



# CS6109 - Compiler Design

## Project Documentation

### Predicting and Classifying Interests of Users Based on Direct Interactions

#### Team - 3

Vivek Ramkumar, 2018103082

Kariketi Tharun Reddy, 2018103034

G. R. Srikanth, 2018103603

## Introduction:

The basis of our project is to provide a textual analysis of the interactions between multiple users, and predict their interests, as well as categorize them.

This is an important function of recommendation systems, that is, to offer a personalized experience for each user, by understanding their preferences.

Direct interactions between users will be subject to lexical, syntax and semantic analysis, from which we will obtain their preferences to items, as well as actions and hobbies.

## List of Modules:

We will employ the standard principles of compiler design, up to intermediate code generation. Lexical, syntax and semantic analysis will be used in the following order to analyse the input text:

1. Identify tokens (cricket, leather bag, smart phone) and verbs in the continuous sense (e.g. eating, playing) and such, using lexical analysis.
2. Obtain the sentiment of the users to find out whether they like the item or not, and show the dependency trees for each dialogue.
3. Getting a long, unorganized list of possible recommendations based on the users' interests, without sentiment considerations.
4. Recommending the products to the users with respect to sentiment, and recommending alternatives based on the interests of friends to users with negative sentiments.

The result will be an organized collection of information obtained from the interaction, showing the preferences and their respective categories.

## Literature Survey:

No	Publication	Author, Year	Methodology	Advantages	Limitations
1.	Short systematic review on e-learning recommender systems	W.M.Chughtai, A.B.Selama, Imran Ghani (2013)	Content-Based Filtering, Hybrid-Based Filtering, Knowledge-Based Filtering	Useful insight on the cold-start issue in e-learning recommender systems.	Limited to four types of filtering approaches.
2.	A systematic review of scholar context-aware recommender systems	Z.D.Champiri, S.R.Shahmirib, S.S.B.Salima (2015)	Kitchenham Systematic Review Methodology	Categorises recommendations into user's context, document context and env. context.	Requires tracking and analyzing previous students' interactions.
3.	Recommender Systems: Review	Akshita.J, Smita.A (2013)	Content-Based Filtering	Discusses various techniques.	Requires combination with hybrid recommenders.
4.	A literature review and classifications of recommender systems research	D.H.Park, H.K.Kim, I.Y.Choi, J.K.Kim (2012)	Data Mining Techniques (K-Means, Link Analysis, etc.)	Provides insight about future trends in the field of recommender systems.	Limited to eight types of data mining techniques.
5.	The use of machine learning algorithms in recommender systems	Ivens Portugal, Paulo Alencar, Donald Cowan (2015)	Bayesian and Decision Tree Algorithms	Identifies research opportunities for software engineering research.	Nowadays, DL algorithms surpass ML algorithms in speed and power.

## Problem Statement:

We can understand that we now have pre-trained deep learning models to work with, over machine learning models.

