Introduction to Recommender Systems

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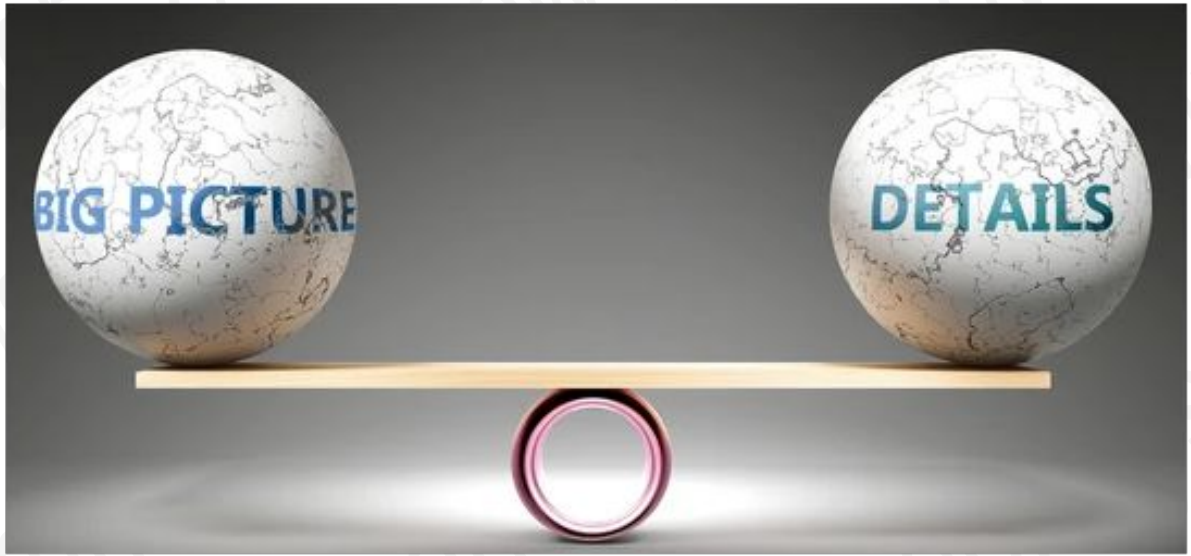
1. Background



1.1. Cyber-Physical-Social System (CPSS)

Cyber-Physical System (CPS) + **Social** → **Cyber-Physical-Social System (CPSS)**

"A system composed of **Physical component** monitored or controlled by a **Cyber component** (computer-based algorithm)."

US National Science Foundation

Examples: **Controlled devices**

- Sensors,
- Actuators,
- Robotics systems, etc.

Human was missing in the design process.

"A major **paradigm shift** to study the impact of **CPS** on **humans** and vice versa."

Fei et al. 2010

Examples: **Smart environments**

- Smart homes,
- Smart manufacturing systems
- Smart museums, etc.

