

Building SMART Recommendation Systems in Python

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AI & Intelligent Systems

<https://github.com/ArthurKakande/PyConAfrica2024>

PyCon Africa 2024 - Accra

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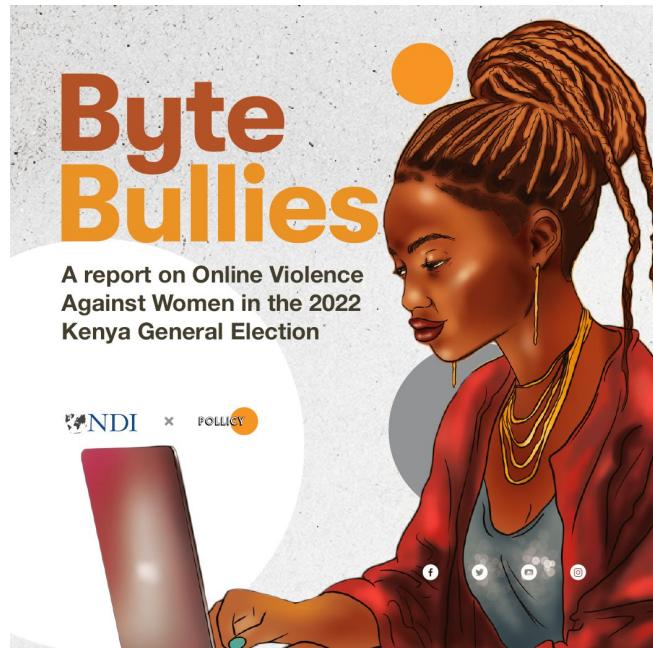


slides

Introductions



Pollicy is an award-winning African feminist civic technology collective. Our work and research spans across the use and implementation of data and technology to engineer social change. In the recent past, we have researched ways through which Africans can take back control of their data and reimagine new ways of tech ownership.



DIGITAL
SAFE-TEA

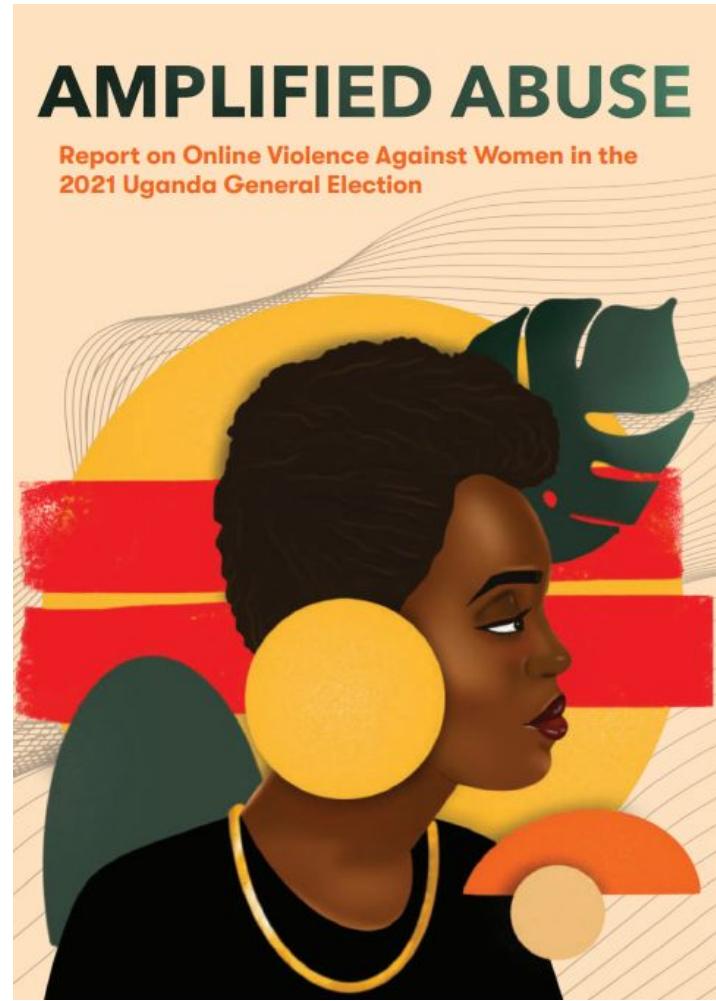
START GAME

INFORMATION

RESOURCES

SHARE

The game interface includes a pink mug with a tea bag, a digital grid floor, and three stylized female characters standing side-by-side.



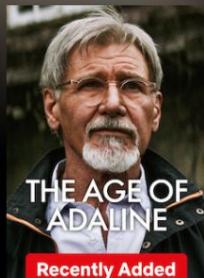
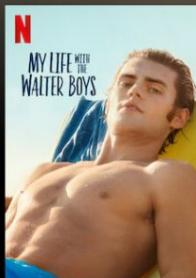
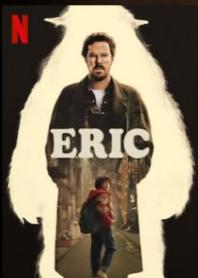
Outline

- What? Why? Who?
- Collaborative Filtering
- Content based Approach
- Knowledge based
- Intellikit Library
- Coding Demo

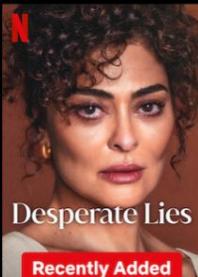
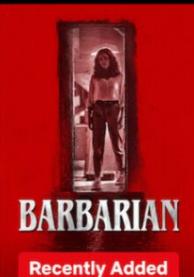
NETFLIX



Your Next Watch



New on Netflix



We Think You'll Love These



My List



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Deals

TODAY'S OFFER !! ?

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Model Seleccionne

Price Select

Type Select

Steering Select

Year Select

SEARCH

401,402 items match

Shop By Make

TOYOTA (62,731)

NISSAN (32,265)

HONDA (28,043)

MAZDA (10,527)

MITSUBISHI (10,359)

SUBARU (9,328)

SUZUKI (33,595)

ISUZU (4,067)

DAIHATSU (28,432)

HINO (2,423)

LEXUS (5,321)

MERCEDES-BENZ (16,423)

BMW (16,522)

VOLKSWAGEN (4,388)

AUDI (5,388)

PEUGEOT (995)

FORD (2,050)

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Earn up to \$300pts with Every Purchase

Vehicles with Points Reward


TOYOTA LAND CRUISER PRADO
 Vehicle Price: **\$17,620**

TOYOTA HILUX
 Vehicle Price: **\$15,190**

TOYOTA HILUX
 Vehicle Price: **\$15,790**

TOYOTA HILUX
 Vehicle Price: **\$12,560**

TOYOTA HILUX
 Vehicle Price: **\$11,330**
NOT REGISTERED YET?
 It only takes 10 seconds!
[see more ...](#)

New Arrivals

Clearance

Premium Class

3rd Party Seller

View vehicles shipping from:

All

Japan

Singapore

UK

UAE

Thailand

Korea

China

**NISSAN CONDOR****DAIHATSU HIJET TRUCK****MERCEDES-BENZ B-CLASS****LAND ROVER RANGE ROVER****MERCEDES-BENZ G-CLASS****TOYOTA PROBOX VAN**

Shipping Schedule

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Sign up & enjoy these features



Earn Points



Favorites



Notify Me



Save Search



Easy Inquiry



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POINT UP CAMPAIGN
EARN 10 POINTS (\$10)
 WHEN YOU CREATE AN ACCOUNT


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Getting Closer To You

BF Tanzania

BF Zambia

BF Malawi

BF Mozambique

Select services

Filter Options

Recommendation Algorithm

Content Based Filtering

Location

SEARCH LOCATION

Care System

Any

Mode of Payment

Any

Select Day

NOTHING SELECTED ▾





What?

Recommender systems are software tools and techniques providing suggestions for items to be of use to a user.



