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ITEM-BASED COLLABORATIVE FILTERING BASED ON NLP TECHNIQUES

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Abstract. The benchmark approach to content-based recommendation systems is exposed in this article. The usage of Word2Vec embeddings made by Google is unleashed. The opportunity of using additional business logic is considered.

Keywords: NLP techniques, Word2Vec, CountVectorizer, cosine similarity, embeddings, content based system, content based recommendation, user based recommendation.

Аннотация. В данной работе представлен подход к рекомендательным системам на основе каталога. Показано использование Word2Vec эмбеддингов, представленных Google. Описана возможность использования дополнительной бизнес логики.

Ключевые слова: NLP подходы, Word2Vec, CountVectorizier, косинусная похожесть, ембеддинги, система основаная на каталоге, рекомендации основанные на каталоге, рекомендации основанные на пользователях.

Анотація. У цій роботі представлено алгоритм для вирішення проблеми рекомендацій на основі каталога. Показано використання Word2Vec ембеддінгів, представленных Google.

Ключові слова: NLP підходи, Word2Vec, CountVectorizier, косинусна схожість, ембеддинги, система основана на каталозі, рекомендації основані на користувачах. DOI: https://doi.org/10.31649/1999-9941-2021-51-2-17-22.

Introduction

Understanding users' preferences and proposing them the most relevant products is essential for every commercial business which involves the process of interacting with users. As nowadays the web infrastructure is developing rapidly, lot's of commercial activities move to the space of the internet. Thus, the demand for recommendation systems arises. Recommendation system is an engine which goal is to recommend relevant items to users. Many world famous companies like Netflix, Amazon, YouTube, etc, use them to attract more people to their websites and increase their income. The recommendation systems can be divided into two groups: content based [1] and user based [2]. Content based recommendation systems focus on the content, its taxonomy and metadata for making predictions, while the user based ones require user interactions like clicks or ratings the user left for items. Nevertheless user based recommendation systems are much more powerful than content based, they require lot's of computational power that can afford working with big data. On the opposite, when building a content based recommendation system, the one is interested only in the catalog of items, and as a rule the number of items is always smaller than the number of users in the system. Content based recommendation system is a nice start for a small company that just appeared on the market of web products. With the development of the sphere of Natural Language Processing (NLP), new opportunities for content-based recommendation systems appeared. The new approach to recommendation systems is proposed in this article, the problem is stated as measuring the similarities between items' metadata and is addressed as an NLP task. The system uses a hybrid algorithm based on counting words in a statement and Word2Vec model provided by Google. The possibility of using an additional business logic is considered. Finally, the results are viewed with respect to Movielens dataset.

Data preparation

Constructed system was validated using the famous Movielens [1] dataset, which contains catalogues of movies, their metadata and intersections of users with a catalog. The columns that were used are the following: title, movie_id and genres (Fig. 1).

As the constructed algorithm is based on content metadata – it was decided to enrich Movielens dataset with IMDB database to get more relative columns.

	movield	title	genres
0	1	Toy Story (1995)	Adventure Animation Children Comedy Fantasy
1	2	Jumanji (1995)	Adventure Children Fantasy
2	3	Grumpier Old Men (1995)	Comedy Romance
3	4	Waiting to Exhale (1995)	Comedy Drama Romance
4	5	Father of the Bride Part II (1995)	Comedy

Figure 1 - Original Movielens data

As genres columns were already in our dataset, this field was enriched with more data from IMDB, other columns were just added (Fig. 2).