Cassandras 2016

Enhance Human- CPS Interaction

1.1. Cyber-Physical-Social System (CPSS)

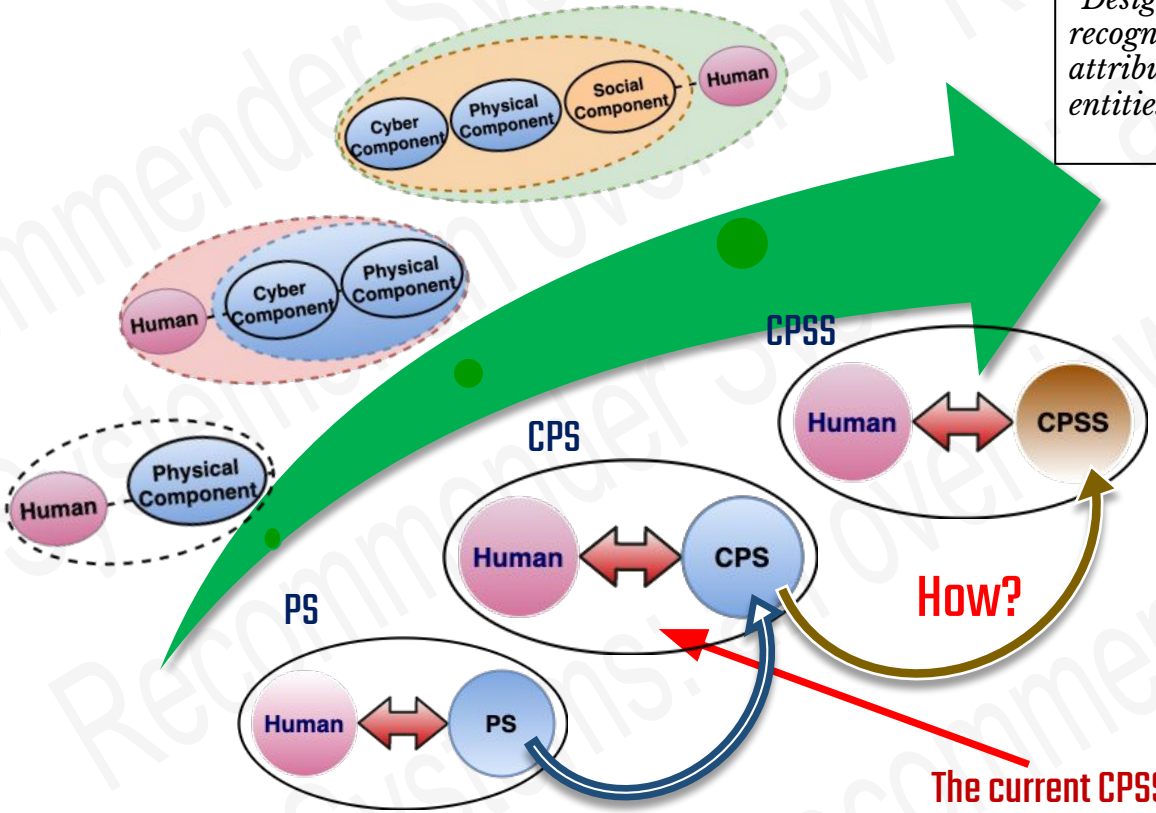
Cyber-Physical System (CPS) + **Social** → **Cyber-Physical-Social System (CPSS)**

Concerned with the integration of

- **Computation,**
- **Networking** and
- **Physical processes**

Enhance Human- CPS Interaction

1.1. Cyber-Physical-Social System (CPSS)



> *"Designing a human-centric machine effectively requires recognising human-like traits, at least a metaphorical attribution of human-like qualities to non-human entities."* Duffy et al. 2003.
>
> (social Robotics)

Social component:- deeply ingrained in

- ✔ Emotional
- ✔ Cognitive and
- ✔ Behavioural facets.

1.1. Cyber-Physical-Social System (CPSS)

Personality in Social interaction:

"Personality describes the unique patterns of thoughts, feelings, and behaviors that distinguish a person from others. A product of both biology and environment, it remains fairly consistent throughout life.."

https://www.verywellmind.com/what-is-personality-2795416

- Quality of experience: How well the individuals know each other?
- Recognising personal preferences, interests as well as limitations and opportunities such as disability, knowledge and skills of individuals becomes a necessity to ensure a seamless experience within a CPSS.

Personalisation

Since 1990's

1.2. Personalisation

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> "Personalisation, broadly known as customization, refers to tailoring a service or a product in a way that it fits to specific individuals' **preferences**, **cognition**, **needs** or **capabilities** under a given context."
>
> *(Goy et al, 2015)*

1.2. Personalisation

Source: **Politiken** (Based on Our Yale List)

- Decision making has become extremely challenging with the overwhelming number of products and services.

2. Recommender Systems (RecSys)

- "Algorithms that provide suggestions for items that are **presumed** most pertinent to a particular user." [1]

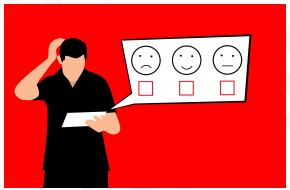
- Typically, the suggestions refer to various decision-making processes such as:

  - What product to purchase,
  - What music to listen to,
  - Which movies to watch,
  - What news to read,
  - Which route to take,
  - which place to visit, etc.

2. Recommender Systems (RecSys)

Data	Machine Learning Model	Predictions
User Preference	Recommender System	Recommendations

Explicit feedback



Implicit feedback

Indirect behaviour towards an item.

- previous purchase
- previous watch
- previous read
- previous click
- etc.

Predict future behaviours

RecSys Paradigms

- There are three common approaches namely Collaborative Filtering, Content-Based filtering and Hybrid Recommender Systems.