Why?

- Users rely on recommendations
- Users lack sufficient personal expertise
- Number of items is very large e.g. around 1010 books in Amazon
- Recommendations need to be personalized

POLLLICY



Why?

- Sell more diverse items
- Increase user satisfaction (Users enjoy the recommendations)
- Increase user fidelity (Users feel recognized (but not creeped out))
- Understand users

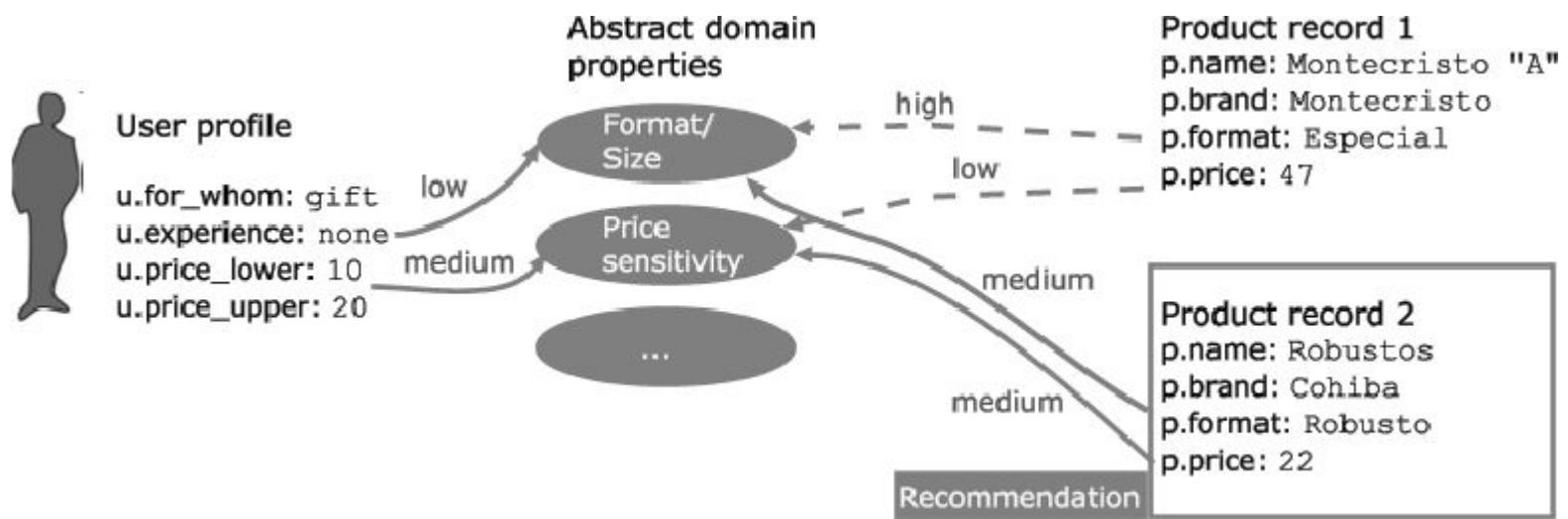


Who?

- Retailers and e-commerce in general
- Amazon, Netflix, etc.
- Service sites, e.g. travel sites
- Media organizations
- Dating apps

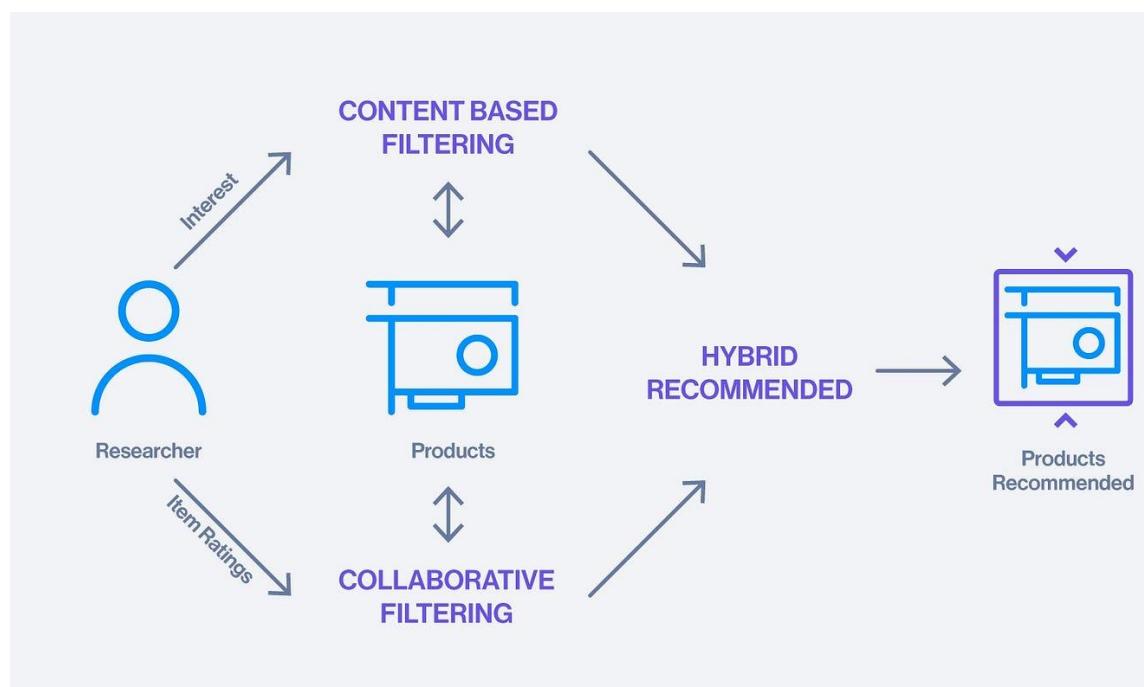
The recommender system problem

Estimate the utility for a user of an item for which the user has not expressed utility



Approaches

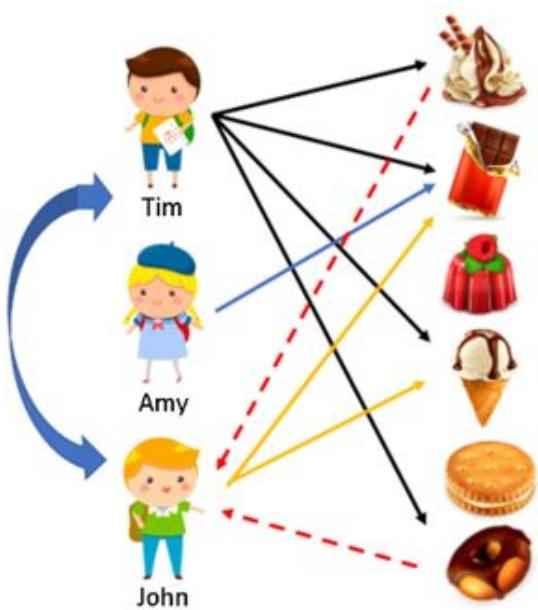
- Collaborative filtering
- Content-based (item features)
- Knowledge-based (expert system)
- Hybrid
- Others



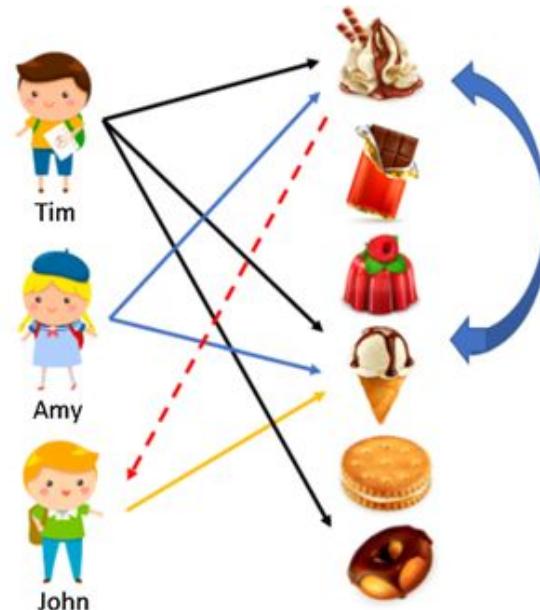
Collaborative Filtering

How does collaborative filtering work?

