Recommendation Systems
Final Project - Autorec Report
Winter SEMESTER 2021-2022

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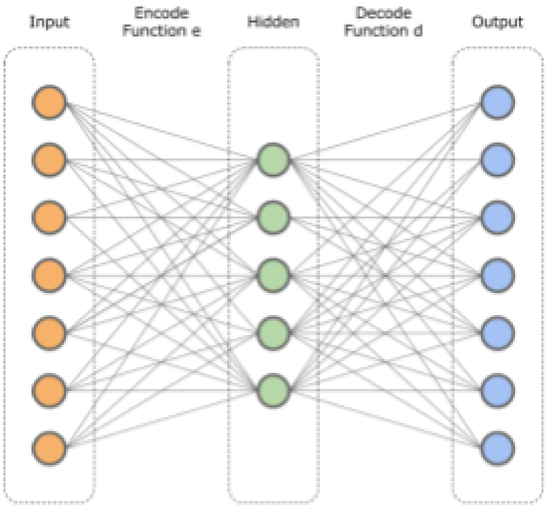
Github Project Link: https://github.com/aviadar/RecSys_AutoRecProject

1. Anchor Paper

AutoRec: Autoencoders Meet Collaborative Filtering

Baseline Matrix Factorization model is essentially a linear model, so when taking into consideration a complex nonlinear user preference - the basic model will have trouble predicting this complex relationship. The suggested approach uses collaborative filtering along with an autoencoder architecture and uses explicit feedback CF which is integrated with nonlinear transformations. AutoRec consists of an input layer (encoder), a hidden layer, and a reconstruction layer (decoder) , the same as Autoencoders.



Typical AutoEncoder architecture

In AutoRec, instead of explicitly embedding users/items into low-dimensional space, it uses the column/row of the interaction matrix as the input, then reconstructs the interaction matrix in the output layer. But AutoRec differs from autoencoders so rather than learning the hidden representations, AutoRec focuses on reconstructing the output layer. It uses a partially observed interaction matrix as the input, aiming to reconstruct a completed rating matrix.

The model:

$$h(R_{*_i}) = f(W \cdot g(VR_{*_i} + \mu) + b)$$

R_{*_i} - i column in the rating matrix

$f,\ g$ - activation functions

$W,\ V$ - weight matrices

$h(R_{*_i})$ - i column reconstruction of the rating matrix

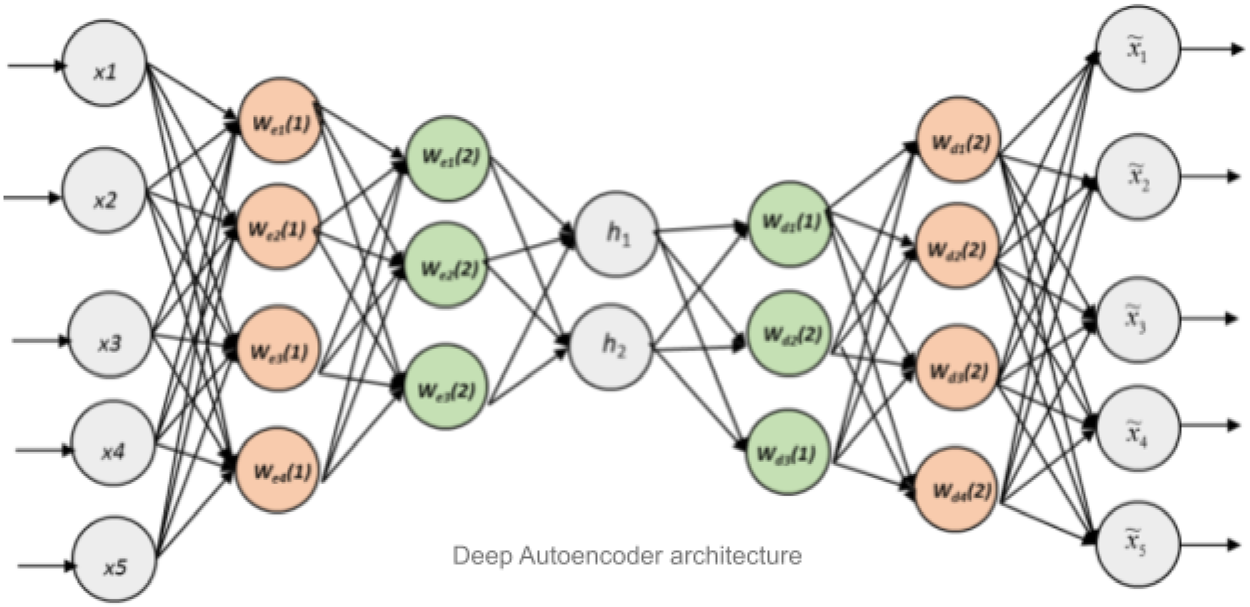
The objective is:

