データの読み込み

In [1]:
```
# This Python 3 environment comes with many helpful analytics libraries installed
# It is defined by the kaggle/python docker image: https://github.com/kaggle/docker-python
# For example, here's several helpful packages to load in

import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)

# Input data files are available in the "../input/" directory.
# For example, running this (by clicking run or pressing Shift+Enter) will list the files in the input directory

import os
print(os.listdir("../input"))

import seaborn as sns
# Any results you write to the current directory are saved as output.
```

```
['DSS_DMC_Description.pdf', 'carInsurance_train.csv', 'carInsurance_test.csv']
```

In [2]:
```
train = pd.read_csv('../input/carInsurance_train.csv')
test = pd.read_csv('../input/carInsurance_test.csv')
```

In [3]:
```
train.head()
```

Out[3]:

	Id	Age	Job	Marital	Education	Default	Balance	HHInsurance	CarLoan	Communica
0	1	32	management	single	tertiary	0	1218	1	0	telephone
1	2	32	blue-collar	married	primary	0	1156	1	0	NaN
2	3	29	management	single	tertiary	0	637	1	0	cellular
3	4	25	student	single	primary	0	373	1	0	cellular
4	5	30	management	married	tertiary	0	2694	0	0	cellular

In [4]:
```
test.head()
```

Out[4]:

	Id	Age	Job	Marital	Education	Default	Balance	HHInsurance	CarLoan	Commu
0	4001	25	admin.	single	secondary	0	1	1	1	NaN
1	4002	40	management	married	tertiary	0	0	1	1	cellular
2	4003	44	management	single	tertiary	0	-1313	1	1	cellular
3	4004	27	services	single	secondary	0	6279	1	0	cellular
4	4005	53	technician	married	secondary	0	7984	1	0	cellular

データの確認

In [5]:
```
train.isna().sum()
```

Out[5]:
```
Id                   0
Age                  0
Job                 19
Marital              0
Education          169
Default              0
Balance              0
HHInsurance          0
CarLoan              0
Communication      902
LastContactDay       0
LastContactMonth     0
NoOfContacts         0
DaysPassed           0
PrevAttempts         0
Outcome           3042
CallStart            0
CallEnd              0
CarInsurance         0
dtype: int64
```

In [6]:
```
test.isna().sum()
```

Out[6]:
```
Id                   0
Age                  0
Job                  5
Marital              0
Education           47
Default              0
Balance              0
HHInsurance          0
CarLoan              0
Communication      221
LastContactDay       0
LastContactMonth     0
NoOfContacts         0
DaysPassed           0
PrevAttempts         0
Outcome            757
CallStart            0
CallEnd              0
CarInsurance      1000
dtype: int64
```

In [7]:
```
train.shape
```

Out[7]:
```
(4000, 19)
```

In [8]:
```
test.shape
```

Out[8]:
```
(1000, 19)
```

欠損値の対応

In [9]:
```
train.Job.unique()
```

Out[9]:
```
array(['management', 'blue-collar', 'student', 'technician', 'admin.',
       'services', 'self-employed', 'retired', nan, 'housemaid',
       'entrepreneur', 'unemployed'], dtype=object)
```

In [10]:
```
train[train.Job != train.Job].head()
```

Out[10]:

	Id	Age	Job	Marital	Education	Default	Balance	HHInsurance	CarLoan	Communicatio
27	28	45	NaN	divorced	NaN	0	0	0	0	cellular
239	240	41	NaN	single	NaN	0	942	0	0	cellular
486	487	54	NaN	married	primary	0	981	0	0	cellular
536	537	33	NaN	single	secondary	0	1522	0	1	cellular
605	606	53	NaN	married	primary	0	732	0	0	cellular

In [11]:
```
train.Job.fillna('unknown', inplace=True)
test.Job.fillna('unknown', inplace=True)
```

In [12]:
```
train.Education.unique()
```

Out[12]:
```
array(['tertiary', 'primary', 'secondary', nan], dtype=object)
```

In [13]:
```
train.Education.fillna('other', inplace=True)
test.Education.fillna('other', inplace=True)
```

In [14]:
```
train.Communication.fillna('other', inplace=True)
test.Communication.fillna('other', inplace=True)
```

In [15]:
```
train.Outcome.fillna('unknwon', inplace=True)
test.Outcome.fillna('unknwon', inplace=True)
```

In [16]:
```
train.dtypes
```

Out[16]:
```
Id                 int64
Age                int64
Job               object
Marital           object
Education         object
Default            int64
Balance            int64
HHInsurance        int64
CarLoan            int64
Communication     object
LastContactDay     int64
LastContactMonth  object
NoOfContacts       int64
DaysPassed         int64
PrevAttempts       int64
Outcome           object
CallStart         object
CallEnd           object
CarInsurance       int64
dtype: object
```

In [17]:
```
cat_cols = ['Marital', 'Education', 'Job', 'Communication',
            'LastContactMonth', 'Outcome', 'CallStart', 'CallEnd']
```

In [18]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
for col in cat_cols:
    train[col] = le.fit_transform(train[col])
```

In [19]:
```
train.head()
```

Out[19]:

	Id	Age	Job	Marital	Education	Default	Balance	HHInsurance	CarLoan	Communication	Las
0	1	32	4	2	3	0	1218	1	0	2	28
1	2	32	1	1	1	0	1156	1	0	1	26
2	3	29	4	2	3	0	637	1	0	0	3
3	4	25	8	2	1	0	373	1	0	0	11
4	5	30	4	1	3	0	2694	0	0	0	3

In [20]:
```
X = train.drop('CarInsurance', axis=1)
y = train.CarInsurance
```

In [21]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,
random_state=0)
```

In [22]:
```
import xgboost as xgb
dtrain = xgb.DMatrix(X_train, y_train)
dval = xgb.DMatrix(X_test, y_test)
eval_list = [(dval, 'eval'), (dtrain, 'train')]
```

In [23]:

```
param = {'max_depth': 3,
         'eta': 0.3,
         'silent': 1,
         'objective': 'binary:logistic',
         'nthread' : 4,
         'eval_metric' : 'auc'}
```

