

Analysis of Mobile Strategy Games

Presented by

Linxia Liu

Sneha Lakshmikanthaiah

Vivian Kang

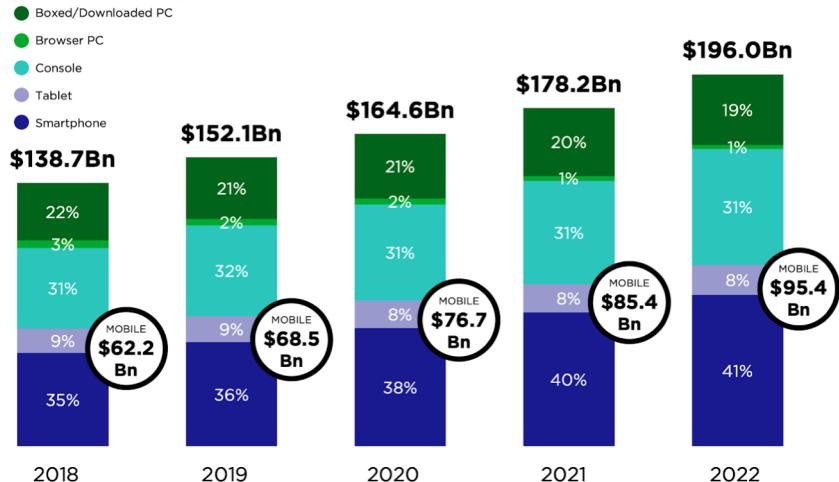
Yuan Liu

Zelong Qian

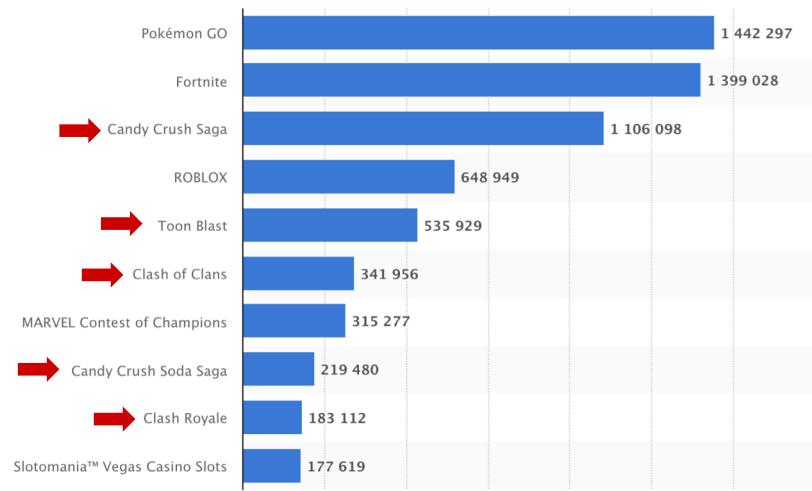
December 2019

Motivation and Key Questions

Mobile game is a highly profitable market



5 of Top 10 mobile games are strategy games



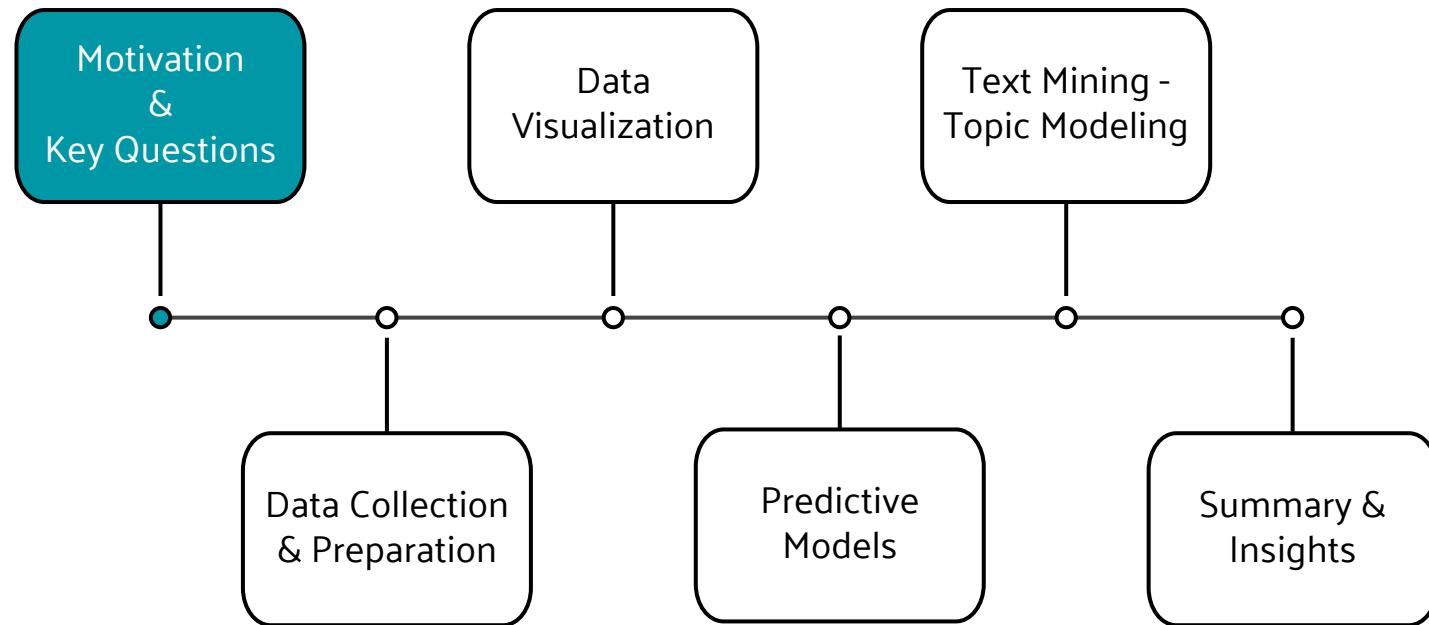
7...

Source:<https://www.statista.com/statistics/263988/top-grossing-mobile-ios-gaming-apps-ranked-by-daily-revenue/>

Key questions:

- What factors make a successful mobile strategy game?
- How to develop the next trending mobile strategy game?

Presentation Outline



■ Prepare the Kaggle Dataset

Attributes (Missing Values)	
URL	Description
ID	Developer
Name	Age Rating
Subtitle (11746)	Languages (60) ➔
Icon URL	Size (1) ➡
Average User Rating (9446)	Primary Genre ➡
User Rating Count (9446)	Genres
Price (24)	Original Release Date
In-app Purchases (9324)	Current Version Release Date

18 attributes, 17007 observations

Preparation steps:

- ① Drop *Subtitle, Primary Genre*
- ② Drop rows with empty *Average User Rating* and *Size*
- ③ Fill empty *In-app Purchases* with 0
- ④ Fill empty *Languages* with 'EN'
- ⑤ Prepared dataset: 16 attributes, 7561 observations

Web Scrape Review Comments From AppStore

AppStore Page of Kingdom Rush

<https://apps.apple.com/us/app/kingdom-rush-hd/id489265199>

This app is available only on the App Store for iPhone and iPad.



Kingdom Rush HD 12+
Ironhide S.A.
★★★★★ 4.9, 5.6K Ratings
Free · Offers In-App Purchases

Ratings and Reviews

4.9 out of 5

5.6K Ratings

★★★★★

Madeofbutterscotch, 12/30/2018

I am in AWE.

Disclaimer: I have not had very good experience with this genre of game overall.

Review: this is not a game. This is a revolutionary edit of the classic TD game. [more](#)

★★★★★

Mauigator, 05/18/2018

Favorite Tower Defense game

Kingdom Rush games are the best TD games imo. Game balance is perfect, the game can be beaten with the heroes included and the iron & heroic challenges can test your skills more

★★★★★

Puglyface, 06/09/2018, 06/09/2018

Amazing, but too easy..