$argmin_{W,V,\mu,b}\Sigma_i||R_{*_i} - h(R_{*_i})||^2 + \lambda(||W||^2 + ||V||^2)$

Note that we disregard values where the ratings are 0.

2. Suggested Improvement

The suggested improvement can be achieved quite easily: turn the autoencoder network and turn it into a deep network.



Deep Autoencoder architecture

The improvement should give an option to use a more complex nonlinear prediction model, and thus yield better results in the process.

We suggest 2 different improvements:

- A hidden layer in the encoder and a hidden layer in the decoder.
- Includes 2 hidden layers in the encoder and 2 hidden layers in the decoder.

3. Comparison Model

Matrix Factorization is selected as the baseline model for comparison.

4. Algorithm Evaluation

a. DataSet Selection

The Selected DataSets are:

1. Movielens-1m
2. Netflix Prize

b. Hyperparameters Optimization

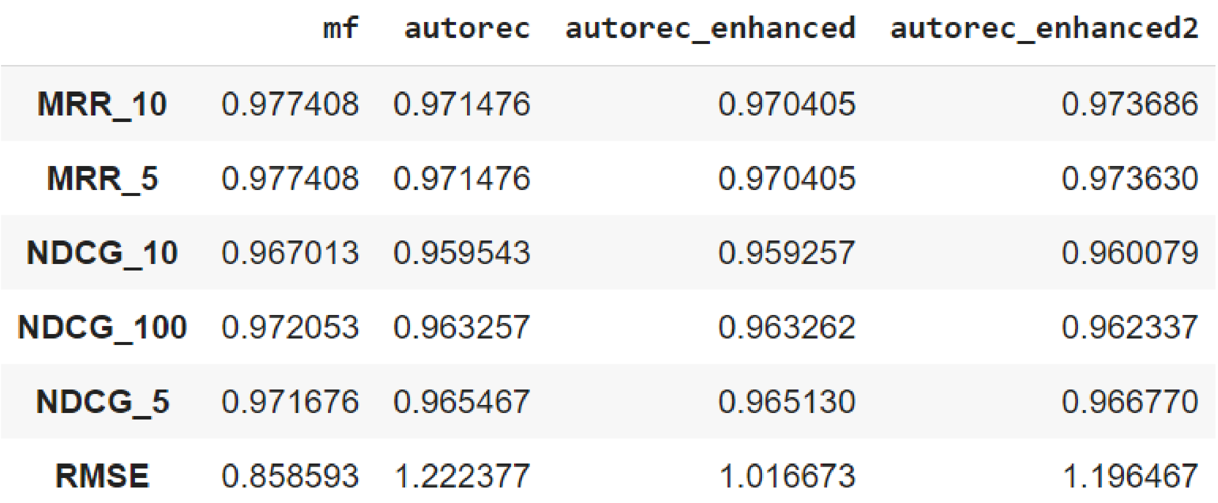
1. MF Hyperparameters:
    a. Latent dimension = {10, 20, 30, 40}
        i. Netflix Best Hyperparameter = 40
        ii. Movielens Best Hyperparameter = 40
    b. Learning rate = {1e-3, 1e-4}
        i. Netflix Best Hyperparameter = 0.001
        ii. Movielens Best Hyperparameter = 0.001
2. Autorec Hyperparameters:
    a. Regularization = {0.001, 0.0001}
        i. Netflix Best Hyperparameter = 0.0001
        ii. Movielens Best Hyperparameter = 0.0001
    b. Hidden units size = {300, 500, 700, 900}
        i. Netflix Best Hyperparameter = 900
        ii. Movielens Best Hyperparameter = 300
    c. Learning rate = {1e-3, 1e-4}
        i. Netflix Best Hyperparameter = 0.001
        ii. Movielens Best Hyperparameter = 0.001
    d. Encoder activation = {relu, elu, sigmoid}
        i. Netflix Best Hyperparameter = Sigmoid
        ii. Movielens Best Hyperparameter = Sigmoid
    e. Decoder activation = {relu, elu, sigmoid}
        i. Netflix Best Hyperparameter = RELU
        ii. Movielens Best Hyperparameter = ELU
3. Autorec Enhanced Hyperparameters:
    a. Regularization = {0.001, 0.0001}
        i. Netflix Best Hyperparameter = 0.0001
        ii. Movielens Best Hyperparameter = 0.0001
    b. Hidden units size = {50, 100}
        i. Netflix Best Hyperparameter = 100

