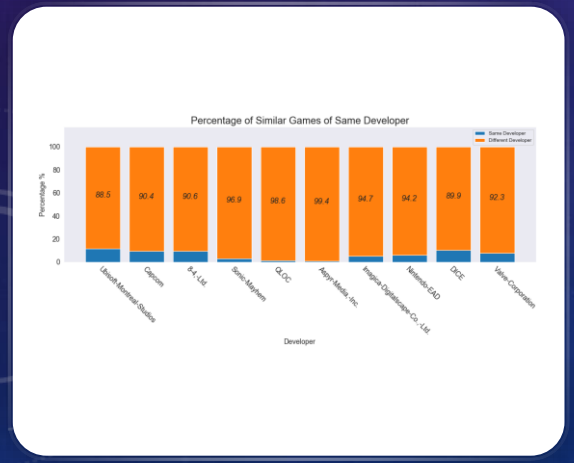




EXTREMELY LOW PERCENTAGE OF SIMILAR GAMES OF THE SAME CHARACTER OR FRANCHISE

These features will not be important for the content-based filtering system, as they will tend to recommend games not within the target similar games list.



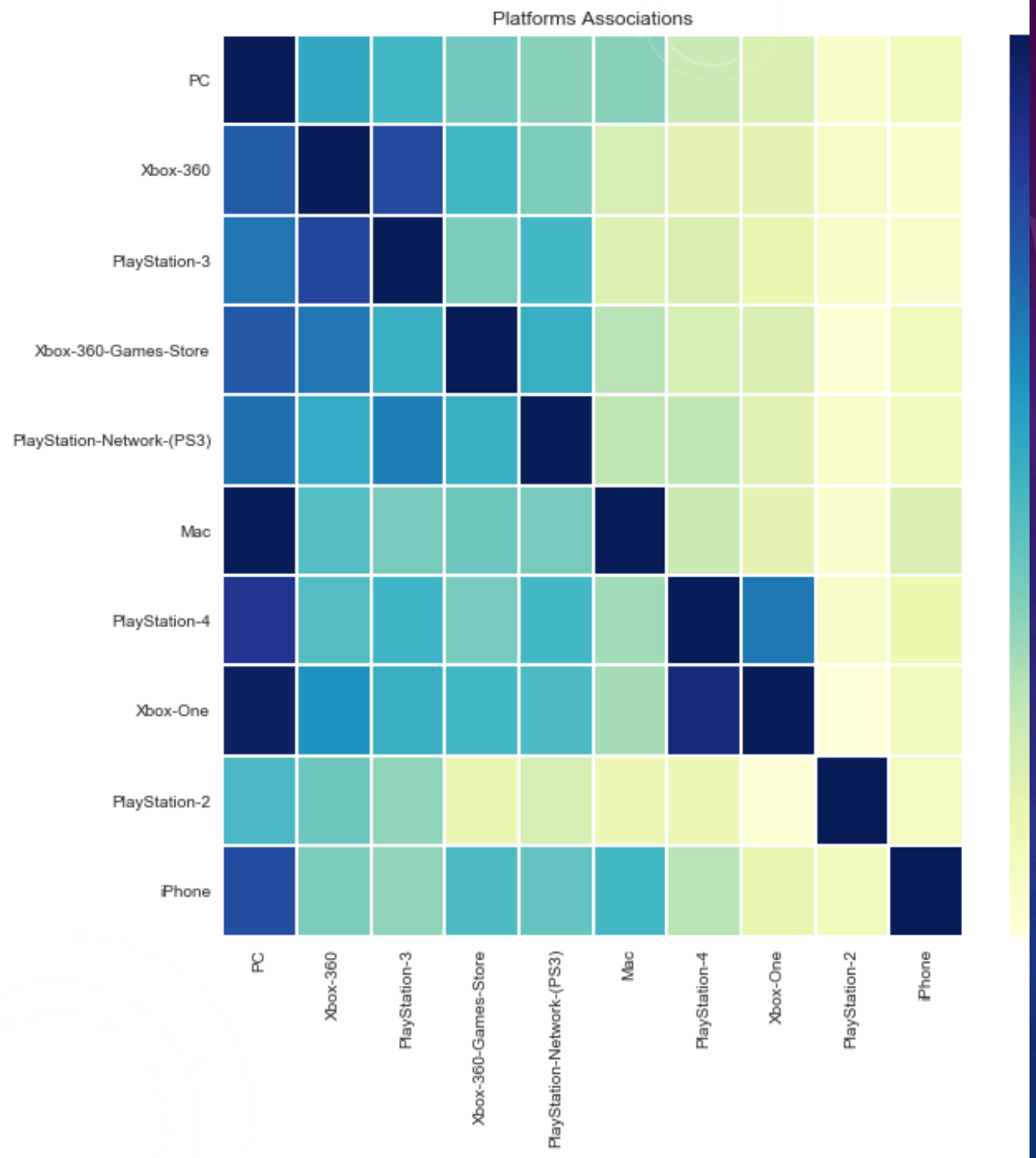


EXTREMELY LOW PERCENTAGE OF SIMILAR GAMES OF THE SAME PUBLISHER OR DEVELOPER