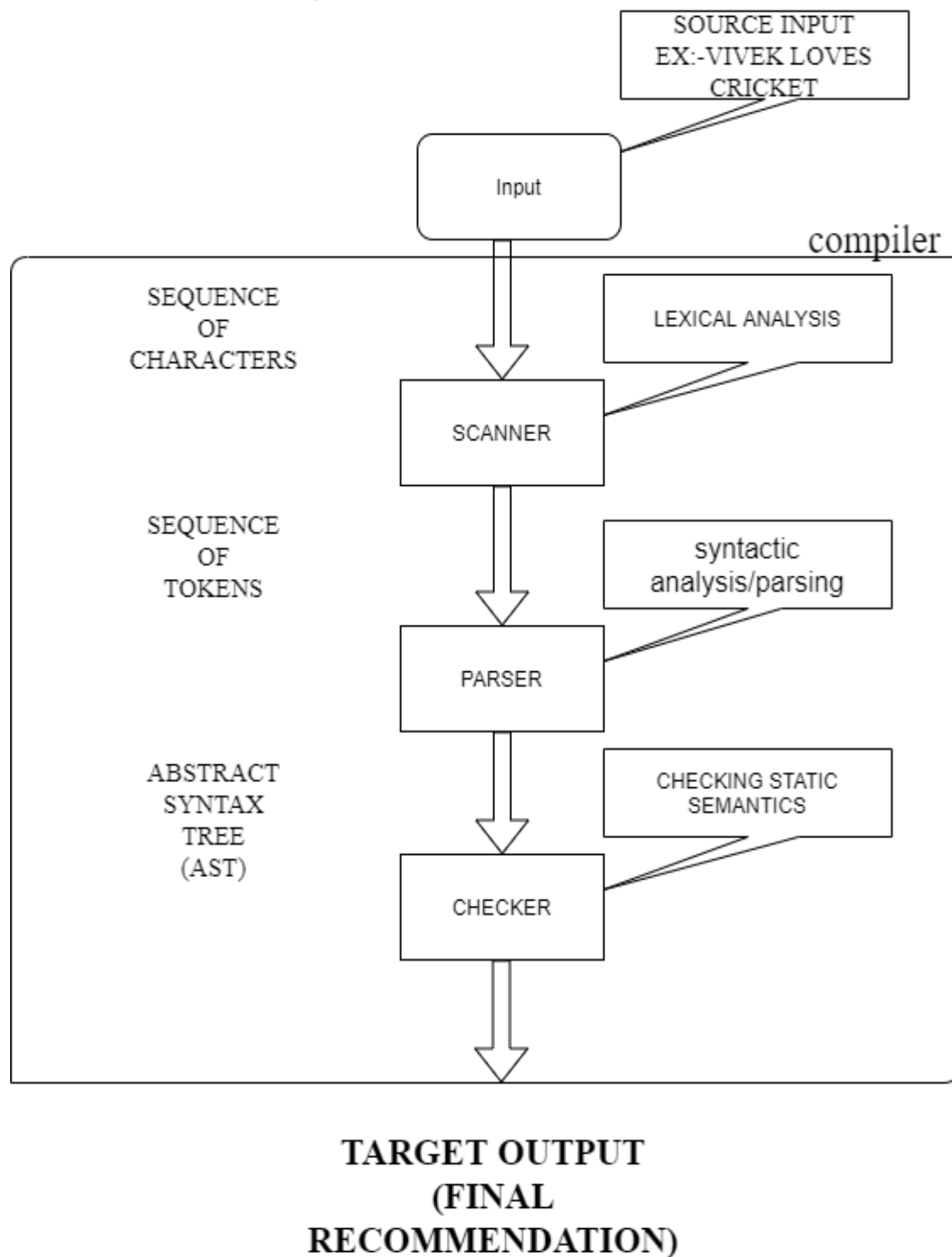
We will try to separate the tokens and tag them, whilst filtering out useless words.

The sentiment of the user's statement also needs to be considered while recommending.

To obtain the raw recommendations, we need to check for correlations between the tokens and the product names.

Organizing the recommendations and allocating them to each user will give us our final set of recommendations.

## Architecture Diagram:



## Pseudocode:

### Module - I:

For each dialogue in conversation:

    Split dialogue in tokens and store them

    doc = nlp(dialogue)

    For each token in token\_list:

        if tag == 'NOUN', add to noun\_list

        else if tag == 'VERB' add to verb\_list

    End for loop...

*#Using Spacy's functions, we can identify entities.*

    For entity in doc.ents:

        Append entity to users

        Append entity\_lab to user\_types

    End for loop...

End for loop....

*#Remove any leftover stop words in the nouns list*

nouns = [word for word in nouns if not word in stopwords.words()]

Store all tokens in a data frame, and return the data frame

## Module - II:

#Obtain sentiments using the NLTK Vader Sentiment Analyzer

Create a data frame to store sentiment values

sid = SentimentIntensityAnalyzer()

For each dialogue in conversation:

    Calculate polarity scores for each dialogue

    Append values to sentiments data frame corresponding  
    to each sentiment

    Return the sentiment values data frame

End for loop....

*#Displaying the dependency trees....*

For each dialogue in conversation:

*#Use loaded dictionary of English words from Spacy library*

    nlp = spacy.load('en\_core\_web\_md')

    doc = nlp(dialogue)

*#Displacy is a visualization library for NLP*

    displacy.render(doc, style = 'dep')

End for loop...

