

分类排序应用 => CTR预估

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七月在线 寒老师  
2016年8月20日

# 主要内容

- 广告与CTR预估
- 从LR到Mllib建模
- 从LR到RF与GBDT建模
- Facebook: LR+GBDT?
- 从FM到FFM对CTR建模
- 深度学习走一个?
  - Google wide & deep model
  - 2016 最新进展: FNN

Field  
Factorization machine

LR

FM + Deep



# LR部分

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- Online advertising and click through rate prediction
- Data set and features
- Spark MLlib and the Pipeline API
- MLlib pipeline for Click Through Rate Prediction
- Questions



# Online Advertising



## What's News

## SEC Appeals on the Slow Track

The regulator's use of its own tribunal has coincided with longer delays in the agency's handling of appeals, according to a Wall Street Journal analysis.

### SEC to Retrench on SAC's Cohen

The Securities and Exchange Commission said it pared back its case against Steven A. Cohen and disclosed settlement talks with him, a reversal that reflects a major shift in the legal landscape since the government declared victory in its long pursuit of the hedge-fund billionaire's firm.



### Valeant Deal With Walgreens Has Unusual Twist

Valeant's distribution deal with Walgreens has an unusual twist that allows the Canadian drugmaker to repurchase its drugs at the pharmacy without physically taking them back.



### Bomb Kills Six American Soldiers In Afghanistan



### China Unveils Economic Blueprint for 2016

China's leadership has mapped out an economic blueprint for next year that focuses on reducing industrial overcapacity, slashing costs for businesses, cutting unsold property inventory and fending off financial risks.

China's Economic Miracle Hits Tough Times

### Front-Runners Trump and Clinton Face Off

Republican Donald Trump demanded an apology from Democrat Hillary Clinton for calling his rhetoric an Islamic State recruitment tool—and her campaign stood its ground.

238



CAPITAL JOURNAL

### Regime Change, Good or Bad?



### SpaceX Successfully Lands Rocket



### Wreath Charity Has Ties to Its Supplier



### San Bernardino Shooter's

## Markets

U.S.	EUROPE	ASIA	FX	RATES	FUTURES
DJIA	17251.62	0.72%			
S&P 500	2021.15	0.78%			
Nasdaq	4968.92	0.93%			
Russell 2000	1127.74	0.60%			
DJ Total Mkt	20864.64	0.73%			
Global Dow	2301.28	-0.03%			

Dec 21 '15, 4:32 PM EST

## Opinion

### Another Time, Another Trump

By Dave Shiflett | Commentary

### Treasury's Latest Inversion Failure

Review & Outlook

### Let's Elect Hillary Now

By Bret Stephens | Global View

### THE ALL-NEW BMW 7 SERIES.



# 搜索引擎与广告

The screenshot shows a Google search for "kids shoes". The search bar at the top contains the text "kids shoes" and a blue search button with a magnifying glass icon. Below the search bar, there are tabs for "All", "Shopping", "Maps", "Images", "Videos", "More", and "Search tools". The "All" tab is selected. Below the tabs, it says "About 261,000,000 results (0.59 seconds)".

