

# Wide & Deep Learning for Recommender Systems

## introduction

- search ranking
  - input: a set of user and contextual information
  - output: a ranked list of items
- challenge
  - memorization — learning the frequent co-occurrence of items or features and exploiting the correlation available in the historical data.
  - generalization — is based on transitivity of correlation and explores new feature combinations that have never or rarely occurred in the past
- cross-product transformations
  - AND(user\_installed\_app=netflix, impres-sion\_app=pandora)
  - explains how the co-occurrence of a feature pair correlates with the target label
  - manual feature engineering is often required and do not generalize to query-item feature pairs that have not appeared in the training data
- embedding-based models
  - can generalize to previously unseen query-item feature pairs
  - it is difficult to learn effective low-dimensional representations for queries and items when the underlying query-item matrix is sparse and high-rank
  - lead to nonzero predictions for all query-item pairs, and thus can over-generalize and make less relevant recommendations

## wide & deep learning

- wide
  - generalized linear model —  $y = \mathbf{w}^T \mathbf{x} + b$
  - feature
    - raw input features
    - transformed features — cross-product transformation
- deep
  - feed-forward neural network
  - feature
    - categorical features are first converted into an embedding vector
    - embedding vectors are initialized randomly
  - embedding vectors are then fed into the hidden layers of a neural network in the forward pass
- joint training
  - using a weighted sum of their output and then fed to one common logistic loss function for joint training
  - back-propagating the gradients
    - wide — Follow-the-regularized-leader(FTRL)
    - deep — AdaGrad

$$P(Y=1|\mathbf{x}) = \sigma(\mathbf{w}_{wide}^T [\mathbf{x}, \phi(\mathbf{x})] + \mathbf{w}_{deep}^T \mathbf{a}^{(l_f)} + b)$$

我的理解是将原始特征和deep model产生的output一起作为一个logistic regression模型的输入。