So I downloaded this game yesterday as it took me an hour to, and I can say this game is the best Tower Defense game I've played. And that's saying something. But, the reason more

```
game = []
id_pattern = re.compile(r'(?=<id>)[0-9]+')
game_id = []
rev_title = []
rev_content = []

for l in best_urls:
    url = l
    try:
        page = urlopen(url)
        print(url)
        time.sleep(1)
        soup = BeautifulSoup(page, 'lxml')
        matches = soup.findAll(name = 'div',
                               attrs = {'class': ['we-customer-review lockup ember-view']})

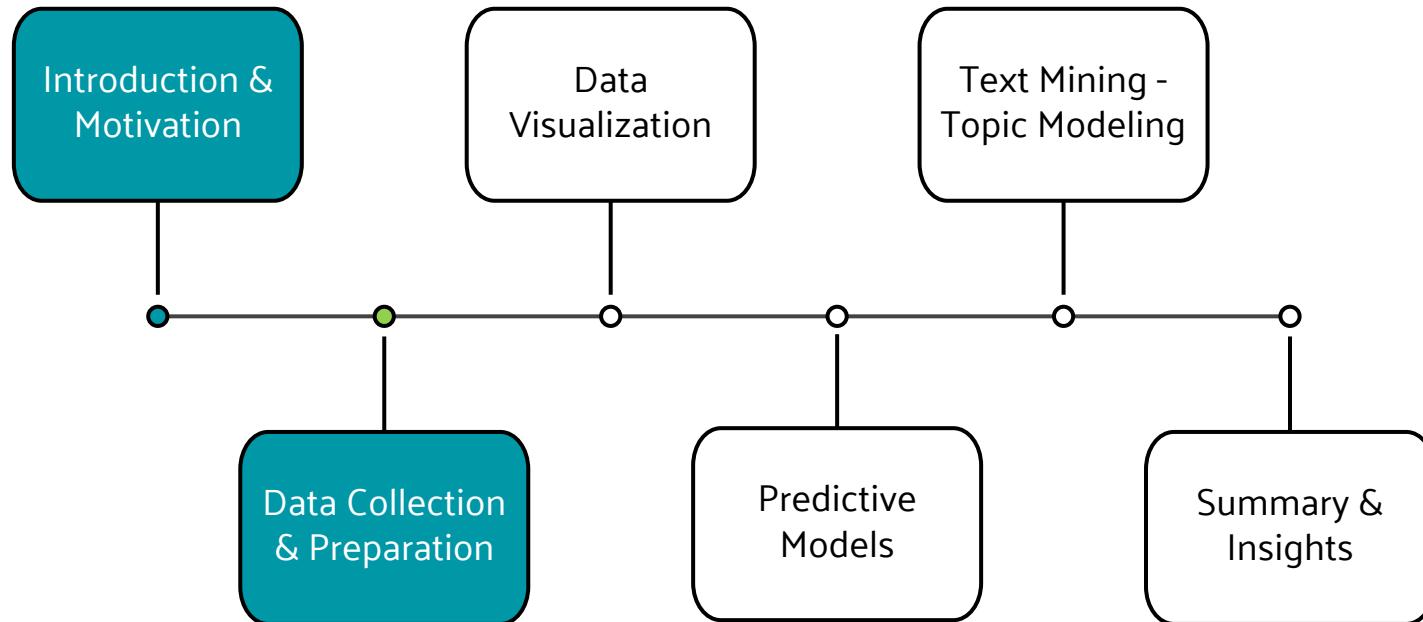
        for m in matches:
            game.append(soup.find(name = 'h1',
                                  attrs = {'class': ['product-header__title app-header__title']}).text)
            game_id.append([num for num in re.findall(id_pattern, url)][0])
            rev_title.append(m.h3.text)
            if not m.find(name = 'p', attrs = {'dir': ['false']}):
                rev_content.append('N/A')
            else:
                rev_content.append(m.find(name = 'p', attrs = {'dir': ['false']}).text)
    except urllib.error.HTTPError:
        print('Could not download page')
```