cas	writers	directors	characters	genres	titleType	year	title	
[Joel Cohen, Tom Hanks, Tim Allen, Don Rickles	[John Lasseter, Pete Docter, Andrew Stanton, J	[John Lasseter]	["Mr. Potato Head", "Slinky Dog", "Buzz Lighty	[Children, Fantasy, Adventure, Animation, Comedy]	movie	1995	Toy Story	0
[Scott Kroopf, Robin Williams Kirsten Dunst,	[Jonathan Hensleigh, Greg Taylor, Jim Strain,	[Joe Johnston]	["Sarah Whittle", "Alan Parrish", "Van Pelt","	[Fantasy, Children, Adventure, Family, Comedy]	movie	1995	Jumanji	1
[Tak Fujimoto, Walter Matthau Jack Lemmon, An	[Mark Steven Johnson]	[Howard Deutch]	["John Gustafson", "Maria Sophia Coletta Raget	[Romance, Comedy]	movie	1995	Grumpier Old Men	2
[Kenneth 'Babyface Edmonds, Whitney Houston	[Terry McMillan, Ronald Bass]	[Forest Whitaker]	["Bernadine Harris", "Robin Stokes", "Savannah	Drama, Romance, Comedy]	movie	1995	Waiting to Exhale	3
[Elliot Davis, Steve Martin Diane Keaton, Mar	[Albert Hackett, Frances Goodrich, Nancy Meyer	[Charles Shyer]	["George Banks", "Annie Banks-MacKenzie", "Nin	[Comedy, Family, Romance]	movie	1995	Father of the Bride Part II	4

Green - enriched

Red - added

Figure 2 – Data after enriching with IMDB

Data transformation

The MovieLens data is made of strings which describe items' metadata, but for an algorithm to work the transformation of relative columns to the matrix of numbers is needed. For this purpose a hybrid transformation, made of CountVectorizer [3] and Word2Vec [4] model, is used. CountVectorizer is a technique of counting words in a sentence or text corpus. Each word is then represented by its frequency of appearance in a sentence (Fig. 3).

BEFORE:

 $Item 1 \longrightarrow ['action', 'adventure', 'crime']$ $Item 2 \longrightarrow ['drama', 'action', 'documentary']$ AFTER (vectorized array): Iaction', 'adventure', 'crime', 'documentary', 'drama', 'horror', 'mystery', 'romance', 'thriller'] $Item 1 \longrightarrow array([1, 1, 1, 0, 0, 0, 0, 0])$ $Item 2 \longrightarrow array([1, 0, 0, 1, 1, 0, 0, 0, 0])$

Figure 3 – The usage of CountVectorizer algorithm

That gives a possibility to represent word sequences as vectors of numbers. CountVectorizer is used only on columns that don't have a strong semantic context (directors, writers, cast, characters, etc.) For the fields with semantic context the other algorithm, known as Word2Vec is used. Word2Vec is a powerful machine learning algorithm that is used in the NLP sphere for semantic text classification, finding similarity between words, etc. Word2Vec learns the embedding space of words in which similar words (the ones that tend to appear in the same context) are closer to each other. Thus, the learned Word2Vec embeddings can be used to represent our columns in a numerical way and also save a semantic context of them (Fig. 4).

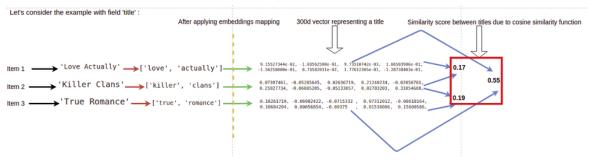


Figure 4 – Example of usage of Word2Vec model

For the purpose of representing not just a single word with Word2Vec, but the whole sentence – the embeddings of sentence's words are averaged. All the highlighted transformations give a possibility to represent content as nested matrices of number related to its metadata, thus the opportunity of using mathematical methods for finding similarity between content can be applied.