### Module - III:

For each noun in noun\_list:

    For each item in complete\_list:

        If lower(noun) is present in lower(item name):

            Append item name to temp\_list

        End for loop...

    Append temp\_list to init\_rec

End for loop...

Return the list init\_rec

### Module - IV:

For index in the range of length of init\_rec:

    If sentiment for user[index] is positive:

        Append random items to final\_rec[index]

    If sentiment for user[index] is negative:

        Choose random items from other user interests

        Append those to final\_rec[index]

*#We have chosen to recommend 5 items per user*

    If sentiment for user[index] is neutral:

        Append random items to final\_rec[index]

End for loop...

Return the list of lists final\_rec

## List of Modules (in detail):

### Module - 1:

The main focus of lexical analysis is to obtain tokens from the given text input.

We need to differentiate between entities (users, organizations, religion, etc.) and interests (garments, tech, etc.).

The technique we are going to employ is called POS tagging. (POS -> Part of Speech)

POS tagging algorithms allocate tags to each token, such as "NOUN", "VERB", "ADJ", etc., based on the similarity to their respective tagged categories.

We will be using the Spacy library, which contains pre-trained NLP models and a huge dictionary of words.

The input is parsed sentence by sentence, from which nouns, verbs, users, and user types are obtained. The respective information is summarized in a pandas data frame.

Keep in mind the input is made to understand short conversations - especially one-liners. Basically, we separate the text blob by the '\n', or newline symbol. This is done by using the splitlines() function.

If any respective dialogue consists of two lines, the parser will be confused and allocate an extra user to the extra line.

This is done with consideration to social messaging applications, as users frequently communicate with short dialogues.



## Module - II:

The main point of understanding the syntax of the sentence is to check the order by which tokens are parsed.

For example, seeing a "not" before a verb, say "enjoying", can imply a negative sentiment.

Sentiment analysis is an important tool in recommendation - it helps recommend products to those who want it.

People who express negative sentiment towards a product will not receive recommendations on it.

Instead, they will get recommendations based on what their friends like.

The NLTK Vader Sentiment Analyzer is an excellent tool for quickly analyzing the sentiment of a sentence.

We will obtain the polarity scores in each sentiment category, i.e "Positive", "Negative", "Neutral", and "Compound", for each user.

The Spacy library consists of one more feature - the ability to show dependency trees.

Dependency trees are useful in understanding the parsing process, in pursuit of finding the sentiments.

The arrows infer dependencies between words. If an arrow points from 'a' to 'b', then it can be understood that 'a' depends on 'b'.

This is useful in seeing how the tokens are tagged, and how the sentence is syntactically analyzed.

## Module - III:

We will check the list of nouns from our summary of tokens to see what the interests of the users are.

If the particular noun is present in any product name, we will store that product name in a new list.

This new list is considered as our initial set of recommendations.

Now, our initial recommendations are quite a large number.

We will pick five products at random, to recommend to each user.

Of course, we do not want to get the same products again in our random selection.

This is easily achieved by using `random.sample(list, k)`, where `k` is the number of items selected. This function also ensures that there is no repetition in the selection of items.

## Module - IV:

This is the final recommendation.

You can see the user's names followed by a list of recommendations based on their interests.

Keep in mind that for the most part the recommendations are accurate, but you may chance upon some outliers, due to the random nature of product selection.

As stated before, the sentiment of the user is considered as a factor in the recommendation process. The compounded polarity score is considered here.

If a user's sentiment is negative, then we pick a random recommendation based on the interests of that user's friends.

Otherwise, if it is positive or neutral, we can directly recommend based on their individual interest.

# Input:

The screenshot shows a Kaggle notebook interface. The notebook is titled "Recommender\_System\_CD\_Project" and is a Python notebook using data from multiple data sources. The main content area displays the following text:

Input and Output

This is the input text.