In [24]:

```
num_round = 250
bst = xgb.train(param, dtrain, num_round, eval_list, early_stopping_round
s=2)
```

```
[0]     eval-auc:0.695181       train-auc:0.697895
Multiple eval metrics have been passed: 'train-auc' will be used for earl
y stopping.

Will train until train-auc hasn't improved in 2 rounds.
[1]     eval-auc:0.716765       train-auc:0.717916
[2]     eval-auc:0.719608       train-auc:0.720543
[3]     eval-auc:0.729629       train-auc:0.733879
[4]     eval-auc:0.736563       train-auc:0.749381
[5]     eval-auc:0.743144       train-auc:0.754882
[6]     eval-auc:0.749341       train-auc:0.758067
[7]     eval-auc:0.748643       train-auc:0.768482
[8]     eval-auc:0.744592       train-auc:0.773661
[9]     eval-auc:0.746565       train-auc:0.78172
[10]    eval-auc:0.752592       train-auc:0.787233
[11]    eval-auc:0.754994       train-auc:0.788592
[12]    eval-auc:0.756681       train-auc:0.792386
[13]    eval-auc:0.759272       train-auc:0.804491
[14]    eval-auc:0.760326       train-auc:0.809091
[15]    eval-auc:0.762587       train-auc:0.813732
[16]    eval-auc:0.762656       train-auc:0.81744
[17]    eval-auc:0.760549       train-auc:0.820491
[18]    eval-auc:0.760891       train-auc:0.822419
[19]    eval-auc:0.762532       train-auc:0.825748
[20]    eval-auc:0.763818       train-auc:0.828178
[21]    eval-auc:0.765721       train-auc:0.835211
[22]    eval-auc:0.768948       train-auc:0.83791
[23]    eval-auc:0.770859       train-auc:0.841895
[24]    eval-auc:0.771118       train-auc:0.843803
[25]    eval-auc:0.770528       train-auc:0.84554
[26]    eval-auc:0.774272       train-auc:0.847045
[27]    eval-auc:0.775409       train-auc:0.847526
[28]    eval-auc:0.774368       train-auc:0.851024
[29]    eval-auc:0.776482       train-auc:0.854434
[30]    eval-auc:0.777776       train-auc:0.855469
[31]    eval-auc:0.774903       train-auc:0.857863
[32]    eval-auc:0.777768       train-auc:0.862475
[33]    eval-auc:0.78054        train-auc:0.868367
[34]    eval-auc:0.779721       train-auc:0.869234
[35]    eval-auc:0.780736       train-auc:0.870733
[36]    eval-auc:0.780802       train-auc:0.871111
```

```
[37]    eval-auc:0.780696       train-auc:0.871691
[38]    eval-auc:0.781193       train-auc:0.872157
[39]    eval-auc:0.785282       train-auc:0.878938
[40]    eval-auc:0.785719       train-auc:0.879086
[41]    eval-auc:0.788003       train-auc:0.8816
[42]    eval-auc:0.789107       train-auc:0.884406
[43]    eval-auc:0.792159       train-auc:0.886732
[44]    eval-auc:0.793712       train-auc:0.887952
[45]    eval-auc:0.793683       train-auc:0.89024
[46]    eval-auc:0.793962       train-auc:0.890456
[47]    eval-auc:0.795044       train-auc:0.89139
[48]    eval-auc:0.795015       train-auc:0.892265
[49]    eval-auc:0.795886       train-auc:0.893102
[50]    eval-auc:0.795012       train-auc:0.894438
[51]    eval-auc:0.793657       train-auc:0.89577
[52]    eval-auc:0.792455       train-auc:0.896475
[53]    eval-auc:0.792009       train-auc:0.89688
[54]    eval-auc:0.794986       train-auc:0.898259
[55]    eval-auc:0.798415       train-auc:0.901852
[56]    eval-auc:0.799062       train-auc:0.902795
[57]    eval-auc:0.799223       train-auc:0.905375
[58]    eval-auc:0.798961       train-auc:0.906283
[59]    eval-auc:0.799082       train-auc:0.906397
[60]    eval-auc:0.799968       train-auc:0.908464
[61]    eval-auc:0.804492       train-auc:0.912678
[62]    eval-auc:0.805033       train-auc:0.913046
[63]    eval-auc:0.805246       train-auc:0.913231
[64]    eval-auc:0.807371       train-auc:0.915818
[65]    eval-auc:0.80734        train-auc:0.917287
[66]    eval-auc:0.808812       train-auc:0.918779
[67]    eval-auc:0.807915       train-auc:0.91947
[68]    eval-auc:0.808027       train-auc:0.920107
[69]    eval-auc:0.808332       train-auc:0.921876
[70]    eval-auc:0.807072       train-auc:0.922467
[71]    eval-auc:0.806802       train-auc:0.922621
[72]    eval-auc:0.807222       train-auc:0.924367
[73]    eval-auc:0.806983       train-auc:0.924595
[74]    eval-auc:0.807112       train-auc:0.926076
[75]    eval-auc:0.809157       train-auc:0.926806
[76]    eval-auc:0.808559       train-auc:0.928867
[77]    eval-auc:0.808254       train-auc:0.929176
[78]    eval-auc:0.80748        train-auc:0.930279
```

```
[79]    eval-auc:0.808303       train-auc:0.930843
[80]    eval-auc:0.807938       train-auc:0.931084
[81]    eval-auc:0.813164       train-auc:0.933673
[82]    eval-auc:0.813592       train-auc:0.934851
[83]    eval-auc:0.814191       train-auc:0.934973
[84]    eval-auc:0.814944       train-auc:0.936082
[85]    eval-auc:0.815485       train-auc:0.937128
[86]    eval-auc:0.815414       train-auc:0.937518
[87]    eval-auc:0.815604       train-auc:0.937653
[88]    eval-auc:0.815128       train-auc:0.939501
[89]    eval-auc:0.814179       train-auc:0.941096
[90]    eval-auc:0.815094       train-auc:0.941662
[91]    eval-auc:0.815706       train-auc:0.94207
[92]    eval-auc:0.81715        train-auc:0.944309
[93]    eval-auc:0.822414       train-auc:0.947442
[94]    eval-auc:0.823559       train-auc:0.94873
[95]    eval-auc:0.822923       train-auc:0.949173
[96]    eval-auc:0.824591       train-auc:0.951035
[97]    eval-auc:0.824134       train-auc:0.951356
[98]    eval-auc:0.824418       train-auc:0.951512
[99]    eval-auc:0.824531       train-auc:0.951993
[100]   eval-auc:0.824367       train-auc:0.952391
[101]   eval-auc:0.822969       train-auc:0.953228
[102]   eval-auc:0.821715       train-auc:0.953477
[103]   eval-auc:0.822931       train-auc:0.954154
[104]   eval-auc:0.823182       train-auc:0.954344
[105]   eval-auc:0.822693       train-auc:0.955018
[106]   eval-auc:0.826035       train-auc:0.956926
[107]   eval-auc:0.826302       train-auc:0.956933
[108]   eval-auc:0.827418       train-auc:0.958314
[109]   eval-auc:0.827473       train-auc:0.959437
[110]   eval-auc:0.828005       train-auc:0.960222
[111]   eval-auc:0.82856        train-auc:0.960485
[112]   eval-auc:0.828721       train-auc:0.960666
[113]   eval-auc:0.829561       train-auc:0.961082
[114]   eval-auc:0.830293       train-auc:0.962139
[115]   eval-auc:0.830438       train-auc:0.962489
[116]   eval-auc:0.831514       train-auc:0.96279
[117]   eval-auc:0.832305       train-auc:0.963713
[118]   eval-auc:0.833225       train-auc:0.964755
[119]   eval-auc:0.833858       train-auc:0.965132
[120]   eval-auc:0.834232       train-auc:0.965139
```

```
[121]   eval-auc:0.83456        train-auc:0.965365
[122]   eval-auc:0.833666       train-auc:0.965891
[123]   eval-auc:0.834244       train-auc:0.966339
[124]   eval-auc:0.835176       train-auc:0.966881
[125]   eval-auc:0.835026       train-auc:0.966951
[126]   eval-auc:0.835035       train-auc:0.967118
[127]   eval-auc:0.834813       train-auc:0.968371
[128]   eval-auc:0.832886       train-auc:0.969248
[129]   eval-auc:0.832774       train-auc:0.969466
[130]   eval-auc:0.836657       train-auc:0.971034
[131]   eval-auc:0.836763       train-auc:0.971208
[132]   eval-auc:0.835204       train-auc:0.97146
[133]   eval-auc:0.83527        train-auc:0.972203
[134]   eval-auc:0.836082       train-auc:0.972473
[135]   eval-auc:0.836211       train-auc:0.972891
[136]   eval-auc:0.837445       train-auc:0.973243
[137]   eval-auc:0.838256       train-auc:0.973903
[138]   eval-auc:0.838662       train-auc:0.974633
[139]   eval-auc:0.841313       train-auc:0.975875
[140]   eval-auc:0.83997        train-auc:0.9762
[141]   eval-auc:0.840819       train-auc:0.976585
[142]   eval-auc:0.842403       train-auc:0.977549
[143]   eval-auc:0.840781       train-auc:0.977851
[144]   eval-auc:0.841748       train-auc:0.978645
[145]   eval-auc:0.841437       train-auc:0.979061
[146]   eval-auc:0.842389       train-auc:0.979404
[147]   eval-auc:0.842752       train-auc:0.979594
[148]   eval-auc:0.842872       train-auc:0.980057
[149]   eval-auc:0.843169       train-auc:0.98027
[150]   eval-auc:0.843801       train-auc:0.980336
[151]   eval-auc:0.84379        train-auc:0.980378
[152]   eval-auc:0.843194       train-auc:0.980438
[153]   eval-auc:0.842775       train-auc:0.980534
[154]   eval-auc:0.842933       train-auc:0.980654
[155]   eval-auc:0.842596       train-auc:0.980933
[156]   eval-auc:0.842268       train-auc:0.980957
[157]   eval-auc:0.842383       train-auc:0.981218
[158]   eval-auc:0.843968       train-auc:0.981196
[159]   eval-auc:0.842987       train-auc:0.981407
[160]   eval-auc:0.843197       train-auc:0.981558
[161]   eval-auc:0.843171       train-auc:0.981657
[162]   eval-auc:0.842619       train-auc:0.981642
```

```
[163]   eval-auc:0.842438       train-auc:0.981931
[164]   eval-auc:0.841595       train-auc:0.982045
[165]   eval-auc:0.841736       train-auc:0.982354
[166]   eval-auc:0.84182        train-auc:0.982449
[167]   eval-auc:0.841679       train-auc:0.982654
[168]   eval-auc:0.84295        train-auc:0.983102
[169]   eval-auc:0.842907       train-auc:0.983235
[170]   eval-auc:0.843876       train-auc:0.983465
[171]   eval-auc:0.844932       train-auc:0.984307
[172]   eval-auc:0.845432       train-auc:0.98495
[173]   eval-auc:0.845774       train-auc:0.985269
[174]   eval-auc:0.845283       train-auc:0.98555
[175]   eval-auc:0.845582       train-auc:0.985811
[176]   eval-auc:0.845271       train-auc:0.985785
[177]   eval-auc:0.846853       train-auc:0.986212
[178]   eval-auc:0.846347       train-auc:0.986379
[179]   eval-auc:0.846281       train-auc:0.986476
[180]   eval-auc:0.844365       train-auc:0.986599
[181]   eval-auc:0.845234       train-auc:0.986931
[182]   eval-auc:0.845055       train-auc:0.98702
[183]   eval-auc:0.845271       train-auc:0.98712
[184]   eval-auc:0.845613       train-auc:0.987229
[185]   eval-auc:0.845461       train-auc:0.98731
[186]   eval-auc:0.845866       train-auc:0.987417
[187]   eval-auc:0.846298       train-auc:0.987602
[188]   eval-auc:0.846928       train-auc:0.987732
[189]   eval-auc:0.846801       train-auc:0.987731
[190]   eval-auc:0.84666        train-auc:0.987911
[191]   eval-auc:0.84639        train-auc:0.987988
[192]   eval-auc:0.845947       train-auc:0.988237
[193]   eval-auc:0.845726       train-auc:0.988308
[194]   eval-auc:0.84559        train-auc:0.988511
[195]   eval-auc:0.845636       train-auc:0.988753
[196]   eval-auc:0.844779       train-auc:0.988883
[197]   eval-auc:0.844584       train-auc:0.988891
[198]   eval-auc:0.844425       train-auc:0.989016
[199]   eval-auc:0.844995       train-auc:0.989119
[200]   eval-auc:0.844811       train-auc:0.989369
[201]   eval-auc:0.845113       train-auc:0.98974
[202]   eval-auc:0.846203       train-auc:0.990066
[203]   eval-auc:0.84574        train-auc:0.990109
[204]   eval-auc:0.846902       train-auc:0.990421
```

```
[205]   eval-auc:0.847509       train-auc:0.990742
[206]   eval-auc:0.848173       train-auc:0.990919
[207]   eval-auc:0.84851        train-auc:0.990924
[208]   eval-auc:0.848976       train-auc:0.991109
[209]   eval-auc:0.849301       train-auc:0.991292
[210]   eval-auc:0.849818       train-auc:0.991461
[211]   eval-auc:0.84922        train-auc:0.991518
[212]   eval-auc:0.848861       train-auc:0.991459
[213]   eval-auc:0.84897        train-auc:0.991507
Stopping. Best iteration:
[211]   eval-auc:0.84922        train-auc:0.991518
```

