Virtual Reality Application Comfort Level Rating Evaluator

LYU2201 Final Year Project Term1 Presentation
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Outline

- Introduction
- Background
- Motivation
- Data Preparation
- Models
- Experiments
- Conclusion

Introduction

- Virtual Reality (VR)

Virtual reality is a simulated experience that use pose tracking and 3D displays to give the user an immersive feel of a virtual world[1].

- Virtual Reality Application

VR video game

VR education

Virtual meeting

Introduction

- Problem

1 in 400 people may experience terrible dizziness while using VR[2].

Introduction

- VR Application Comfort Level Rating

Comfortable
Avoid camera movement, player motion, or disorienting effects.

Moderate
Some camera movement, player motion, or occasionally disorienting effects.

Intense
Significant camera movement, player motion, or disorienting effects.

Introduction

- Comfort application example

Job simulator

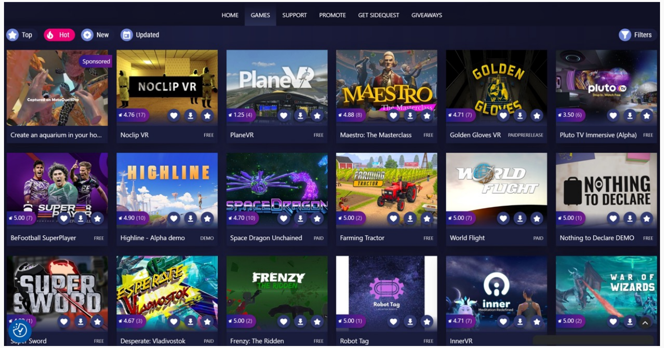
- Intense application example

Epic roller coasters

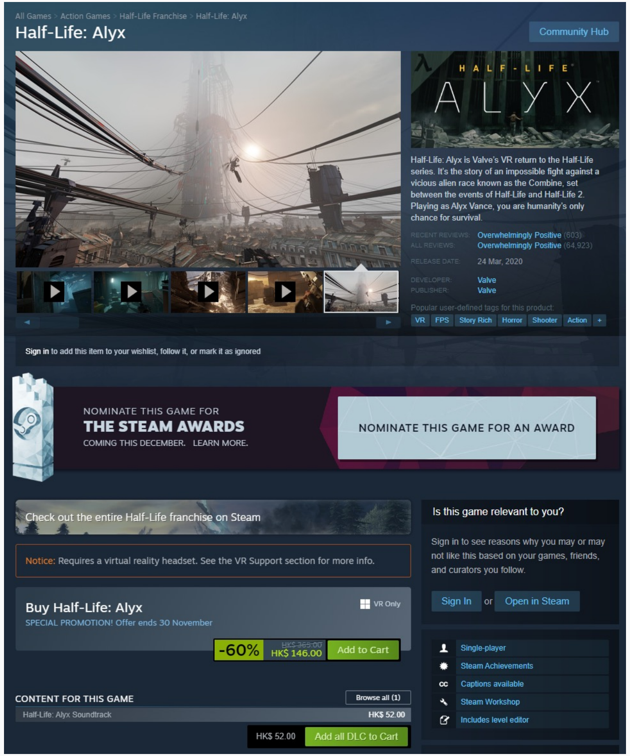
Background

- Five VR application platforms

Steam, Oculus Store, Oculus App Lab, SideQuest, and VIVEPORT.



Background



All Games > Action Games > Half-Life Franchise > Half-Life: Alyx

Half-Life: Alyx

Community Hub

Half-Life: Alyx is Valve's VR return to the Half-Life series. It's the story of an impossible fight against a vicious alien race known as the Combine, set between the events of Half-Life and Half-Life 2. Playing as Alyx Vance, you are humanity's only chance for survival.

RECENT REVIEWS: Overwhelmingly Positive (603)
ALL REVIEWS: Overwhelmingly Positive (64,923)

RELEASE DATE: 24 Mar, 2020

DEVELOPER: Valve
PUBLISHER: Valve

Popular user-defined tags for this product:
VR FPS Story Rich Horror Shooter Action +

Sign in to add this item to your wishlist, follow it, or mark it as ignored

NOMINATE THIS GAME FOR
THE STEAM AWARDS
COMING THIS DECEMBER. LEARN MORE.

NOMINATE THIS GAME FOR AN AWARD

Check out the entire Half-Life franchise on Steam

Notice: Requires a virtual reality headset. See the VR Support section for more info.