Every time you want to get some new recommendations, tweak this and run the cells below it.

```
In [17]: text = """ Rahul : I like to play on my tablet.
Gokul : My dog does not enjoy using dog shampoo.
Ankita : I love to wear a kurta.
Badrinath : I frequently wear a shirt.
Vijay : I am searching for a nice watch.
Srikanth : I like to play cricket."""
```

```
In [18]: conversation, token_summary = get_tokens(text)
```

The right sidebar shows the notebook's version (18 of 18) and a list of sections: Notebook, CS6109 - Compiler Design Project, Importing Standard Libraries, Obtaining Data, Lexical Analysis, Syntax Analysis, Input (3), Execution Info, Log, and Comments (0).

# Output:

## Module 1(tokenization):

The screenshot shows the same Kaggle notebook interface, but now displaying the output of the tokenization module. The main content area displays the following text:

```
In [19]: token_summary
```

```
Out[19]:
```

	Users	Nouns	Verbs	User_Types
0	[Rahul]	[tablet]	[like, play]	[PERSON]
1	[Gokul]	[dog, shampoo]	[enjoy, using]	[PERSON]
2	[Ankita]	[kurta]	[love, wear]	[PERSON]
3	[Badrinath]	[shirt]	[wear]	[PERSON]
4	[Vijay]	[watch]	[searching]	[PERSON]
5	[Srikanth]	[cricket]	[like, play]	[PERSON]

```
In [20]: sentiments = get_sentiments(conversation)
```

```
In [21]: sentiments
```

The right sidebar shows the notebook's version (18 of 18) and a list of sections: Notebook, CS6109 - Compiler Design Project, Importing Standard Libraries, Obtaining Data, Lexical Analysis, Syntax Analysis, Input (3), Execution Info, Log, and Comments (0).

## Module 2(Syntax analyser):

The screenshot shows a Kaggle notebook interface. The left sidebar contains the Kaggle logo and navigation links: Home, Compete, Data, Notebooks (selected), Discuss, Courses, and More. Below these are 'Recently Viewed' items. The main area displays the notebook 'Recommender\_System\_CD\_Project' by user 'danoozy44'. The code cell 'In [21]:' shows the variable 'sentiments'. The output 'Out[21]:' is a table with sentiment scores for five dialogues.

	Dialogue	Compound	Negative	Neutral	Positive
0	Rahul : I like to play on my tablet.	0.5994	0.000	0.505	0.495
1	Gokul : My dog does not enjoy using dog shampoo.	-0.3875	0.247	0.753	0.000
2	Ankita : I love to wear a kurta.	0.6369	0.000	0.488	0.512
3	Badrinath : I frequently wear a shirt.	0.0000	0.000	1.000	0.000
4	Vijay : I am searching for a nice watch.	0.4215	0.000	0.641	0.359
5	Srikanth : I like to play cricket.	0.5994	0.000	0.380	0.620

Below the table, text explains that arrows infer dependencies between words in dependency trees and that this is useful for seeing how tokens are tagged and how the sentence is syntactically analyzed.

The right sidebar shows 'Version 18 of 18', a 'Notebook' link, and a table of contents with items like 'CS6109 - Compiler Design Project', 'Importing Standard Libraries', 'Obtaining Data:', 'Lexical Analysis:', 'Syntax Analysis: Input (3)', 'Execution Info', 'Log', and 'Comments (0)'.

## Module 3(Initial Recommendation):

The screenshot shows the same Kaggle notebook interface. The code cell 'In [23]:' shows the function call 'rec\_1 = create\_init\_rec(token\_summary)'. The output 'Out[23]:' is a list of product names recommended for the user.

```
['cm key 354 Wired USB Tablet Keyboard',  
'Shortcut enterprises Model no 488 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 456 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 428 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 483 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 476 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 477 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 497 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 460 Mobile/Tablet Speaker',  
'Shortcut enterprises Model no 434 Mobile/Tablet Speaker',  
'couponsmall key 343 Wired USB Tablet Keyboard',  
'Oriental Universal 360° Rotation Rubber Suction Cup Car Mount Stand H  
older ABS Colorful For Tablet PC & Mobile Phone',  
'i-Static Universal Car Tablet Holder',  
'Autosun OK Stand Smartphone & Tablet Stand',  
'Smartpro 10.5v,2.9a for Tablet Charger 75 Adapter',  
'Generix pack of 5 Micro USB On-the-go For Mobile Phones & Tablets OTG  
Cable',  
'Generix Pack of 2 Micro USB On-the-go For Mobile Phones & Tablets OTG  
Cable',
```

The right sidebar shows 'Version 19 of 19', a 'Notebook' link, and the same table of contents as in the previous screenshot.