特徴エンジニアリング

In [25]:

```
def read_and_fillna():
    train = pd.read_csv('../input/carInsurance_train.csv')
    test = pd.read_csv('../input/carInsurance_test.csv')
    train.Job.fillna('unknown', inplace=True)
    test.Job.fillna('unknown', inplace=True)
    train.Education.fillna('other', inplace=True)
    test.Education.fillna('other', inplace=True)
    train.Communication.fillna('other', inplace=True)
    test.Communication.fillna('other', inplace=True)
    train.Outcome.fillna('unknwon', inplace=True)
    test.Outcome.fillna('unknwon', inplace=True)
    return train, test
```

In [26]:
```
def make_model(train, cat_cols):
    from sklearn.preprocessing import LabelEncoder
    from sklearn.model_selection import train_test_split
    import xgboost as xgb

    le = LabelEncoder()
    for col in cat_cols:
        train[col] = le.fit_transform(train[col])
    X = train.drop('CarInsurance', axis=1)
    y = train.CarInsurance
    X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                        test_size=0.3, ra
ndom_state=0)
    dtrain = xgb.DMatrix(X_train, y_train)
    dval = xgb.DMatrix(X_test, y_test)
    eval_list = [(dval, 'eval'), (dtrain, 'train')]
    param = {'max_depth': 3,
             'eta': 0.3,
             'silent': 1,
             'objective': 'binary:logistic',
             'nthread' : 4,
             'eval_metric' : 'auc'}

    num_round = 250
    bst = xgb.train(param, dtrain, num_round, eval_list, early_stopping_r
ounds=2)
```

In [27]:
```
train, test = read_and_fillna()
```

Age

In [28]:
```
train.Age.describe()
```

Out[28]:
```
count    4000.000000
mean       41.214750
std        11.550194
min        18.000000
25%        32.000000
50%        39.000000
75%        49.000000
max        95.000000
Name: Age, dtype: float64
```

In [29]:
```
def make_AgeGroup(df):
    df["AgeGroup"] = df.Age.apply(lambda x : 0 if x >= 10 and x <= 19 els
e
                                      (1 if x >= 20 and x <= 29 else
                                       (2 if x >= 30 and x <= 39 else
                                        (3 if x >= 40 and x <= 49 else
                                         (4 if x >= 50 and x <= 59 else
                                          (5 if x >= 60 and x <= 69 else
                                           (6 if x >= 70 and x <= 79 else
                                            (7 if x >= 80 and x <= 80 else
8)))))))
```

In [30]:
```
make_AgeGroup(train)
make_AgeGroup(test)
```

In [31]:
```
pd.pivot_table(train[['AgeGroup', 'CarInsurance', 'Age']], columns=['CarI
nsurance'], index=['AgeGroup'], aggfunc=['count'])
```

Out[31]:

	count	
	Age	
CarInsurance	0	1
AgeGroup		
0	4	11
1	257	261
2	980	558
3	635	353
4	454	247
5	44	114
6	17	43
7	2	7
8	3	10

Job

In [32]:
```
train.Job.unique()
```

Out[32]:
```
array(['management', 'blue-collar', 'student', 'technician', 'admin.',
       'services', 'self-employed', 'retired', 'unknown', 'housemaid',
       'entrepreneur', 'unemployed'], dtype=object)
```

In [33]:
```
pd.pivot_table(train[['Job', 'CarInsurance', 'Age']], columns=['CarInsura
nce'], index=['Job'], aggfunc=['count'])
```

Out[33]:

	count	
	Age	
CarInsurance	0	1
Job		
admin.	274	185
blue-collar	540	219
entrepreneur	86	35
housemaid	72	37
management	501	392
retired	103	146
self-employed	86	54
services	218	112
student	44	87
technician	406	254
unemployed	56	74
unknown	10	9

In [34]:
```
def make_isWork(df):
    df['isWork'] = df.Job.apply(lambda x : 0 if x == "retired"
                                or x == "student"
                                or x == "unemployed"
                                else 1)
```

In [35]:
```
make_isWork(train)
make_isWork(test)
```

In [36]:
```
train.drop('Job', axis=1, inplace=True)
test.drop('Job', axis=1, inplace=True)
```