Buy Half-Life: Alyx
SPECIAL PROMOTION! Offer ends 30 November

VR Only

-60% ~~HK$ 365.00~~ HK$ 146.00 Add to Cart

CONTENT FOR THIS GAME Browse all (1)

Half-Life: Alyx Soundtrack HK$ 52.00

HK$ 52.00 Add all DLC to Cart

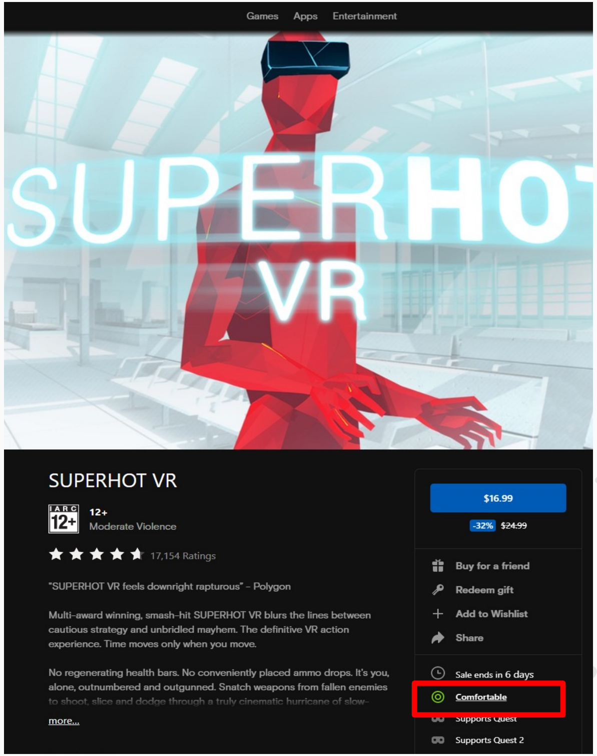
Is this game relevant to you?

Sign in to see reasons why you may or may not like this based on your games, friends, and curators you follow.

Sign In or Open in Steam

- Single-player
- Steam Achievements
- Captions available
- Steam Workshop
- Includes level editor

Application page on Steam



Games Apps Entertainment

SUPERHOT VR

IARC 12+
12+
Moderate Violence

★★★★★ 17,154 Ratings

"SUPERHOT VR feels downright rapturous" – Polygon

Multi-award winning, smash-hit SUPERHOT VR blurs the lines between cautious strategy and unbridled mayhem. The definitive VR action experience. Time moves only when you move.

No regenerating health bars. No conveniently placed ammo drops. It's you, alone, outnumbered and outgunned. Snatch weapons from fallen enemies to shoot, slice and dodge through a truly cinematic hurricane of slow–

more...

$16.99

-32% ~~$24.99~~

Buy for a friend
Redeem gift
Add to Wishlist
Share

Sale ends in 6 days
Comfortable
Supports Quest
Supports Quest 2

Application page on Oculus Store

Motivation

- To systematically determine a comfort level rating of a VR application is time-consuming.

- A quick comfort level rating evaluator tool can benefit the users, developers as well as the VR application platforms.

Motivation

- User

It can help the users who tend to feel discomfort when experience intense content.

- Developer

It can help developers at the application development stage and improve the final product quality.

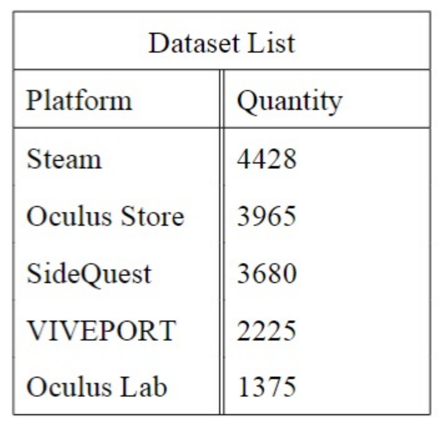
- Platform

It can reduce the financial and time consumption to determine the comfort level rating of the application.

Data preparation

- Utilized *scrapy* to collect application information from the five VR application platform.

- Dataset Quantity



Dataset List	
Platform	Quantity
Steam	4428
Oculus Store	3965
SideQuest	3680
VIVEPORT	2225
Oculus Lab	1375

Data preparation

- Game description

Example from *Ocean Rift* :

Ocean Rift is the world's first VR aquatic safari park. Explore a vivid underwater world full of life including dolphins, sharks, turtles, sea snakes, rays, whales, manatees, sea lions and even prehistoric animals! You are free to swim around each of the 14 habitats using innovative motion controls. Activate the education mode to learn more about the animals you come across. There are over 40 fully narrated information points to find.

- User reviews

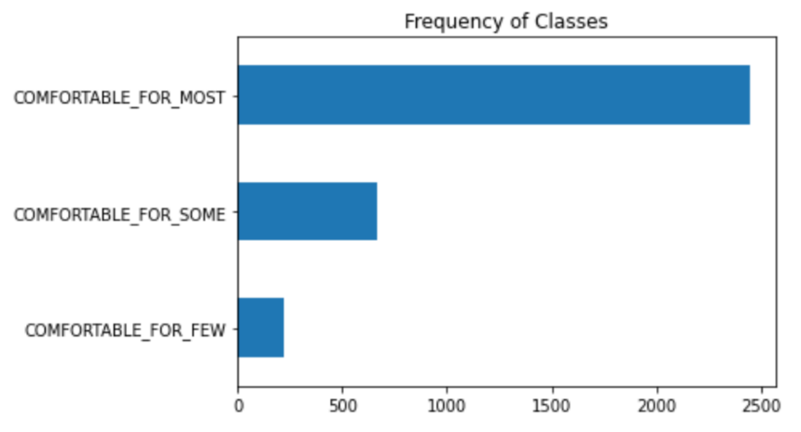
Examples from *Ocean Rift* :

1. I bought this years ago for my old Oculus Go, and it's still a great app on Quest years later. A wonderful way to relax, as long as you steer clear of the great whites and sea monsters.