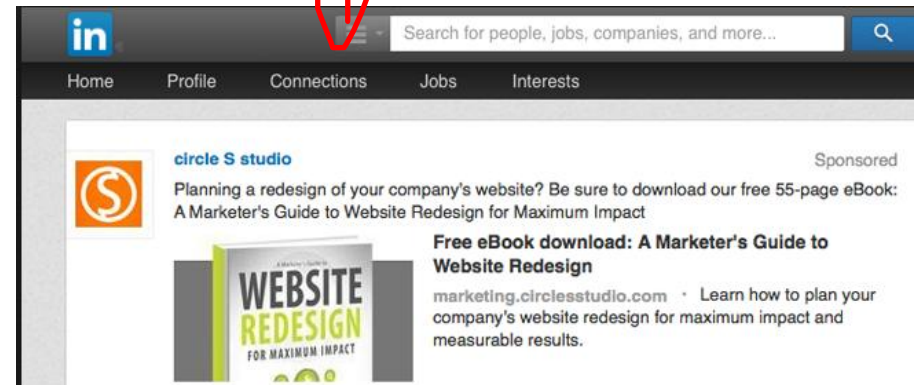
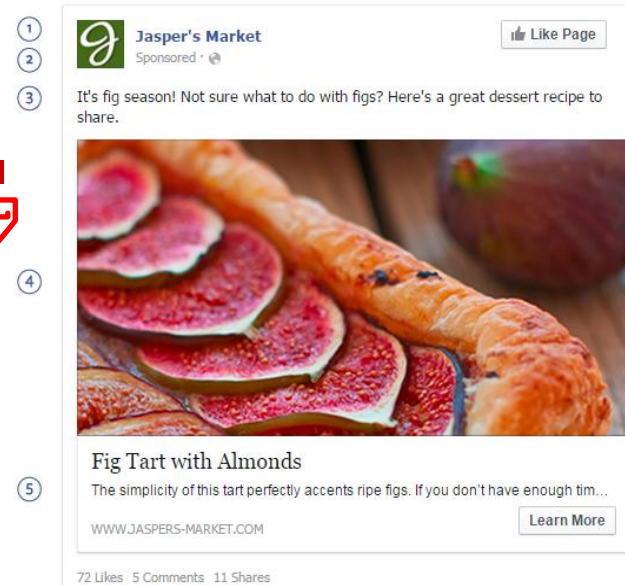
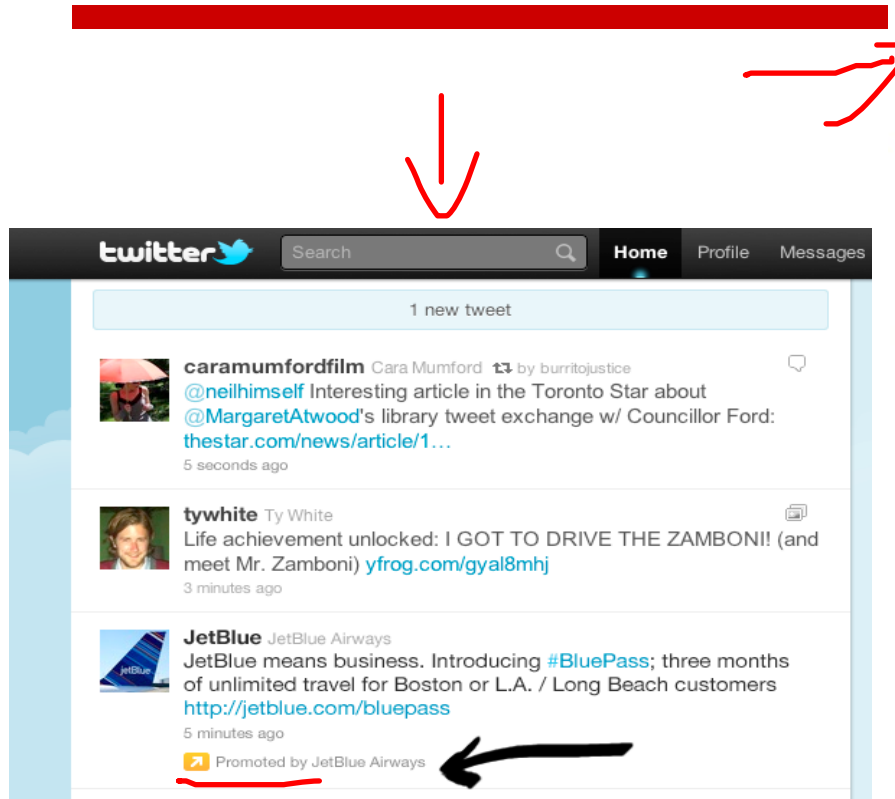
The search results are listed in two columns. Each result is an advertisement, marked with a yellow "Ad" icon in a red circle. The results are:

- Kids' Shoes at Zappos - Zappos.com**  
Ad [www.zappos.com/Kid-Shoes](http://www.zappos.com/Kid-Shoes) ▼  
Free Shipping & Free Returns. Huge Selection of Kids' Shoes
- Kids Shoes - Zara.com**  
Ad [www.zara.com/Kids-Shoes](http://www.zara.com/Kids-Shoes) ▼  
4.2 ★★★★★ rating for zara.com  
Shop Kid's Shoes At Zara During the Special Winter Sale.  
Fashion Catalogs · Online Store · Autumn Winter Collection  
Free Shipping - Girls Special Prices - Baby's Special Prices - Zara Winter Sale
- Kids' Shoes Up To 70% Off - NordstromRack.com**  
Ad [www.nordstromrack.com/Kids-Shoes](http://www.nordstromrack.com/Kids-Shoes) ▼  
Why Pay More For Kids' Shoes? Score Free S&H Over \$100 +90-Day Returns!
- OshKosh® Up to 75% Off**  
[www.oshkosh.com/](http://www.oshkosh.com/) ▼  
Save Up to 75% Off Everything!  
Save On Oshkosh Kids Shoes.
- Bass Pro®- Shoes**  
[www.basspro.com/Shoes](http://www.basspro.com/Shoes) ▼  
Free Shipping On Orders Of \$50+ .  
Shop Shoes & Boots Today!
- Kids' Shoes at JCPenney®**  
[www.jcpenny.com/KidsShoes](http://www.jcpenny.com/KidsShoes) ▼  
4.3 ★★★★★ rating for jcpenny.com  
Save on Kids' Shoes at JCPenney®



