



Introduction to Recommender Systems

Bereket A. Yilma

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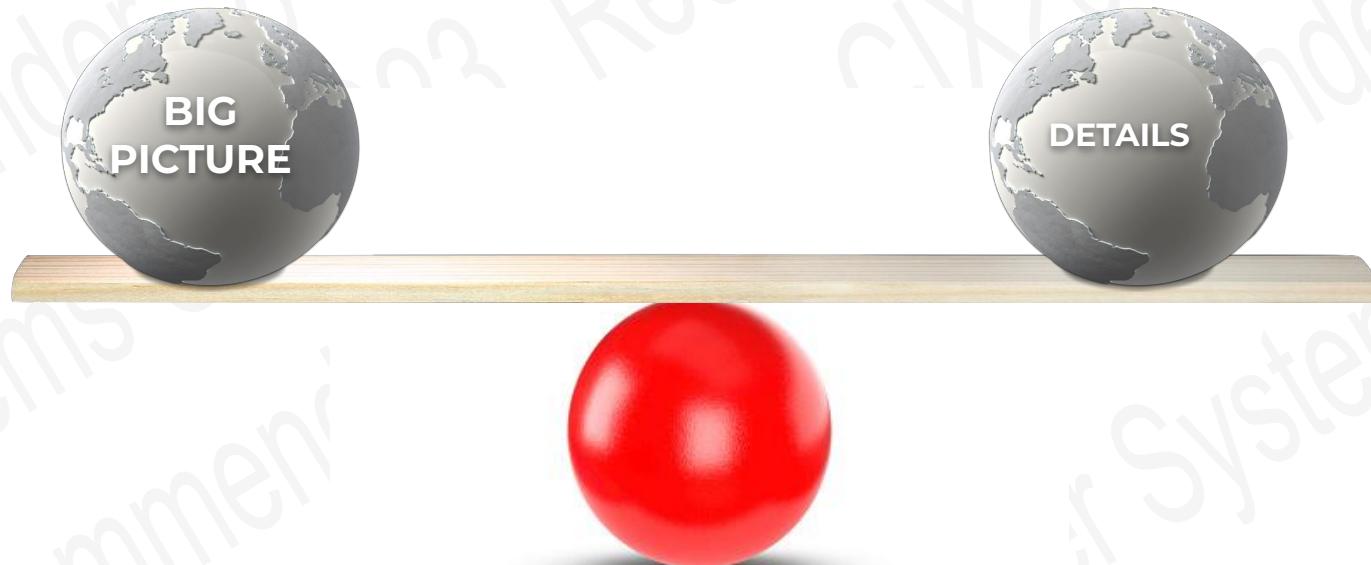


Session 1: Introduction



- Background
 - ◆ Why RecSys?
- RecSys Paradigms
- The RecSys Pipeline

1. Background



1. Background: Cyber-Physical-Social System (CPSS)

Cyber-Physical System (CPS)



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. Background: Cyber-Physical-Social System (CPSS)

Cyber-Physical System (CPS)

+ Social

Cyber-Physical-Social System (CPSS)