2.I’m not a video game guy but my friend said to give this a try. It is outstanding. Watch out for the whales, they sneak up behind you!!!

Data analysis

- Oculus Store dataset:



- Problem

Imbalanced data[3] – the number of each category differs significantly

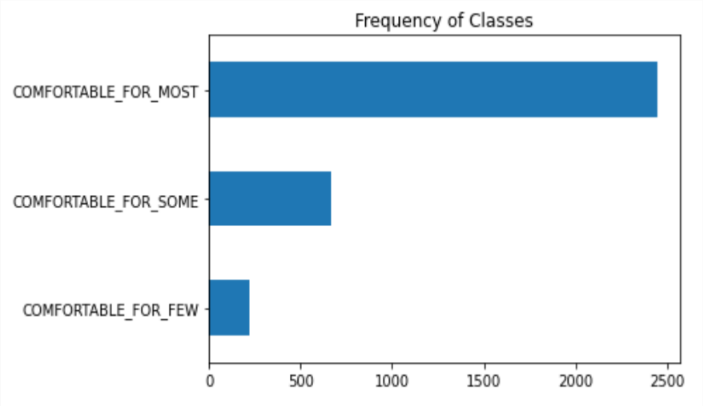
Mitigate the Problem

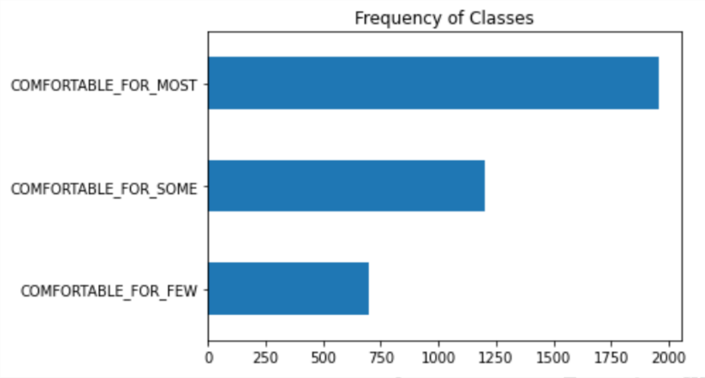
- Over-sampling

Over-sample the data samples of a minority class.

- Under-sampling

Under-sample the data samples of a majority class.





Oversampled Training Dataset

Feature Engineering

Feature engineering[4] is an important part of the machine learning workflow, which is to "translate" the raw data into a form that the model can understand.

- Count Vectors
- TF-IDF Vectors
- Word Embeddings

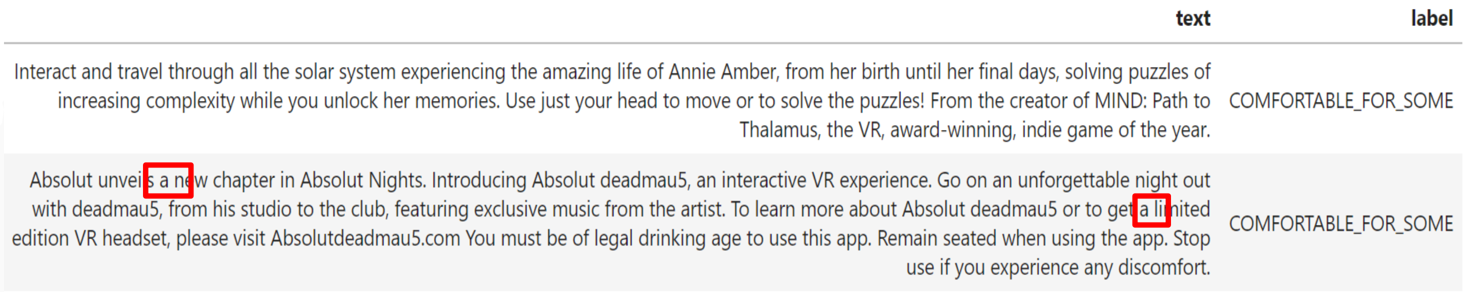
Feature Engineering

- Count Vectors[5]