- User has seen/liked certain items
- Community has seen/liked certain items
- Recommend to users items similar to the ones they have seen/liked
- Based on finding similar users
- Based on finding similar items



(a) User-based filtering



(b) Item-based filtering

Ratings data



ITEMS 



	1	2	3	4	5	6	7	8	9	1	1	1
1	1			5				2		0	1	2
2	5		1		5		4			5	3	2
3		5	5			1		3			2	4
4		3			5	4				5		1
5				2	5	4			4	5		
6	4		3			1			4		2	
7		4	1		4		5				4	1

USERS

ITEMS

	1	2	3	4	5	6	7	8	9	10	11	12
1	1			5				2		3		
2	5		1		5		4		5	3	2	
3		5	5			1		3		2	4	
4		3			5	4			5	5	1	
5				2	5	4		4	5			
6	4		3			1		4		2		
7		4	1		4		5			4	1	



$$\text{dist}(i, j) = \frac{\sum_{\alpha \in U_i \cap U_j} |r_i(\alpha) - r_j(\alpha)|}{|U_i \cap U_j|}$$

Compute user intersection size

USERS

ITEMS

	1	2	3	4	5	6	7	8	9	1 0	1 1	1 2	$ U_i \cap U_j $	$\text{dis}(i, j)$
1	1			5				2		3			0	
2	5		1		5		4			5	3	2	3	
3		5	5			1		3			2	4	3	
4		3		5	4				5		1			
5				2	5	4			4	5			3	
6	4		3			1			4		2		1	
7		4	1		4		5				4	1	3	

Compute user distance

ITEMS

	1	2	3	4	5	6	7	8	9	10	11	12
1	1			5				2		3		
2	5		1		5		4		5	3	2	
3		5	5			1		3		2	4	
4		3		5	4			5	5	1		
5				2	5	4		4	5			
6	4		3			1		4		2		
7		4	1		4		5			4	1	

$|U_i \cap U_j|$ $\text{dis}(i, j)$

0	
3	0.33
3	2.67
3	0.00
1	3.00
3	0.67

Pick top-3 most similar

	ITEMS											
	1	2	3	4	5	6	7	8	9	10	11	12
2	5		1		5		4			5	3	2
4		3		5	4				5	5	1	
5			2	5	4			4	5			
7		4	1		4	5				4	1	

$|U_i \cap U_j|$ dis (i, j)

3	0.33
3	0.00
3	0.67

Estimate unrated items

ITEMS

USERS

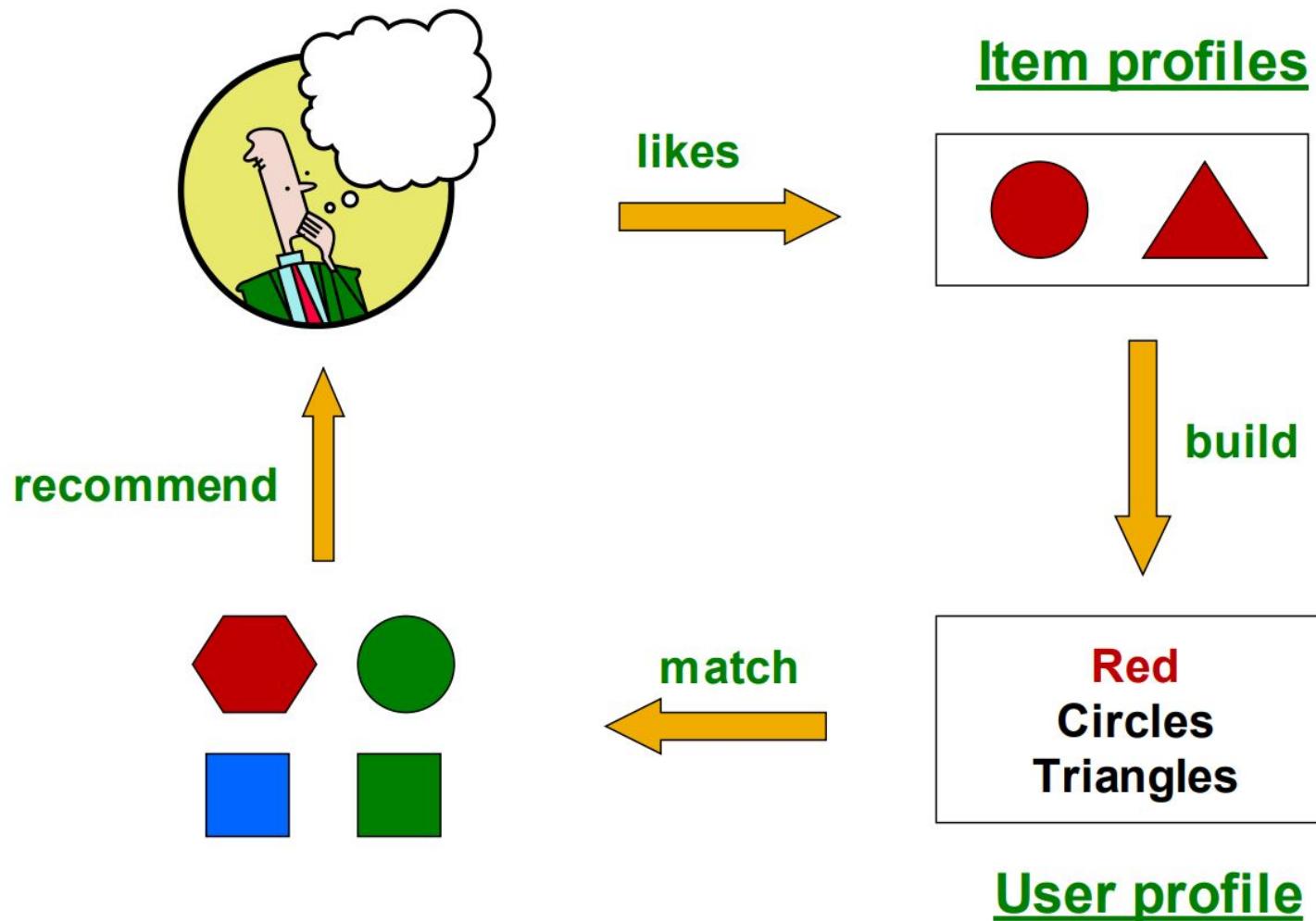
	1	2	3	4	5	6	7	8	9	10	11	12
2	5		1		5		4			5	3	2
4	5.0	3	1.0	2.0	5	4	4.5	-	4.0	5	3.5	1
5				2	5	4			4	5		
7		4	1		4		5			4	1	

$|U_i \cap U_j|$ dis (i, j)

3	0.33
3	0.00
3	0.67

Content-Based Approach

Plan of action



How does the content-based approach work?