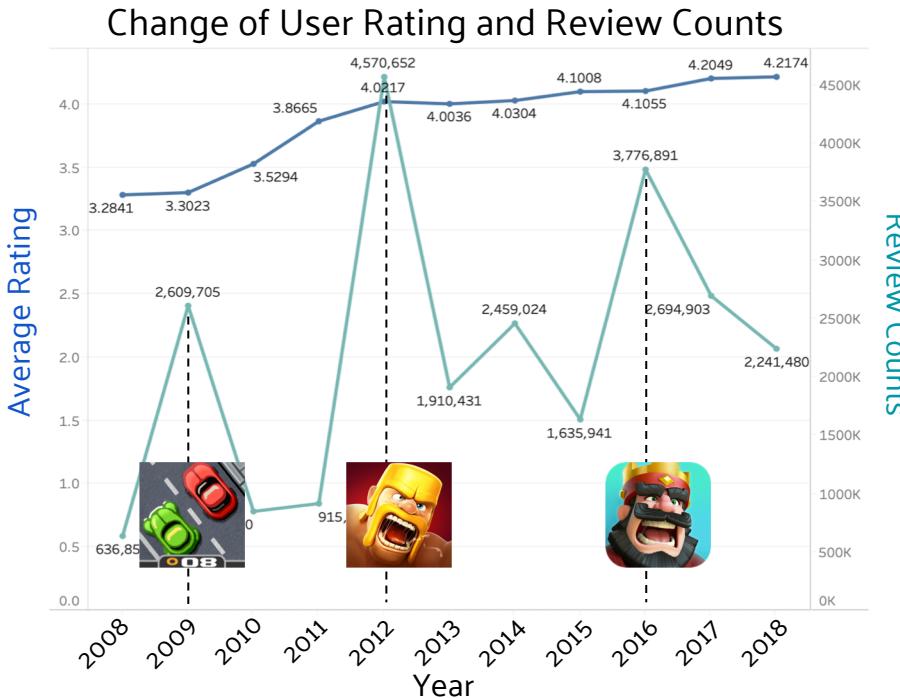
19287 Reviews were collected



Presentation Outline



Improving Game Quality and Users' Satisfaction Over Years

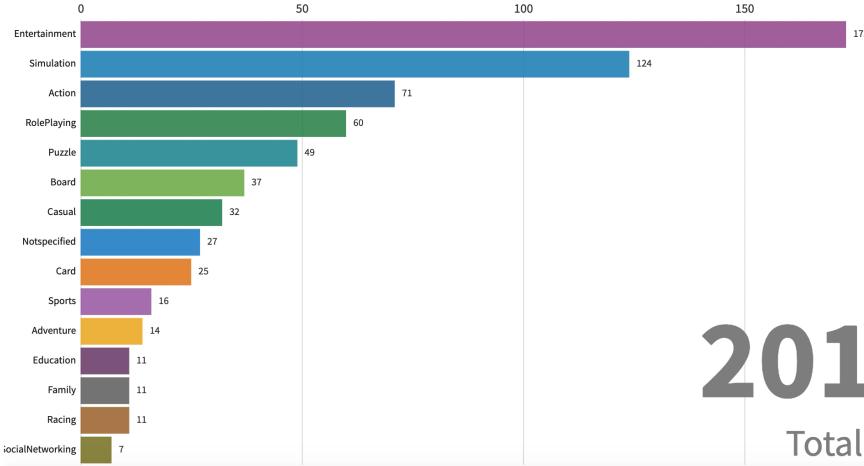


Takeaway: need to develop game with good quality to meet the improving standards

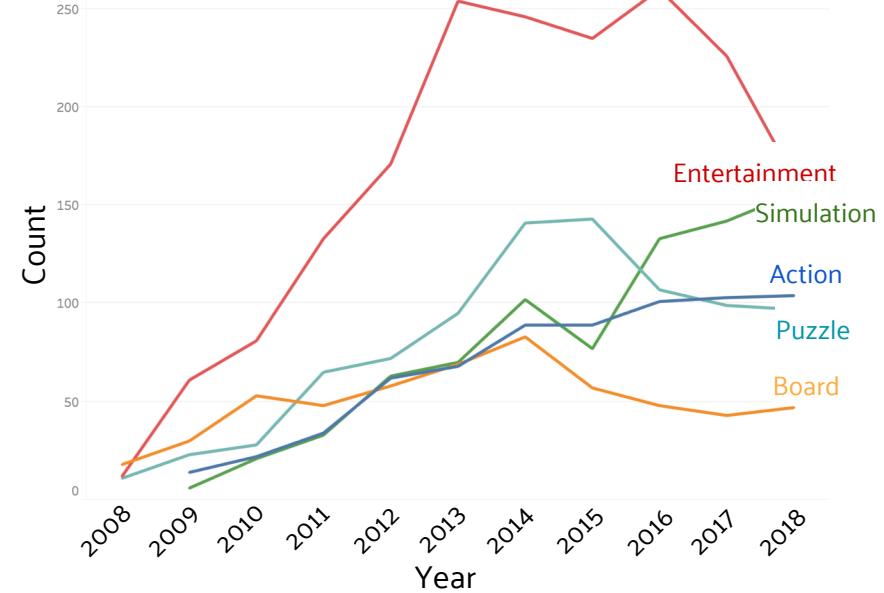


Changing Game Sub-Genres Over Years

Annual Trend for Strategy Game Sub-Genres



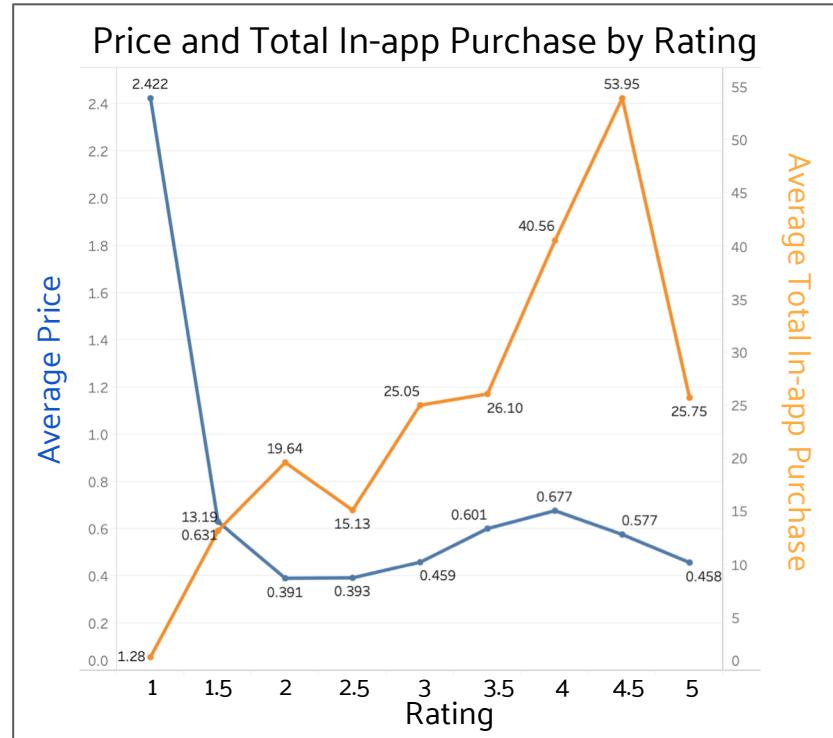
Top 5 Sub-Genres by Year



Takeaway: focus on the development of action and simulation strategy games



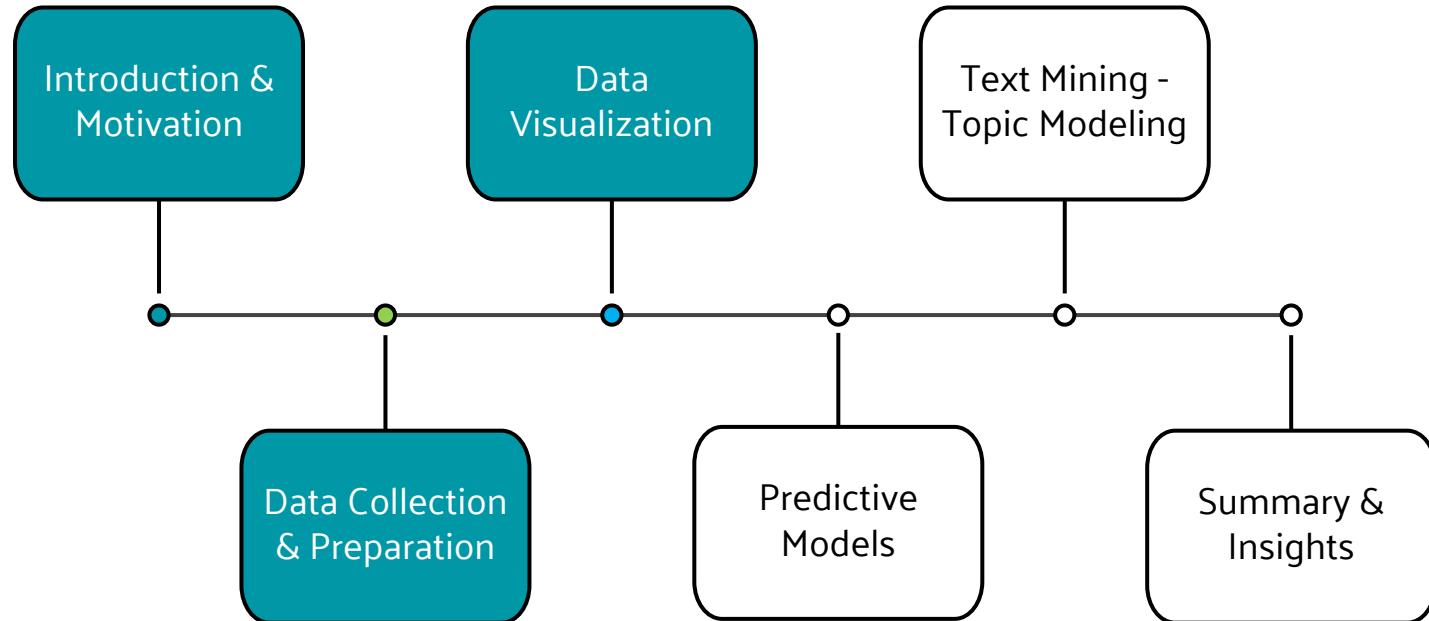
■ Free-to-Play Mode with In-app Purchase is Popular



Takeaway: price the game low but include features for in-app purchases



Presentation Outline



Feature Engineering

Attributes	
URL	Description
ID	Developer
Name	Age Rating
Icon URL	Languages
Average User Rating	Size
User Rating Count	Genres
Price	Original Release Date
In-app Purchases	Current Version Release Date

16 attributes, 7561 observations

- *Release Duration* =
Data Collection Date - Original Release Date
- *Update Duration* =
Current Version Date - Original Release Date

Numeric Attributes	
Top Game (≥ 4.5)	Minimum Age
Length of Name	Language Number
Size	Genre Number
Price	Release Duration (in days)
Total In-app Purchases	Update Duration (in days)

10 attributes, 7561 observations



Feature Selection via Correlation Analysis

top_game	1	-0.011	0.049	-0.051	0.11	0.016	0.03	-0.028	-0.057	-0.25
Price	-0.011	1	0.16	-0.046	-0.094	0.042	-0.021	0.0031	0.13	0.062
Size	0.049	0.16	1	-0.053	0.22	0.26	0.065	-0.011	-0.054	-0.25
name_length	-0.051	-0.046	-0.053	1	-0.029	-0.042	0.032	0.087	-0.17	0.00021
total_in_app_purchase	0.11	-0.094	0.22	-0.029	1	0.28	0.25	0.092	0.034	-0.18
min_age	0.016	0.042	0.26	-0.042	0.28	1	0.056	-0.0072	-0.034	-0.15
lang_num	0.03	-0.021	0.065	0.032	0.25	0.056	1	0.0038	0.079	-0.028
genres_num	-0.028	0.0031	-0.011	0.087	0.092	-0.0072	0.0038	1	0.11	0.11
update_duration	-0.057	0.13	-0.054	-0.17	0.034	-0.034	0.079	0.11	1	0.62
release_duration	-0.25	0.062	-0.25	0.00021	-0.18	-0.15	-0.028	0.11	0.62	1
top_game	Price	Size	name_length	total_in_app_purchase	min_age	lang_num	genres_num	update_duration	release_duration	