Martial

In [37]:
```
pd.pivot_table(train[['Marital', 'CarInsurance', 'Age']], columns=['CarIn
surance'], index=['Marital'], aggfunc=['count'])
```

Out[37]:

	count	
	Age	
CarInsurance	0	1
Marital		
divorced	273	210
married	1471	833
single	652	561

Education

In [38]:
```
pd.pivot_table(train[['Education', 'CarInsurance', 'Age']], columns=['Car
Insurance'], index=['Education'], aggfunc=['count'])
```

Out[38]:

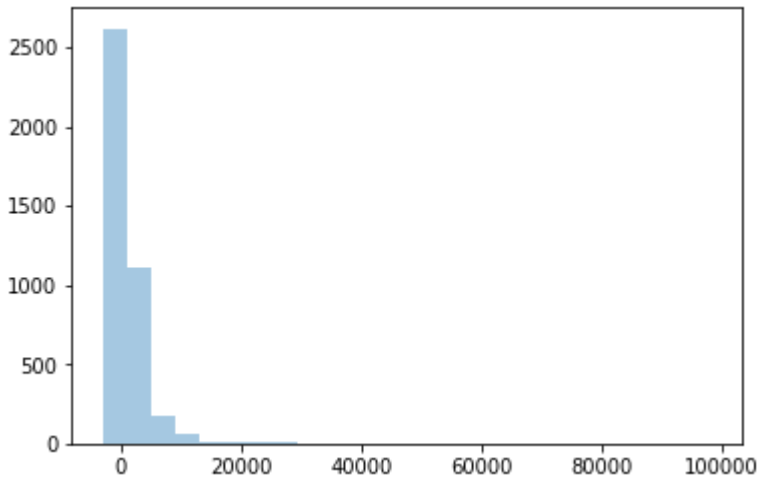
	count	
	Age	
CarInsurance	0	1
Education		
other	90	79
primary	366	195
secondary	1258	730
tertiary	682	600

Balance

In [39]:
```
train.Balance = train.Balance.astype('float')
test.Balance = test.Balance.astype('float')
```

In [40]:
```
sns.distplot(train.Balance.values, kde=False, rug=False, bins=25)
```

Out[40]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff4daa4b7b8>
```

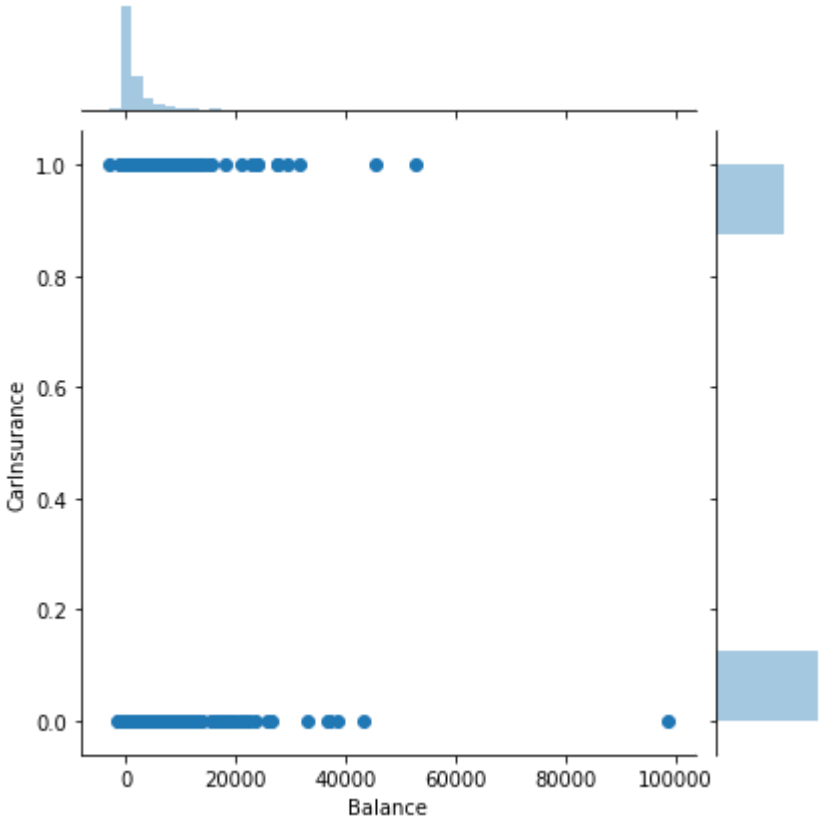


In [41]:
```
sns.jointplot('Balance', 'CarInsurance', data=train)
```

```
/opt/conda/lib/python3.6/site-packages/scipy/stats/stats.py:1713: FutureW
arning: Using a non-tuple sequence for multidimensional indexing is depre
cated; use `arr[tuple(seq)]` instead of `arr[seq]`. In the future this wi
ll be interpreted as an array index, `arr[np.array(seq)]`, which will res
ult either in an error or a different result.
  return np.add.reduce(sorted[indexer] * weights, axis=axis) / sumval
```

Out[41]:

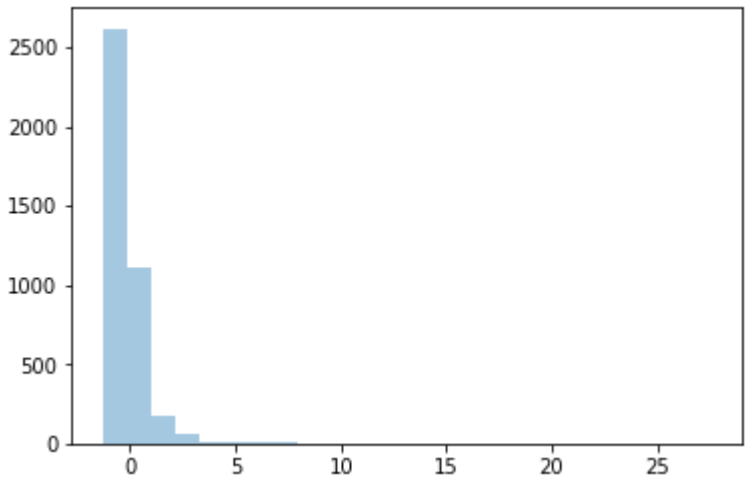
```
<seaborn.axisgrid.JointGrid at 0x7ff4d918acf8>
```



In [42]:
```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
train.Balance = sc.fit_transform(train.Balance.values.reshape(-1, 1))
test.Balance = sc.fit_transform(test.Balance.values.reshape(-1, 1))
```

In [43]:
```
sns.distplot(train.Balance.values, kde=False, rug=False, bins=25)
```

Out[43]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff4d8775cc0>
```



In [44]:
```
train.Balance.describe()
```

Out[44]:
```
count    4.000000e+03
mean     4.639344e-17
std      1.000125e+00
min     -1.307582e+00
25%     -4.049934e-01
50%     -2.795310e-01
75%      2.451222e-02
max      2.759433e+01
Name: Balance, dtype: float64
```

Communication

In [45]:
```
train.Communication.unique()
```

Out[45]:
```
array(['telephone', 'other', 'cellular'], dtype=object)
```

In [46]:
```
pd.pivot_table(train[['Communication', 'CarInsurance', 'Age']], columns=[
'CarInsurance'], index=['Communication'], aggfunc=['count'])
```

Out[46]:

	count	
	Age	
CarInsurance	0	1
Communication		
cellular	1518	1313
other	734	168
telephone	144	123

In [47]:
```
train["isMobile"] = train.Communication.apply(lambda x : 1 if x == "Cellu
lar" or x == "telephone" else 0)
test["isMobile"] = test.Communication.apply(lambda x : 1 if x == "Cellula
r" or x == "telephone" else 0)
```

LastContactDay & Month

In [48]:
```
pd.pivot_table(train[['LastContactMonth', 'CarInsurance', 'Age']], columns=['CarInsurance'], index=['LastContactMonth'], aggfunc=['count'])
```