RELATIVELY HIGH PERCENTAGE OF SIMILAR GAMES OF THE SAME PLATFORM

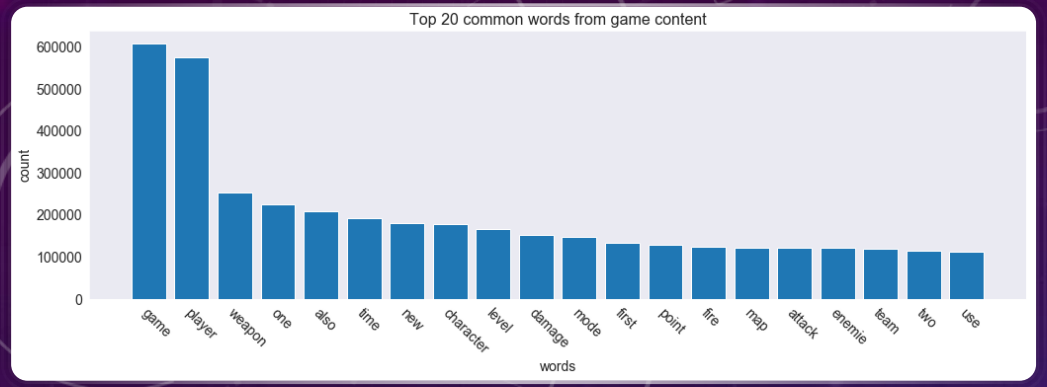
The publisher and developer features might not be important for the content-based filtering system, as they will tend to recommend games not within the target similar games list.

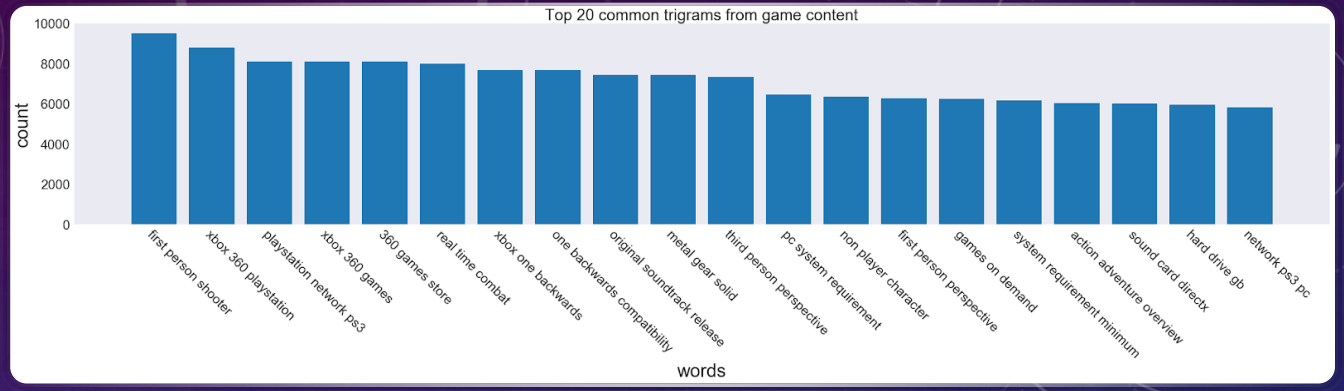
The platforms feature will be important.