Algorithm

The algorithm is based on a cosine similarity, that is a mere choice for NLP tasks (1).

$$k(x, y) = xy^{T} / ||x|| ||y||$$
(1)

The cosine similarity is computed between each column of each item in the dataset, thus for each item we have a matrix of similarities with others by a particular column. Because of the fact that one data column regarding an item can be much more important for the final recommendation than the other one, the additional business logic is added. The additional set of columns' weights that can be configured manually was added. Each attribute/column matrix is multiplied by a related weight parameter that gives an opportunity to decrease/increase contribution of it to the final similarity calculation. This makes the overall system more flexible and extendable towards new logic. Finally, the similarity matrices by columns are averaged to produce a final similarity matrix for an item (Fig. 5). Then, top N recommendations can be retrieved using a similarity score.

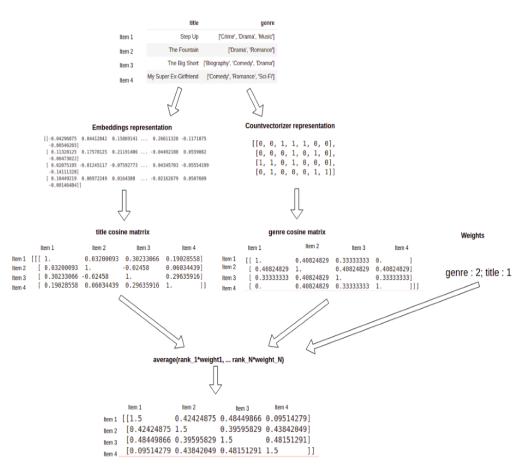


Figure 5 – Example of similarity calculation on two columns of data

Experiments

Experiments were conducted with respect to different weights sets. For each set of weights two experiments were done. For each experiment the item was randomly chosen and the top-4 related recommendations by similarity score were shown. From the first experiment (Fig. 6) it's obvious that given and predicted movies have similar titles by semantics and overlapping genres, as the highest weights were set to genre and title columns.

With different weights, the other picture appears. From the second experiment (Fig. 7), it's obvious that items have the biggest similarity by such fields as: characters, cast, directors, which is not a surprise if to look at weights.

	movield		title yea	to	onst tit	tleType	genres	characters	r	iconst di	ectors writer	s cast
ACTUAL ITEM	96629	Death	stalker (1983) 1983.0) tt0087	7127	movie	['Action', 'Fantasy', 'Adventure']	["Codille", "Oghris", "Kaira", "Deathst	['nm072 'nm038 'nm007 'nm007	4605',	'James ['Howan dellati'] Cohen	Hill' Barbi
<pre>weights = {'title': 10,</pre>								П				
'genres': 6, 'directors': 2.												
'writers': 1,								4				
'cast': 4,	n	novield	title	year	tcon	st titleT)	pe genre	s characters	nconst	directors	writers	cast
'characters': 3,	43	44	Mortal Kombat (1995)	1995.0	#011385	55 mo	['Action Fantasy 'Adventure	Cage", "Shang	['nm0003392', 'nm0000483', 'nm0795225', 'nm000	['Paul W.S. Anderson']	['Ed Boon', 'John Tobias', 'Kevin Droney']	['George S. Clinton', 'Christopher Lambert', '
'titleType': 2} TOP 4 PREDICTED ITEMS →	389	393	Street Fighter (1994)	1994.0	11011130	01 ma	('Fantasy 'Action 'Adventure 'Comedy	"Ken", "Bison",	['nm0002155', 'nm0000241', 'nm0000471', 'nm000	['Steven E. de Souza']	["Steven E. de Souza"]	['Edward M. Abroms', 'Jean- Claude Van Damme',
	481	485	Last Action Hero (1993)	1993.0	tt010736	62 ma	('Fantasy 'Action 'Comedy 'Adventure	"Jack Slater",	['nm0745030', 'nm0000216', 'nm0000719', 'nm013	['John McTieman']	['Zak Penn', 'Adam Leff', 'Shane Black', 'Davi	['Stephen J. Roth', 'Amold Schwarzenegger',
	645	653	Dragonheart (1996)	1996.0	tt011613	36 ma	['Action vie 'Fantasy 'Adventure	Glockenspur",	['nm0250867', 'nm0000598', 'nm0000125', 'nm000	['Rob Cohen']	['Patrick Read Johnson', 'Charles Edward Pogue']	['David Eggby', 'Dennis Quaid', 'Sean Connery'