Micros: x | Sign in: x | Online: x | Cloud: x | Subnet: x | Recom: x | Java Sc: x | localh: x | Recom: x | Whats: x | cs6109: x | +

kaggle.com/danoozy44/recommender-system-cd-project

Machine learning ... Vimala vishnu MP3Juices - Free M... 4:11 Watch later Google Translate Watch Indian TV Se... opencv-face-recog... WhatsApp Other bookmarks

kaggle

Home Compete Data Notebooks Discuss Courses More

Recently Viewed

- Recommender\_Syst...
- Haarcascades
- Python Dataset Dow...
- Reddit India Flair De...
- View Active Events

Search

```
t',
'APS Sleeve for iBall Slide 7334q Tablet',
'BILLYS Cases with Holder for All 7 Inch Tab/Tablet 360° Rotating',
'Fastway Book Cover for Wespro 7 Inch Capacitiv Tablet',
'APS Sleeve for Datawind Ubislate 18Ci Tablet',
'APS Sleeve for Vox V105 Calling Tablet',
'iCare Flip Cover for Universal Rotate 7 inch Tablet',
'Unique Designes Flip Cover for domo x3G tablet (7inch)',
'Cotab R2 \xa0360 Degree rotatable Ring stand holder for all smartphon
es , Tablets & iPhones Mobile Holder Mobile Holder',
'Shortkut enterprises 510 Mobile/Tablet Speaker',
'Corcepts Universal Tablet HD Ultra Clear Transparency Guard Glass for
8" Tablet spg8105 Tempered Glass for Dell Venue 8 Tablet (WiFi+3G+32G
B)',
'Corcepts Universal Tablet HD Ultra Clear Transparency Guard Glass for
8" Tablet spg8126 Tempered Glass for Lenovo Miix 2 180UT OF STOCK',
'All-New Fire HD 8 Tablet, 8 HD Display, Wi-Fi, 16 GB - Includes Speci
al Offers, Magenta',
'All-New Fire HD 8 Tablet, 8 HD Display, Wi-Fi, 32 GB - Includes Speci
al Offers, Magenta',
'Fire HD 8 Tablet with Alexa, 8 HD Display, 32 GB, Tangerine - with Sp
ecial Offers,',
'Amazon SW USB Official OEM Charger and Power Adapter for Fire Tablets
and Kindle eReaders,,,\r\nAmazon SW USB Official OEM Charger and Power A
```

Version 19 of 19

Notebook

CS6109 - Compiler Design Project

Importing Standard Libraries:

Obtaining Data:

Lexical Analysis:

Syntax Analysis:

Input (3)

Execution Info

Log

Comments (0)

Micros: x | Sign in: x | Online: x | Cloud: x | Subnet: x | Recom: x | Java Sc: x | localh: x | Recom: x | Whats: x | cs6109: x | +

kaggle.com/danoozy44/recommender-system-cd-project

Machine learning ... Vimala vishnu MP3Juices - Free M... 4:11 Watch later Google Translate Watch Indian TV Se... opencv-face-recog... WhatsApp Other bookmarks

kaggle

Home Compete Data Notebooks Discuss Courses More

Recently Viewed

- Recommender\_Syst...
- Haarcascades
- Python Dataset Dow...
- Reddit India Flair De...
- View Active Events