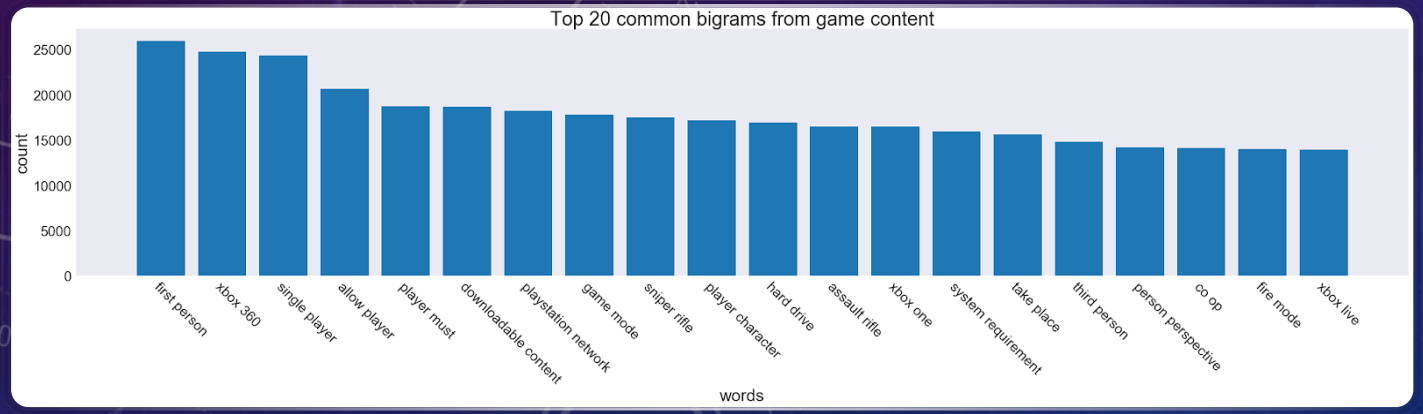


STRONG ASSOCIATIONS BETWEEN MOST CONSOLES AND PC, BECAUSE MOST VIDEO GAMES HAVE A PC VERSION

We expect the content-based system to capture these associations, in addition to game exclusivities, to recommend games of the same associations and exclusivity.