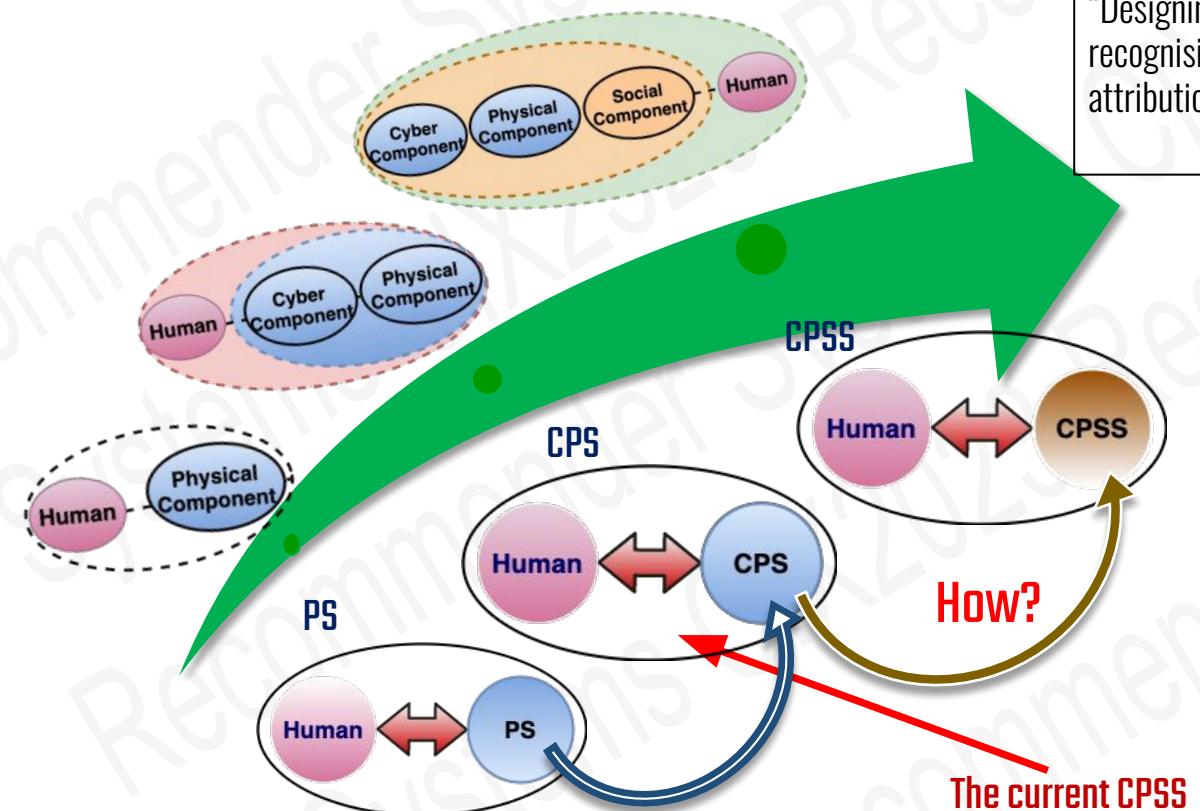
Concerned with the integration of

- Computation,
- Networking and
- Physical processes



Enhance Human- CPS Interaction

1. Background: 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. Background: Cyber-Physical-Social System (CPSS)

Personality in Social interaction:

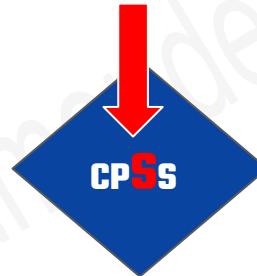


“Personality describes the **unique patterns of thoughts, feelings, and behaviors** that distinguish a person from others. A product of both biology and environment, it remains fairly consistent throughout life.”

- 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.