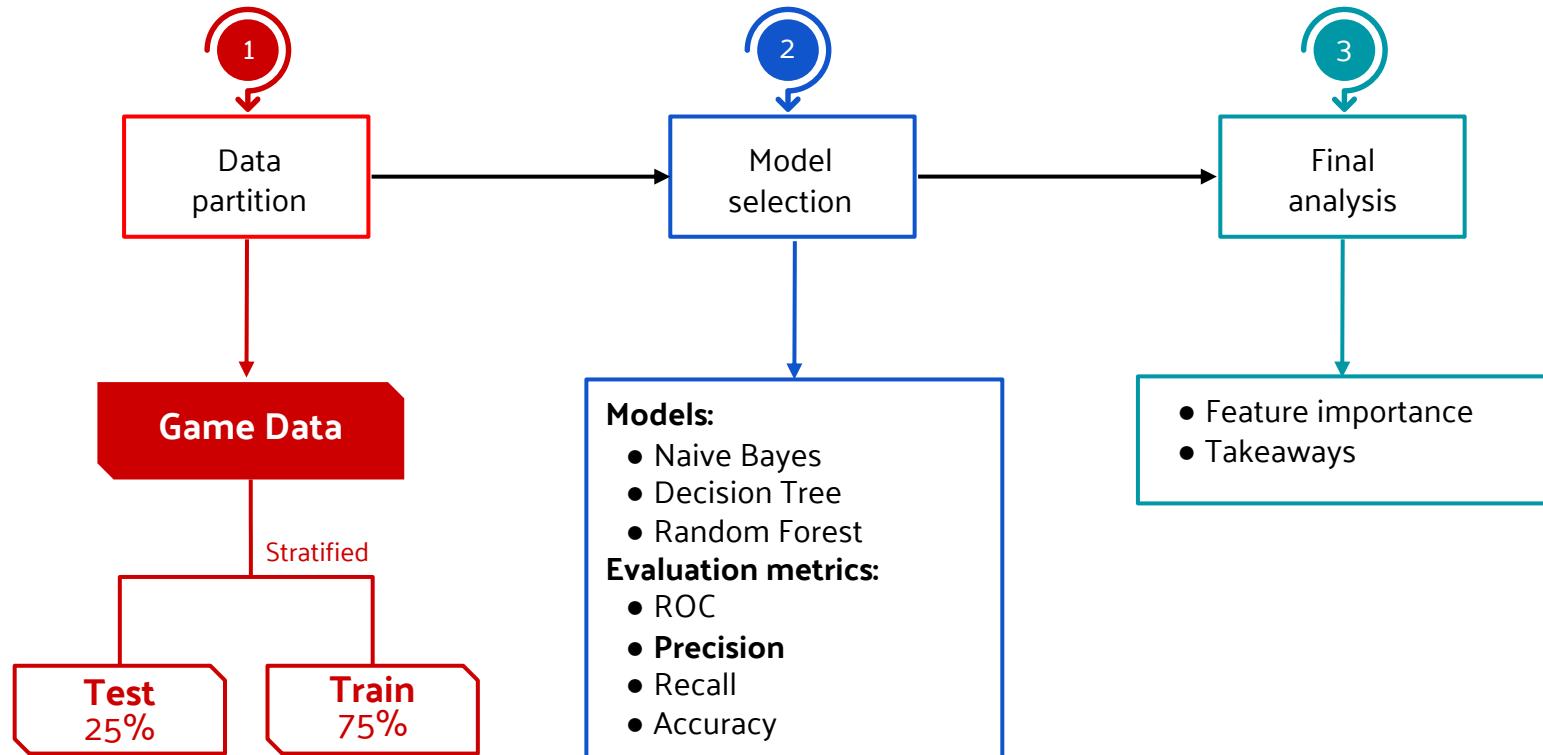
8 attributes, 7561 observations
 Label: *top_game*
 Features: the other 7 attributes



Correlation with <i>Top_game</i> attribute		
Attributes	Corr.Coeff.	p-Value
Price	-0.010612	3.562137e-01
Size	0.048810	2.175272e-05
Name_length	-0.050888	9.553334e-06
Total_in_app_purchase	0.106886	1.170882e-20
Min_age	0.015624	1.743314e-01
Lang_num	0.029974	9.146931e-03
Genres_num	-0.027620	1.631783e-02
Update_duration	-0.056886	7.433527e-07
Release_duration	-0.247693	4.387974e-106



■ Modeling Process Overview

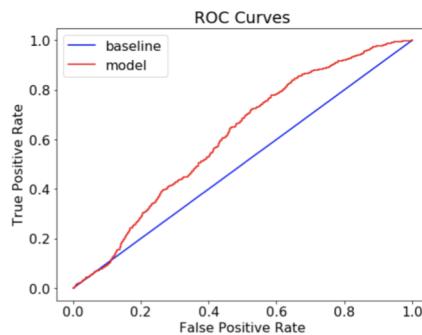


Random Forest with Randomized Search Works Best

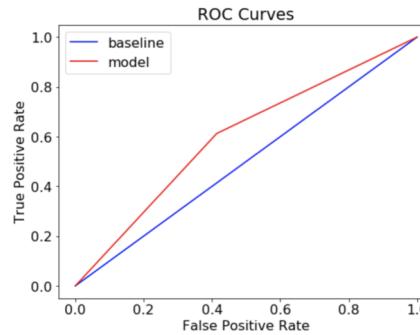
Benchmark: ROC: 0.51, Accuracy: 0.53

Better prediction

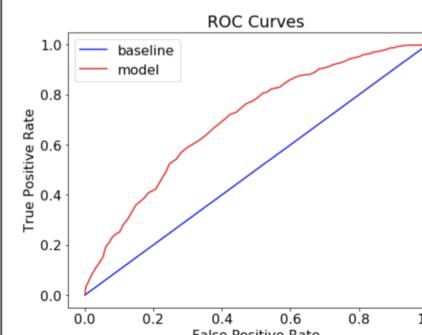
Naive Bayes



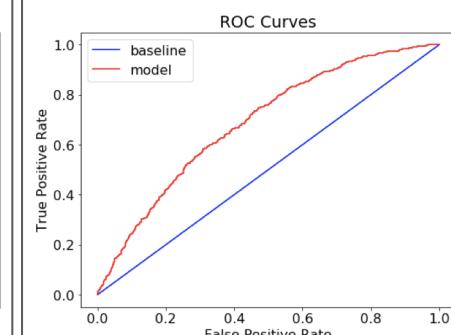
Decision Tree



Random Forest (RF)



RF with Randomized Search



- ROC: 0.61
- **Precision: 0.54**
- Recall: 0.93
- Accuracy: 0.56

- ROC: 0.6
- **Precision: 0.61**
- Recall: 0.61
- Accuracy: 0.60

- ROC: 0.7
- **Precision: 0.51**
- Recall: 0.7
- Accuracy: 0.65

- ROC: 0.69
- **Precision: 0.73**
- Recall: 0.62
- Accuracy: 0.64

$$\text{Precision} = \frac{\text{tp}}{\text{tp} + \text{fp}}$$



For game development, type-I error cost is higher than type-II error cost



Release Time is the Most Important Factor

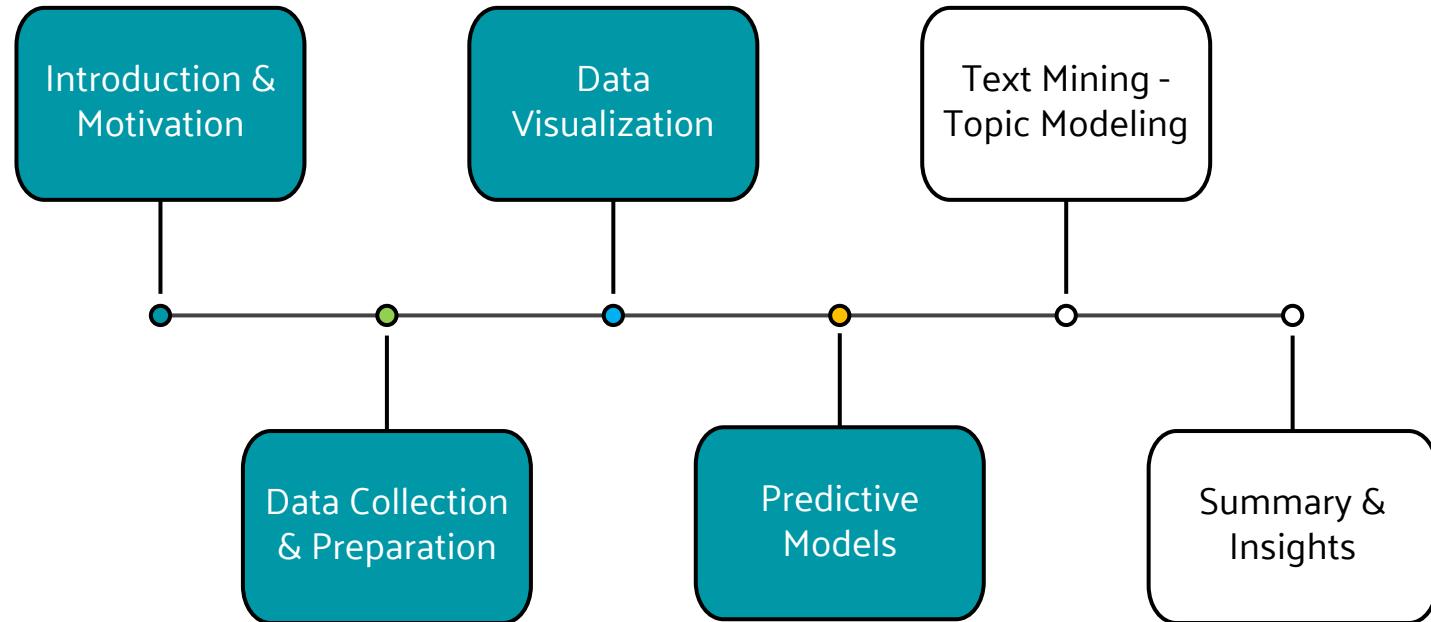
Results from RF with randomized search		
Feature	Importance	Impact Direction
Release_duration	0.435910	Negative
Size	0.158005	Positive
Update_duration	0.147155	Negative
Total_in_app_purchase	0.133703	Positive
Name_length	0.085568	Negative
Lang_num	0.029927	Positive
Genres_num	0.009732	Negative

Takeaways:

- Develop new games than updating old games
- Include more dedicate in-app purchase contents
- Use shorter game name



Presentation Outline



■ Need an Efficient Way to Analyze Reviews



Kingdom Rush Frontiers HD 9+

Ironhide S.A.