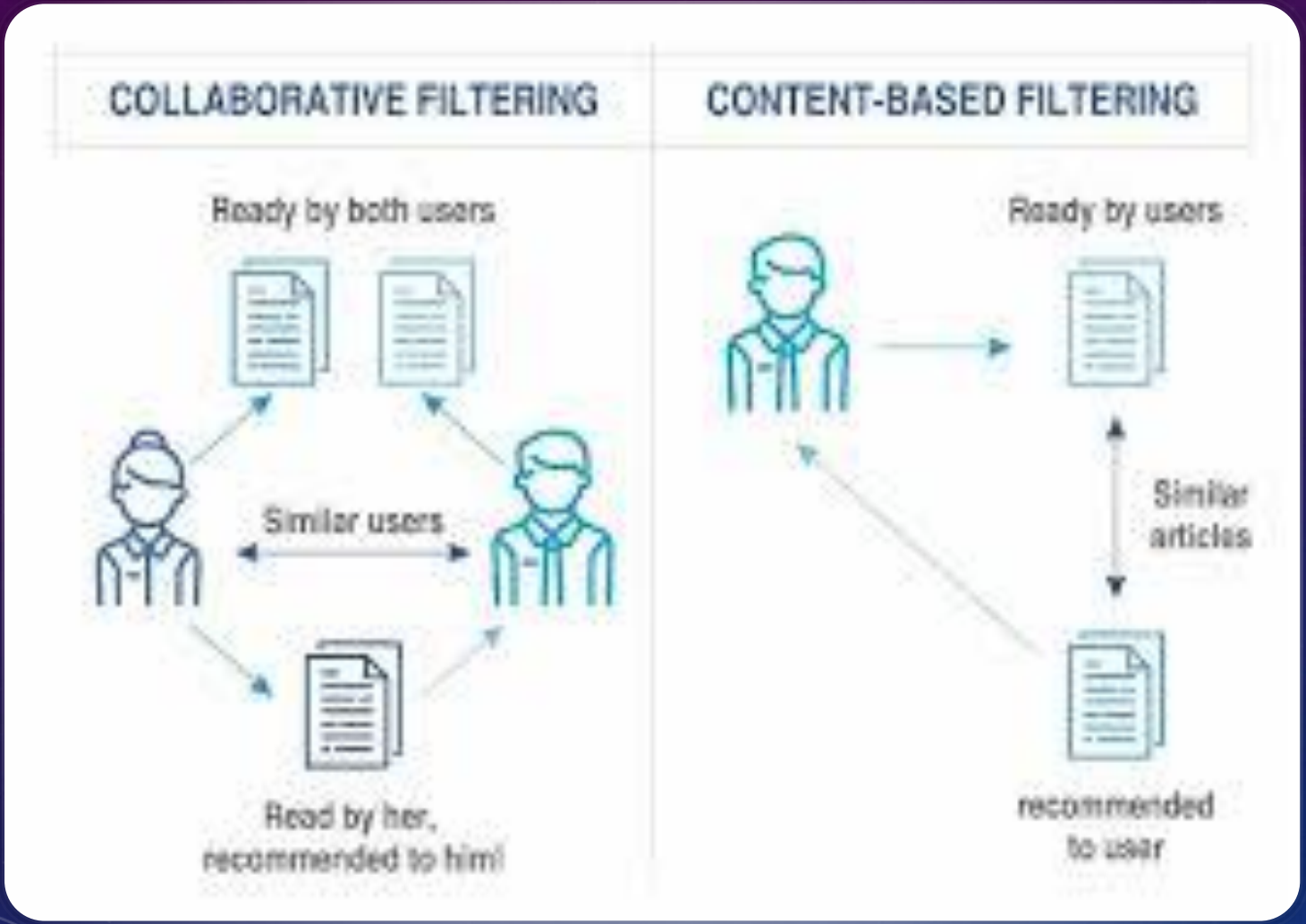






The content-based filtering algorithm will place more weight on the words that appear less frequently and less weight on these terms shown.

MOST POPULAR TERMS CORRESPOND TO COMMON GAME WORDS AND ACTION GAMES



MODELING

1. Content-Based Filtering

Evaluated using GiantBomb Similar Games List

Metrics measured: Precision, Recall, F1 score

2. Collaborative-Based Filtering

Evaluated using error metrics: RMSE and MAE

PRE-PROCESSING

Content-Based Filtering

- Replace missing content feature values (NaN) with an empty space (‘’).
- Reduce dataset to only include only one record for each unique game, for a total of 4223 records.
- Create a “bag of words” feature, an amalgamation of all content features into one feature (each term separated by a space).

Collaborative-Based Filtering

- To ensure some form of similarities and interaction between users, dataset is reduced to only include users that have at least 2 reviews, and games that have been reviewed at least two times.
- Every rating is increased by 1, as matrix factorization assigns a value of 0 to missing ratings.
- User-item ratings matrix is formed.

Content-Based Filtering

Table 1. Results of TF-IDF recommendations for each bag of words combination

Bag of Words includes:	Avg. Precision	Avg. Recall	Avg. F1
Every feature	0.087	0.191	0.103
Every feature except characters	0.088	0.193	0.104
Every feature except characters and game body*	0.109	0.206	0.122
Every feature except characters, game body, franchises	0.110	0.209	0.123
Every feature except characters, game body, franchises, publishers	0.111	0.211	0.125

* "Game body" refers to full length description of the game

GENRES, THEMES, CONCEPTS, DEVELOPERS, PLATFORMS, AND SHORT SUMMARY OF THE GAME ARE THE BEST FEATURES.

Precision = # of games from the recommendations that are in the similar games list / 10
Recall = # of games from the recommendations that are in the similar games list / # of games in the similar games list
F1 = 2 *(precision * recall / precision + recall)

EXAMPLE: PAC-MAN

Similar Games list for Pac-Man
Lock-n-Chase
Lady Bug
Katamari Damacy
Spore
Mario Bros.
Dig Dug
Bit Boy!!
Bit Trip Void
The Legend of Zelda: Spirit Tracks
Jungler
Gubble
Monaco: What's Yours Is Mine
Grand Theft Auto
Wolfenstein-3D
Metal Gear
Galaxian

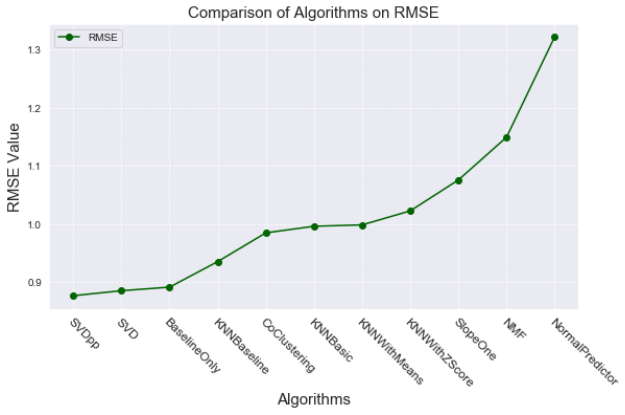
Target Variable (above list), Recommended List/System Output (above right list)