Search

Recommender\_System\_CD\_Project

Python notebook using data from multiple data sources · 51 views · 9m ago

```
['Puma evoSPEED HPI Willow Cricket Bat',
'Metro Sports Leather Cricket Ball - Size: 5, Diameter: 23 cm',
'SG VS 319 Plus Kashmir Willow Cricket Bat',
'SG RSD Plus Kashmir Willow Cricket Bat',
'AVM Splash 20-20 Kashmir Willow Cricket Bat',
'SS Ton Professional English Willow Cricket Bat',
'SS Ton Heritage English Willow Cricket Bat',
'GM Purist 909 English Willow Cricket Bat',
'CW Legend Tennis Kashmir Willow Cricket Bat',
'SM Bravo Kashmir Willow Cricket Bat',
'Spick Cricket Shoes',
'SS League Special Cricket Ball',
'SM Sway Cricket Ball - Size: 5, Diameter: 2.5 cm',
'Sun Sports Hanging Ball Club Cricket Ball - Size: 5, Diameter: 2.5
cm',
'SG Prosoft Cricket Ball',
'APG Diamond Cricket Ball - Size: 5, Diameter: 2.5 cm',
'Stanford League Special Cricket Ball - Size: 5.1\\2, Diameter: 1.5
cm',
'THREE WICKETS Tricolor Kashmir Willow Cricket Bat']]
```

Version 19 of 19

Notebook

CS6109 - Compiler Design Project

Importing Standard Libraries:

Obtaining Data:

Lexical Analysis:

Syntax Analysis:

Input (3)

Execution Info

Log

Comments (0)

## Module 4(Final recommendation):

The screenshot shows a Kaggle notebook titled "Recommendations are:". The notebook content is as follows:

```