★★★★★ 4.8, 2.4K Ratings

\$2.99 - Offers In-App Purchases



cyninin, 04/01/2018

Love it!

This game is up there with **best tower defense games**. It's so **entertaining** and there's actually a reason to **replay levels**. The game is also **visually pleasing** and has a **cute but scary design** to it... somehow. It's also hilarious because there are so many **references** in the game, and if you look **hard** enough every level has 2 references to something.

It would be very **interesting** if you could make every level endless instead of only the challenge levels. What would be even cooler is a **level designer** where you could make and share levels with the community. 5 stars 100%



Gameplay

*best tower defense games,
replay levels, references, hard,
level designer*



Art design

*visually pleasing, cute but scary
design*

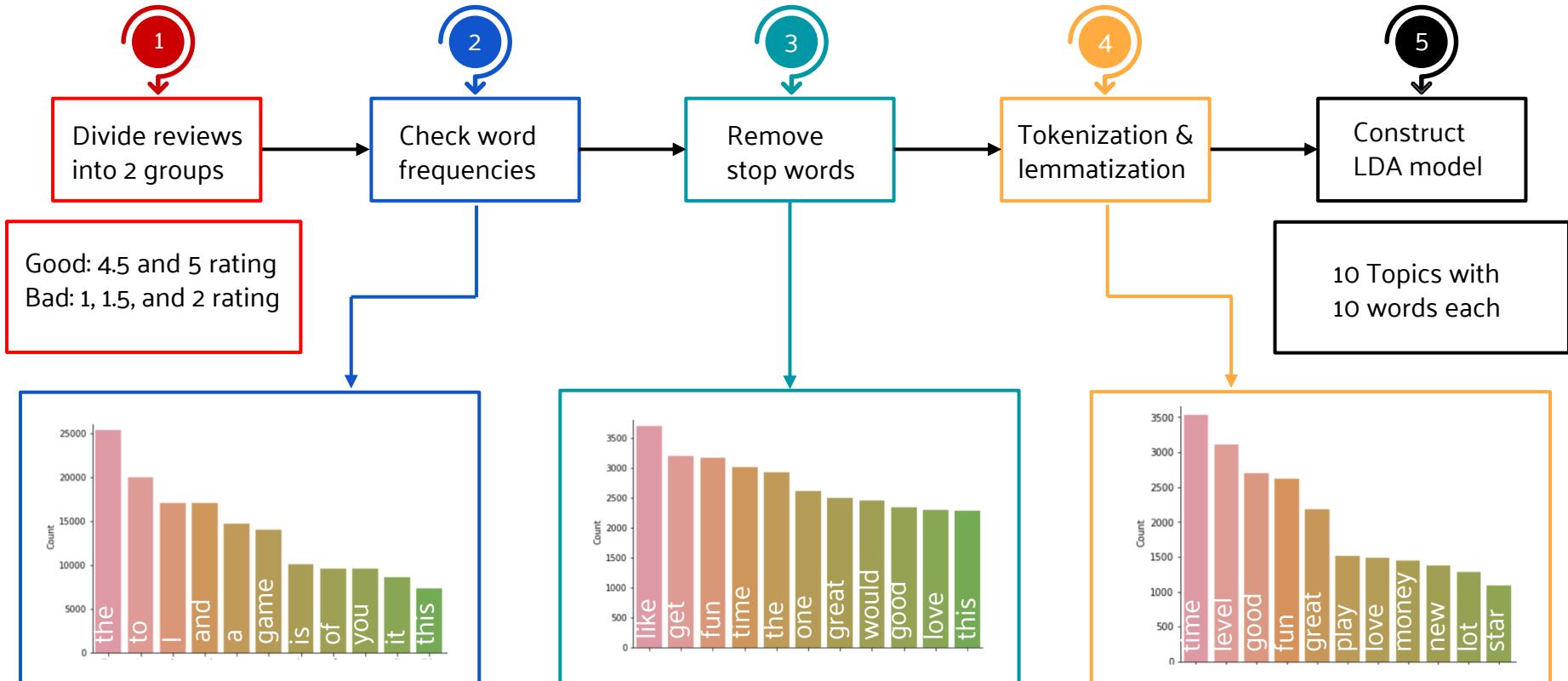


User experience

entertaining, interesting



Topic Modeling Procedures



Good Games - Many Topics VS. Bad Games - App Quality

Good game topics



Gameplay

Challenge, Level, Puzzle, Tower Defense, Card, War, Story, Mode, Enemy, Upgrade, Resource, Building, Attack



Art design

Graphic, Background, Color, Music, Sound



User experience

Ads, Time, Free, Money, Purchase



App quality

Update, Version

Bad game topics



App quality

Crash, Bug, Error, Glitch, Fix, Issue, Stuck

Takeaways:

- App quality is the determining factor
- To improve rating, focus more on gameplay



Good Game Example - Strategy War Game



Gameplay

War, Level, Defense, Attack,
Upgrade, Enemy, Resource,
Building, Upgrade, Mode



Art design

Graphic, Background,
Color, Music, Sound



User experience

Time, Free, Money,
Purchase

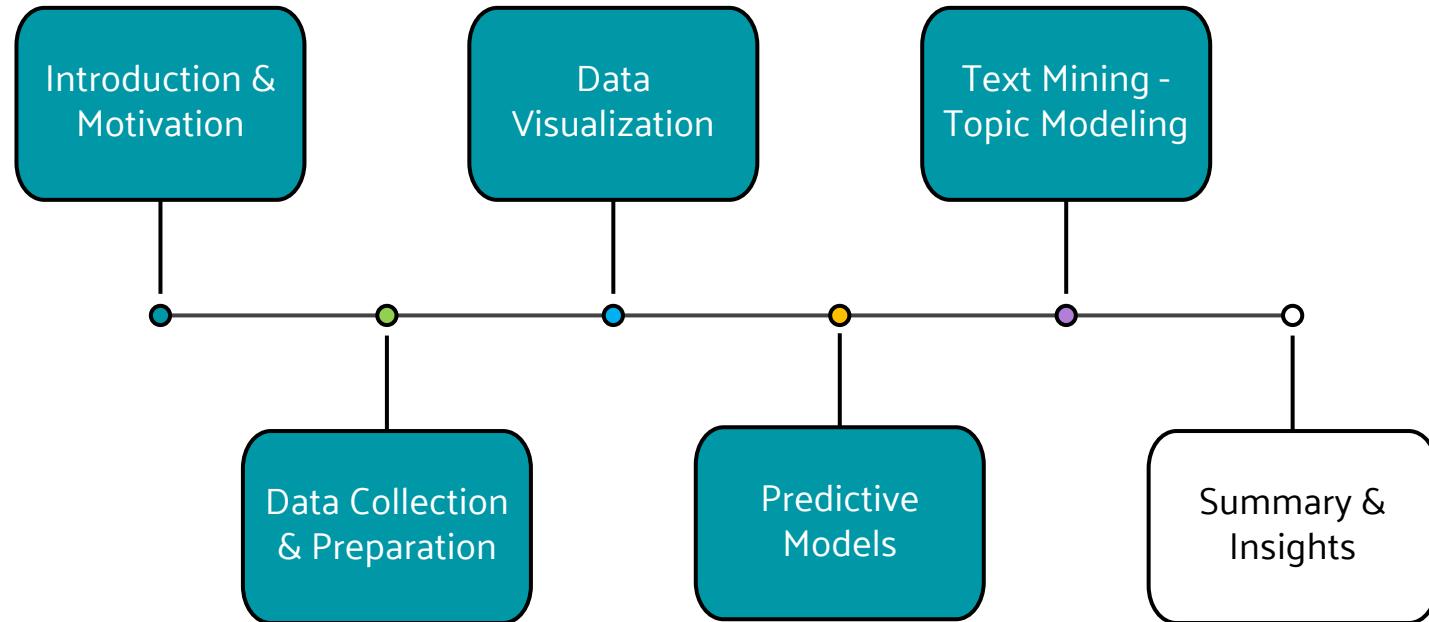


App quality

Update



Presentation Outline



■ Summary

What we did

- Conducted EDA to understand annual change of rating and genres, and the impact of pricing tactics and age group on rating
- Constructed models to predict top games and to figure out the important features in making a good game
- Web-scraped user reviews and conducted topic modeling to understand users' opinions on good and bad games