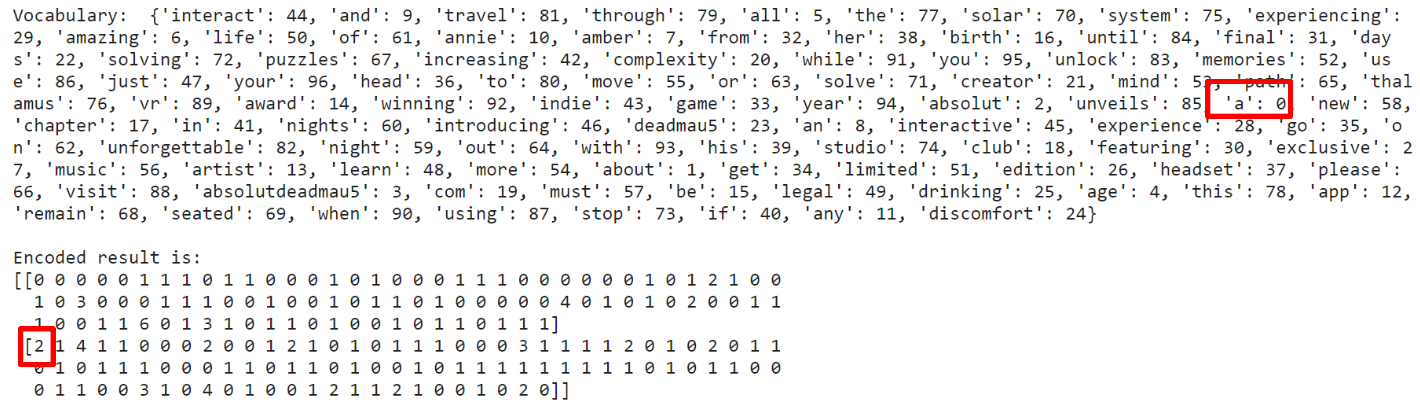
Count Vector is a matrix notation of the dataset in which every row represents a document from the corpus, and every cell represents the frequency count of a term in the document.

Count Vectors

- Example



text	label
Interact and travel through all the solar system experiencing the amazing life of Annie Amber, from her birth until her final days, solving puzzles of increasing complexity while you unlock her memories. Use just your head to move or to solve the puzzles! From the creator of MIND: Path to Thalamus, the VR, award-winning, indie game of the year.	COMFORTABLE_FOR_SOME
Absolut unveils a new chapter in Absolut Nights. Introducing Absolut deadmau5, an interactive VR experience. Go on an unforgettable night out with deadmau5, from his studio to the club, featuring exclusive music from the artist. To learn more about Absolut deadmau5 or to get a limited edition VR headset, please visit Absolutdeadmau5.com You must be of legal drinking age to use this app. Remain seated when using the app. Stop use if you experience any discomfort.	COMFORTABLE_FOR_SOME



```
Vocabulary:  {'interact': 44, 'and': 9, 'travel': 81, 'through': 79, 'all': 5, 'the': 77, 'solar': 70, 'system': 75, 'experiencing':
29, 'amazing': 6, 'life': 50, 'of': 61, 'annie': 10, 'amber': 7, 'from': 32, 'her': 38, 'birth': 16, 'until': 84, 'final': 31, 'day
s': 22, 'solving': 72, 'puzzles': 67, 'increasing': 42, 'complexity': 20, 'while': 91, 'you': 95, 'unlock': 83, 'memories': 52, 'us
e': 86, 'just': 47, 'your': 96, 'head': 36, 'to': 80, 'move': 55, 'or': 63, 'solve': 71, 'creator': 21, 'mind': 53, 'path': 65, 'thal
amus': 76, 'vr': 89, 'award': 14, 'winning': 92, 'indie': 43, 'game': 33, 'year': 94, 'absolut': 2, 'unveils': 85, 'a': 0, 'new': 58,
'chapter': 17, 'in': 41, 'nights': 60, 'introducing': 46, 'deadmau5': 23, 'an': 8, 'interactive': 45, 'experience': 28, 'go': 35, 'o
n': 62, 'unforgettable': 82, 'night': 59, 'out': 64, 'with': 93, 'his': 39, 'studio': 74, 'club': 18, 'featuring': 30, 'exclusive': 2
7, 'music': 56, 'artist': 13, 'learn': 48, 'more': 54, 'about': 1, 'get': 34, 'limited': 51, 'edition': 26, 'headset': 37, 'please':
66, 'visit': 88, 'absolutdeadmau5': 3, 'com': 19, 'must': 57, 'be': 15, 'legal': 49, 'drinking': 25, 'age': 4, 'this': 78, 'app': 12,
'remain': 68, 'seated': 69, 'when': 90, 'using': 87, 'stop': 73, 'if': 40, 'any': 11, 'discomfort': 24}

Encoded result is:
[[0 0 0 0 0 1 1 1 0 1 1 0 0 0 1 0 1 0 0 0 1 1 1 0 0 0 0 0 0 1 0 1 2 1 0 0
  1 0 3 0 0 0 1 1 1 0 0 1 0 0 1 0 1 1 0 1 0 0 0 0 0 4 0 1 0 1 0 2 0 0 1 1
  1 0 0 1 1 6 0 1 3 1 0 1 1 0 1 0 0 1 0 1 1 0 1 1 1]
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  0 1 1 0 0 3 1 0 4 0 1 0 0 1 2 1 1 2 1 0 0 1 0 2 0]]
```

Feature Engineering

- TF-IDF Vectors[6]

Let’s define some notations, N is the number of samples we have in our dataset, d is a given sample from our dataset, D is the collection of all samples, and w is a given word in a sample.