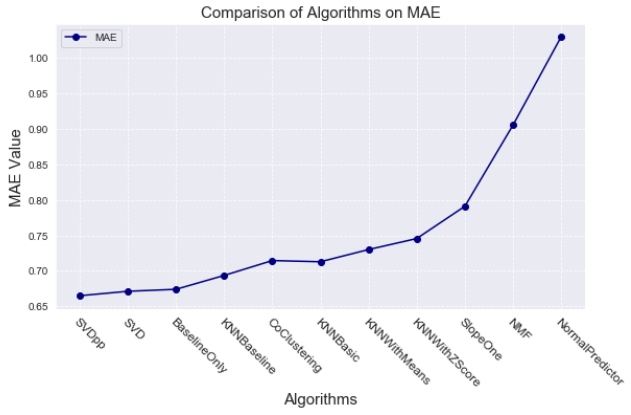
Recommended Games	In Similar Games list?
Dig Dug	Yes
Ms. Pac Man	No
Galaxian	Yes
Galaga	No
Centipede	No
Mario Bros.	Yes
Frogger	No
Pac Man Championship Edition	No
Tetris	No
Space Invaders	Yes

Precision: 0.4 (Pretty good!)
Recall: 0.25

Closer look at the similar games list, Wolfenstein 3D, GTA, Metal Gear? Doesn't seem similar.

Recommended list displays games most would agree are like Pac-Man. This shows that the similar games list is limited and contains flaws and does not provide an objective list of similar games for their respective game.





Algorithm	test_rmse	test_mae	fit_time	test_time
SVDpp	0.876658	0.664882	7.524015	0.250665
SVD	0.885243	0.671107	1.715744	0.075928
BaselineOnly	0.891370	0.673919	0.101063	0.024599
KNNBaseline	0.935266	0.693460	0.165082	0.315176
CoClustering	0.984642	0.714413	1.319195	0.056860
KNNBasic	0.995987	0.712726	0.131267	0.310606
KNNWithMeans	0.998343	0.729940	0.228719	0.340424
KNNWithZScore	1.022443	0.745451	0.382309	0.289892
SlopeOne	1.075540	0.790935	0.152590	0.161901
NMF	1.149029	0.905406	1.807499	0.040558
NormalPredictor	1.321550	1.029843	0.019945	0.043218

SVD++ AND SVD PRODUCE BEST PREDICTIONS IN COLLABORATIVE FILTERING PROBLEM

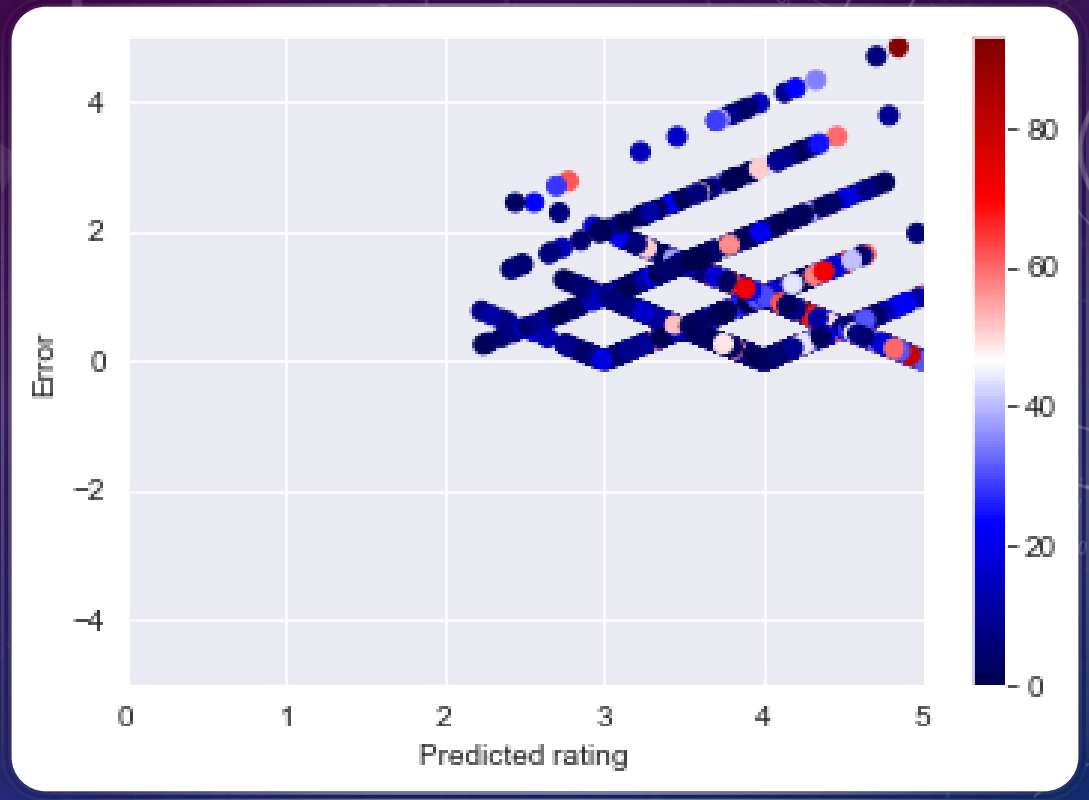
Table 3. SVDpp and SVD evaluation of test data