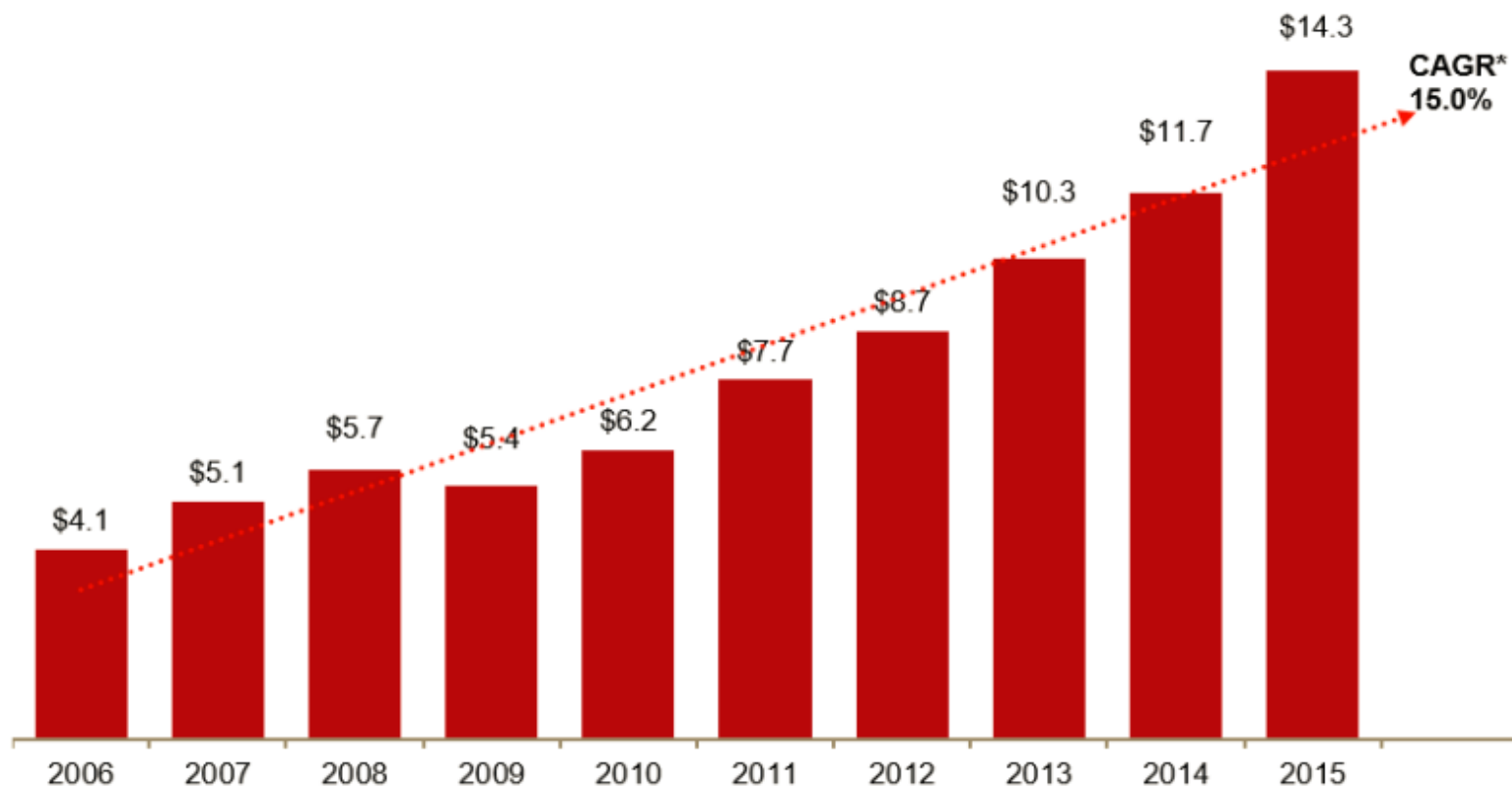
# FLAG

## Facebook linkedIn Twitter



# 广告营收是大头

Second-quarter revenue 2006-2015 (\$ billions)



Source: IAB/PwC Internet Ad Revenue Report, HY 2015

\* CAGR: Compound Annual Growth Rate



# 在线广告的形式

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- ☐ Retargeting – Using cookies, track if a user left a webpage without making a purchase and retarget the user with ads from that site
- ☐ Behavioral targeting – Data related to user's online activity is collected from multiple websites, thus creating a detailed picture of the user's interests to deliver more targeted advertising
- ☐ Contextual advertising – Display ads related to the content of the webpage
- ☐ Geo targeting – Ads are presented based on the user's suspected geography



# 在线广告的角色

Publishers:

- ☐ Earn revenue by displaying ads on their sites
- ☐ Google, Wall Street Journal, Twitter

Advertisers:

- ☐ Pay for their ads to be displayed on publisher sites
- ☐ Goal is to increase business via advertising

Matchmakers:

- ☐ Match publishers with advertisers
- ☐ Interaction with advertisers and publishers occurs real time



# 广告收费形态

CTR

- ☐ CPM (Cost-Per-Mille): is an inventory based pricing model. Is when the price is based on 1,000 impressions. 1000
- ☐ CPC (Cost-Per-Click): not Is a performance-based metric. This means the Publisher only gets paid when (and if) a user clicks on an ad
- ☐ CPA (Cost Per Action): Best deal of all for Advertisers in terms of risk because they only pay for media when it results in a sale



# Click-through rate (CTR)

- Ratio of users who click on an ad to the number of total users who view the ad

$$\text{CTR} = \frac{\text{Clicks}}{\text{Impressions}} \times 100\%$$

- Used to measure the success of an online advertising campaign
- Very first online ad shown for AT&T on website HotWired has a 44% Click-through rate
- Today, typical click through rate is less than 1%
- In a pay-per-click setting, revenue can be maximized by choosing to display ads that have the maximum CTR, hence the problem of CTR Prediction.