Recommendations are:

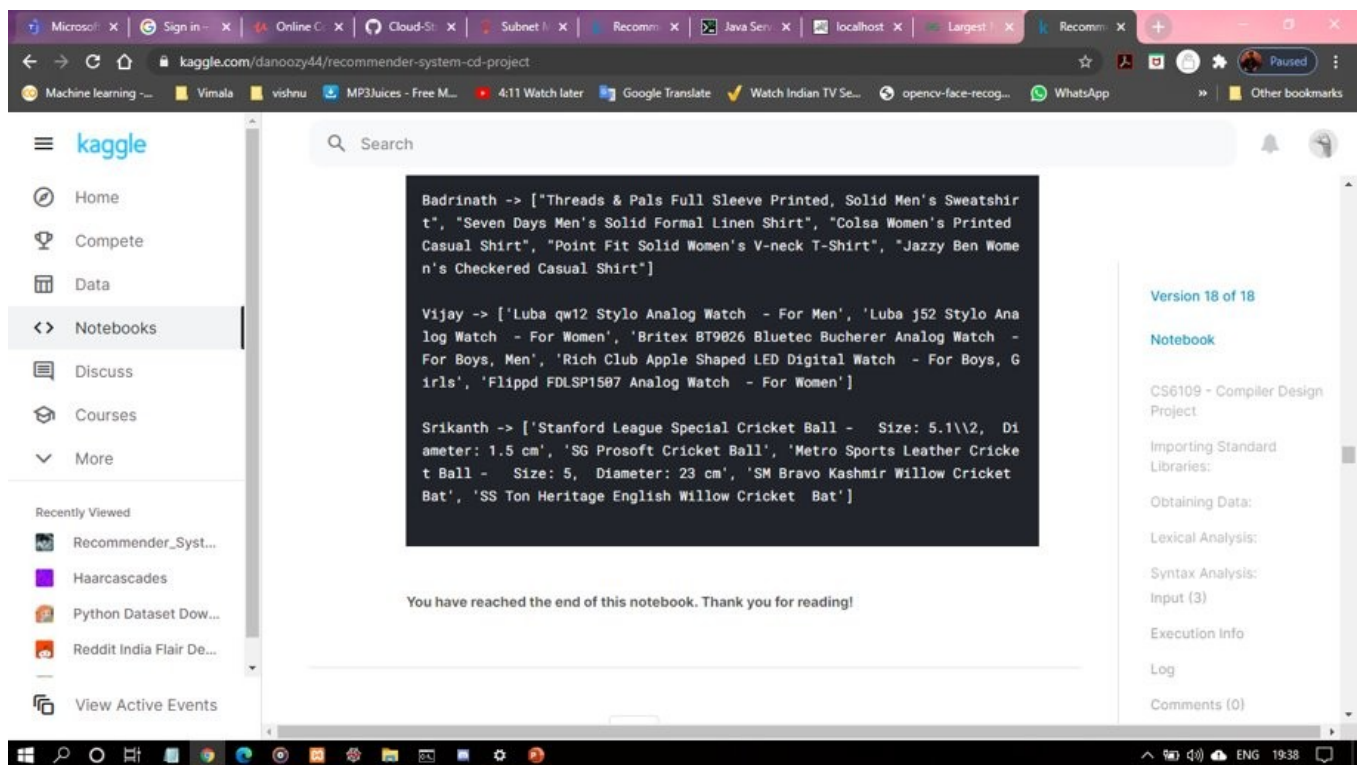
Rahul -> ['All-New Fire HD 8 Tablet, 8" HD Display, Wi-Fi, 32 GB - Includes Special Offers, Black', 'Amazon Fire HD 6 Standing Protective Case(4th Generation - 2014 Release), Cayenne Red', 'Amazon 5W USB Official OEM Charger and Power Adapter for Fire Tablets and Kindle eReaders', 'Amazon 9W PowerFast Official OEM USB Charger and Power Adapter for Fire Tablets and Kindle eReaders', 'Amazon 9W PowerFast Official OEM USB C charger and Power Adapter for Fire Tablets and Kindle eReaders', 'Generic Pack of 2 Micro USB On-the-go For Mobile Phones & Tablets OTG Cable', 'All-New Fire HD 8 Tablet, 8 HD Display, Wi-Fi, 16 GB - Includes Special Offers, Magenta']

Gokul -> ['All-New Fire HD 8 Tablet, 8 HD Display, Wi-Fi, 16 GB - Includes Special Offers, Magenta', 'Salwar Studio Self Design Kurta & Salwar', 'gurjari oxidised kurta button brooch Brooch', 'Threads & Pals Full Sleeve Printed, Solid Men's Sweatshirt', 'Rich Club Apple Shaped LED Digital Watch - For Boys, Girls', 'SS Ton Heritage English Willow Cricket Bat']

Ankita -> ['gurjari oxidised kurta button brooch Brooch', 'Salwar Studio Self Design Kurta & Salwar', 'Fab Nisa Solid Women's Straight Kurta', 'Cynthia's Fashion Women's, Girl's Kurta, Pyjama & Dupatta Set', 'Lajo Women's Kurta, Pyjama & Dupatta Set']
```