For each item, we create an item profile. A profile is a set (vector) of features.
e.g. Movies: author, title, actor, director,... Text/Blogs: Set of “important” words in document

We can pick important features using; Usual heuristic from text mining is TF-IDF (Term frequency * Inverse Doc Frequency)

- Term ... Feature
- Document ... Item

	Melissa McCarthy	Actor A	Actor B	...	Johnny Depp	Comic Genre	Spy Genre	Pirate Genre
Movie X	0	1	1	0	1	1	0	1
Movie Y	1	1	0	1	0	1	1	0

Cosine Similarity

Cosine similarity is the cosine of the angle between the vectors; that is, it is the dot product of the vectors divided by the product of their lengths

$$\text{cosine similarity} = S_C(A, B) := \cos(\theta) = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\| \|\mathbf{B}\|}$$

Cosine Similarity Example with IDF

Term	idf	Doc1			Doc2			Doc3		
		tf	tf·idf	tf·idf (norm.)	tf	tf·idf	tf·idf (norm.)	tf	tf·idf	tf·idf (norm.)
car	1,65	27,00	44,55	0,8974	4,00	6,60	0,0756	24,00	39,60	0,5953
auto	2,08	3,00	6,24	0,1257	33,00	68,64	0,7867	0,00	0,00	0,0000
insurance	1,62	0,00	0,00	0,0000	33,00	53,46	0,6127	29,00	46,98	0,7062
best	1,5	14,00	21,00	0,4230	0,00	0,00	0,0000	17,00	25,50	0,3833
Eu.-Length			49,65	1,0000		87,25	1,0000		66,52	1,0000

The pairwise cosine similarities of the documents are:

$$\text{sim}(\text{Doc1}, \text{Doc2})$$

$$= 0.8974 \cdot 0.0756 + 0.1257 \cdot 0.7867 + 0.0000 \cdot 0.6127 + 0.4230 \cdot 0.0000$$

$$= 0.1668$$

$$\text{sim}(\text{Doc1}, \text{Doc3})$$

$$= 0.8974 \cdot 0.5953 + 0.1257 \cdot 0.0000 + 0.0000 \cdot 0.7062 + 0.4230 \cdot 0.3833$$

$$= 0.6963$$

$$\text{sim}(\text{Doc2}, \text{Doc3})$$

$$= 0.0756 \cdot 0.5953 + 0.7867 \cdot 0.0000 + 0.6127 \cdot 0.7062 + 0.0000 \cdot 0.3833$$

$$= 0.4777$$

Content Based Filtering in intellikit

Here's how a movie recommender system can be implemented;

```
# Load the movies dataset
```

```
movies = pd.read_csv("/content/imdb_top_1000.csv")
```

```
# Select the columns to focus on and merge them into a single column
```

```
movies["document"] = movies[["Series_Title", "Genre", "Overview", "Director",
"Released_Year", "Star1", "Star2", "Star3", "Star4"]].apply(lambda x: " ".join(x), axis=1)
```

```
# Set the series_title column as the id column
```

```
movies = movies.set_index("Series_Title")
```

```
# Get the user's query
```

```
query = input("2012, Drama, A movie about a boy who gets lost and is adopted by an
aussie family")
```

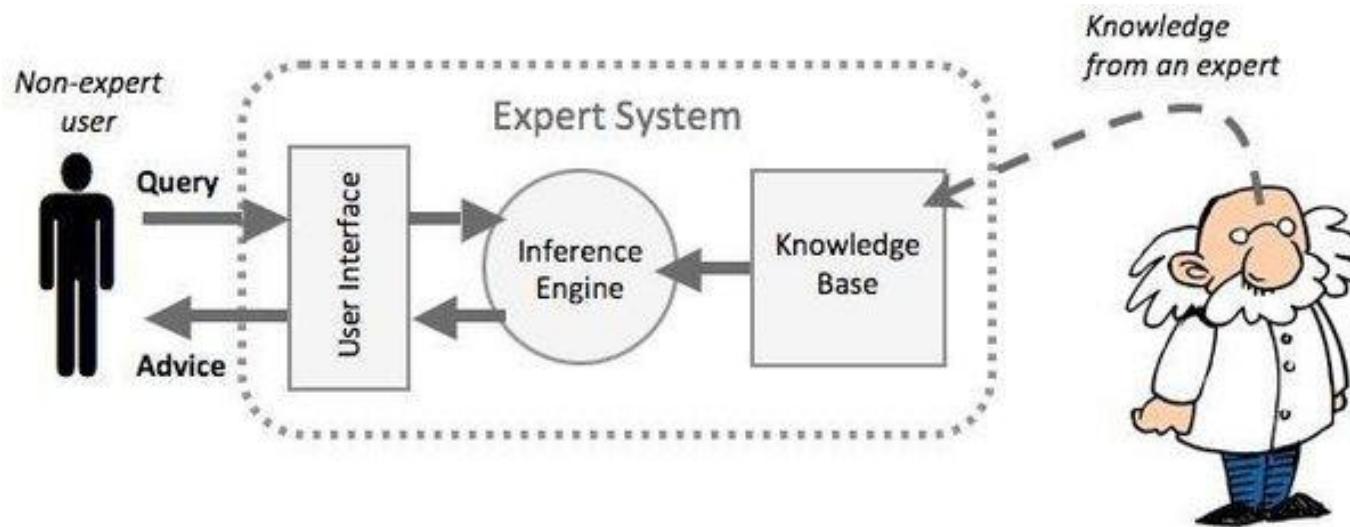
```
top_similar_docs_vsm = ik.vector_space_model(query, movies["document"], k=5)
```

Knowledge-Based Recommenders

How knowledge based systems work

KBS (also known as Expert systems) solve problems by automatically combining explicitly represented knowledge in a knowledge base

The primary inference mechanisms used is called Case-Based Reasoning (CBR)

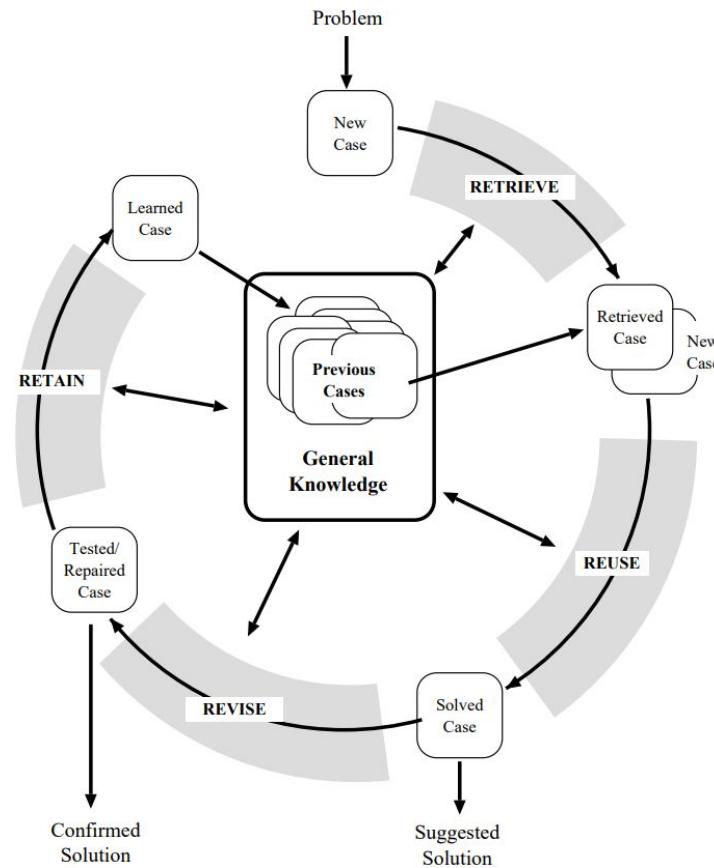


Case Based Reasoning and Similarity

The main principle of CBR is:
similar problems have similar
solutions

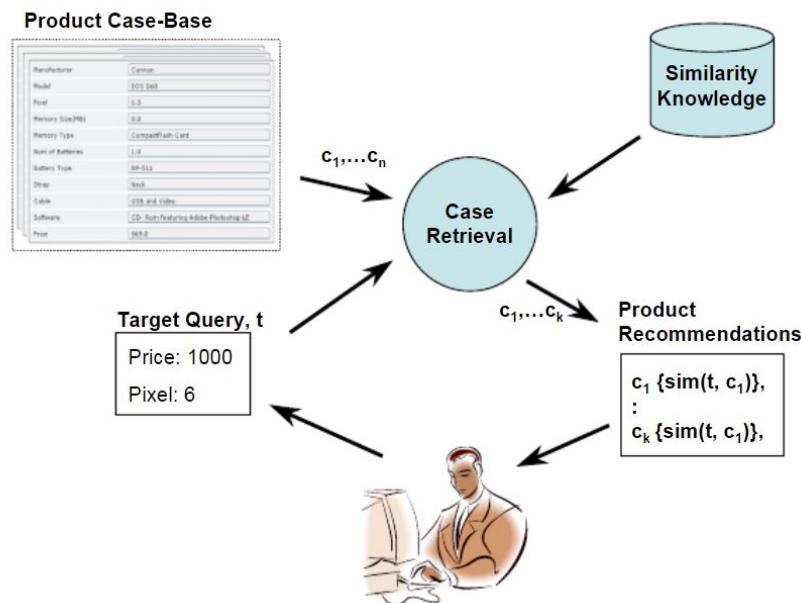
Cases = Experience =
Problem/Solution pair