TF-IDF score is composed by two parts:

✓ Term Frequency (TF):

$$\mathrm{TF}(w, d) = \log\left(1 + f(w, d)\right)$$

,where $f(w,d)$ is the frequency of the term w in the sample d.

✓ Inverse Document Frequency (IDF):

$$IDF(w, D) = \log\left(\frac{N}{f(w, D)}\right)$$

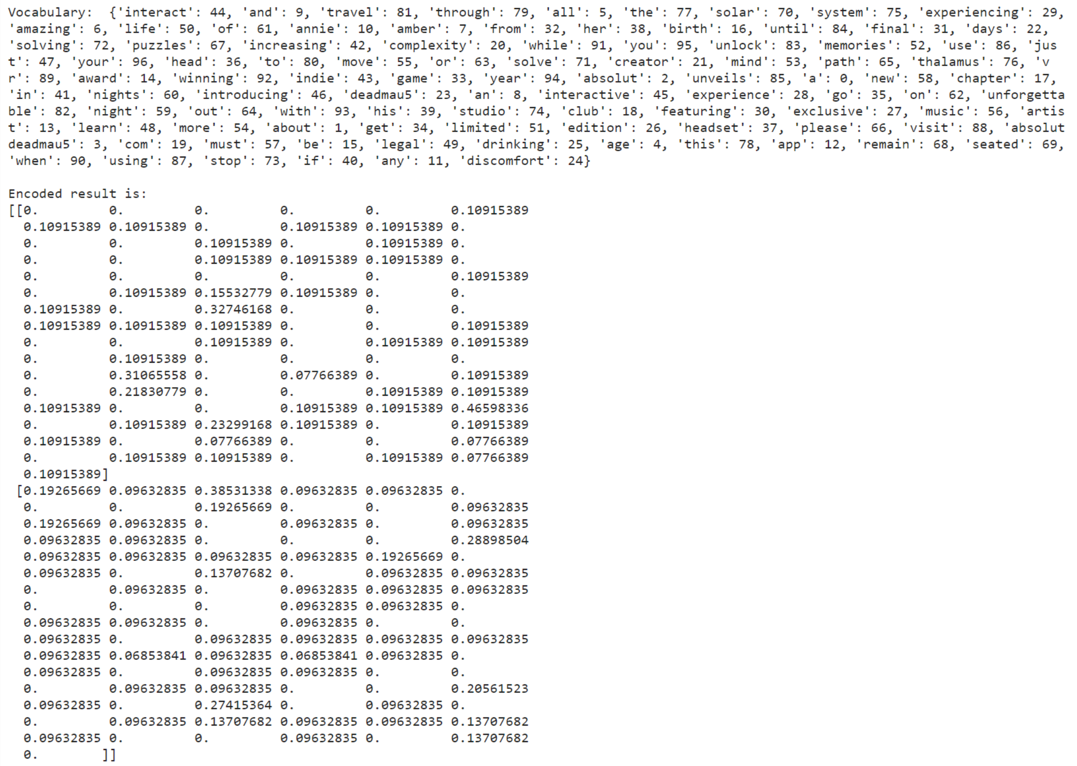
,where $f(w,$D) is the number of samples containing term w.

TF-IDF score (TF-IDF):

$$TF\_IDF(w, d, D) = TF(w, d) \times IDF(w, D)$$

TF-IDF Vectors

- Example



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deadmau5': 3, 'com': 19, 'must': 57, 'be': 15, 'legal': 49, 'drinking': 25, 'age': 4, 'this': 78, 'app': 12, 'remain': 68, 'seated': 69,
'when': 90, 'using': 87, 'stop': 73, 'if': 40, 'any': 11, 'discomfort': 24}