The right sidebar of the notebook shows the following information:

- Version 18 of 18
- Notebook
- CS6109 - Compiler Design Project
- Importing Standard Libraries:
- Obtaining Data:
- Lexical Analysis:
- Syntax Analysis:
- Input (3)
- Execution Info
- Log
- Comments (0)



## Results Discussion:

Since we've checked for subsequences of the occurring string, the nouns, inside product names, of course we cannot guarantee an accuracy of 100%.

Regardless, the recommendation system seems to work fairly well - it recommends what the users want based on their interests.

For users with negative sentiment - it doesn't recommend the products associated with the user. Rather, it recommends products associated with the user's friends.

We also ensure any product recommendation is not repeated for the same user.

The end result is fairly straight-forward. It works for most cases, with some exceptions, a rare case.

S.No	Input	Module I (Tokenization)	Module II (Compound Sentiment)	Module III (Initial Rec.)	Module IV (Output)
1.	Rahul : I like to play on my tablet.  Ankita : I love to wear a kurta.	[Rahul][tablet][like, play] [PERSON]  [Ankita][kurta][love, wear] [PERSON]	0.5994  0.6369	Long list of tech and garment products including tablets and kurtas	Fire Tablet with Alexa, Fab Nisa Solid Women's Straight Kurta
2.	John : Do you like this shirt?  Adam : Yes, I like this shirt very much.	[John][shirt][like][PERSON]  [Adam][shirt][like][PERSON]	0.333  0.510	Long list of garment products, primarily shirts.	JadeBlue Men's Self Design Formal Linen Shirt, Palm Tree Printed Boy's Round Neck T-Shirt
3.	John : Is this laptop good?  Adam : No, it is not a good laptop.	[John][laptop][][PERSON]  [Adam][laptop][][PERSON]	0.4404  -0.5583	Long list of laptop batteries, tech products and laptops.	HP Pavilion G71 6 Cell Laptop Battery, and dummy recommendations, as Adam has a negative sentiment.
4.	John : Hello.  Adam : Hey.	[John][][][PERSON]  [Adam][][][PERSON]	0.0  0.0	List not generated, as no products mentioned.	No recommendations, as it is a neutral conversation.
5.	Vivek : I like to play cricket.  Srikanth : I also like to play cricket.	[Vivek][cricket][like, play] [PERSON]  [Srikanth][cricket][like, play] [PERSON]	0.5994  0.5994	Long list of cricket balls, bats, stumps, gloves, helmets and apparel.	SM Bravo Kashmir Willow Cricket Bat, Spick Cricket Shoes, APG Diamond Cricket Ball - Size: 5, Diameter: 2.5 cm
6.	Caesar : What do you think of this helmet?  Brutus : It's a very good helmet, sire.	[Caesar][helmet][think] [PERSON]  [Brutus][helmet, sire][] [PERSON]	0.0  0.4927	Long list of bike helmets, construction helmets and such.	Saviour HPSAV FR SS1 RE Freedom With Ratchet Red Construction Helmet, Autoplus AH6 Helmet Lock
7.	Donatello : We should get a new microwave.  D'Artagnan : No need! The heat of our laptop is more than enough.  Plumius: I think a fire will do the trick.	[Donatello][microwave][should] [PERSON]  [D'Artagnan][need, heat, laptop] [PERSON]  [Plumius][fire, trick][think, will] [PERSON]	0.00  -0.3595  -0.3818	Long list of mixed products, including kitchenware and technology gadgets.	No recommendation, as the algorithm has extracted negative sentiments from two statements.



8.	Shelly : I'm going to buy a new watch.  Chrissy : I'll provide you company!	[Shelly][watch][going, buy][PERSON]  [Chrissy][company]['ll, provide][PERSON]	0.0  0.0	Long list of apparel, including hand-wear and watches.	Realme Classic Watch(Black Strap, Regular), Casio G-Shock World time Analog-Digital Multi-Colour Dial Men's Watch
9.	Andy : This towel has become rough.  Travis : Has it? Use the shirt on the drying rack instead. It's better.	[Andy][towel][become][PERSON]  [Travis][shirt, drying, rack][Use][PERSON]	0.0  0.4404	Long list of garments, mostly shirts and towels.	Amber Cotton Bath Towel, JBG Home Store Cotton Face Towel, Huetrap Graphic Print Men's Round Neck T-Shirt
10.	Lin-Yang : What a smooth car! You are very lucky.  Leopold : Yes, it cost me a lot. Nice colour, isn't it?	[Lin-Yang][car][][PERSON]  [Leopold][lot, colour][cost][PERSON]	0.5244  0.6705	Long list of automobile-based apparel, and miscellaneous products.	Allure Auto CM 1599 Car Mat Honda Mobilio, Packy Poda Car Mat Nissan Terrano, Allure Auto CM 1159 Car Mat Ford Fiesta

## Conclusion:

The information obtained from direct interactions can be a valuable tool, as we can create recommendation systems on the basis of user-user interactions, such as comments on a forum, rather than user-site interactions.

Previous systems understand and provide recommendations based on similarities between users, which might lead to a bias evaluation for user preferences. This provides a solution for this issue by integrating direct interactions into recommendation systems.

However, there is still much left to improve, and a full accuracy of such systems is never guaranteed, but this approach will definitely up the bar in extending further recommendation systems.

## References:

1. C.Li, F.Xiong, "Social Recommendations with Multiple Influence from Direct User Interactions", Aug. 2017.
2. C. Pan, W. Li, Research paper recommendation with topic analysis in Computer Design and Applications IEEE, 4 (2010), pp. V4-264
3. J.A. Konstan, J. Riedl, Recommender Systems: From Algorithms to User Experience, User Model User-Adapt Interact, 22 (2012), pp. 101-123