To solve a problem we retrieve
case with a similar problem
from the case base



Case Based Recommenders

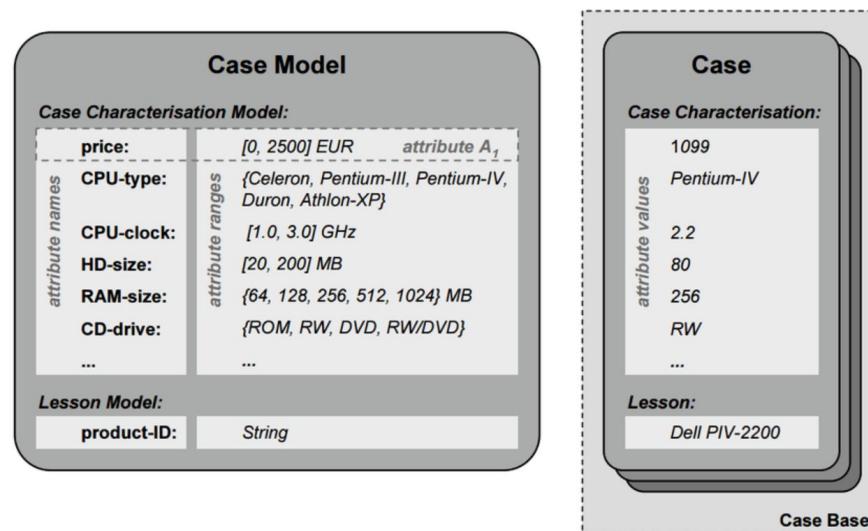
In its simplest form a case-based recommendation system will retrieve and rank product suggestions by comparing the **user's target query** to the **descriptions of products stored** in its casibase using **similarity knowledge** to identify products that are close matches to the target query.



Case Representation

Content/items are represented in an unstructured or semi-structured manner.

- Attribute-value case representation
- Object-oriented case representation



Product Recommendation

→ Representation of a „travel case“

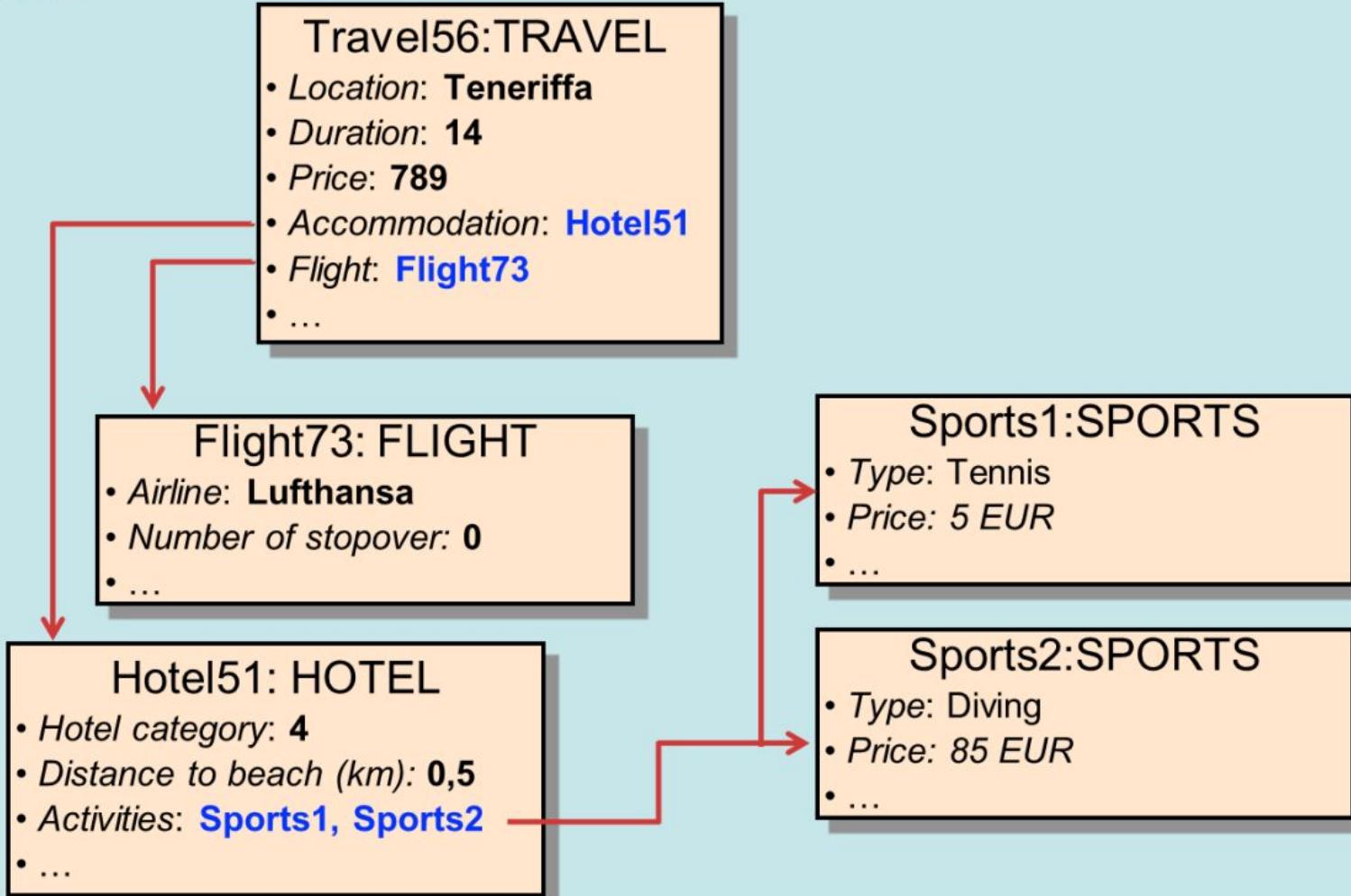
Characterization

- *Country*: SYMBOL {Teneriffa, Lanzarote, Mallorca, Ibiza...}
- *Accommodation*: SYMBOL {Flat, Hotel, Bungalow, Camping, ...}
- *Accommodation-Name*: STRING
- *Price*: REAL [100,10000]
- *Sport offers*: SYMBOL SET {Diving, Sailing, Golf, Tennis, ...}
- ...