# 数据集

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- Sample of the dataset used for the Display Advertising Challenge hosted by Kaggle:  
<https://www.kaggle.com/c/criteo-display-ad-challenge/>
- Consists of a portion of Criteo's traffic over a period of 7 days.

criteo labs

Completed • \$16,000 • 718 teams

**Display Advertising Challenge**

Tue 24 Jun 2014 – Tue 23 Sep 2014 (15 months ago)



~~SIN~~

CTR

1, 2, 3, 4

## Dataset Features

### Data fields

- ☐ Label - Target variable that indicates if an ad was clicked (1) or not (0).
- ☐ I1-I13 - A total of 13 columns of integer features (mostly count features).
- ☐ C1-C26 - A total of 26 columns of categorical features. The values of these features have been hashed onto 32 bits for anonymization purposes.



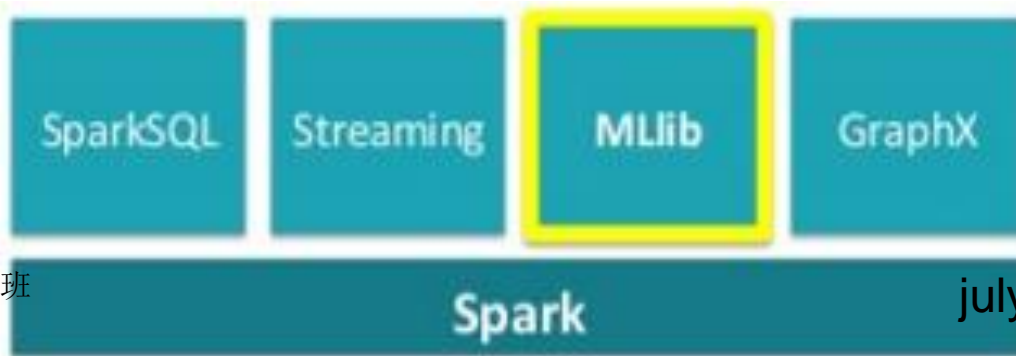




# Spark MLlib



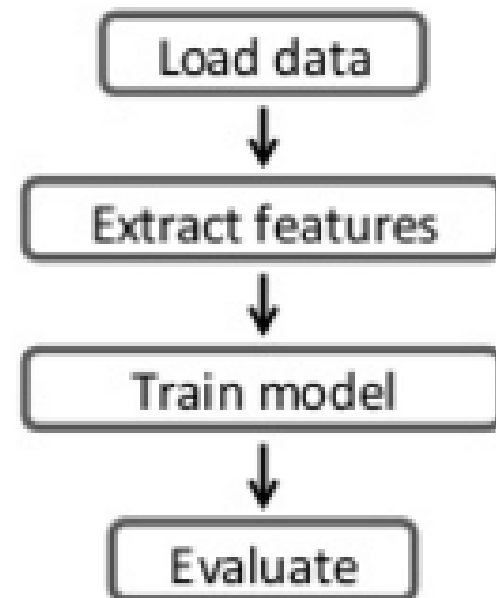
- Spark's machine learning (ML) library.
- Goal is to make ML scalable and easy
- Includes common learning algorithms and utilities, like classification, regression, clustering, collaborative filtering, dimensionality reduction
- Includes lower-level optimization primitives and higher level pipeline APIs
- Divided into two packages
  - Spark.mllib: original API built on top of RDDs
  - Spark.ml: provides higher level API built on top of DataFrames for construct