What we found

- Develop new games than updating old games
- Focus on developing action and simulation strategy games
- App quality is the determining factor for being a good game
- Focus more on gameplay after achieving good app quality
- Include more dedicated in-app purchase items than charging a lot for downloads

Future work

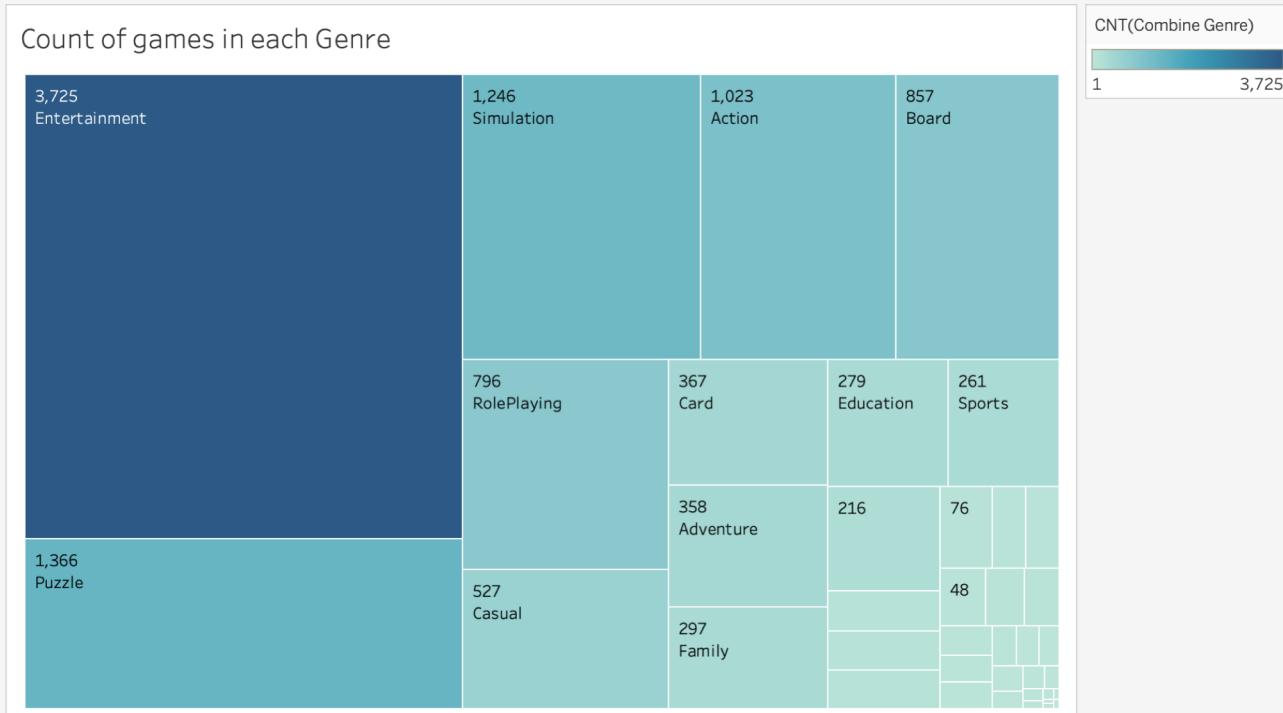
- Optimize the predictive model by training on more data from Android platform
- Further explore the topic modeling by optimizing stop word selection and associating the topics to each game

Thank you!



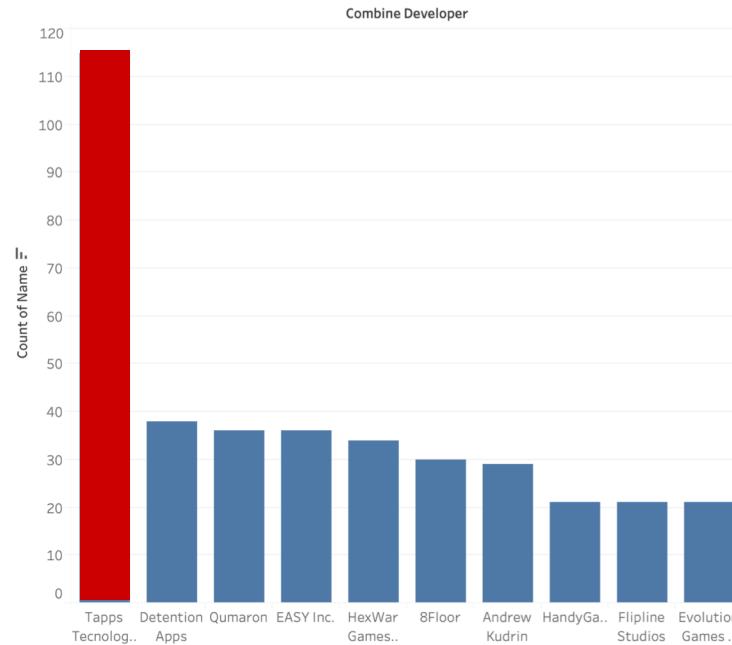
Supplementary Information

Game Genre Distribution

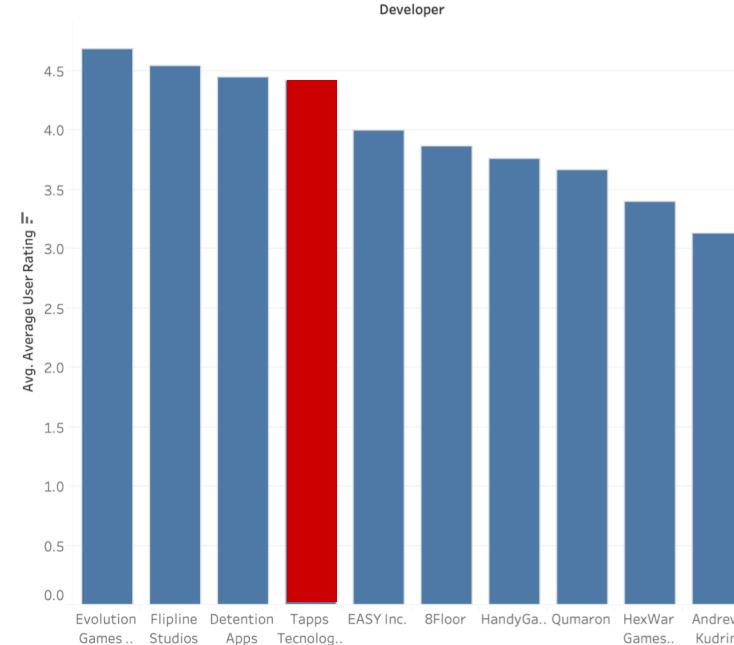


Top 10 Developers

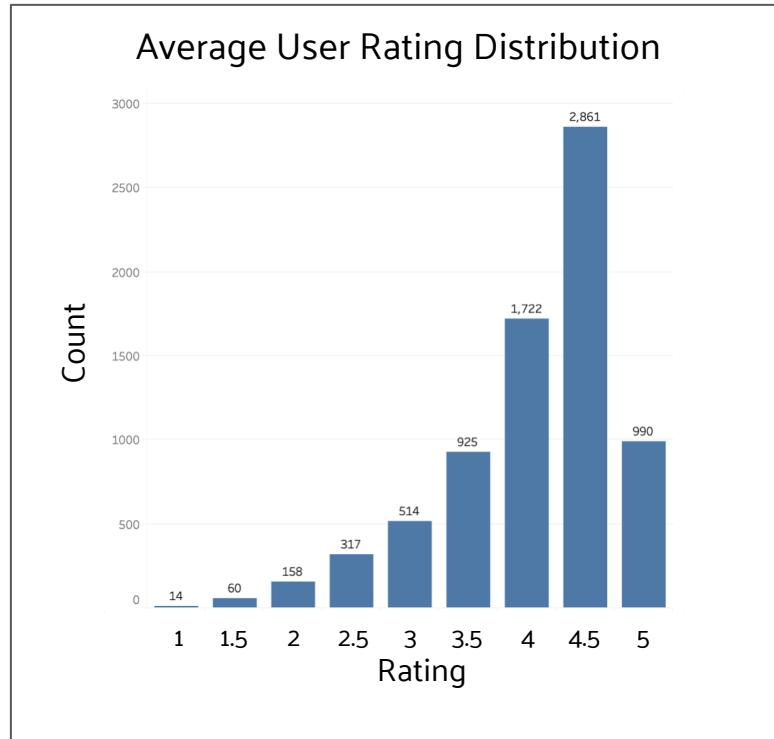
Top 10 Developers with the most games published