“Solution information”

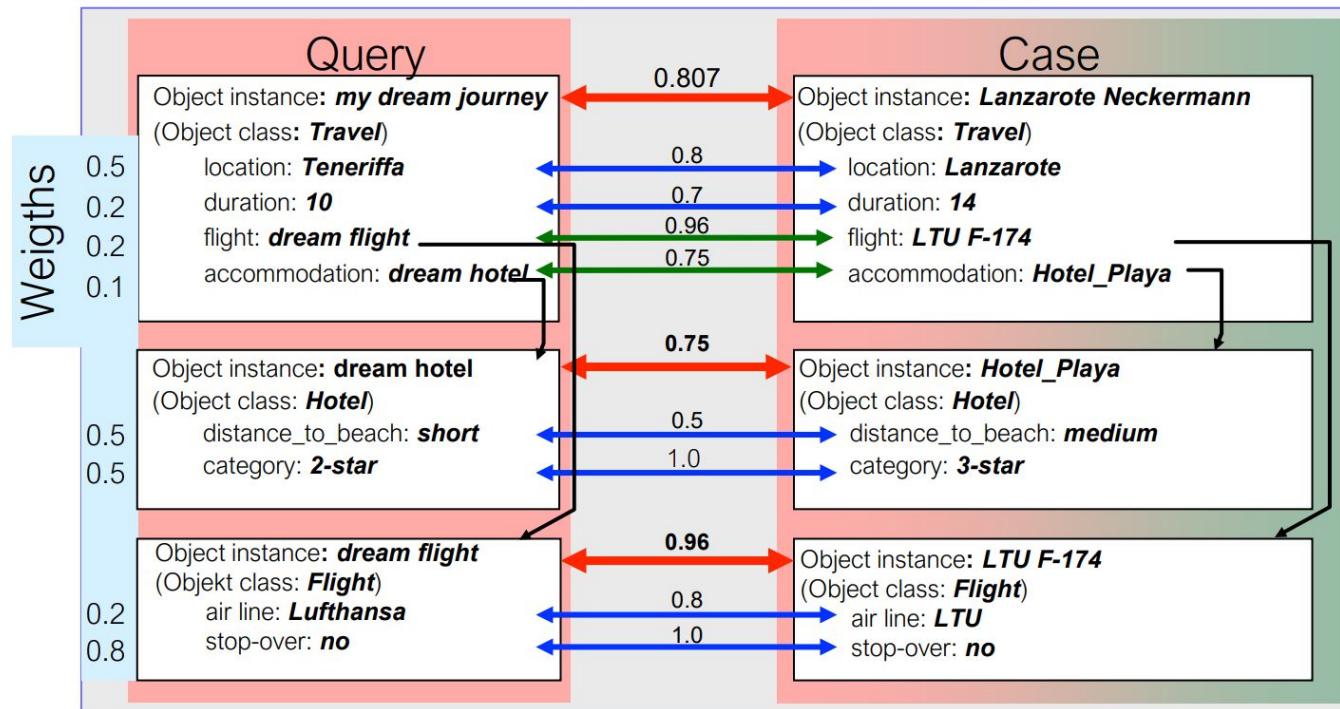
- *Product description*: STRING

A Case



Similarity Assessment

The second important distinguishing feature of case-based recommender systems relates to their use of various sophisticated approaches to similarity assessment when it comes to judging which cases to retrieve in response to some user query.



The “intellikit” Python library

Pros

- Intellikit is a flexible library for CBR, IR and NLP tasks.
- has inbuilt similarity and distance measures for your task
- has inbuilt retrievers (linear retriever, MACFAC)
- Is open source and expandable

Cons

- Hasn't been tested on very large datasets
- does not include very complex similarity and distance measures
- No API connection so you may have to create your own
- Add more +++

Installation

<https://arthurkakande.github.io/intellikit/installation/>

- PyPI: pip install intellikit
- Importing: import intellikit as ik

The screenshot shows the PyPI project page for 'intellikit 0.0.5'. At the top, there's a search bar and navigation links for Help, Sponsors, Log in, and Register. Below the header, the package name 'intellikit 0.0.5' is displayed with a green 'Latest version' button. A command line interface (CLI) section shows 'pip install intellikit' followed by a lock icon. To the right, it says 'Released: May 26, 2024'. A brief description follows: 'A python toolkit for case based reasoning, information retrieval, natural language processing and other techniques for AI and intelligent systems.' On the left, a sidebar titled 'Navigation' includes 'Project description' (which is currently selected), 'Release history', and 'Download files'. Below that is 'Verified details' with a note about PyPI verification. The main content area, titled 'Project description', contains the package name 'intellikit' and its version 'v0.0.5'. It also lists 'pypi' and 'conda' as available platforms. The detailed description reiterates the toolkit's purpose: 'A python toolkit for case based reasoning, information retrieval, natural language processing and other techniques for AI and intelligent systems.' It also describes the toolkit's architecture and dependencies. At the bottom, there's a note for maintainers and a link to ArthurKakande's GitHub profile.

Adding a case base

intellikit allows you to use a pandas dataframe as a case base

intellikit currently takes in attribute-value case representation and object-oriented case representation

Building your first recommendation system

1. Specify the similarity measures
2. Specify the query and select relevant features
3. Assign weights
4. Choose the number of top results to see
5. Choose a retriever and give it all the above specifications
6. (You may need to do some data preprocessing based on your dataframe)

The Query

A query in this context is what the user wants (An ideal situation). Queries can be generated through;

- User **account information** (user's profile, previous usage history e.g. a movie they just watched)
- Requested through **dialogue** with the user
- A simple **search tab**

Millions of cheap flights. One simple search.

From Accra (ACC)	To Country, city or airport	Depart Add date	Return Add date	Travellers and cabin class 1 Adult, Economy	Search
---------------------	--------------------------------	--------------------	--------------------	--	--------

Add nearby airports Add nearby airports
 Direct flights

Similarity

Similarity Measures - Hamming Distance

Hamming Distance: Looks at the number of positions at which the corresponding symbols are different. The symbols may be strings, numbers, etc, e.g.

- "karolin" and "kathrin" is 3.
- "karolin" and "kerstin" is 3.
- "kathrin" and "kerstin" is 4.
- 0000 and 1111 is 4.
- 2173896 and 2233796 is 3.

In intellikit this distance is also normalised to give a hamming similarity score

```
ik.sim_hamming()
```

```
ik.dis_hamming()
```

Similarity Measures - Strings

Levenshtein (Edit distance): Minimal number of insert, delete, or replace operations of single characters to transform the strings into one another. e.g;

$$d(\text{,,car"}, \text{,,cars"}) = 1$$

$$d(\text{,,car"}, \text{,,vehicle"}) = 7$$

In intellikit we have both the Levenshtein distance and the normalised levenshtein distance which serves as similarity.

```
ik.sim_levenshtein()
```

```
ik.dis_levenshtein()
```

Similarity Measures - Strings

N-Grams:

Splitting of both strings into all possible substrings of length N

Distance defined based on number of identical sub-strings

e.g.: q=“CAKE”, c=“PROCAKE”, n=3

- {“CAK”, “AKE”}, = {“Pro”, “roC”, “oCA”, “CAK”, “AKE”}
- $2/5 = 0.4$

This distance is also normalised to a similarity measure

```
ik.sim_ngram()
```

Similarity Measures - Strings

Exact Match

While the previous measures return some sort of value ranging from 0 to 1 on how similar the strings are, the exact match returns 0 or 1. It's much suitable for systems where the strings (categories are already listed - and have less chances of errors) e.g.:

- q="cake", c="cake" is 1.
- "karolin" and "kathrin" is 0.
- "karolin" and "kerstin" is 0.
- "kathrin" and "kerstin" is 0.

```
ik.sim_stringEM()
```

Similarity Measures - Numerical Attributes

City block metric (the sum of absolute differences between points across all the dimensions) `ik.sim_cityblock()`