Personalization

Since 1990's



1. Background: Cyber-Physical-Social System (CPSS)

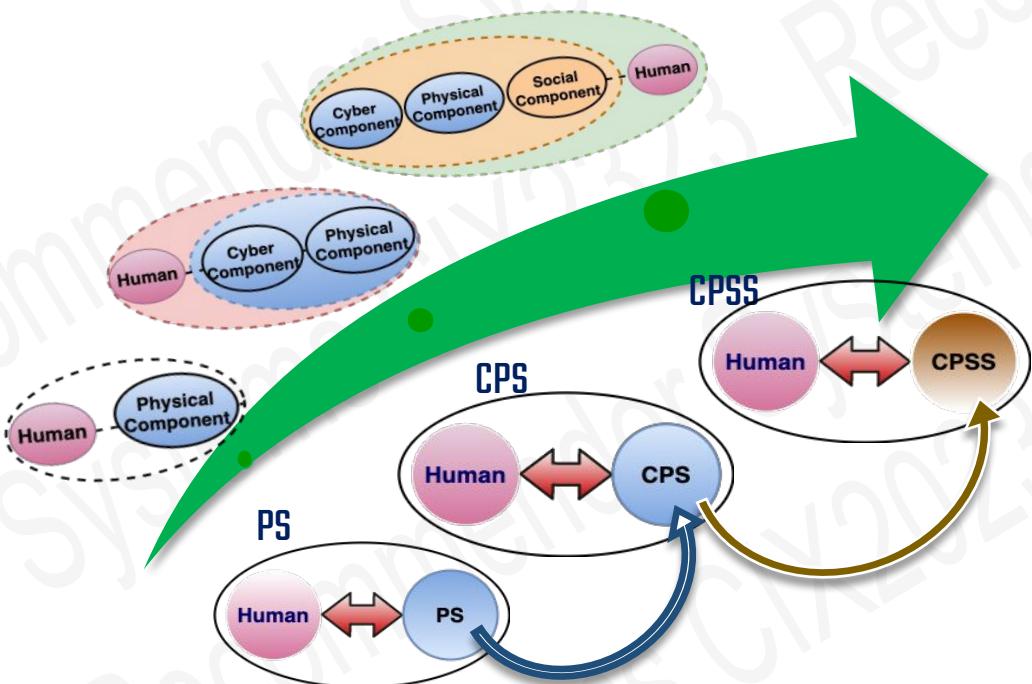
Personalization



“Personalization, 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)

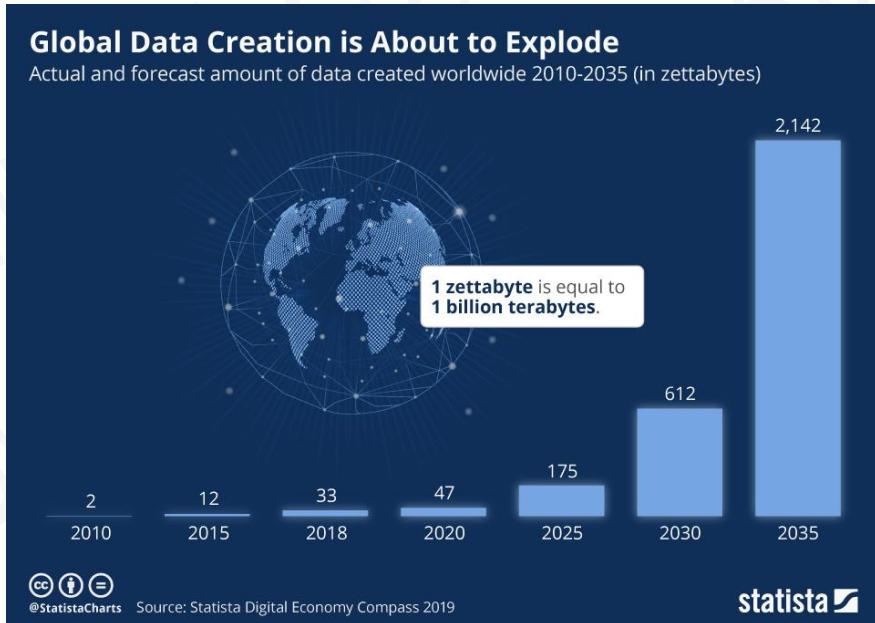
1. Background: Cyber-Physical-Social System (CPSS)