      ii. Movielens Best Hyperparameter = 100
   c. Hidden layer factor = {2, 3}
      i. Netflix Best Hyperparameter = 2
      ii. Movielens Best Hyperparameter = 3
   d. Learning rate = {1e-3, 1e-4}
      i. Netflix Best Hyperparameter = 0.001
      ii. Movielens Best Hyperparameter = 0.001
   e. Encoder activation = {relu, elu, sigmoid}
      i. Netflix Best Hyperparameter = ELU
      ii. Movielens Best Hyperparameter = Sigmoid
   f. Decoder activation = {relu, elu, sigmoid}
      i. Netflix Best Hyperparameter = ELU
      ii. Movielens Best Hyperparameter = ELU

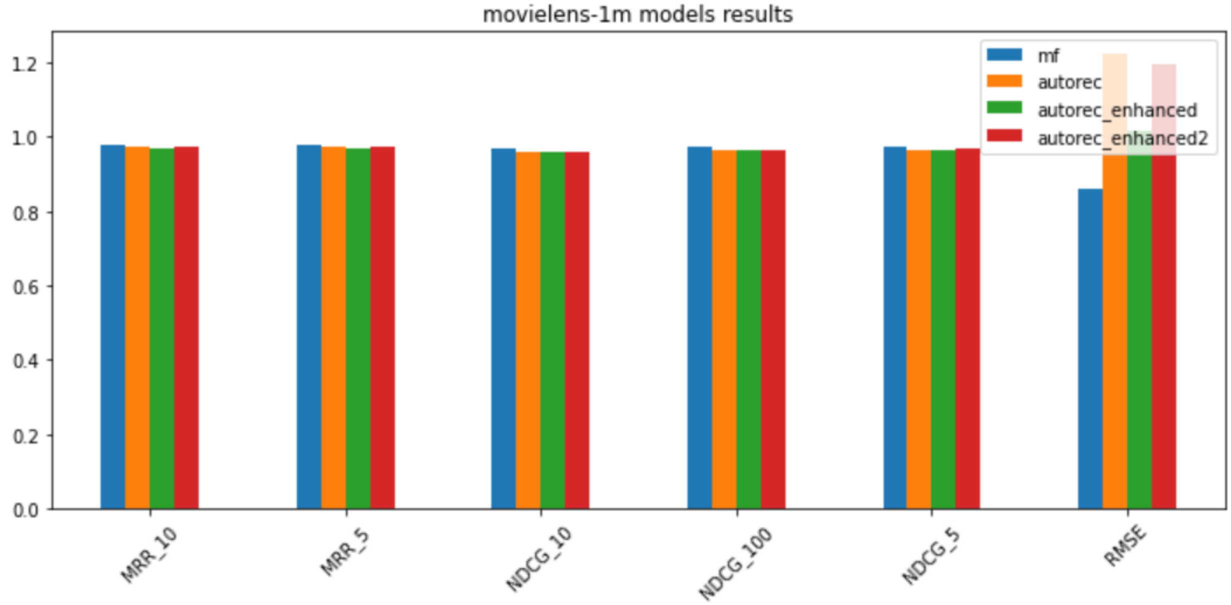
4. Autorec Enhanced 2 Hyperparameters:
   a. Regularization = {0.001, 0.0001}
      i. Netflix Best Hyperparameter = 0.0001
      ii. Movielens Best Hyperparameter = 0.0001
   b. Hidden units size = {50, 100}
      i. Netflix Best Hyperparameter = 100
      ii. Movielens Best Hyperparameter = 50
   c. Hidden layer factor = {2, 3}
      i. Netflix Best Hyperparameter = 2
      ii. Movielens Best Hyperparameter = 2
   d. Learning rate = {1e-3, 1e-4}
      i. Netflix Best Hyperparameter = 0.001
      ii. Movielens Best Hyperparameter = 0.001
   e. Encoder activation = {relu, elu, sigmoid}
      i. Netflix Best Hyperparameter = ELU
      ii. Movielens Best Hyperparameter = ELU
   f. Decoder activation = {relu, elu, sigmoid}
      i. Netflix Best Hyperparameter = ELU
      ii. Movielens Best Hyperparameter = ELU