Euclidean distance (the distance between two points)
`ik.sim_euclidean()`

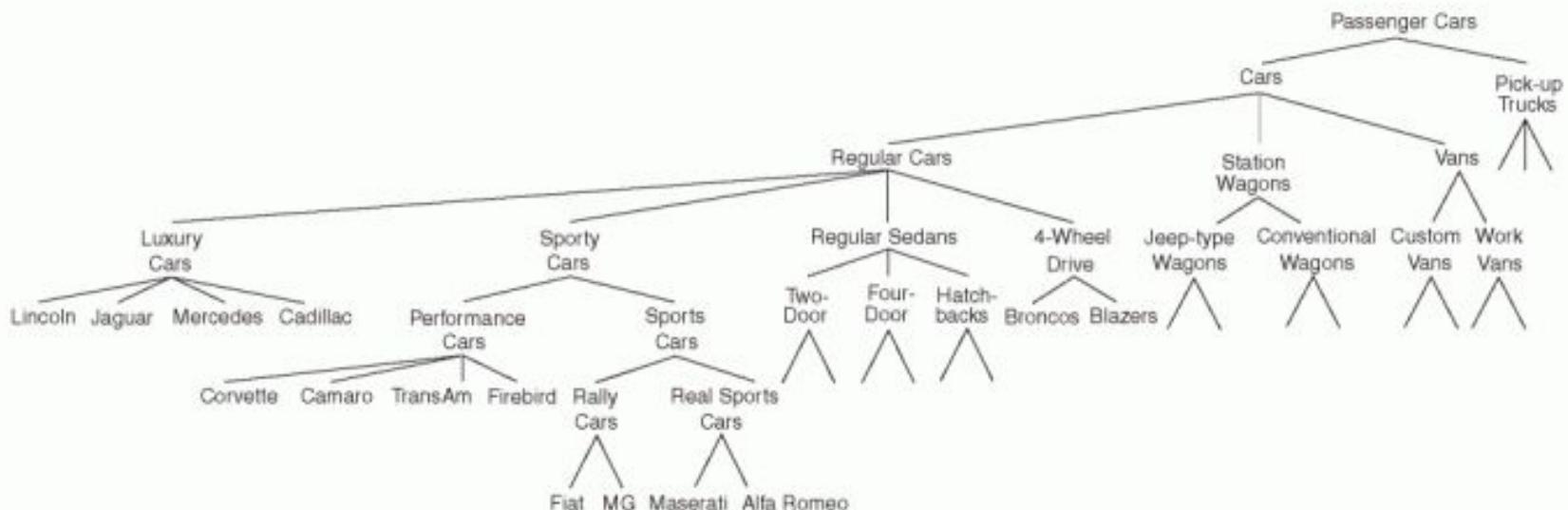
Weighted Euclidean distance (Same as above but weighted)
`ik.sim_weighted()`

Exact Match (returns 0 if the number isn't an exact match and 1 if it is)
`ik.sim_numEM()`

Log similarity (converts the two figures to log 10 and obtain the difference, this figure is similar to a normalised city block metric above) `ik.sim_logDifference()`

Advanced Measures - Taxonomies

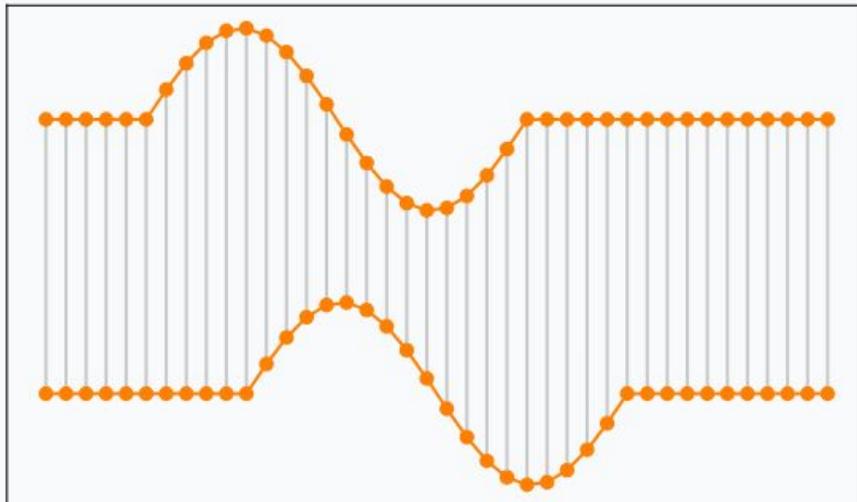
Taxonomies can often be used to represent items that are closer based on categories they fall in e.g. items that share a manufacture, or colours like brown and yellow might be best structured closer to each other using a taxonomy.



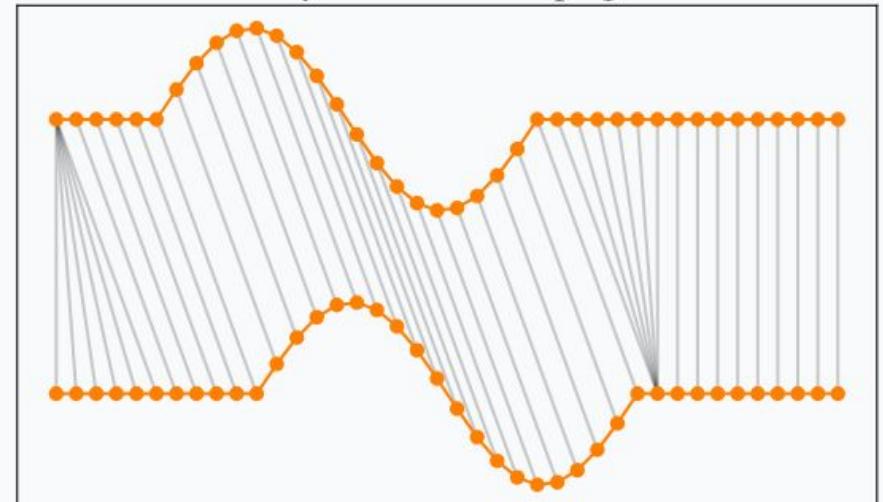
Advanced Measures - Time Series

Time series cases if they match can be easily compared the same way numerical features are compared. When not, a complex method called Dynamic Time Warping can be used. Dynamic time warping (DTW) is a way of comparing two, temporal sequences that don't perfectly sync up through mathematics

Euclidean distance



Dynamic Time Warping



Attribute weights

Intellikit also takes in a weight for each attribute, where no weight is specified, a default weight of 1 for each feature is assumed. However users are encourage to create a weight variable.

```
feature_weights = {  
    'Colour': 0.2,  
    'Price': 0.5,  
    'Manufacturer': 0.3,  
}
```



Retrievers

Linear Search

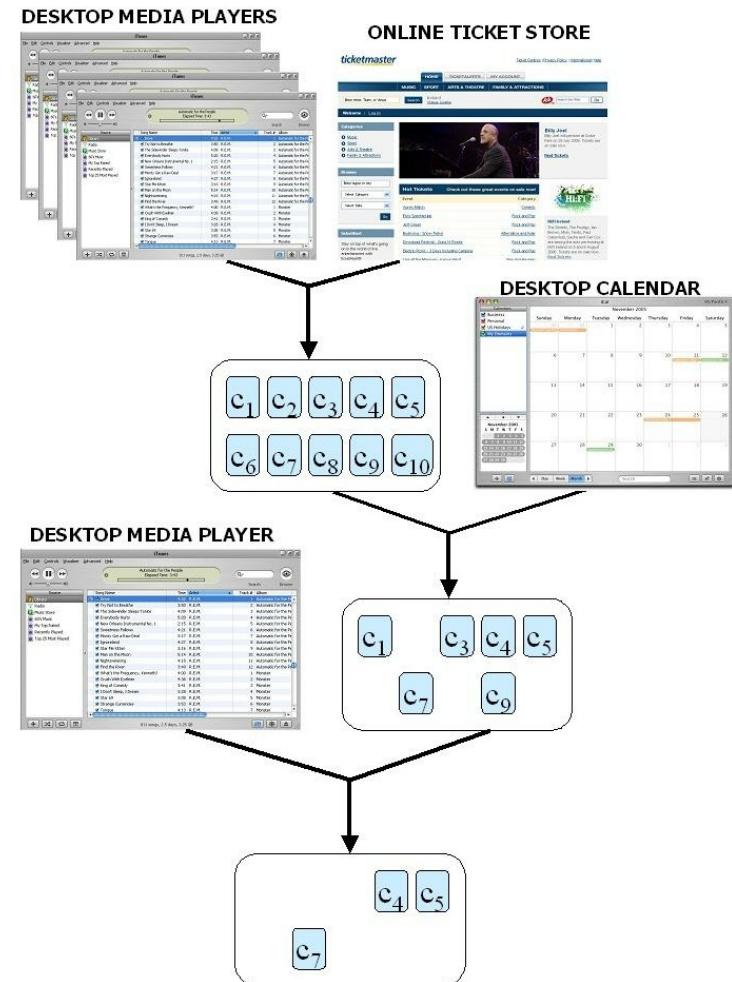
The linear retriever performs a K-NN search by computing all similarities between the query and each case one by one sequentially

```
linearRetriever(df, query, similarity_functions, feature_weights, top_n=1)
```