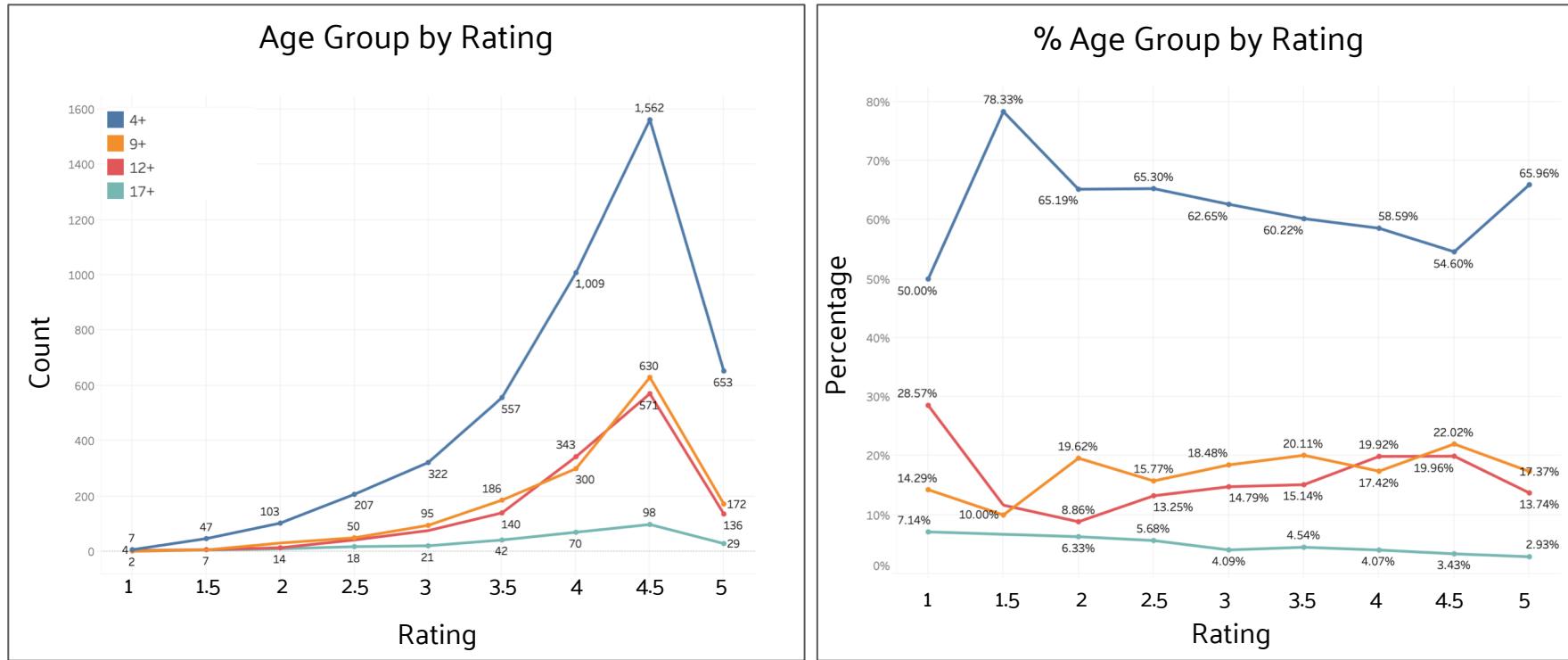
Avg user rating by Top 10 Developer



User Rating Distribution



Games with Wider Age Group are More Popular



Takeaway: develop strategy games with art designs and contents for wider age group



Hyperparameters and Optimized Parameters for RF

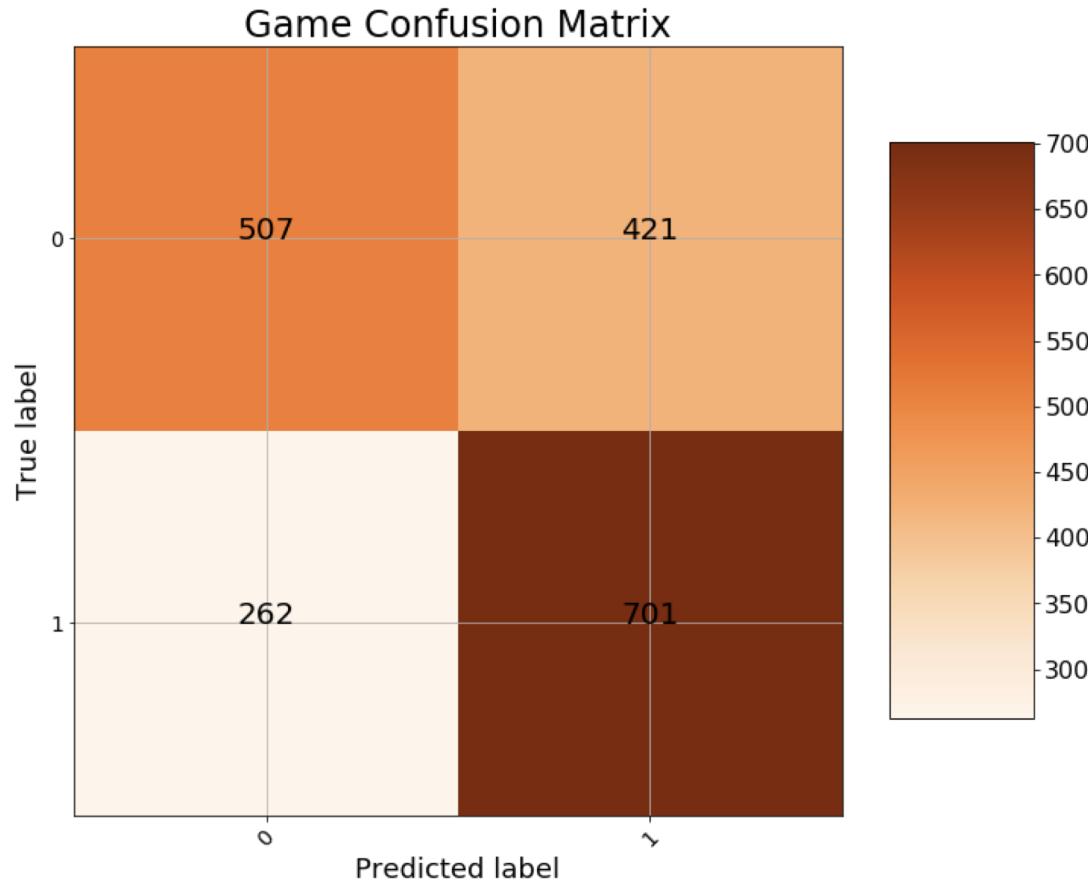
```
# Hyperparameter grid
param_grid2 = {
    'n_estimators': np.linspace(10, 1000).astype(int),
    'max_depth': [None] + list(np.linspace(3, 100).astype(int)),
    'max_features': ['auto', 'sqrt', None] + list(np.arange(0.5, 1, 0.1)),
    'max_leaf_nodes': [None] + list(np.linspace(10, 50, 500).astype(int)),
    'min_samples_leaf': [5, 20, 50],
    'min_samples_split': [2, 5, 10],
    'bootstrap': [True, False]
}
```