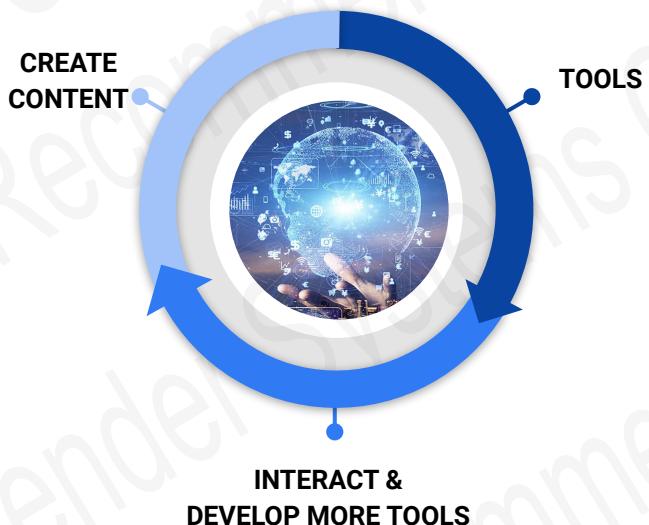
What came out of this evolution?



1. Background

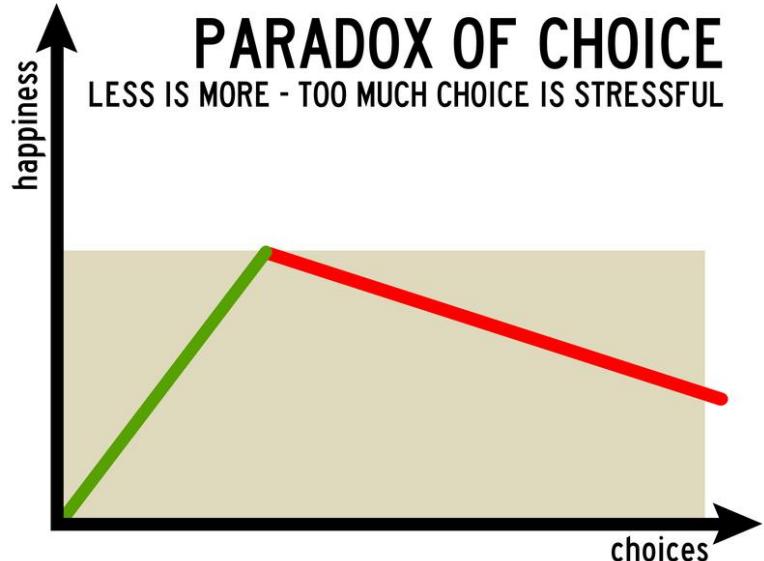


Limitless options on the web



1. Background

Abundance creates a problem



1. Background



Source: Politiken (Based on Our Yale List)

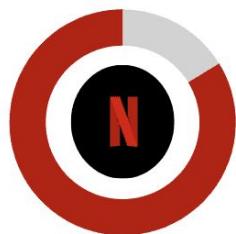
Decision making has become extremely challenging with the overwhelming number of products and services.

1. Background

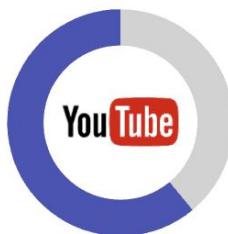


Recommender Systems (RecSys)

- “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:



80%
of content consumed on
Netflix is due to
recommendations.



60%
of video clicks on
YouTube's homepage
are attributed to
recommendations



35%
of its revenue is generated
by its recommendation
engine

- 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.

Recommender Systems (RecSys)



Personalization



Recommender Systems (RecSys)



Data

Machine Learning Model

Predictions

User Preference

Recommender System

Recommendations

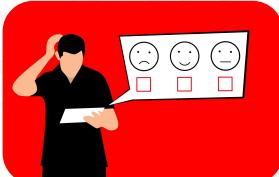
Explicit Feedback



Implicit Feedback

Indirect behaviour towards an item.

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



Predict future behaviours



RecSys Paradigms



RecSys Paradigms



There are three common approaches to design Recommender Systems.