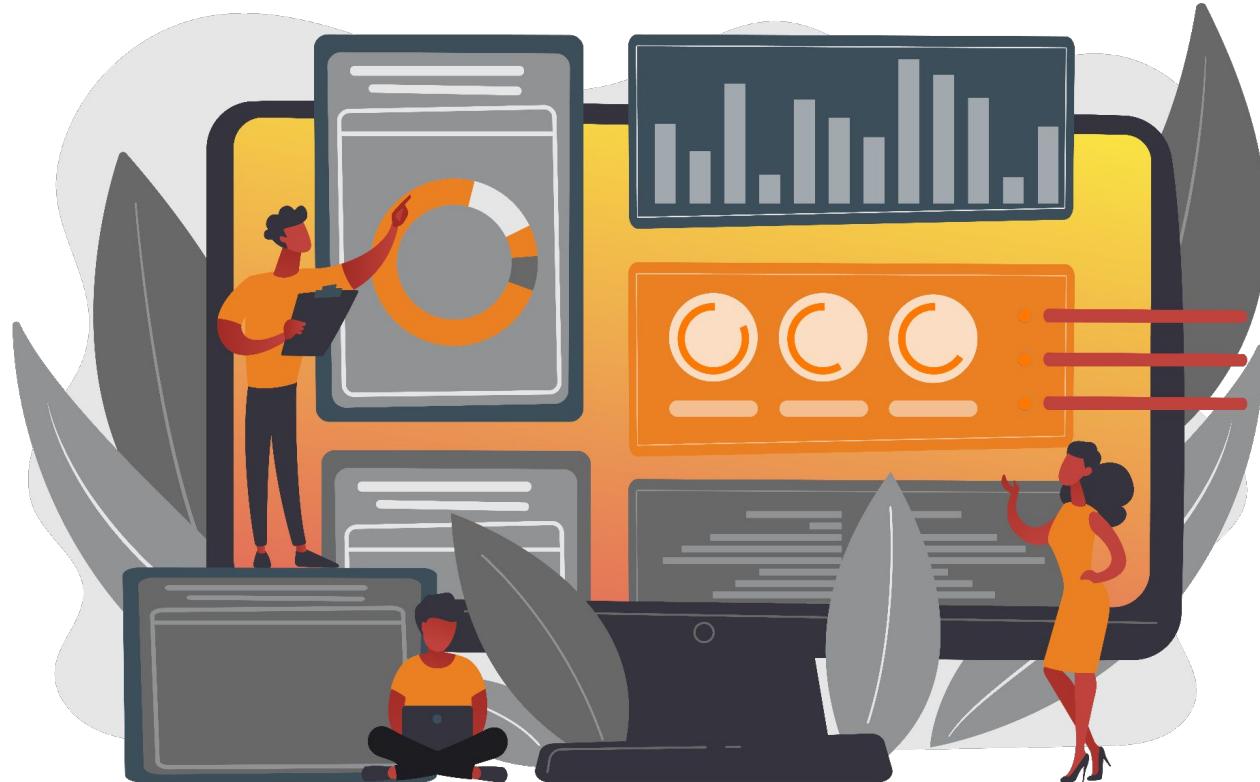
MACFAC Retriever

MAC = Many Are Called, FAC = Few Are Chosen. This performs a two-staged retrieval where the first phase (MAC) uses a lightweight similarity to remove irrelevant cases for the second phase (FAC) where the final similarity for the filtered cases is evaluated.

```
macfacRetriever(df, query, mac_features,  
fac_features, similarity_functions,  
feature_weights, top_n_mac=2,  
top_n_fac=1)
```



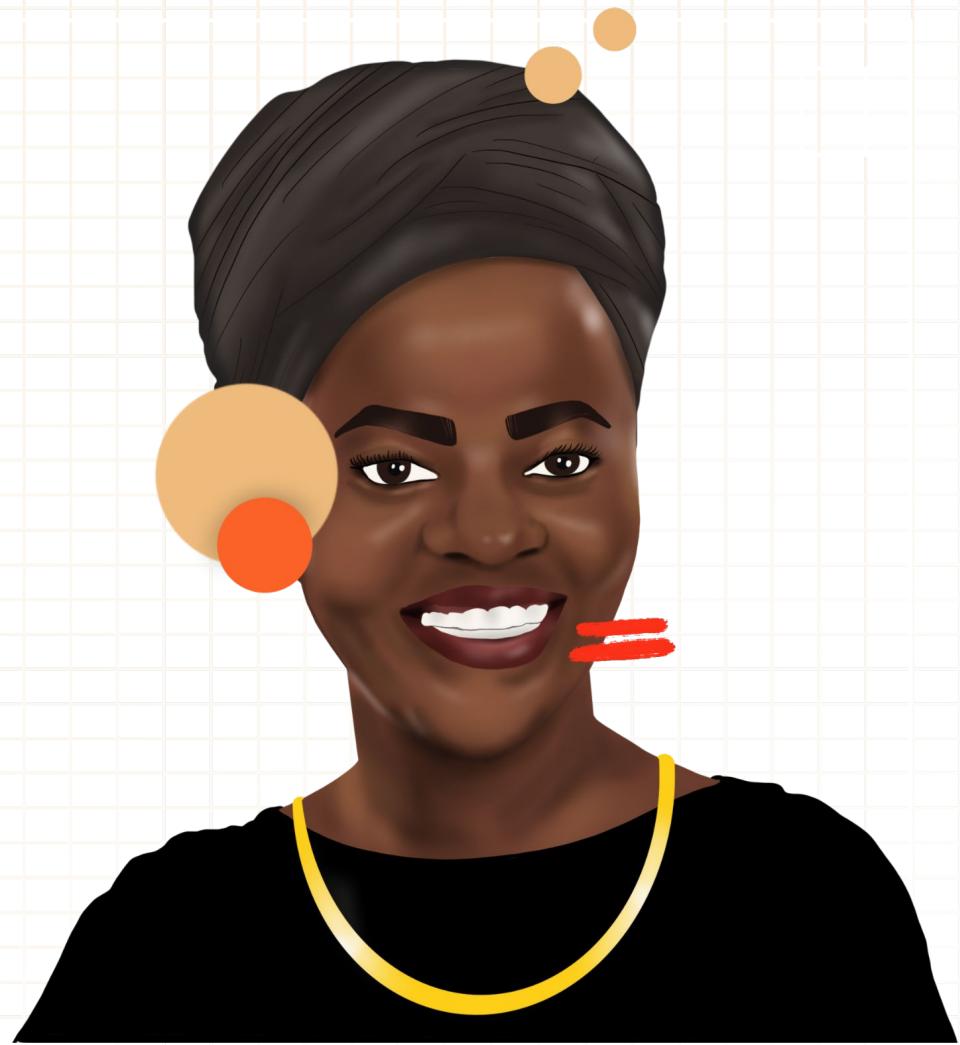
Demo Time



let's write some Python Code!!!

POLLICY

QUESTIONS & ANSWERS



Thank You!

POLICY