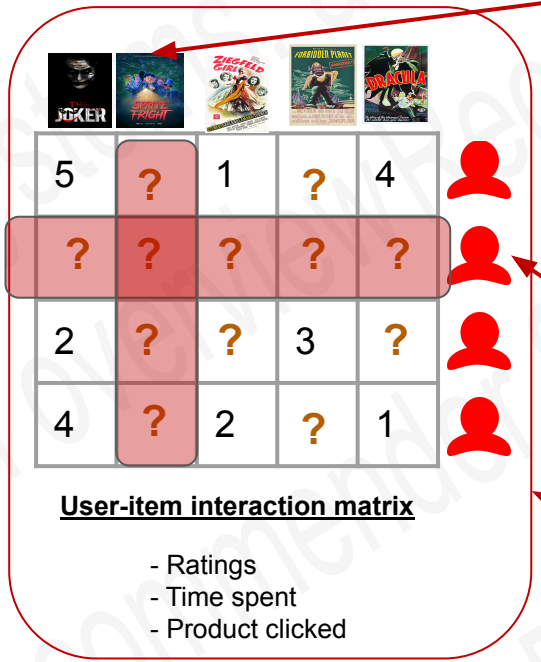
1. Collaborative Filtering

"Similar users like similar things"

Users

- Subscribers
- Readers
- Buyers
- etc.

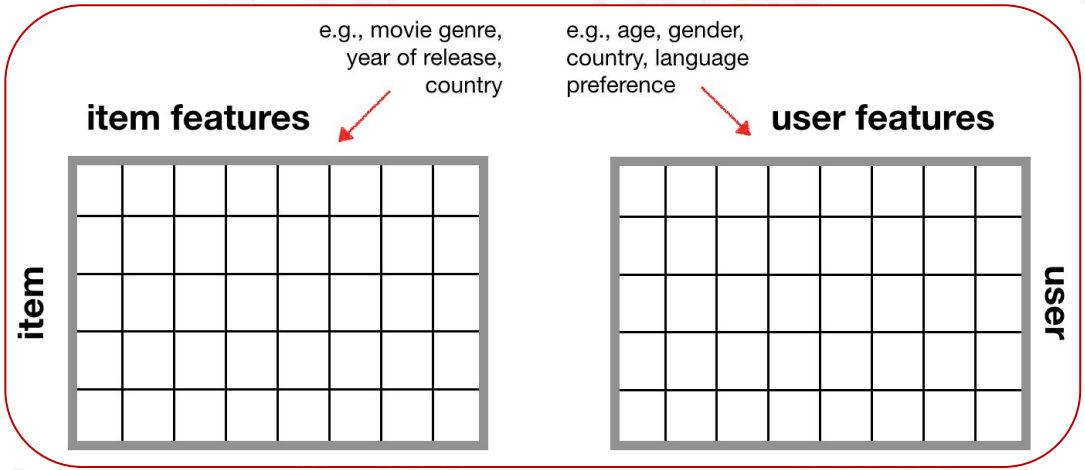
COLD START



RecSys Paradigms

2. Content-Based Filtering:

- Works based on the comparison of the analogy between the **user's profile** and **content of the items**.
- Use additional information about **users** and/or **items ("Features")** that explain the observed **user-item** interactions.



- Suffer less from cold start problem.
- only new users/items with unseen features suffer from cold start problem.

RecSys Paradigms

3. Hybrid Recommender Systems:

- Combine CF and CBF approaches
- Usually take two forms
  - Train two models independently (one CF model and one CBF model) and combine their suggestions.
  - Directly build a single model that unifies both approaches (often a Neural Network)
    - Input (Prior information user/item) + user-item interaction