# 工作流程

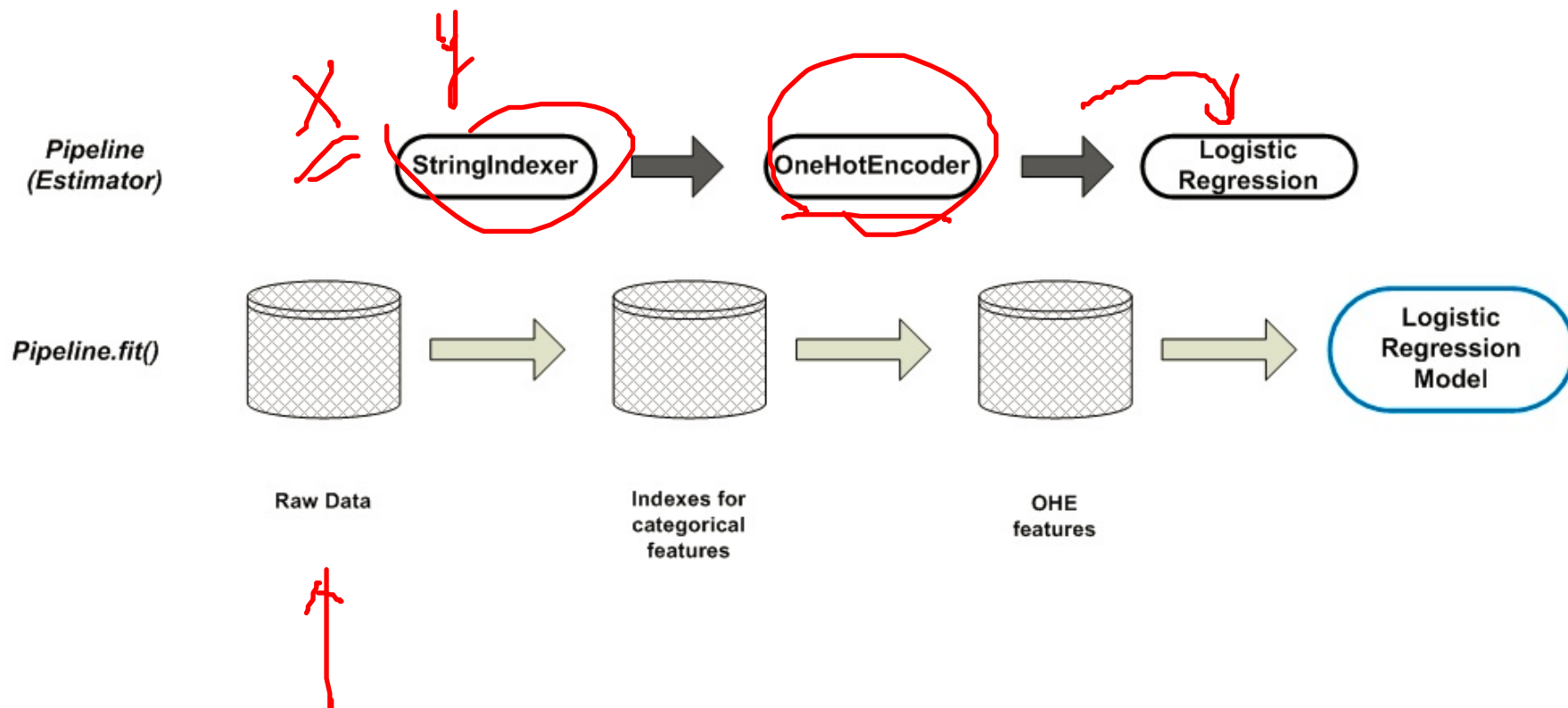
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- ❑ DataFrame: Equivalent to a relational table in Spark SQL
- ❑ Transformer: An algorithm that transforms one DataFrame into another
- ❑ Estimator: An algorithm that can be fit on a DataFrame to produce a Transformer
- ❑ Pipeline: Chains multiple transformers and estimators to workflow
- ❑ Parameter: Common API for specifying parameters





# LR总体流程



## Step 1 - Parse Data into Spark SQL DataFrames

- ❑ Spark SQL converts a RDD of Row objects into a DataFrame
- ❑ Rows are constructed by passing key/value pairs where keys define the column names of the table
- ❑ The data types are inferred by looking at the data

```
def parseData(data, sqlContext):
```

```
# Split the csv file by comma and convert each line to a tuple.
```

```
parts = data.map(lambda l: l.split(",", -1))
```

```
features = parts.map(lambda p: Row(Label=(p[0]), IntFeature1=(p[1]), IntFeature2=(p[2]), IntFeature3=(p[3]), IntFeature4=(p[4]), IntFeature5=(p[5]), IntFeature6=(p[6]), IntFeature7=(p[7]), IntFeature8=(p[8]), IntFeature9=(p[9]), IntFeature10=(p[10]), IntFeature11=(p[11]), IntFeature12=(p[12]), IntFeature13=(p[13]), CatFeature1=(p[14]), CatFeature2=(p[15]), CatFeature3=(p[16]), CatFeature4=(p[17]), CatFeature5=(p[18]), CatFeature6=(p[19]), CatFeature7=(p[20]), CatFeature8=(p[21]), CatFeature9=(p[22]), CatFeature10=(p[23]), CatFeature11=(p[24]), CatFeature12=(p[25]), CatFeature13=(p[26])))
```

```
# Apply the schema to the RDD.
```

```
return sqlContext.createDataFrame(features)
```



## Step 2 – Feature Transformer using StringIndexer

- ❑ Encodes a string column to a column of indices
- ❑ Indices are from 0 to max number of distinct string values, ordered by frequencies
- ❑ If column is numeric, cast it to string and index string values