Out[48]:

	count	
	Age	
CarInsurance	0	1
LastContactMonth		
apr	150	156
aug	342	194
dec	7	34
feb	129	133
jan	86	48
jul	364	209
jun	283	171
mar	15	64
may	760	289
nov	215	132
oct	27	91
sep	18	83

NoOfContacts

In [49]:
```
pd.pivot_table(train[['NoOfContacts', 'CarInsurance', 'Age']], columns=[
'CarInsurance'], index=['NoOfContacts'], aggfunc=['count'])
```

Out[49]:

	count	
	Age	
CarInsurance	0	1
NoOfContacts		
1	912.0	773.0
2	671.0	414.0
3	311.0	205.0
4	156.0	81.0
5	114.0	52.0
6	62.0	26.0
7	34.0	15.0
8	27.0	14.0
9	18.0	2.0
10	13.0	5.0
11	7.0	8.0
12	11.0	NaN
13	6.0	2.0
14	6.0	1.0
15	2.0	1.0
16	3.0	NaN
17	9.0	2.0
18	3.0	NaN
19	3.0	NaN
20	4.0	NaN
21	3.0	1.0
22	3.0	NaN
23	3.0	NaN
24	2.0	1.0
25	4.0	NaN
26	1.0	NaN
27	1.0	NaN
28	1.0	NaN

	count	
	Age	
CarInsurance	0	1
NoOfContacts		
29	NaN	1.0
30	1.0	NaN
32	1.0	NaN
34	1.0	NaN
38	1.0	NaN
41	1.0	NaN
43	1.0	NaN

DaysPassed

In [50]:
```
train.DaysPassed.value_counts()
```

Out[50]:

-1	3042
92	38
182	33
91	24
183	24
93	16
95	16
94	14
97	13
181	13
189	12
184	12
90	11
178	10
370	10
105	9
196	9
104	8
350	8
185	8
188	8
98	8
169	8
195	7
187	7
176	6
175	6
88	6
168	6
343	6
...	
310	1
308	1
474	1
532	1
127	1
544	1
121	1
115	1
73	1
71	1

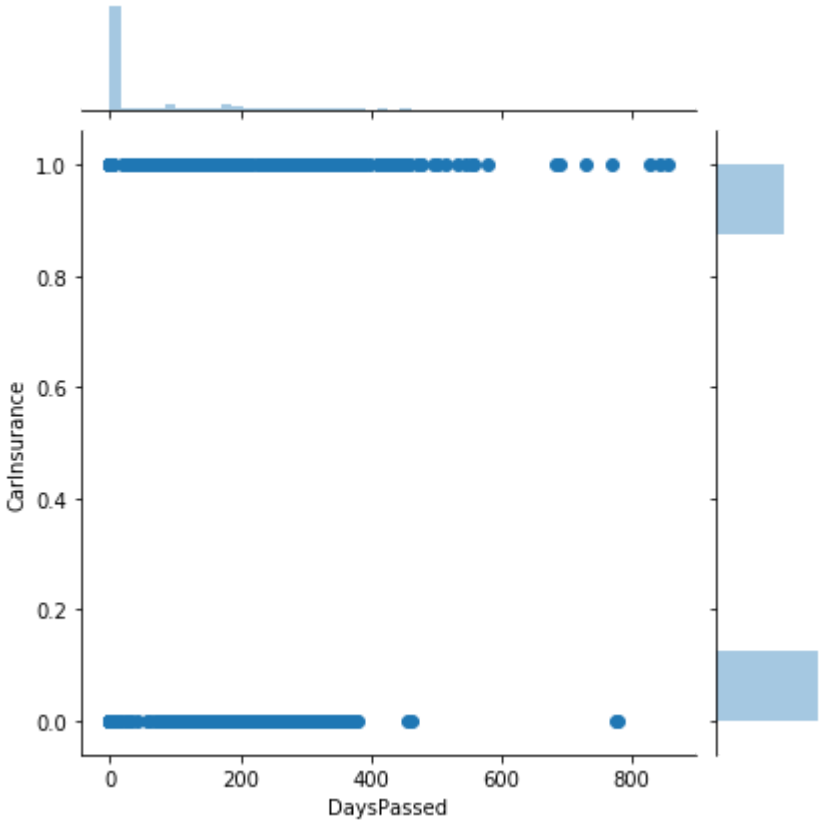
```
67        1
65        1
61        1
57        1
53        1
49        1
43        1
37        1
35        1
27        1
21        1
15        1
13        1
854       1
775       1
828       1
728       1
690       1
558       1
842       1
Name: DaysPassed, Length: 330, dtype: int64
```

In [51]:
```
sns.jointplot('DaysPassed', 'CarInsurance', data=train)
```

```
/opt/conda/lib/python3.6/site-packages/scipy/stats/stats.py:1713: FutureW
arning: Using a non-tuple sequence for multidimensional indexing is depre
cated; use `arr[tuple(seq)]` instead of `arr[seq]`. In the future this wi
ll be interpreted as an array index, `arr[np.array(seq)]`, which will res
ult either in an error or a different result.
  return np.add.reduce(sorted[indexer] * weights, axis=axis) / sumval
```

Out[51]:

```
<seaborn.axisgrid.JointGrid at 0x7ff4d8731320>
```



PrevAttempts

In [52]:
```
train.PrevAttempts.value_counts()
```

Out[52]:
```
0     3042
1      335
2      251
3      125
4       79
5       60
6       25
7       21
8       18
10      10
9        9
14       5
12       5
13       4
19       4
11       3
23       1
18       1
58       1
30       1
Name: PrevAttempts, dtype: int64
```

In [53]:
```
pd.pivot_table(train[['PrevAttempts', 'CarInsurance', 'Age']], columns=[
'CarInsurance'], index=['PrevAttempts'], aggfunc=['count'])
```

Out[53]:

	count	
	Age	
CarInsurance	0	1
PrevAttempts		
0	1997.0	1045.0
1	149.0	186.0
2	109.0	142.0
3	47.0	78.0
4	33.0	46.0
5	26.0	34.0
6	9.0	16.0
7	6.0	15.0
8	4.0	14.0
9	5.0	4.0
10	NaN	10.0
11	1.0	2.0
12	1.0	4.0
13	2.0	2.0
14	3.0	2.0
18	1.0	NaN
19	2.0	2.0
23	1.0	NaN
30	NaN	1.0
58	NaN	1.0

Outcom

In [54]:
```
train.Outcome.unique()
```

Out[54]:
```
array(['unknwon', 'failure', 'other', 'success'], dtype=object)
```

In [55]:
```
pd.pivot_table(train[['Outcome', 'CarInsurance', 'Age']], columns=['CarInsurance'], index=['Outcome'], aggfunc=['count'])
```

Out[55]:

	count	
	Age	
CarInsurance	0	1
Outcome		
failure	261	176
other	103	92
success	35	291
unknwon	1997	1045

Time

In [56]:
```
train['isCallStart'] = 0
train['isCallEnd'] = 0
test['isCallStart'] = 0
test['isCallEnd'] = 0

for idx, time in enumerate(train.CallStart):
    (h, m, s) = time.split(':')
    result = int(h) * 3600 + int(m) * 60 + int(s)
    train.loc[idx, 'isCallStart'] = result

for idx, time in enumerate(train.CallEnd):
    (h, m, s) = time.split(':')
    result = int(h) * 3600 + int(m) * 60 + int(s)
    train.loc[idx, 'isCallEnd'] = result
```

In [57]:
```
def make_time_column(df):
    df["diffTime"] = df.isCallStart - df.isCallEnd
    df[['isCallStart', 'isCallEnd', 'diffTime']] = df[['isCallStart', 'is
CallEnd', 'diffTime']].astype("float")
    df.drop(['CallStart', 'CallEnd'], axis=1, inplace=True)
```

In [58]:
```
make_time_column(train)
make_time_column(test)
```

In [59]:
```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
train[['isCallStart', 'isCallEnd', 'diffTime']] = sc.fit_transform(train
[['isCallStart', 'isCallEnd', 'diffTime']])
test[['isCallStart', 'isCallEnd', 'diffTime']] = sc.fit_transform(test[[
'isCallStart', 'isCallEnd', 'diffTime']])
```