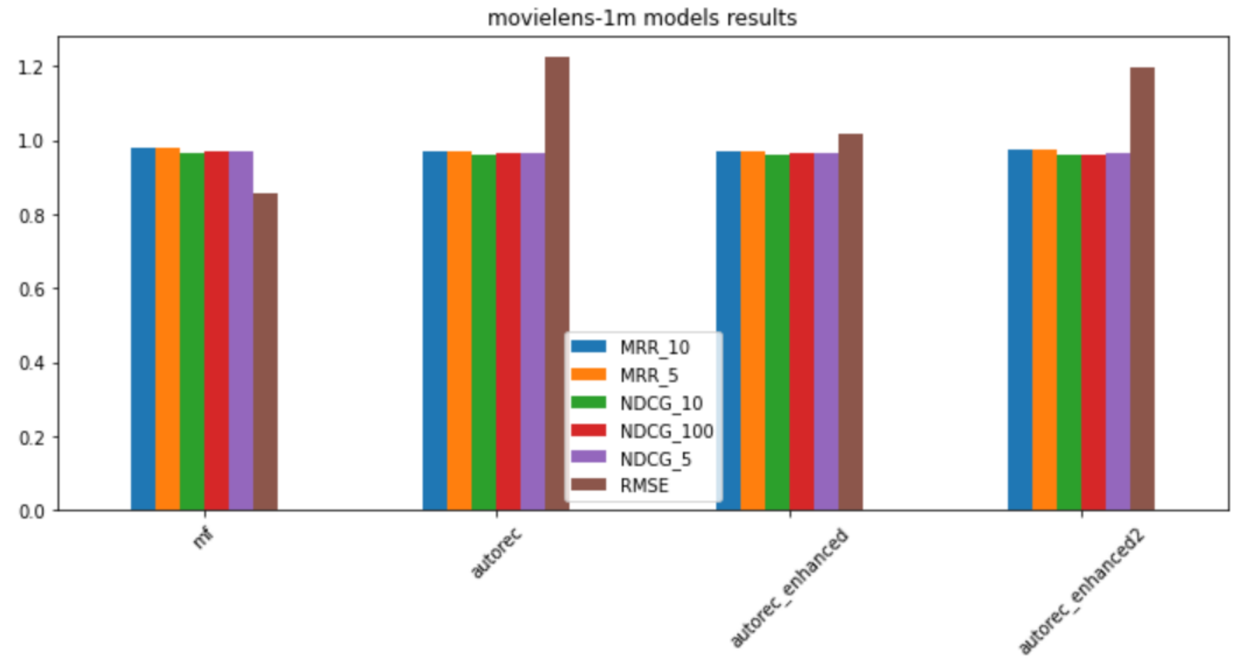
c. Performance Evaluation

1. Movielens-1M:

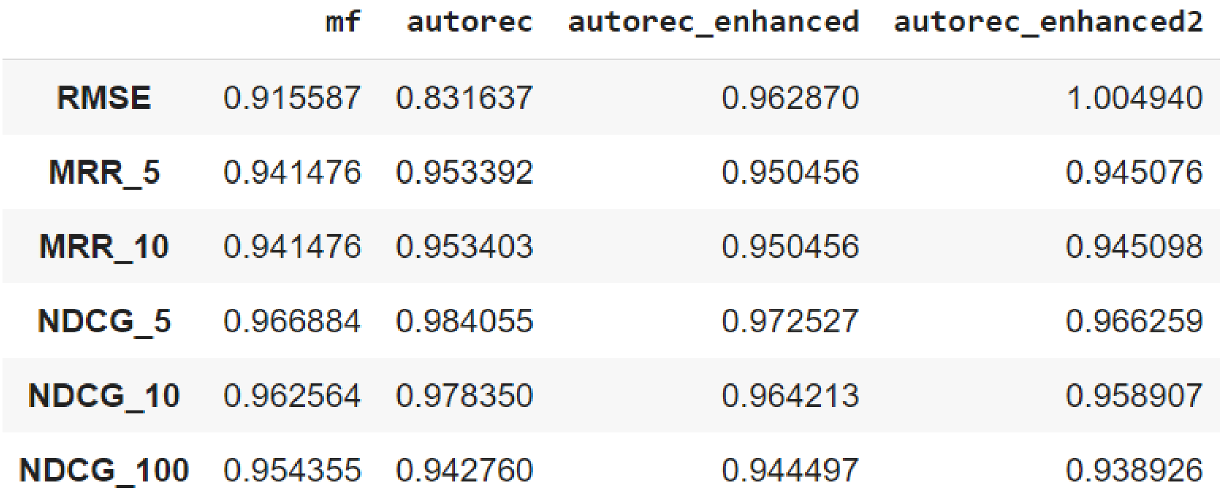


	mf	autorec	autorec_enhanced	autorec_enhanced2
MRR_10	0.977408	0.971476	0.970405	0.973686
MRR_5	0.977408	0.971476	0.970405	0.973630
NDCG_10	0.967013	0.959543	0.959257	0.960079
NDCG_100	0.972053	0.963257	0.963262	0.962337
NDCG_5	0.971676	0.965467	0.965130	0.966770
RMSE	0.858593	1.222377	1.016673	1.196467