↓

id	category
0	a
1	b
2	c
3	a
4	a
5	c

id	category	categoryIndex
0	a	0.0
1	b	2.0
2	c	1.0
3	a	0.0
4	a	0.0
5	c	1.0



### Step 3 - Feature Transformer using One Hot Encoding

- ❑ Maps a column of label indices to a column of binary vectors
- ❑ Allows algorithms which expect continuous features, to use categorical features

id	category	categoryIndex
0	a	0.0
1	b	2.0
2	c	1.0
3	a	0.0
4	a	0.0
5	c	1.0


id	category	categoryIndex	categoryVec
0	a	0.0	SparseVector(2, {0: 1.0})
1	b	2.0	SparseVector(2, {})
2	c	1.0	SparseVector(2, {1: 1.0})
3	a	0.0	SparseVector(2, {0: 1.0})
4	a	0.0	SparseVector(2, {0: 1.0})
5	c	1.0	SparseVector(2, {1: 1.0})



## Step 4 – Feature Selector using Vector Assembler

- ❑ Transformer that combines a given list of columns into a single vector column
- ❑ Useful for combining raw features and features generated by different feature transformers into a single feature vector

id	hour	mobile	userFeatures	clicked
0	18	1.0	[0.0, 10.0, 0.5]	1.0

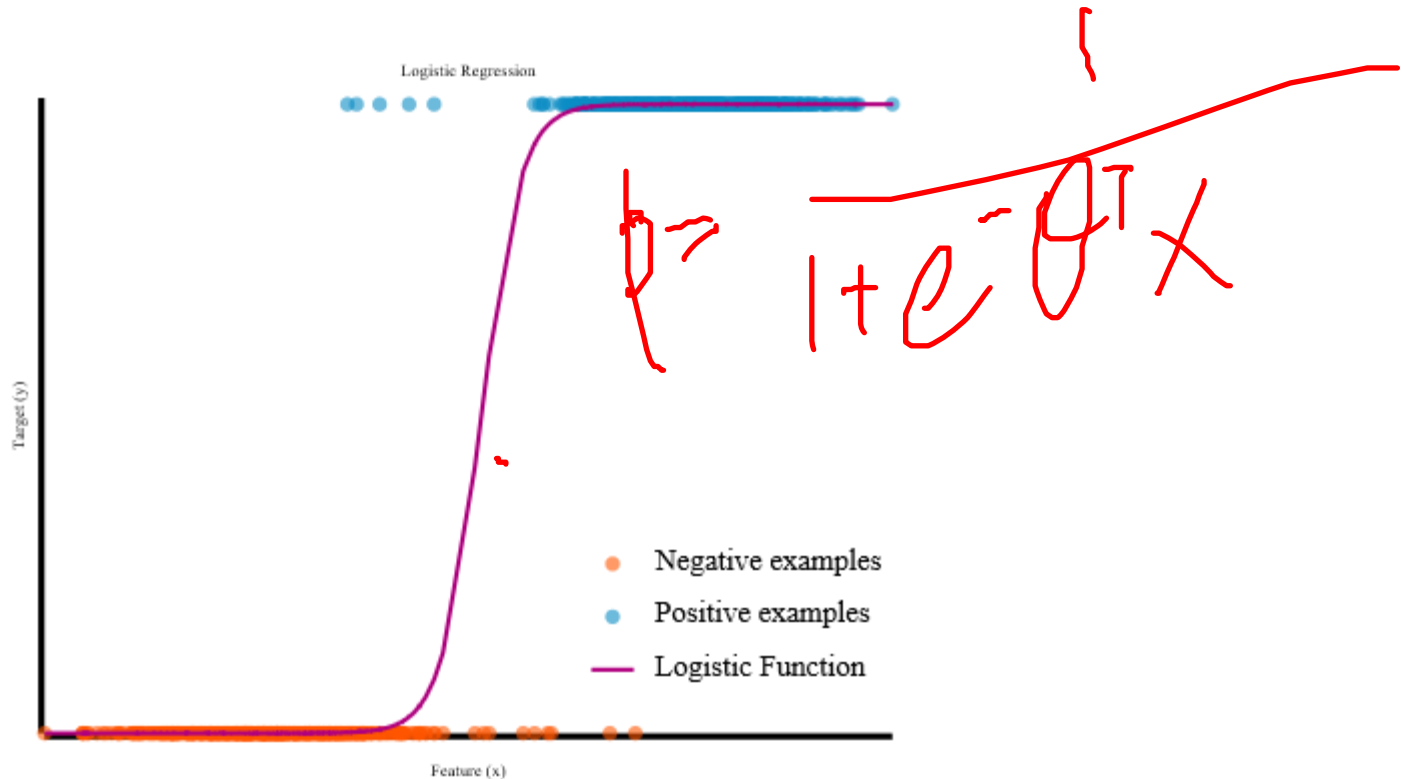


id	hour	mobile	userFeatures	clicked	features
0	18	1.0	[0.0, 10.0, 0.5]	1.0	[18.0, 1.0, 0.0, 10.0, 0.5]