Encoded result is:
[[0.         0.         0.         0.         0.         0.10915389
  0.10915389 0.10915389 0.         0.10915389 0.10915389 0.
  0.         0.         0.10915389 0.         0.10915389 0.
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  0.         0.         0.         0.         0.         0.10915389
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  0.         0.10915389 0.         0.         0.         0.
  0.         0.31065558 0.         0.07766389 0.         0.10915389
  0.         0.21830779 0.         0.         0.10915389 0.10915389
  0.10915389 0.         0.         0.10915389 0.10915389 0.46598336
  0.         0.10915389 0.23299168 0.10915389 0.         0.10915389
  0.10915389 0.         0.07766389 0.         0.         0.07766389
  0.         0.10915389 0.10915389 0.         0.10915389 0.07766389
  0.10915389]
 [0.19265669 0.09632835 0.38531338 0.09632835 0.09632835 0.
  0.         0.         0.19265669 0.         0.         0.09632835
  0.19265669 0.09632835 0.         0.09632835 0.         0.09632835
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  0.09632835 0.09632835 0.09632835 0.09632835 0.19265669 0.
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  0.09632835 0.         0.27415364 0.         0.09632835 0.
  0.         0.09632835 0.13707682 0.09632835 0.09632835 0.13707682
  0.09632835 0.         0.         0.09632835 0.         0.13707682
  0.        ]]
```

Feature Engineering

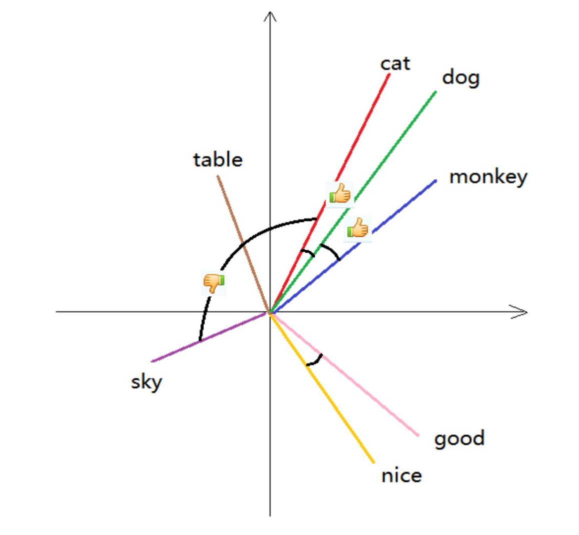
- Word Embeddings[7]

Word embedding is a form of representing words and documents using a dense vector representation.

Benefit: semantically similar words could be “close” in the vector space!