In [60]:

```
cat_cols = ['Marital', 'Education', 'Communication',
            'LastContactMonth', 'Outcome']

make_model(train, cat_cols)
```

```
[0]     eval-auc:0.805461       train-auc:0.843845
Multiple eval metrics have been passed: 'train-auc' will be used for earl
y stopping.

Will train until train-auc hasn't improved in 2 rounds.
[1]     eval-auc:0.854935       train-auc:0.878551
[2]     eval-auc:0.861044       train-auc:0.887408
[3]     eval-auc:0.862193       train-auc:0.88986
[4]     eval-auc:0.86773        train-auc:0.898391
[5]     eval-auc:0.873595       train-auc:0.903397
[6]     eval-auc:0.875166       train-auc:0.905741
[7]     eval-auc:0.879566       train-auc:0.909439
[8]     eval-auc:0.885511       train-auc:0.914387
[9]     eval-auc:0.886972       train-auc:0.917139
[10]    eval-auc:0.88952        train-auc:0.918847
[11]    eval-auc:0.890745       train-auc:0.921649
[12]    eval-auc:0.892542       train-auc:0.923362
[13]    eval-auc:0.893384       train-auc:0.924535
[14]    eval-auc:0.895435       train-auc:0.927988
[15]    eval-auc:0.897425       train-auc:0.929414
[16]    eval-auc:0.897631       train-auc:0.930781
[17]    eval-auc:0.897595       train-auc:0.932208
[18]    eval-auc:0.89748        train-auc:0.93341
[19]    eval-auc:0.898585       train-auc:0.934499
[20]    eval-auc:0.901816       train-auc:0.937007
[21]    eval-auc:0.902859       train-auc:0.938091
[22]    eval-auc:0.90287        train-auc:0.939094
[23]    eval-auc:0.904182       train-auc:0.941049
[24]    eval-auc:0.904511       train-auc:0.942365
[25]    eval-auc:0.905828       train-auc:0.943278
[26]    eval-auc:0.905926       train-auc:0.94393
[27]    eval-auc:0.905302       train-auc:0.945311
[28]    eval-auc:0.905516       train-auc:0.945758
[29]    eval-auc:0.905237       train-auc:0.946369
[30]    eval-auc:0.905542       train-auc:0.946539
[31]    eval-auc:0.905686       train-auc:0.947442
[32]    eval-auc:0.905301       train-auc:0.948264
[33]    eval-auc:0.905076       train-auc:0.949809
[34]    eval-auc:0.906362       train-auc:0.950933
[35]    eval-auc:0.906819       train-auc:0.951552
[36]    eval-auc:0.906471       train-auc:0.952219
```

```
[37]    eval-auc:0.906581       train-auc:0.953686
[38]    eval-auc:0.906885       train-auc:0.954887
[39]    eval-auc:0.90738        train-auc:0.955329
[40]    eval-auc:0.907521       train-auc:0.955581
[41]    eval-auc:0.909183       train-auc:0.95686
[42]    eval-auc:0.909503       train-auc:0.957208
[43]    eval-auc:0.909126       train-auc:0.958158
[44]    eval-auc:0.909629       train-auc:0.959115
[45]    eval-auc:0.90977        train-auc:0.959549
[46]    eval-auc:0.910553       train-auc:0.960308
[47]    eval-auc:0.911131       train-auc:0.961035
[48]    eval-auc:0.911602       train-auc:0.961608
[49]    eval-auc:0.911832       train-auc:0.962787
[50]    eval-auc:0.911404       train-auc:0.963231
[51]    eval-auc:0.9108 train-auc:0.96373
[52]    eval-auc:0.910699       train-auc:0.964128
[53]    eval-auc:0.910403       train-auc:0.965209
[54]    eval-auc:0.910676       train-auc:0.965479
[55]    eval-auc:0.910578       train-auc:0.966197
[56]    eval-auc:0.910351       train-auc:0.966588
[57]    eval-auc:0.910794       train-auc:0.966703
[58]    eval-auc:0.911059       train-auc:0.966934
[59]    eval-auc:0.911076       train-auc:0.96708
[60]    eval-auc:0.910823       train-auc:0.967371
[61]    eval-auc:0.911047       train-auc:0.96787
[62]    eval-auc:0.911502       train-auc:0.96834
[63]    eval-auc:0.912839       train-auc:0.968949
[64]    eval-auc:0.913187       train-auc:0.969706
[65]    eval-auc:0.913662       train-auc:0.970076
[66]    eval-auc:0.913552       train-auc:0.970497
[67]    eval-auc:0.913271       train-auc:0.970919
[68]    eval-auc:0.913458       train-auc:0.971182
[69]    eval-auc:0.913458       train-auc:0.971419
[70]    eval-auc:0.913291       train-auc:0.971667
[71]    eval-auc:0.913656       train-auc:0.971884
[72]    eval-auc:0.91411        train-auc:0.972523
[73]    eval-auc:0.914024       train-auc:0.973027
[74]    eval-auc:0.91399        train-auc:0.973126
[75]    eval-auc:0.914059       train-auc:0.973415
[76]    eval-auc:0.914953       train-auc:0.973651
[77]    eval-auc:0.914976       train-auc:0.973998
[78]    eval-auc:0.915123       train-auc:0.974454
```

```
[79]    eval-auc:0.914712       train-auc:0.975192
[80]    eval-auc:0.914729       train-auc:0.975625
[81]    eval-auc:0.914568       train-auc:0.976236
[82]    eval-auc:0.914576       train-auc:0.976249
[83]    eval-auc:0.914576       train-auc:0.976395
[84]    eval-auc:0.914131       train-auc:0.976689
[85]    eval-auc:0.914309       train-auc:0.97674
[86]    eval-auc:0.914407       train-auc:0.977268
[87]    eval-auc:0.91443        train-auc:0.977814
[88]    eval-auc:0.915039       train-auc:0.978037
[89]    eval-auc:0.915034       train-auc:0.978582
[90]    eval-auc:0.915014       train-auc:0.978975
[91]    eval-auc:0.914438       train-auc:0.979451
[92]    eval-auc:0.914548       train-auc:0.979831
[93]    eval-auc:0.915062       train-auc:0.98008
[94]    eval-auc:0.914804       train-auc:0.980339
[95]    eval-auc:0.914864       train-auc:0.980585
[96]    eval-auc:0.914976       train-auc:0.98073
[97]    eval-auc:0.914973       train-auc:0.980925
[98]    eval-auc:0.914674       train-auc:0.981273
[99]    eval-auc:0.914326       train-auc:0.981357
[100]   eval-auc:0.913961       train-auc:0.981714
[101]   eval-auc:0.913952       train-auc:0.982042
[102]   eval-auc:0.913877       train-auc:0.982463
[103]   eval-auc:0.91401        train-auc:0.982884
[104]   eval-auc:0.913564       train-auc:0.983217
[105]   eval-auc:0.913411       train-auc:0.983539
[106]   eval-auc:0.913245       train-auc:0.984032
[107]   eval-auc:0.913161       train-auc:0.984507
[108]   eval-auc:0.912879       train-auc:0.98477
[109]   eval-auc:0.912623       train-auc:0.98514
[110]   eval-auc:0.912796       train-auc:0.985322
[111]   eval-auc:0.913325       train-auc:0.985503
[112]   eval-auc:0.913294       train-auc:0.985796
[113]   eval-auc:0.913601       train-auc:0.986048
[114]   eval-auc:0.914041       train-auc:0.986233
[115]   eval-auc:0.913734       train-auc:0.986426
[116]   eval-auc:0.913472       train-auc:0.986495
[117]   eval-auc:0.913565       train-auc:0.986901
[118]   eval-auc:0.913514       train-auc:0.987268
[119]   eval-auc:0.913404       train-auc:0.987481
[120]   eval-auc:0.913163       train-auc:0.98764
```

```
[121]   eval-auc:0.912674       train-auc:0.98779