	movield	title	year	tconst	titleType	genres	characters	nconst	directors	writers	cast	
ACTUALITEM ───→ weights = {'title': 10,	4386	Cats & Dogs 20 (2001)	01.0 tt	0239395	movie	['Children', 'Comedy', 'Action', 'Family']	"Professor Brody",	['nm0675013', 'nm0000285', 'nm0001497', 'nm000	['Lawrence Guterman']	['John Requa', 'Glenn Ficarra']	['Craig Perry', 'Alec Baldwin', 'Tobey Maguire	
'genres': 6, 'directors': 2, 'writers': 1,							Ţ					
'cast': 4,	movield	title	year	tconst	titleType	genres	characters	nconst	directors	writers	cast	
'characters': 3,	374	Richie Rich (1994)	1994.0	tt0110989	movie	['Children', 'Comedy', 'Family']	["Lawrence Van Dough", "Regina Rich", "Ri	['nm0005428', 'nm0000346', 'nm0001346', 'nm048	['Donald Petrie']	['Neil Tolkin', 'Tom S. Parker', 'Jim Jennewein']	['Joel Silver', 'Macaulay Culkin', 'Edward Her	
'titleType': 2}	586	Home Alone (1990)	1990.0	tt0099785	movie	['Children', 'Comedy', 'Family']	["Peter", "Marv", "Kevin", "Harry"]	['nm0616141', 'nm0000346', 'nm0000582', 'nm082	['Chris Columbus']	['John Hughes']	['John Muto', 'Macaulay Culkin', 'Joe Pesci',	
	634	Theodore Rex (1995)	1995.0	tt0114658	movie	['Comedy', 'Action', 'Family']	["Dr. Veronica Shade", "Spinner", "Elizar	['nm0787603', 'nm0000155', 'nm0000090', 'nm048	['Jonathan R. Betuel']	['Jonathan R. Betuel']	['Rick Shaine', 'Whoopi Goldberg', 'Armin Muel	
	840	House Arrest (1996)	1996.0	tt0116571	movie	['Children', 'Comedy', 'Family']	["Janet Beindorf", "T.J. Krupp", "Ned Bei	['nm0740462', 'nm0000130', 'nm0001629', 'nm039	['Harry Winer']	['Michael Hitchcock']	['Ronald Roose', 'Jamie Lee Curtis', 'Kevin P0	

Figure 6 – The first experiment with different weights sets

		movield		title	year	tconst	titleTyp	e genn	es characte	ers nconst	directors	writers		cast	rect
ACTUAL ITEM	24277	115135	(5	in Island imindis indzuli) (2014)	2014.0	n1863192	mov	ie ['Dram 'Wa		r, 'nm0758656', r, 'nm5705214',	['George Ovashvili']	['Roelof Jan Minneboo', 'George Ovashvili', 'N	Gorec Salr Ma	lyas 0.556349	[[18705 91861000001 5, 0.5095807.
'genres': 1,					×				×	п		×			
'directors': 10.															
'writers': 10,										4					
'cast': 10,		mov	rield	tit	le y	ar t	const ti	tleType	genres	characte	rs no	onst	lirectors	writers	ca
<pre>'characters': 10, 'titleType': 1}</pre>	10	19	171	Jeffn (199		5.0 tt01:	13464	movie	['Comedy', 'Drama']	["Man #2", "Jeffrey "Man #1", "Steve		836', [Ch 117',	ristopher Ashley']	['Paul Rudnick']	['Stephe Endelmar 'Steve Webe 'Michael
P 4 PREDICTED ITEMS →	6	13	661	James ar the Gia Pea (199	nt 199	5.0 tt01:	16683	movie	['Fantasy', 'Children', 'Musical', Animation'	["James", "Old Man "Grasshopper", "Au		057°, 921',	['Henry Selick']	['Roald Dahf, 'Karey Kirkpatrick', 'Jonathan	['Ti Burtor 'Paul Terry 'Joanr Lumley',
	10	a 1	.085	Old Ma and ti Sea, Ti (195	ne 195	8.0 1100	52027	movie	['Drama', 'Adventure']	["Cafe Proprietor "The C Man","Narrator	Id 'nm0000	075', 626',	['John Sturges', 'Fred nemann']	['Ernest Hemingway', 'Peter Viertef]	['Dimit Tiomkir 'Spenci Tracy 'Felipe P
	15	4 1	.575	Gabb (199		5.0 tt01:	16384	movie	['Drama', 'Romance',	["Gabbeh", "C Man", "Old Woman "Unc	. nm0595	956',	['Mohsen hmalbaf']	['Mohsen Makhmalbaf']	['Shaghaye Djodat 'Hossei