Word Embeddings

- For example



projection of the embedding vectors to 2D

For our experiments, we used a pre-trained word embeddings, wiki-news-300d-1M.vec[8].

Models

- Naive Bayes Classifier[9]

Naive Bayes is a classification technique based on Bayes’ Theorem with an assumption of independence among predictors.

- Bayes’ Theorem[10]

$$P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$$

$$P\left(y \mid x_1, \ldots, x_n\right) = \frac{P\left(x_1 \mid y\right) P\left(x_2 \mid y\right) \ldots P\left(x_n \mid y\right) P(y)}{P\left(x_1\right) P\left(x_2\right) \ldots P\left(x_n\right)}$$

For one of our training sample, X is given as

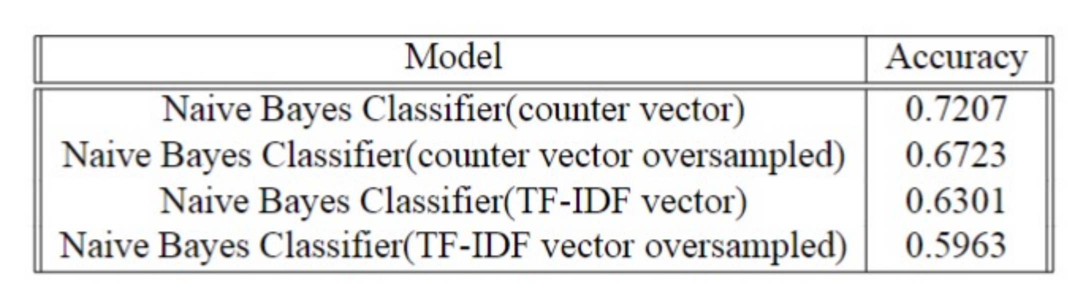
$$X = (x_1, x_2, x_3, \ldots., x_n)$$

Therefore, the prediction is to find the y attaining the maximum of LHS

$$y = \operatorname{argmax}_y P(y) \prod_{i=1}^{n} P\left(x_i \mid y\right)$$

Models

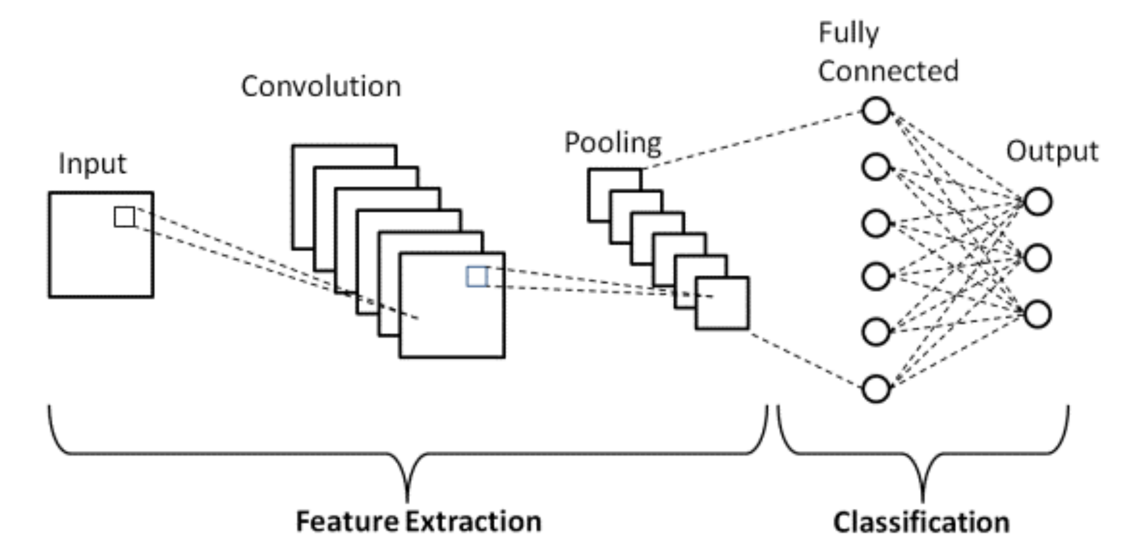
- Naive Bayes Classifier

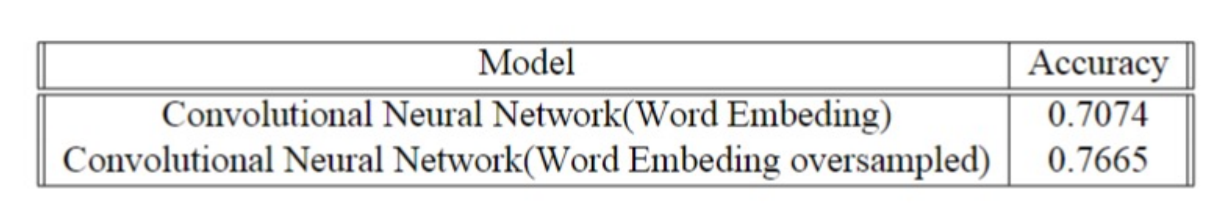


Model	Accuracy
Naive Bayes Classifier(counter vector)	0.7207
Naive Bayes Classifier(counter vector oversampled)	0.6723
Naive Bayes Classifier(TF-IDF vector)	0.6301
Naive Bayes Classifier(TF-IDF vector oversampled)	0.5963

Models

- Convolutional Neural Network (CNN)[11]

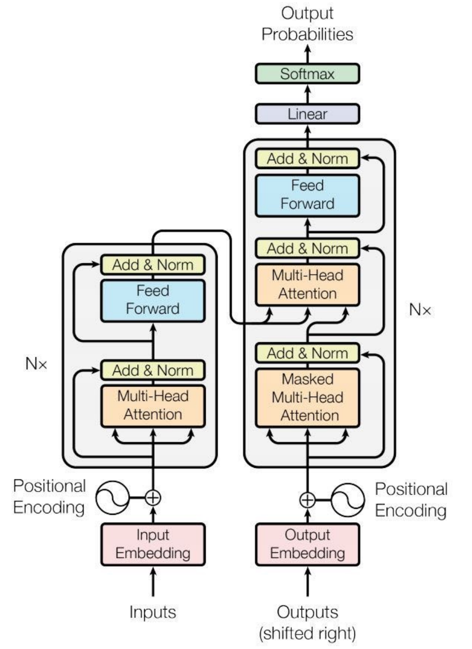




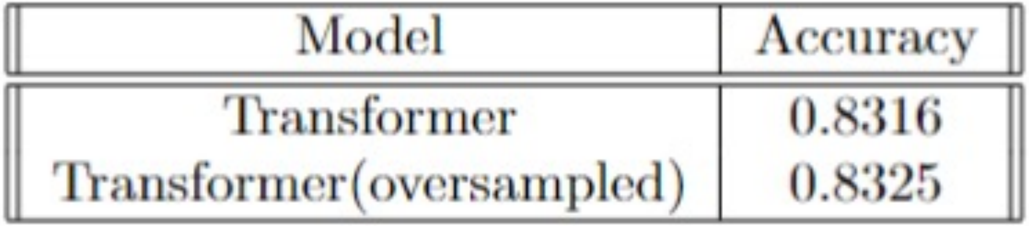
Model	Accuracy
Convolutional Neural Network(Word Embeding)	0.7074
Convolutional Neural Network(Word Embeding oversampled)	0.7665

Models

- Transformer[12]



Transformer encoder and decoder architecture

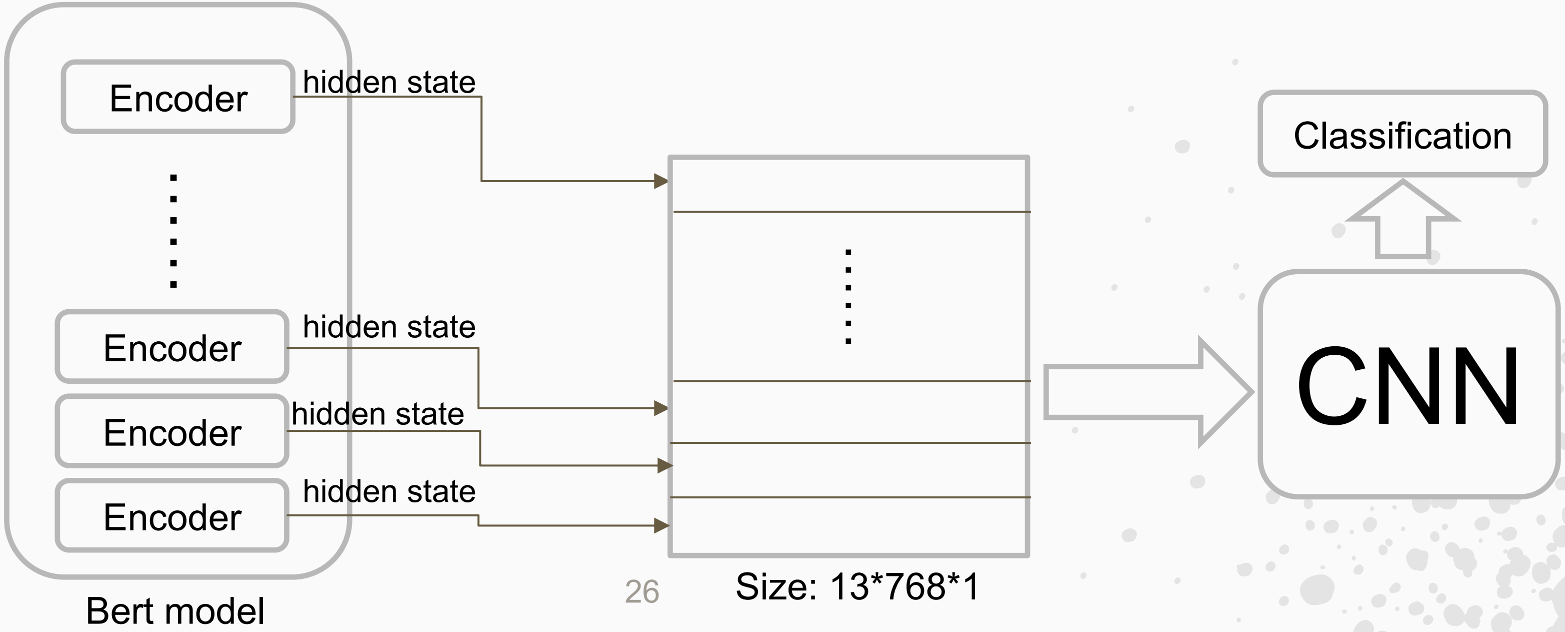


Model	Accuracy
Transformer	0.8316
Transformer(oversampled)	0.8325

Models

