



Project3

Knowledge Graph-Based Recommender System

- **Introduction**
- **Task Description**
- **Reference**

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- Recommender systems infer the preferences of users and recommend relevant information to users.
- Recommender systems recommend items to users according to a score function.
 - Score function predicts how likely the user would be interested in the item.
 - Getting from historical user-item interaction records or additional side information.

- Based on what can we recommend an item (to a user)?
 - The items that the user interacted with.
 - The users who have interacted with similar.
 - The feature of users and items. 
-  Historical user-item interaction records
- Additional side information, like the Knowledge Graph

- Typical methods of Recommender System:
 - Collaborative Filtering method: Recommend according to **historical user-item interaction records**.
 - Content-based method: Recommend according to **item features**.
 - Hybrid method: Recommend according to **both** historical user-item interaction records and user/item features.

- Knowledge Graph-based (KG-based) Recommender System is a kind of hybrid method:
 - Use historical user-item interaction records.
 - Use a Knowledge Graph as the additional side information.
 - The knowledge graph is always used to describe the items.

Knowledge Graph (KG) is an abstract representation of knowledge in the real world.

- From the data structure view:
 - KG is a directed heterogeneous graph, entities are the vertices, relationships are the edges
- From the content view:
 - KG is a structured representation of knowledge.
 - It can provide some features about the users/items in the recommender system.

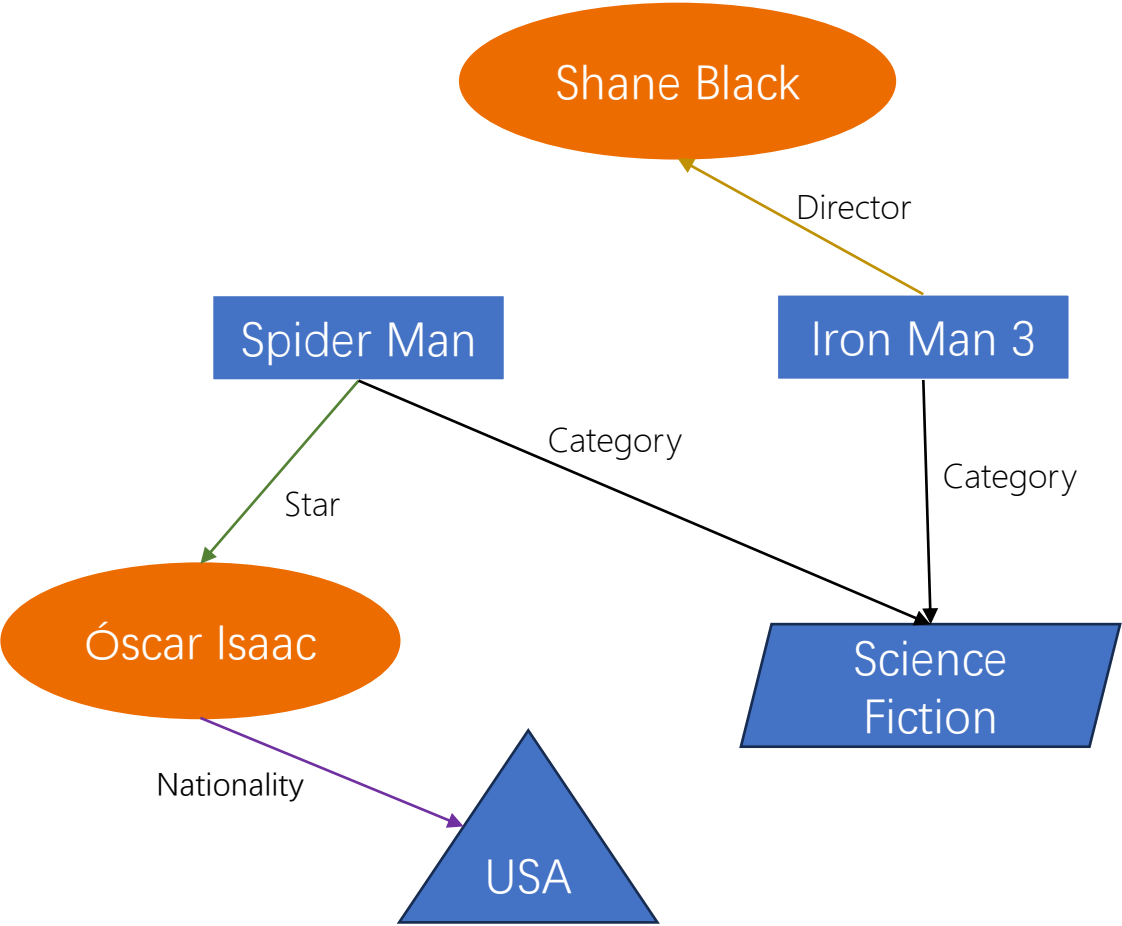
Knowledge Graph

- It records the facts by describing the **relations** between **entities**.
- A relation in the KG is always represented as a relation triple:
 - Head entity: the subject of this relation
 - Relation type: the category of this relation
 - Tail entity: the object of this relation

A simple example of the KG

Head Entity	Relation Type	Tail Entity
Spider Man	Star	Óscar Isaac
Iron Man 3	Category	Science Fiction
Óscar Isaac	Nationality	USA
Spider Man	Star	Daniel Kaluuya
Spider Man	Category	Science Fiction
Iron Man 3	Director	Shane Black

The relations in the KG



- The key to constructing a KG-based Recommender System:
 - Design a score function $f(u, w)$.
 - The score function is essentially a model trained with data.

How to get the score function from data?

- If we only have historical user-item interaction records:
 - Use Collaborative Filtering method
 - Represent the user/item by correlation or matrix factorization (Lecture PPT)
- If we have additional side information:
 - Use hybrid method
 - Represent the user/item by d -dimension embedding vector (Like the representation in the matrix factorization)

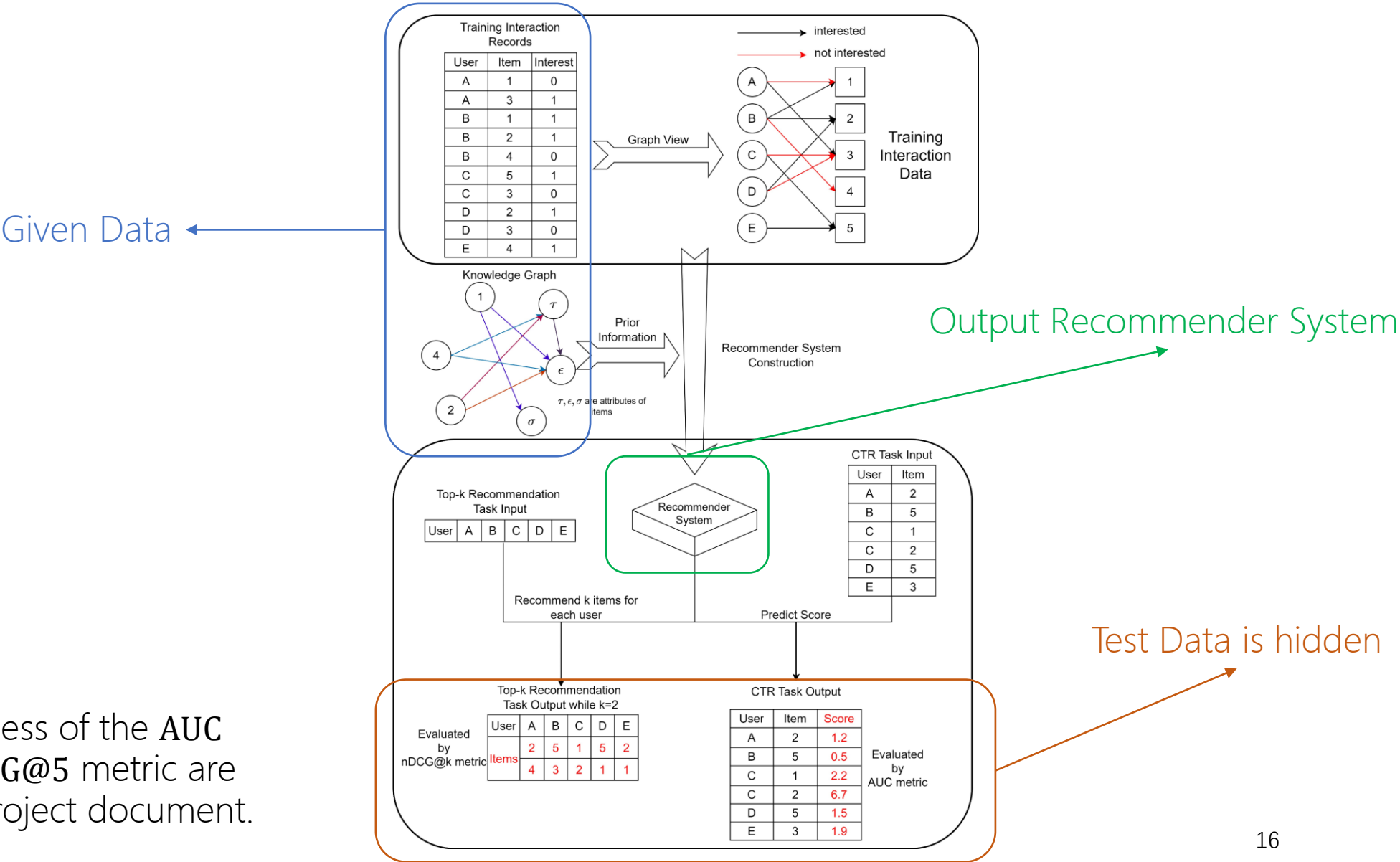
How to get the score function from data?

- If we have additional side information:
 - Represent the user/item by d -dimension embedding vector
 - For the embedding vector of each user/item, it should contain the information from additional side information.
 - Calculate the score of the combination of user and item by their embedding vector:
 - Inner product of vectors
 - MLP
 - For each combination of user and item, the score function should satisfy:
 - If the user has interacted with the item (positive) in the historical data, its score should be **high**.
 - Else, its score should be **low**.

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- Task Description
- Reference

- Input:
 - Interaction record set Y_{train}
 - Knowledge graph $\mathcal{G} = (V, E)$
- Output:
 - A recommender system with a score function $f(u, w)$
- Two tasks in this project:
 - Maximum the **AUC** metric of your score function $f(u, w)$ on a test dataset Y_{test}
 - Maximum the **nDCG@5** metric of your score function $f(u, w)$ on a test dataset Y_{test}

Task Description



Evaluation process of the **AUC** metric and **nDCG@5** metric are shown in the project document.

- URL of the OJ platform is: <https://spaces.sustech.cloud/>
- You need to submit a ZIP file that contains at least one file named `kgrs.py`
 - The `kgrs.py` should be placed in the root directory of your ZIP file.
 - The requirements of `kgrs.py` are shown in the project document.
- You can add other necessary files in your ZIP file.
- The total size of your ZIP file cannot exceed 1MB.

- Max CPU thread num: 8
- Max Memory size: 8GB
- Time Limitation:
 - Initialization of your algorithm: 60 seconds.
 - Training process of your algorithm: 600 seconds.
 - Evaluation process of **AUC** metric: 30 seconds.
 - Evaluation process of **nDCG@5** metric: 60 seconds.

- Total score of this project is 15 points
- For **AUC** and **nDCG@5**, they each have 7.5 points

	Score = 5	Score = 7	Score = 7.5
AUC	≥ 0.6	≥ 0.65	≥ 0.7
nDCG@5	≥ 0.05	≥ 0.075	≥ 0.12

- A report is necessary! You will get 0 score in this project if you haven't submitted the report!

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Reference

- [1] Q. Guo *et al.*, “A Survey on Knowledge Graph-Based Recommender Systems,” *IEEE Transactions on Knowledge and Data Engineering*, pp. 1–1, 2020, doi: [10/ghxwqg](https://doi.org/10/ghxwqg).
- [2] Y. Zhang, Q. Ai, X. Chen, and P. Wang, “Learning over Knowledge-Base Embeddings for Recommendation.,” *arXiv*, vol. abs/1803.06540, 2018, [Online]. Available: <http://arxiv.org/abs/1803.06540>
- [3] H. Wang, F. Zhang, M. Zhao, W. Li, X. Xie, and M. Guo, “Multi-Task Feature Learning for Knowledge Graph Enhanced Recommendation.,” in *The World Wide Web Conference*, ACM, 2019, pp. 2000–2010. doi: [10/ghcqwt](https://doi.org/10/ghcqwt).