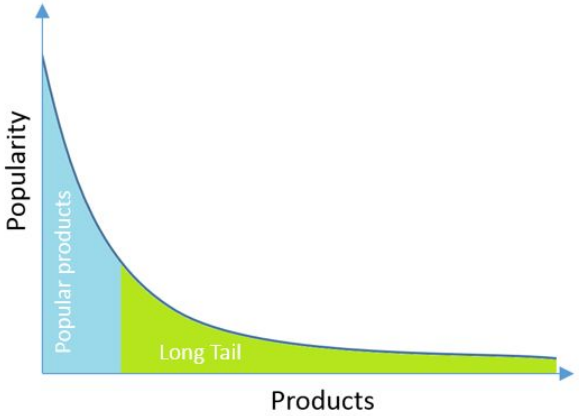
RecSys Issues & Challenges

- Cold start
- Sparisty
- Diversity
- Scalability

5				4
4				1

User-item interaction matrix

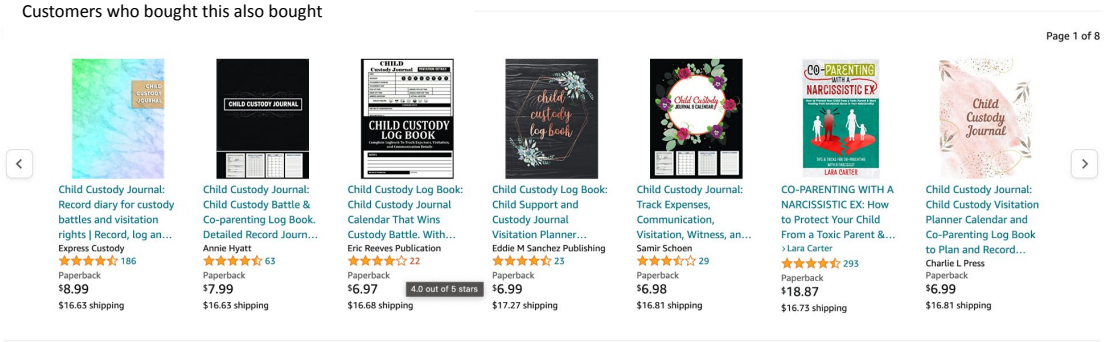
- Ratings
- Time spent
- Product clicked



$$\text{Sparsity} = \frac{\#\ \text{ratings}}{\text{total}\ \#\ \text{cells}}$$

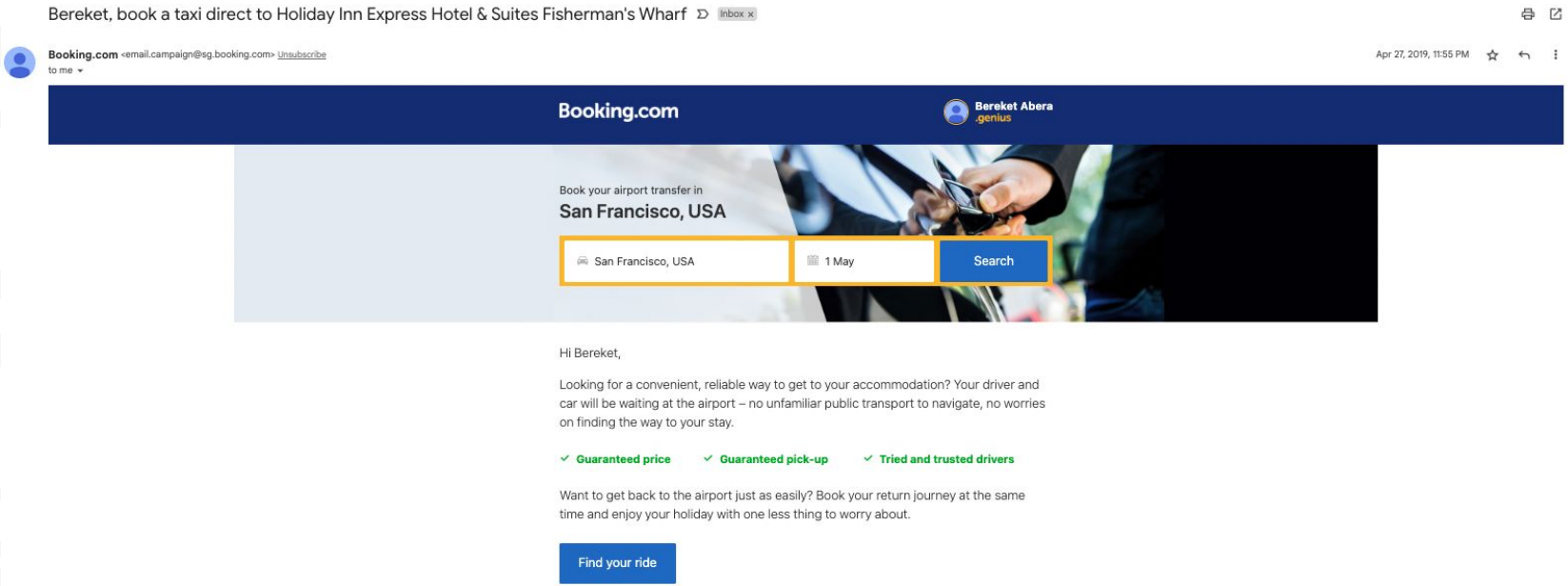
RecSys Issues & Challenges

- Adaptivity: changing business needs
- Robustness: Attack/ stress
- Privacy : Third party, sensitive private information