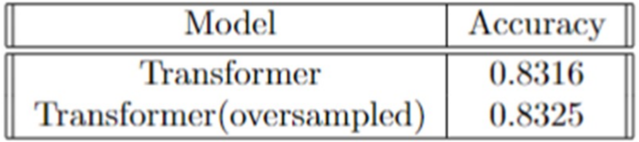
- My modification(Transformer-CNN)

Based on transformer, the BERT transformer model has 13 encoder layers, and each layer has a hidden state.

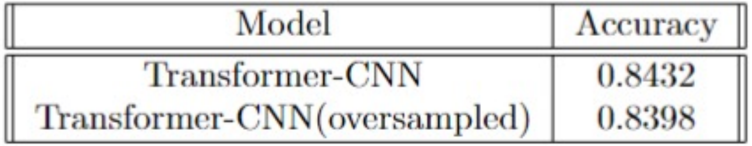


Models

- Result comparing



Model	Accuracy
Transformer	0.8316
Transformer(oversampled)	0.8325



Model	Accuracy
Transformer-CNN	0.8432
Transformer-CNN(oversampled)	0.8398

With CNN modification

Conclusion

- Feature engineering of the counter vector is better than that of the TF-IDF vector in this task.
- For data imbalance problem, oversampling approach could improve accuracy of neutral network model.
- The transformer model performs the best among the models.
- Adding a CNN module behind the transformer model can indeed improve its performance.

Future Work

- Use more extra information to feed models, such as applications’ images, videos, etc.
- Adapt the neural network structure to suit this particular task.

Thank You!

References

[1] Wikipedia. Virtual reality, 2022.

[2] Paola Araiza-Alba, Therese Keane, and Jordy Kaufman. Are we ready for virtual reality in k–12 classrooms? Technology, Pedagogy and Education, 31(4):471–491, 2022.

[3] Giovanna Menardi and Nicola Torelli. Training and assessing classification rules with imbalanced data. Data Mining and Knowledge Discovery, 28:92–122, 2012.

[4] Alice Zheng and Amanda Casari. Feature engineering for machine learning: principles and techniques for data scientists. " O'Reilly Media, Inc.", 2018.

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[11] Keiron O’Shea and Ryan Nash. An introduction to convolutional neural networks, 2015.

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Q&A