[122]   eval-auc:0.912818       train-auc:0.987881
[123]   eval-auc:0.912772       train-auc:0.988072
[124]   eval-auc:0.912774       train-auc:0.988223
[125]   eval-auc:0.913432       train-auc:0.98833
[126]   eval-auc:0.913504       train-auc:0.988357
[127]   eval-auc:0.91365        train-auc:0.9887
[128]   eval-auc:0.913285       train-auc:0.988878
[129]   eval-auc:0.912917       train-auc:0.989188
[130]   eval-auc:0.91275        train-auc:0.989312
[131]   eval-auc:0.912434       train-auc:0.989549
[132]   eval-auc:0.912739       train-auc:0.98971
[133]   eval-auc:0.912816       train-auc:0.989802
[134]   eval-auc:0.912552       train-auc:0.989806
[135]   eval-auc:0.91298        train-auc:0.98998
[136]   eval-auc:0.913144       train-auc:0.990115
[137]   eval-auc:0.913213       train-auc:0.990296
[138]   eval-auc:0.913322       train-auc:0.990307
[139]   eval-auc:0.913202       train-auc:0.990428
[140]   eval-auc:0.91342        train-auc:0.990678
[141]   eval-auc:0.913371       train-auc:0.990774
[142]   eval-auc:0.91397        train-auc:0.990966
[143]   eval-auc:0.914171       train-auc:0.991238
[144]   eval-auc:0.91397        train-auc:0.991414
[145]   eval-auc:0.91401        train-auc:0.99149
[146]   eval-auc:0.9139 train-auc:0.991781
[147]   eval-auc:0.913967       train-auc:0.991849
[148]   eval-auc:0.914228       train-auc:0.99188
[149]   eval-auc:0.914294       train-auc:0.992087
[150]   eval-auc:0.914067       train-auc:0.992253
[151]   eval-auc:0.914565       train-auc:0.992425
[152]   eval-auc:0.914332       train-auc:0.992583
[153]   eval-auc:0.914596       train-auc:0.992739
[154]   eval-auc:0.914645       train-auc:0.992979
[155]   eval-auc:0.91472        train-auc:0.993045
[156]   eval-auc:0.914766       train-auc:0.993114
[157]   eval-auc:0.914389       train-auc:0.993178
[158]   eval-auc:0.914231       train-auc:0.99341
[159]   eval-auc:0.914631       train-auc:0.993534
[160]   eval-auc:0.91453        train-auc:0.993744
[161]   eval-auc:0.913955       train-auc:0.993844
[162]   eval-auc:0.91384        train-auc:0.993891
```

```
[163]   eval-auc:0.91334        train-auc:0.993993
[164]   eval-auc:0.913207       train-auc:0.994064
[165]   eval-auc:0.912971       train-auc:0.994087
[166]   eval-auc:0.91279        train-auc:0.994177
[167]   eval-auc:0.912641       train-auc:0.994285
[168]   eval-auc:0.91229        train-auc:0.994369
[169]   eval-auc:0.912413       train-auc:0.994427
[170]   eval-auc:0.91208        train-auc:0.99451
[171]   eval-auc:0.911873       train-auc:0.99461
[172]   eval-auc:0.911758       train-auc:0.994659
[173]   eval-auc:0.912005       train-auc:0.994814
[174]   eval-auc:0.911973       train-auc:0.994932
[175]   eval-auc:0.911706       train-auc:0.995033
[176]   eval-auc:0.911677       train-auc:0.995099
[177]   eval-auc:0.911542       train-auc:0.995217
[178]   eval-auc:0.911257       train-auc:0.995333
[179]   eval-auc:0.911251       train-auc:0.995369
[180]   eval-auc:0.911372       train-auc:0.995495
[181]   eval-auc:0.911424       train-auc:0.995529
[182]   eval-auc:0.911323       train-auc:0.995625
[183]   eval-auc:0.911338       train-auc:0.995676
[184]   eval-auc:0.911162       train-auc:0.995733
[185]   eval-auc:0.911323       train-auc:0.99574
[186]   eval-auc:0.911217       train-auc:0.995766
[187]   eval-auc:0.911349       train-auc:0.995791
[188]   eval-auc:0.911838       train-auc:0.995835
[189]   eval-auc:0.911821       train-auc:0.995996
[190]   eval-auc:0.911392       train-auc:0.996046
[191]   eval-auc:0.911657       train-auc:0.996067
[192]   eval-auc:0.911666       train-auc:0.996119
[193]   eval-auc:0.9117 train-auc:0.996124
[194]   eval-auc:0.911706       train-auc:0.996237
[195]   eval-auc:0.91162        train-auc:0.996395
[196]   eval-auc:0.911519       train-auc:0.996499
[197]   eval-auc:0.911364       train-auc:0.996578
[198]   eval-auc:0.91103        train-auc:0.996764
[199]   eval-auc:0.911493       train-auc:0.996839
[200]   eval-auc:0.911387       train-auc:0.996847
[201]   eval-auc:0.91128        train-auc:0.99688
[202]   eval-auc:0.911116       train-auc:0.996968
[203]   eval-auc:0.911375       train-auc:0.997098
[204]   eval-auc:0.911413       train-auc:0.997213
```

```
[205]   eval-auc:0.911404       train-auc:0.997273
[206]   eval-auc:0.911758       train-auc:0.997307
[207]   eval-auc:0.911755       train-auc:0.997325
[208]   eval-auc:0.911775       train-auc:0.997392
[209]   eval-auc:0.911283       train-auc:0.997469
[210]   eval-auc:0.911323       train-auc:0.997464
[211]   eval-auc:0.91097        train-auc:0.997533
[212]   eval-auc:0.910869       train-auc:0.997584
[213]   eval-auc:0.91086        train-auc:0.997643
[214]   eval-auc:0.910509       train-auc:0.997707
[215]   eval-auc:0.910734       train-auc:0.997765
[216]   eval-auc:0.910662       train-auc:0.997818
[217]   eval-auc:0.910765       train-auc:0.997831
[218]   eval-auc:0.910852       train-auc:0.997916
[219]   eval-auc:0.910929       train-auc:0.997948
[220]   eval-auc:0.910826       train-auc:0.997963
[221]   eval-auc:0.910906       train-auc:0.997982
[222]   eval-auc:0.910714       train-auc:0.997974
[223]   eval-auc:0.910811       train-auc:0.998037
[224]   eval-auc:0.910734       train-auc:0.99805
[225]   eval-auc:0.910734       train-auc:0.998053
[226]   eval-auc:0.910659       train-auc:0.998092
[227]   eval-auc:0.910512       train-auc:0.998103
[228]   eval-auc:0.910386       train-auc:0.99811
[229]   eval-auc:0.910478       train-auc:0.99815
[230]   eval-auc:0.910415       train-auc:0.998232
[231]   eval-auc:0.91032        train-auc:0.998274
[232]   eval-auc:0.910242       train-auc:0.99828
[233]   eval-auc:0.910627       train-auc:0.99834
[234]   eval-auc:0.910553       train-auc:0.998371
[235]   eval-auc:0.910003       train-auc:0.99841
[236]   eval-auc:0.910058       train-auc:0.998438
[237]   eval-auc:0.910256       train-auc:0.998543
[238]   eval-auc:0.910187       train-auc:0.99856
[239]   eval-auc:0.910276       train-auc:0.998609
[240]   eval-auc:0.910285       train-auc:0.998617
[241]   eval-auc:0.910075       train-auc:0.998671
[242]   eval-auc:0.909747       train-auc:0.998732
[243]   eval-auc:0.909773       train-auc:0.99878
[244]   eval-auc:0.909629       train-auc:0.998835
[245]   eval-auc:0.909678       train-auc:0.998866
[246]   eval-auc:0.909822       train-auc:0.998892
```

```
[247]   eval-auc:0.909923       train-auc:0.998888
[248]   eval-auc:0.909908       train-auc:0.998873
Stopping. Best iteration:
[246]   eval-auc:0.909822       train-auc:0.998892
```