		movie	d	title year	tcon	st titleTyp	e genre	s ch	aracters	nconst	directors	writers	cast
ACTUAL ITEM	18930	9419	2 [evil's Diary 2007.0 007)	tt10188	20 tvMovi	['Mystery e 'Drama 'Horror	, "G	Wilson''', Georgia''', nique'''	['nm1547448', 'nm0424481', 'nm1011682', 'nm171	['Farhad Mann']		Steve Schmidt', Alexz Johnson', 'Miriam McD
weights = {'title': 1,										1011272			
'genres': 1,									Π				
'directors': 10,													
'writers': 10,									\checkmark				
'cast': 10,	_	n	ovield	title	year	tconst	titleType	genres	characters	nconst	directors	s writers	cast
'characters': 10, 'titleType': 1}		65	66	Lawnmower Man 2: Beyond Cyberspace (1996)	1996.0	tt0116839	movie	['Action', 'Sci-Fi', 'Thriller']	["'Dr. Cori Platt"', "Jobe Smith"', "Peter P	['nm0751505', 'nm0000920', 'nm0001242', 'nm063			['Ward Russell', 'Patrick Bergin', 'Matt Frewe
TOP 4 PREDICTED ITEMS \longrightarrow		736	749	Man from Down Under, The (1943)	1943.0	tt0031612	movie	['Drama', 'Action', 'Comedy']	["\'Nipper\' Wilson", "Mary Wilson", "Agg	[mm00001452]	['Robert Z Leonard'		['Orville O. Dull', 'Charles Laughton', 'Binni
		762	775	Spirits of the Dead (1968)	1968.0	tiD063715	movie	['Mystery', 'Horror', 'Drama']	["Contessa Frederique de Metzengerstein (segm	'nm0000404', 'nm0000003',	'Federico Fellini'	Allan Poe', 'Roger	['Clement Biddle Wood', 'Jane Fonda', 'Brigitt
		1257	1285	Heathers (1989)	1989.0	tt0097493	movie	['Comedy', 'Crime']	["Veronica", "J.D.", "Heather (McNamara)"	['nm0391431', 'nm0000213', 'nm0000225', 'nm000	['Michae		['Norman Hollyn', 'Winona Ryder', 'Christian S

Figure 7 – The second experiment with different weights sets

Summary and further work

Nevertheless, the proposed system is not based on user activity, it has lots of advantages. It's flexible, not power consuming, easy to extend and flexible. Addressing the issue of recommendation systems as an NLP task, gives a lift to usage of novel NLP techniques like BERT [5]. On the opposite side, it's much less powerful than a user based system and is heavily dependent on the quality of catalog metadata. The particular system can also be used in ensemble with a user based recommendation system to construct a hybrid system. To sum up, the proposed algorithm can be used as an alternative to user based system and is an adequate choice for companies which just started their activity on the web market.

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