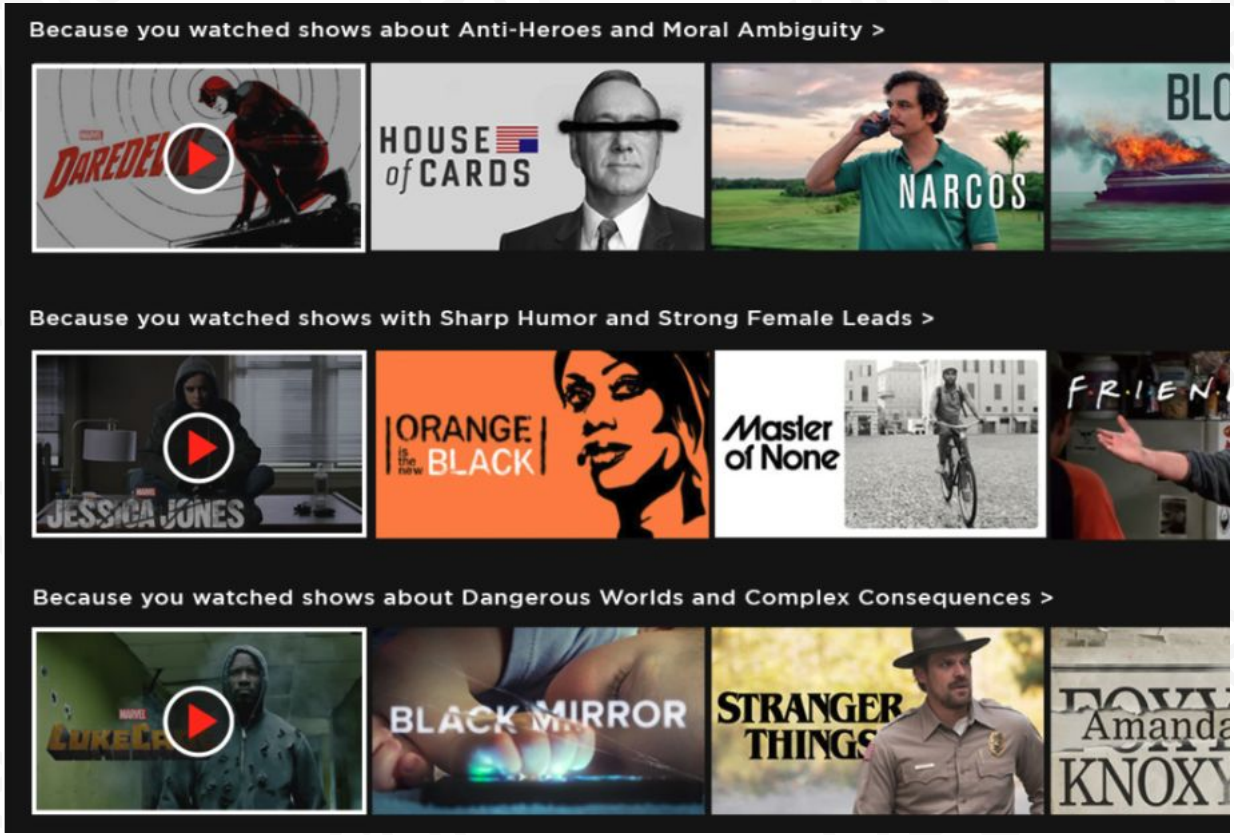
RecSys Issues & Challenges

- **Proactiveness:** Predict when and how to push Recommendations ← implicit request



RecSys Issues & Challenges

- Explainability



RecSys Issues & Challenges

- Evaluation: **How good/bad/ relevant is your Recommender System?**

The typical RecSys Pipeline

RECOMMENDER SYSTEMS

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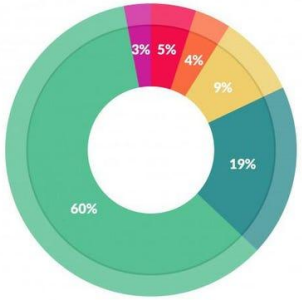
Data Pre-processing → **Model Training** → **Post Processing** → **Evaluation**



What data scientists spend the most time doing

- *Building training sets: 3%*
- *Cleaning and organizing data: 60%*
- *Collecting data sets; 19%*
- *Mining data for patterns: 9%*
- *Refining algorithms: 4%*
- *Other: 5%*

- Sort
- Filter
- Recommend

Modern RecSys Paradigms

Recent Approaches

- Zero-shot RecSys

- Multi-stakeholder aware RecSys

- RL based RecSys: