EECS 598-008, W18
Mining Large-scale Graph Data

Heterogeneous Information Network and Deep Learning Based Music Recommender System

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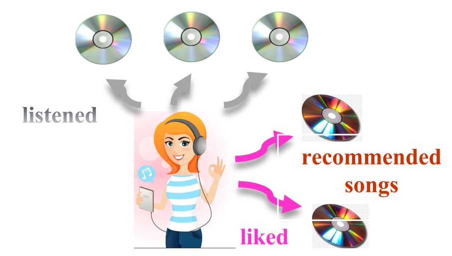
Problem Definition



- **Optimize top-N music recommendation to achieve higher hit rates**
- **INPUT**: user listening history & content information
- **OUTPUT**: top-N songs recommendation for each user

Motivation

Huge numbers of choices

Fail to predict user preference

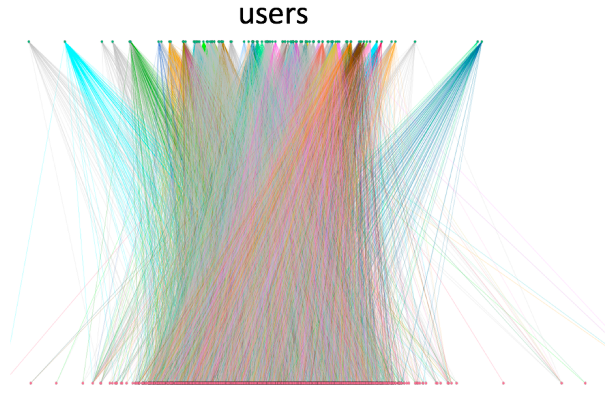
Datasets

Users	Songs	User-song Pairs
14516	10748	1894113

	Min	Max	Average
Songs per User	91	599	130
Users per Song	3	3308	176

Train	Test
80% user	20% user

Visible	Hidden
50% song	50% song



References

- Huan Zhao *et al*. Meta-Graph Based Recommender Fusion over Heterogeneous Information Network
- Danai Koutra *et al*. PNP: Fast Path Ensemble Method for Movie Design
- Shifu Hou *et al*. HinDroid: An Intelligent Android Malware Detection System Based on Structured Heterogeneous Information Network

Acknowledgements

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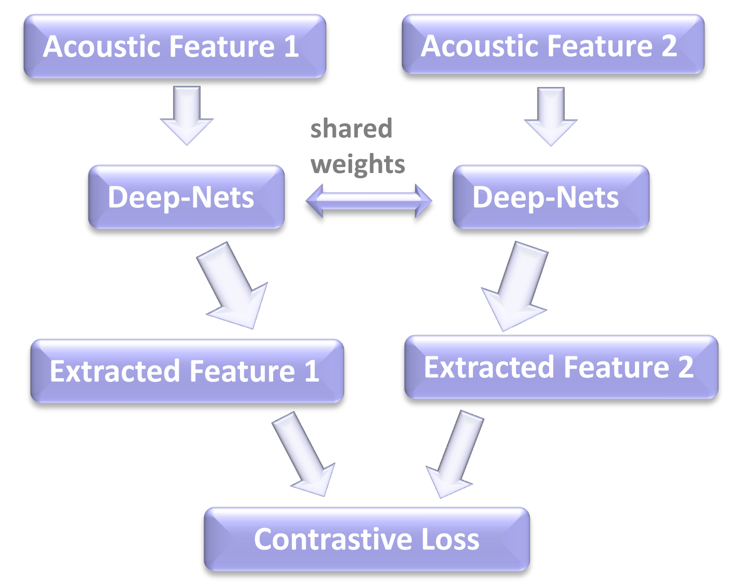
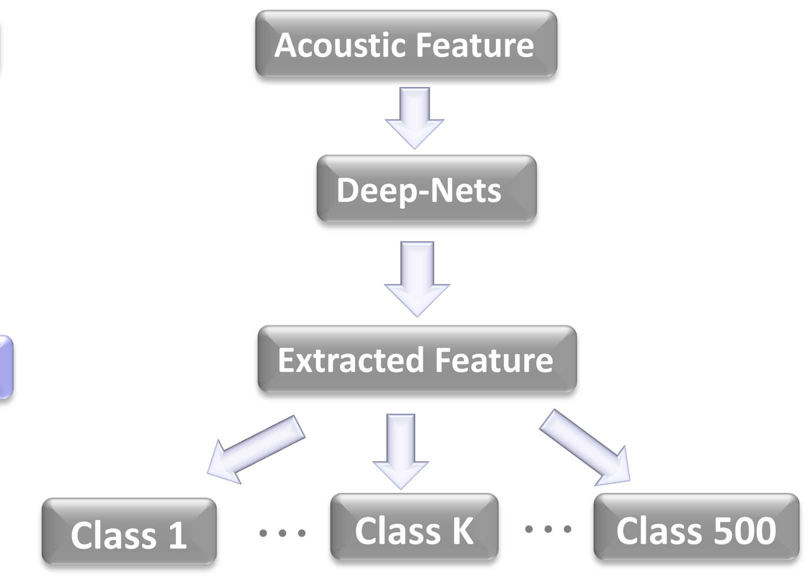
Our Approach

Deep-learning based Acoustic Feature Extraction

- Siamese model

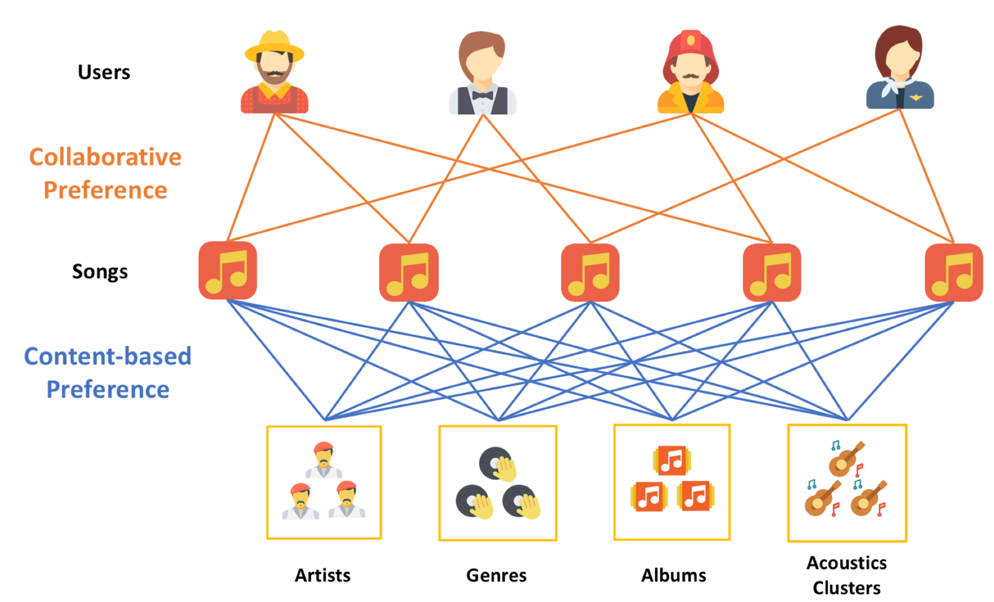


- Multi-classification model



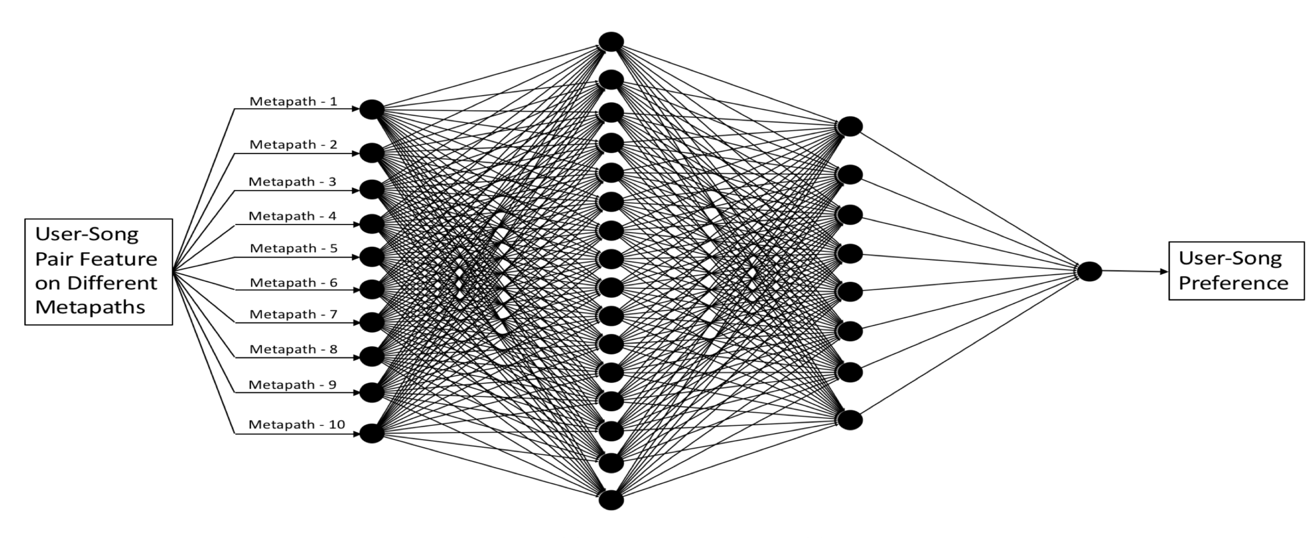
Heterogeneous Graph based Recommendation using Metapaths