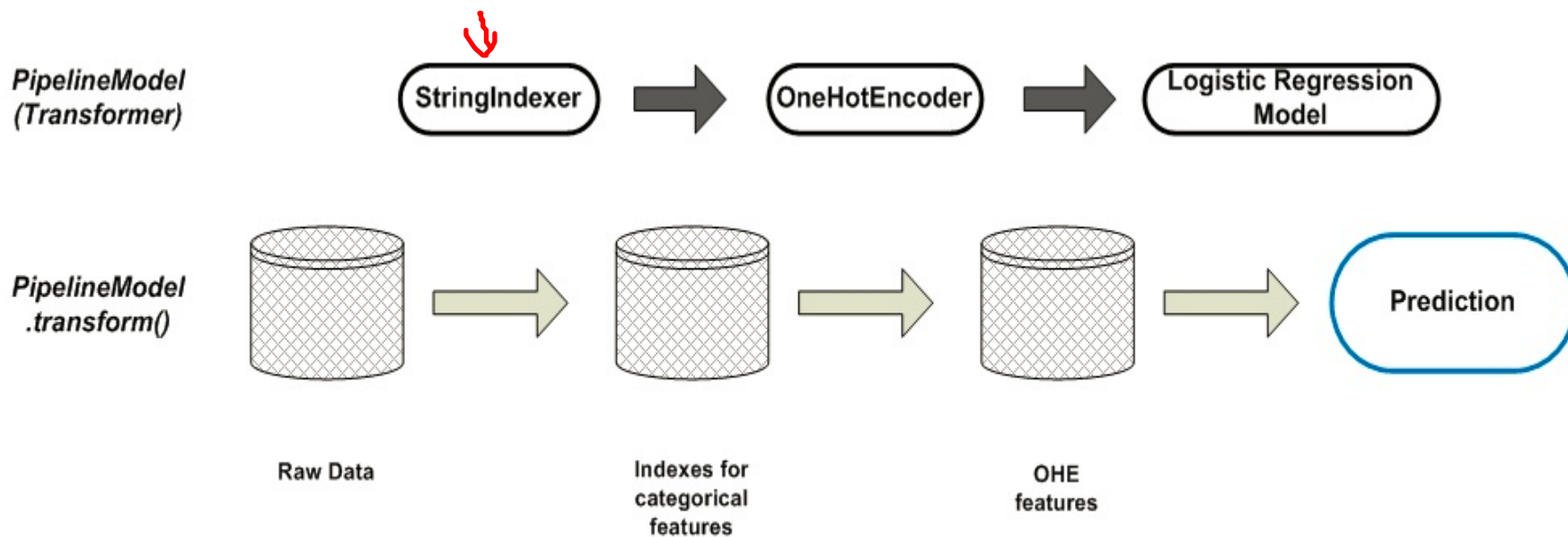




## Step 5 – Train a model using Estimator Logistic Regression



## Apply the pipeline to make predictions





CV



Parameter Tuning using CrossValidator or TrainValidationSplit

```
# Try Cross Validator
from pyspark.ml.tuning import CrossValidator, ParamGridBuilder
from pyspark.ml.evaluation import BinaryClassificationEvaluator

evaluator = BinaryClassificationEvaluator()
paramGrid = ParamGridBuilder().addGrid(lr.maxIter, [0, 1]).build()
numFolds=2

crossval = CrossValidator(
    estimator=pipeline,
    estimatorParamMaps=paramGrid,
    evaluator=evaluator,
    numFolds=numFolds)

cvModel = crossval.fit(dfTrain)
evaluator.evaluate(cvModel.transform(dfTest))
```

Grid Search

~~k-fold~~



Some alternatives:

- ☐ Use Hashed features instead of OHE
- ☐ Use Log loss evaluation or ROC to evaluate Logistic Regression
- ☐ Perform feature selection
- ☐ Use Naïve Bayes or other binary classification algorithms

函数

T-shirt

$$p =$$

$$1 + e^{-ax}$$

20000 T-shirt



CV  $\rightarrow$  parameter

# RF与GBDT ?

见课上讲解与案例

① data

②  $U/U_T$

③ bagging

④  $R^2$

$X \rightarrow Y$

模型状态

~~overfitting~~  
~~undertuning~~

auc

auc

gap

example

Spark

0.58  
0.6

$\approx 0.89$



LR 线性不平衡

RF与GBDT ?