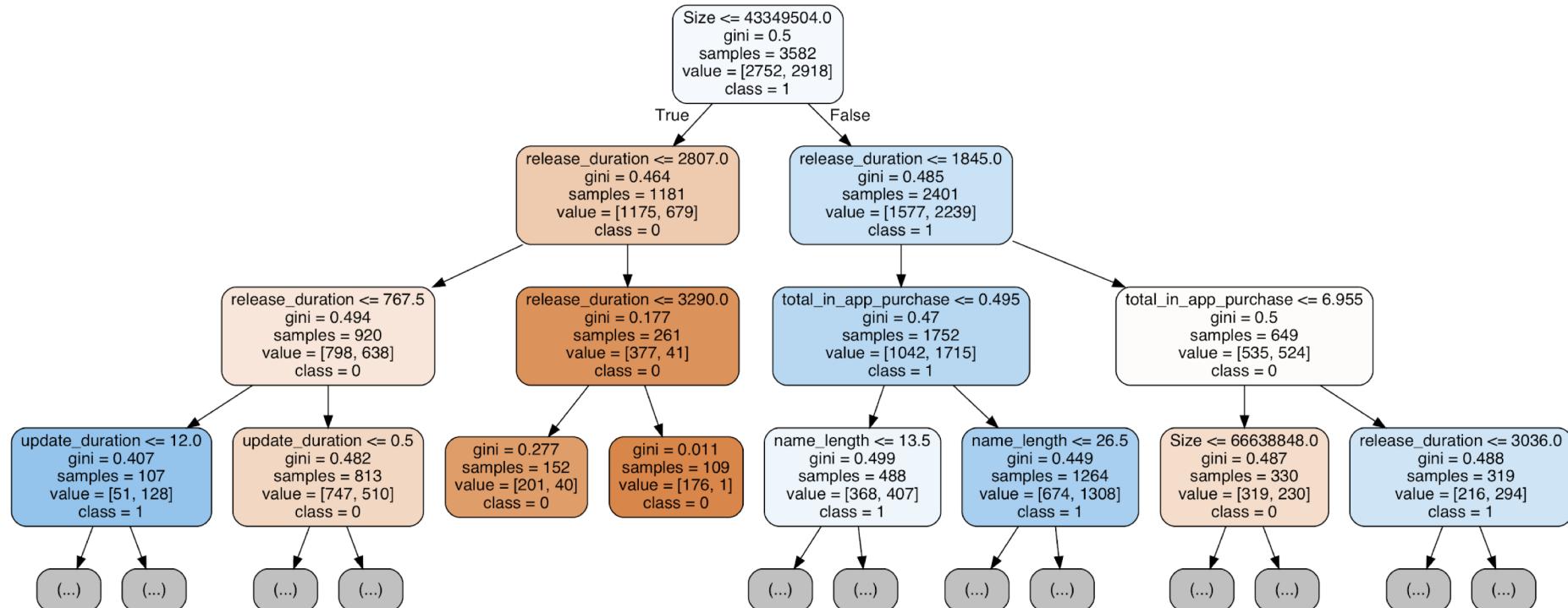
rfs2.best_params_

```
{'n_estimators': 232,
'min_samples_split': 10,
'min_samples_leaf': 20,
'max_leaf_nodes': 42,
'max_features': 0.7999999999999999,
'max_depth': 96,
'bootstrap': True}
```

■ Confusion Matrix for Optimized Random Forest Model



One Tree from Optimized Random Forest Model



Good Game Topics From LDA Model

```
LDA_model.print_topics()
```

```
[(),  
 '0.129*"level" + 0.027*"time" + 0.022*"star" + 0.019*"move" + 0.019*"easy" + 0.016*"fun" + 0.014*"hard" + 0.013*"difficulty" + 0.011*"chess" + 0.011*"challenge"),  
(1,  
 '0.073*"fun" + 0.049*"great" + 0.049*"time" + 0.038*"love" + 0.028*"good" + 0.019*"much" + 0.018*"graphic" + 0.017*"simple" + 0.015*"lot" + 0.013*"addictive"),  
(2,  
 '0.075*"good" + 0.033*"ship" + 0.016*"space" + 0.013*"past" + 0.013*"town" + 0.013*"job" + 0.011*"setting" + 0.010*"evolution" + 0.009*"country" + 0.009*"super"),  
(3,  
 '0.072*"puzzle" + 0.040*"score" + 0.036*"color" + 0.023*"number" + 0.021*"high" + 0.018*"background" + 0.017*"game" + 0.017*"block" + 0.013*"epic" + 0.012*"mistake"),  
(4,  
 '0.033*"player" + 0.028*"tower" + 0.021*"attack" + 0.019*"defense" + 0.017*"war" + 0.017*"monster" + 0.014*"resource" + 0.013*"alliance" + 0.012*"server" + 0.012*"hero"),  
(5,  
 '0.028*"character" + 0.017*"great" + 0.016*"mode" + 0.014*"unit" + 0.014*"different" + 0.014*"enemy" + 0.014*"one" + 0.013*"good" + 0.012*"app" + 0.010*"story"),  
(6,  
 '0.076*"ad" + 0.021*"update" + 0.021*"option" + 0.018*"customer" + 0.017*"bug" + 0.016*"version" + 0.015*"video" + 0.015*"issue" + 0.015*"watch" + 0.014*"free"),  
(7,  
 '0.044*"love" + 0.025*"music" + 0.021*"sound" + 0.017*"ball" + 0.016*"effect" + 0.015*"crash" + 0.015*"graphic" + 0.013*"amazing" + 0.012*"ridiculous" + 0.012*"fight"),  
(8,  
 '0.035*"time" + 0.022*"people" + 0.021*"good" + 0.016*"fun" + 0.015*"new" + 0.014*"thing" + 0.014*"lot" + 0.013*"great" + 0.013*"player" + 0.013*"little"),  
(9,  
 '0.045*"money" + 0.028*"card" + 0.028*"time" + 0.020*"level" + 0.019*"gem" + 0.016*"gold" + 0.016*"day" + 0.015*"coin" + 0.015*"player" + 0.015*"free")]
```

Bad Game Topics From LDA Model

```
LDA_model_worst.print_topics()  
  
[(0,  
  '0.080*"level" + 0.034*"gold" + 0.027*"right" + 0.020*"cube" + 0.020*"stuff" + 0.020*"thank" + 0.018*"error" + 0.  
018*"pop" + 0.016*"building" + 0.015*"computer"''),  
 (1,  
  '0.064*"time" + 0.040*"first" + 0.030*"open" + 0.028*"single" + 0.026*"glitch" + 0.025*"level" + 0.022*"fix" + 0.  
020*"crap" + 0.018*"phone" + 0.016*"board"''),  
 (2,  
  '0.050*"card" + 0.040*"download" + 0.035*"review" + 0.034*"good" + 0.032*"game" + 0.027*"life" + 0.026*"name" + 0  
.023*"prestige" + 0.023*"bad" + 0.017*"iphone"''),  
 (3,  
  '0.045*"level" + 0.032*"crash" + 0.028*"upgrade" + 0.028*"update" + 0.025*"money" + 0.025*"time" + 0.024*"buildin  
g" + 0.022*"app" + 0.020*"ship" + 0.018*"great"''),  
 (4,  
  '0.053*"top" + 0.029*"issue" + 0.029*"good" + 0.026*"purchase" + 0.025*"idea" + 0.022*"developer" + 0.022*"update  
" + 0.019*"playstation" + 0.017*"thing" + 0.016*"hard"''),  
 (5,  
  '0.027*"user" + 0.026*"place" + 0.023*"terrible" + 0.023*"watch" + 0.018*"option" + 0.016*"quality" + 0.015*"unit  
" + 0.015*"love" + 0.014*"turn" + 0.014*"favorite"''),  
 (6,  
  '0.062*"tower" + 0.050*"fix" + 0.043*"load" + 0.027*"level" + 0.024*"move" + 0.017*"nice" + 0.016*"force" + 0.016  
*"stuck" + 0.016*"little" + 0.015*"certain"''),  
 (7,  
  '0.101*"ad" + 0.049*"many" + 0.026*"lot" + 0.023*"review" + 0.023*"time" + 0.021*"second" + 0.021*"control" + 0.0  
19*"minute" + 0.018*"money" + 0.018*"black"''),  
 (8,  
  '0.031*"money" + 0.029*"day" + 0.028*"option" + 0.026*"bar" + 0.025*"week" + 0.023*"shut" + 0.018*"close" + 0.018  
*"waste" + 0.017*"many" + 0.015*"phone"''),  
 (9,  
  '0.032*"star" + 0.027*"problem" + 0.021*"money" + 0.020*"great" + 0.017*"fake" + 0.017*"win" + 0.015*"start" + 0.  
015*"time" + 0.014*"bad" + 0.014*"much"'')]
```

Good Game Example - Tower Defense Game



Gameplay

Upgrade, War, Mode,
Challenge, Building, Attack,
Defense



Art design

Graphic, Music,
Sound



User experience

Money, Purchase, Free



App quality

Version



Good Game Example - Puzzle Type Game



Gameplay

Challenge, Puzzle, Level



Art design

Graphic, Music,
Sound



User experience

Time, Free, Purchase,
Money



App quality

Update, Version