- In Heterogeneous graph, we define **Metapaths** in different relationships to model the preference between entities
- **Entities**: User, Song
- **Relationships**:
  - User-Song: ***R***
  - Song-Artist: ***T***
  - Song-Genre: ***E***
  - Song-Album: ***M***
  - Song-Acoustic: ***C***



Combination of Metapaths by using Machine Learning Techniques

- We **combine** different Metapaths by using **Multi-layer Perceptron Regression** with 2 hidden layers on listening history of user-item pairs
- **Supervised Learning** helps us automatically learn from observed history then effectively select useful Metapath features



Experimental Results

Single Metapaths Comparison in Music Recommendation

Metapaths	*Single Path Average Hit Rate*
RR^TR	20.07%
RTT^T	25.30%
REE^T	0.82%
RMM^T	26.93%
RCC^T	6.94%
RR^TRTT^T	13.49%
RR^TREE^T	0.46%
RR^TRMM^T	15.17%
RR^TRCC^T	1.65%
REE^TTT^T	2.11%
REE^TMM^T	1.69%
REE^TCC^T	0.25%
RTT^TMM^T	23.41%
RTT^TCC^T	7.79%
RMM^TCC^T	8.03%

We choose 5 best Metapaths to perform Metapath (5), and 10 best Metapaths to perform Metapaths (10). Red stands for Metapaths used in Metapaths (5), Blue stands for Metapaths used in Metapaths (10).

Observation:

1. **Artist and Album** perform much better than other content features in music recommendation
2. **Acoustic feature** is helpful in content-based recommendation
3. **Genre** performs badly in recommendation. The same genre contains too many songs and it is not informative in music recommendation

Comparison with Other Baseline Models in Music Recommendation

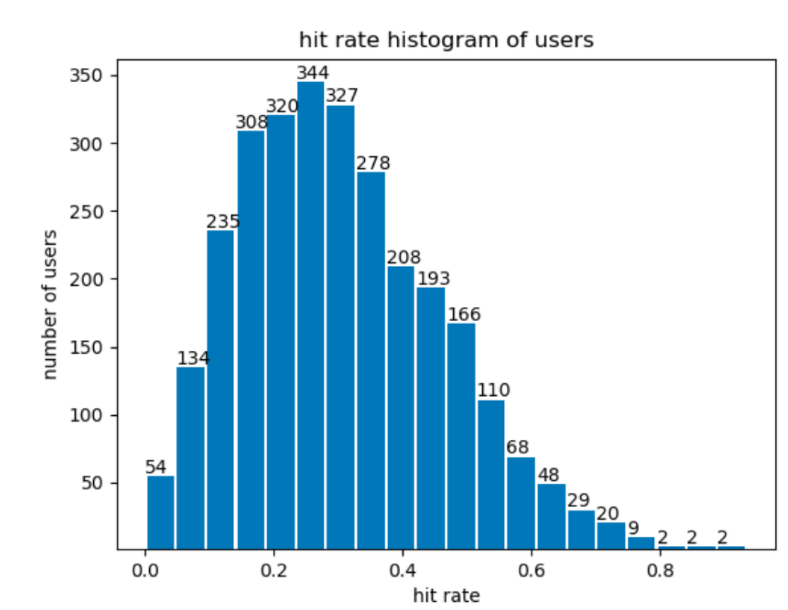
Observation:

1. **Metapath-based recommendation** outperforms traditional collaborative filtering and matrix factorization methods
2. By utilizing **machine learning** techniques, Metapath-based recommendation achieves higher hit rates

Methods	*Average Hit Rate*
Random Guess	0.62%
Popular-based Recommendation	7.30%
Collaborative Filtering	14.11%
Metapaths (5) + Matrix Factorization	12.11%
Metapaths (10) + Matrix Factorization	12.67%
Metapaths (5) + Linear Regression	28.97%
Metapaths (10) + Linear Regression	30.29%
Metapaths (5) + Neural Network	29.73%
Metapaths (10) + Neural Network	32.28%

Metapaths (5): Using 5 best Metapaths features; Metapaths(10): Using 10 best Metapaths features

Distribution of Metapaths (10) + Neural Network on Hit Rates for Different Users



Observation:
The prediction satisfies Gaussian distribution with **mean=32.28%** and **standard derivation=15.02%**

Conclusions

- Doing **multi-label classification** over acoustic features works better than grouping them according to hyper dimensional distance using listeners' preference
- **Heterogeneous Information Network** based recommendation by combining collaborative preference and content-based preference outperforms other methods
- **Metapaths** combination through **Supervised Learning** yields higher hit rate