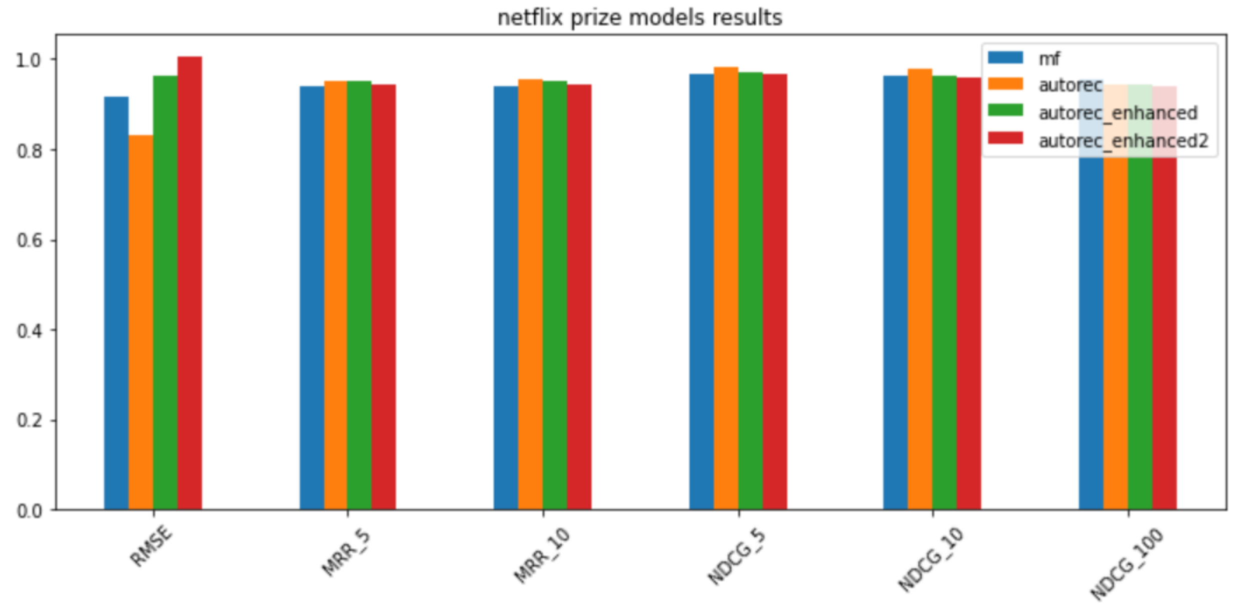


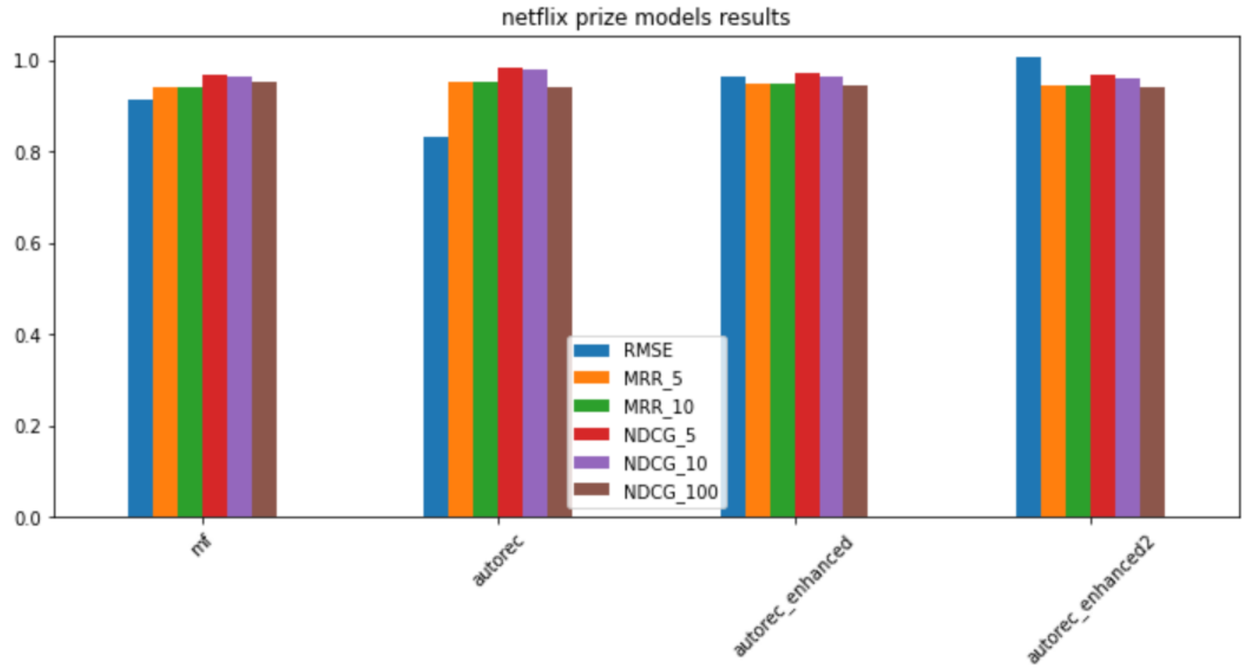


2. Netflix Prize:



	mf	autorec	autorec_enhanced	autorec_enhanced2
RMSE	0.915587	0.831637	0.962870	1.004940
MRR_5	0.941476	0.953392	0.950456	0.945076
MRR_10	0.941476	0.953403	0.950456	0.945098
NDCG_5	0.966884	0.984055	0.972527	0.966259
NDCG_10	0.962564	0.978350	0.964213	0.958907
NDCG_100	0.954355	0.942760	0.944497	0.938926


netflix prize models results
1.0
0.8
0.6
0.4
0.2
0.0
RMSE
MRR_5
MRR_10
NDCG_5
NDCG_10
NDCG_100
mf
autorec
autorec_enhanced
autorec_enhanced2


netflix prize models results
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autorec
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NDCG_100