$$100 = 3-4$$

$$3-4 \text{ 正}$$

$$97-96 \text{ 正}$$

ctr

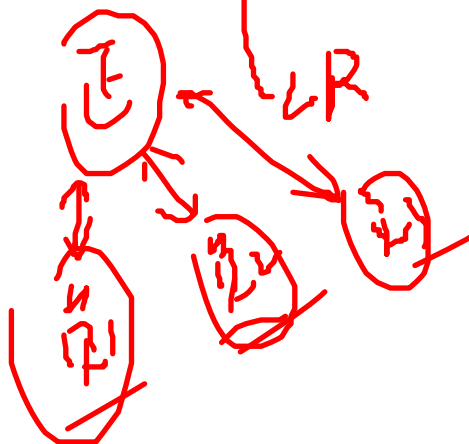
① 平均

$$\rightarrow 2=1$$

$$\frac{1}{2} = \frac{1}{1+e^{-0.1x}}$$

②

Used of catent  
User-duped  
0.4

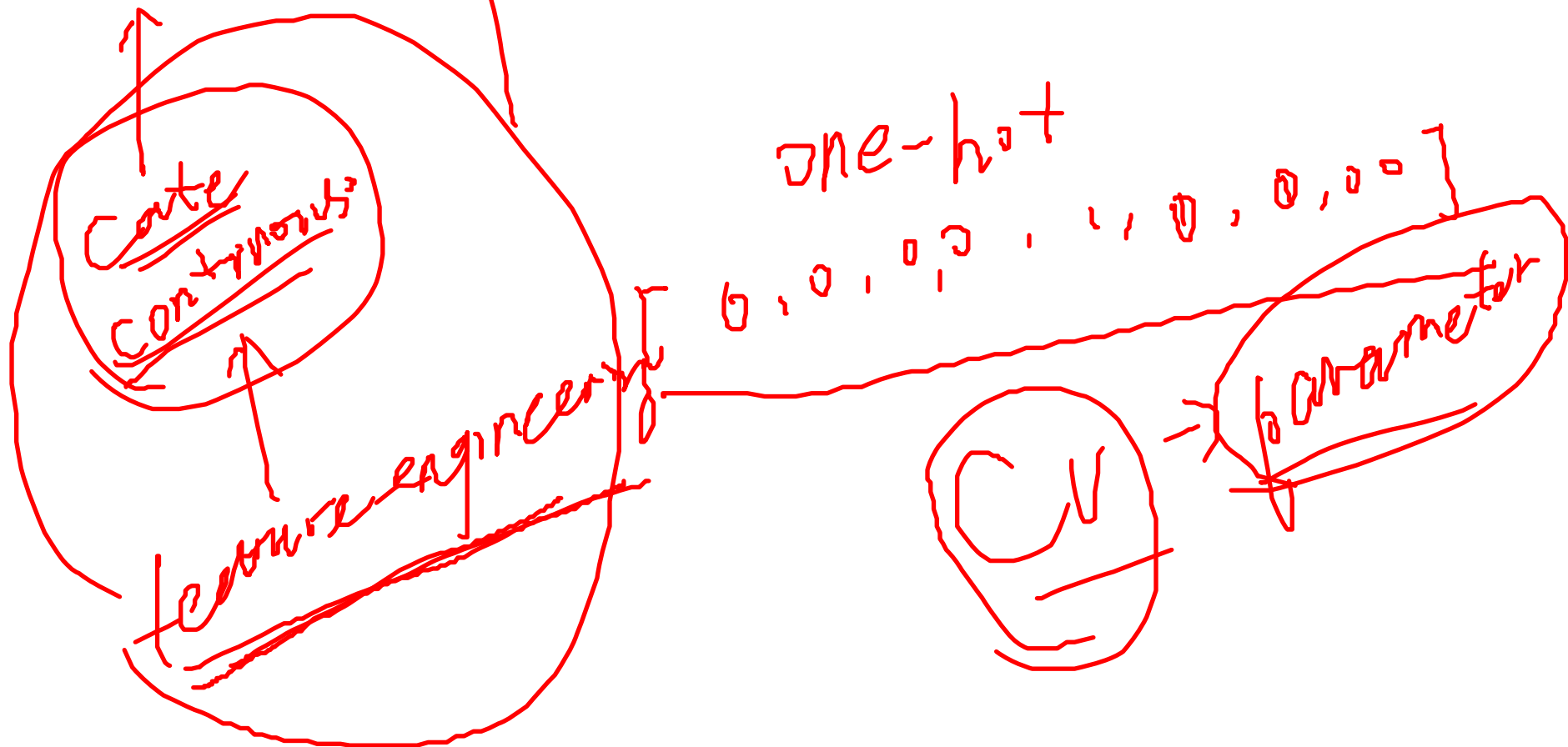


③ DVS-bias  
COEC  
v) 5.4



# RF与GBDT ?

tree based





# LR+GBDT?

2014

见课上讲解

~~bagging~~  
 $\frac{1}{1+e^{-\theta^T x}}$



GBDT  $\leftarrow x + y$

男 & 女 20-25 age  
1, 0



LR+GBDT ?

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64G



# FM

见课上讲解



# FFM

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见课上讲解



# Google wide & deep model

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见课上讲解与案例



# 2016 FNN

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见课上讲解与案例



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感谢大家！

恳请大家批评指正！