1. Collaborative Filtering,
2. Content-Based filtering and
3. Hybrid RecSys

1. Collaborative Filtering

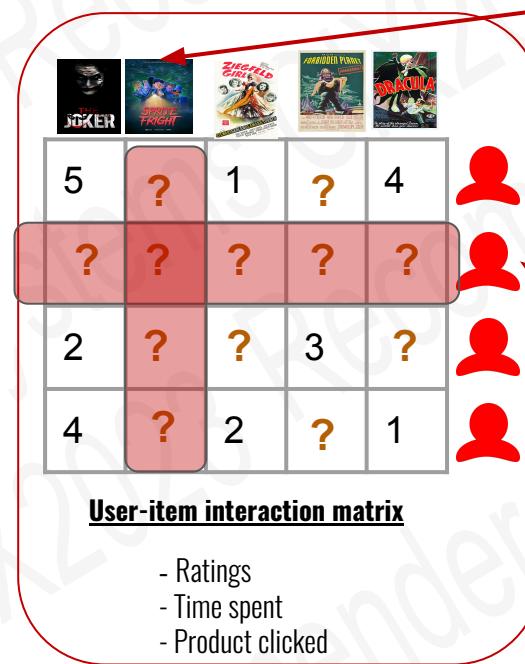
"Similar users like similar things"



Users

- Subscribers
- Readers
- Buyers
- etc.

COLD START



New item

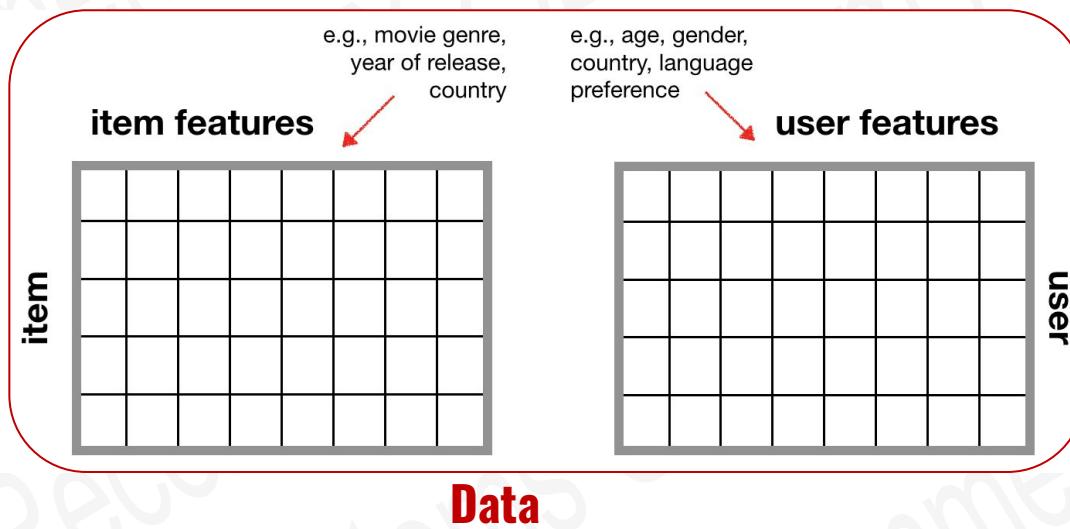
"Customers who bought this item also bought ... "

New user

Data

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.



3. Hybrid Recommender Systems:

- Combine **Collaborative Filtering (CF)** and **Content-Based Filtering (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



Modern RecSys Paradigms



Recent Approaches

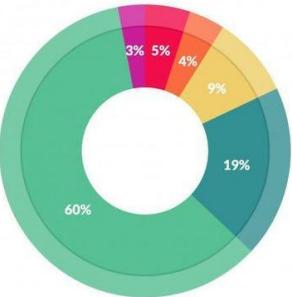
- Multi-stakeholder aware RecSys
- Large Language Models (LLMs) as RecSys
 - Zero & Few shot RecSys

More in Session 3



The typical RecSys Pipeline

Data Pre-processing



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%



Model Training



Post Processing

- Sort
- Filter
- Recommend



Evaluation