Algorithm	RMSE	MAE
SVDpp	0.8682	0.6662
SVD	0.8708	0.6679

Best parameters according to GridSearchCV:

1.n_epochs: 25
2.lr_all: 0.01
3.reg_all: 0.4

Recommend games based on best predicted rating



THE COLLABORATIVE BASED SYSTEM OVERPREDICTS DUE TO POSITIVELY SKEWED DISTRIBUTION OF RATINGS

RECOMMENDATION TO GAMERS

- Gamers should opt to use the content-based filtering method in recommending games, as the dataset is highly skewed towards positive ratings, adversely impacting the collaborative based filtering system.
- Games with slightly lower to lower ratings will be overpredicted on.

- If using the content-based filtering method, be aware that the features considered are genres, themes, concepts, platforms, developers, and short game summary.
- If the gamer enjoys their game due to other features, such as their favorite character, or franchise, the system is unlikely to recommend a sequel/prequel/spin-off to their game.

- For the results of the content-based filtering, this does not mean that the recommendations are correct, as the features were determined through evaluating the system with GiantBomb's opinion of list of similar-games to the target game.
- We don't have an objective measure of the content-based model performance, as the similar games list has limits and flaws.
- Do additional research on the games prior to deciding to play them.

LIMITATIONS AND FUTURE WORK

- Add new games and game information to increase the number of games that can be recommended.
- A new evaluator list for the recommendations should also be determined, possibly through surveying gamers to determine what they feel are the most similar games to the games they have played and strengthening how accurate the system will recommend games.
- Multiple surveys of similar games should provide enough evidence to determine a consensus list of similar games that can be used to evaluate the system.

- For the collaborative-based filtering method, the dataset lacks negatively rated games, causing the system to overpredict ratings, so adding more reviews for these games may help alleviate this issue, but if not, will increase the amount of reviews for each game to make better rating predictions.
- Another idea that could be implemented is a hybrid system that combines collaborative based filtering with content-based filtering, and add sentiment analysis, which would use the user review feature to recommend games tailored towards the individual querying the system.

CONCLUSION

- Dataset is highly skewed towards positive ratings for games. Many users only rated one game and many games only reviewed one time.
- Relatively high percentage of similar games of the same genre, theme, concept, and platform as the target game. Extremely low percentage for characters, franchises, publisher, and developers.
- The content-based system recommended games used a combination of genres, themes, concepts, platforms, developers, and short game summary to best predict similar games to the target game, with a precision of 0.111 (average of 1 game in similar games list, out of 10 recommendations), a recall of 0.211 (average of 20% of the games in similar games list are recommended), and the harmonic mean of precision and recall, the F1 score, of 0.125.
- For collaborative-based filtering, the best algorithm that evaluating the overall dataset was determined to be the matrix factorization algorithms, SVDpp and SVD. Both algorithms fitted the training data, and evaluated using the test data, for which the errors were: SVDpp RMSE and MAE of 0.8682 and 0.6662 respectively, SVD RMSE and MAE 0.8708 and 0.6679.
- However, the system overpredicts ratings, as a result of the uneven distribution of the ratings (heavily skewed to positive ratings). In this case, content-based filtering is the preferable method to recommending the games.

Overall, we've scratched the surface with recommending games as accurately as possible. Further surveying and reviews of gamers should improve the recommendation system by both balancing the distribution of games for the collaborative based system and provide a consensus list of similar games, to give an objective measure of the content-based system.