In [61]:

```
train.head()
```

Out[61]:

	Id	Age	Marital	Education	Default	Balance	HHInsurance	CarLoan	Communication	LastCor
0	1	32	2	3	0	-0.089700	1	0	2	28
1	2	32	1	1	0	-0.107359	1	0	1	26
2	3	29	2	3	0	-0.255179	1	0	0	3
3	4	25	2	1	0	-0.330371	1	0	0	11
4	5	30	1	3	0	0.330692	0	0	0	3

モデル作成

In [62]:
```
def make_model(train, cat_cols, dtrain, dval):
    eval_list = [(dval, 'eval'), (dtrain, 'train')]
    param = {'max_depth': 4,
             'min_child_weight' : 1,
             'gamma' : 1,
             'subsample' : 1,
             'colsample_bytree' : 1,
             'alpha' : 0.5,
             'labmda' : 0.5,
             'nthread' : 5,
             'eta': 0.15,
             'silent': 1,
             'objective': 'binary:logistic',
             'eval_metric' : 'auc'}

    num_round = 300
    bst = xgb.train(param, dtrain, num_round, eval_list, early_stopping_r
ounds=2)
    return bst
```

In [63]:
```
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
le = LabelEncoder()
for col in cat_cols:
    train[col] = le.fit_transform(train[col])
    test[col] = le.fit_transform(test[col])
```

In [64]:
```
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
X = train
y = train.CarInsurance
X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size=0.3, random
_state=0)
```

In [65]:
```
test_id = X_test.Id.values
test_carInsurance = X_test.CarInsurance.values
X_train.drop(['Id', 'CarInsurance'], axis=1, inplace=True)
X_test.drop(['Id', 'CarInsurance'], axis=1, inplace=True)
```

```
/opt/conda/lib/python3.6/site-packages/pandas/core/frame.py:3697: Setting
WithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-doc
s/stable/indexing.html#indexing-view-versus-copy
  errors=errors)
```

In [66]:
```
import xgboost as xgb
dtrain = xgb.DMatrix(X_train, y_train)
dval = xgb.DMatrix(X_test, y_test)
```

In [67]:

```
cat_cols = ['Marital', 'Education', 'Communication',
            'LastContactMonth', 'Outcome']

bst = make_model(train, cat_cols, dtrain, dval)
```

```
[0]     eval-auc:0.843711       train-auc:0.873992
Multiple eval metrics have been passed: 'train-auc' will be used for earl
y stopping.

Will train until train-auc hasn't improved in 2 rounds.
[1]     eval-auc:0.857401       train-auc:0.888068
[2]     eval-auc:0.858789       train-auc:0.889743
[3]     eval-auc:0.868222       train-auc:0.898518
[4]     eval-auc:0.86839        train-auc:0.900772
[5]     eval-auc:0.868581       train-auc:0.902292
[6]     eval-auc:0.869914       train-auc:0.90469
[7]     eval-auc:0.87459        train-auc:0.908159
[8]     eval-auc:0.880214       train-auc:0.911055
[9]     eval-auc:0.882404       train-auc:0.914217
[10]    eval-auc:0.882466       train-auc:0.914551
[11]    eval-auc:0.883489       train-auc:0.915835
[12]    eval-auc:0.885043       train-auc:0.918721
[13]    eval-auc:0.885757       train-auc:0.919617
[14]    eval-auc:0.887242       train-auc:0.920942
[15]    eval-auc:0.888807       train-auc:0.922525
[16]    eval-auc:0.890478       train-auc:0.924871
[17]    eval-auc:0.891534       train-auc:0.926951
[18]    eval-auc:0.892957       train-auc:0.928164
[19]    eval-auc:0.895962       train-auc:0.930997
[20]    eval-auc:0.897326       train-auc:0.932759
[21]    eval-auc:0.897847       train-auc:0.93358
[22]    eval-auc:0.898956       train-auc:0.934713
[23]    eval-auc:0.901668       train-auc:0.937263
[24]    eval-auc:0.901987       train-auc:0.938511
[25]    eval-auc:0.902735       train-auc:0.939382
[26]    eval-auc:0.903814       train-auc:0.940139
[27]    eval-auc:0.904308       train-auc:0.941018
[28]    eval-auc:0.904941       train-auc:0.943245
[29]    eval-auc:0.90524        train-auc:0.943767
[30]    eval-auc:0.906739       train-auc:0.9445
[31]    eval-auc:0.90758        train-auc:0.945211
[32]    eval-auc:0.907701       train-auc:0.945981
[33]    eval-auc:0.907763       train-auc:0.946823
[34]    eval-auc:0.908723       train-auc:0.948778
[35]    eval-auc:0.909281       train-auc:0.949077
[36]    eval-auc:0.909593       train-auc:0.949645
```

```
[37]    eval-auc:0.909997       train-auc:0.950733
[38]    eval-auc:0.909675       train-auc:0.951515
[39]    eval-auc:0.910371       train-auc:0.952047
[40]    eval-auc:0.910199       train-auc:0.953082
[41]    eval-auc:0.909999       train-auc:0.953735
[42]    eval-auc:0.910571       train-auc:0.954585
[43]    eval-auc:0.910761       train-auc:0.954991
[44]    eval-auc:0.910699       train-auc:0.95594
[45]    eval-auc:0.910288       train-auc:0.956393
[46]    eval-auc:0.910279       train-auc:0.956551
[47]    eval-auc:0.910285       train-auc:0.956867
[48]    eval-auc:0.910929       train-auc:0.957337
[49]    eval-auc:0.911182       train-auc:0.958014
[50]    eval-auc:0.911919       train-auc:0.958921
[51]    eval-auc:0.911936       train-auc:0.9594
[52]    eval-auc:0.912264       train-auc:0.960366
[53]    eval-auc:0.912376       train-auc:0.960858
[54]    eval-auc:0.913394       train-auc:0.961732
[55]    eval-auc:0.913947       train-auc:0.962622
[56]    eval-auc:0.914018       train-auc:0.963339
[57]    eval-auc:0.914254       train-auc:0.963866
[58]    eval-auc:0.914999       train-auc:0.964656
[59]    eval-auc:0.914545       train-auc:0.965208
[60]    eval-auc:0.914818       train-auc:0.966004
[61]    eval-auc:0.91485        train-auc:0.966996
[62]    eval-auc:0.915008       train-auc:0.967428
[63]    eval-auc:0.915643       train-auc:0.967847
[64]    eval-auc:0.915402       train-auc:0.968195
[65]    eval-auc:0.915764       train-auc:0.968901
[66]    eval-auc:0.915917       train-auc:0.969333
[67]    eval-auc:0.916017       train-auc:0.970077
[68]    eval-auc:0.916072       train-auc:0.970568
[69]    eval-auc:0.916069       train-auc:0.971027
[70]    eval-auc:0.915563       train-auc:0.971239
[71]    eval-auc:0.915802       train-auc:0.971581
[72]    eval-auc:0.915678       train-auc:0.971815
[73]    eval-auc:0.915707       train-auc:0.972114
[74]    eval-auc:0.916662       train-auc:0.972333
[75]    eval-auc:0.91776        train-auc:0.972977
[76]    eval-auc:0.918137       train-auc:0.973599
[77]    eval-auc:0.918894       train-auc:0.974045
[78]    eval-auc:0.918994       train-auc:0.974389
```

```
[79]    eval-auc:0.918779       train-auc:0.974714
[80]    eval-auc:0.918813       train-auc:0.974739
[81]    eval-auc:0.919342       train-auc:0.975209
[82]    eval-auc:0.919368       train-auc:0.975879
[83]    eval-auc:0.918925       train-auc:0.976141
[84]    eval-auc:0.918868       train-auc:0.976303
[85]    eval-auc:0.918738       train-auc:0.976604
[86]    eval-auc:0.918839       train-auc:0.976744
[87]    eval-auc:0.918764       train-auc:0.97708
[88]    eval-auc:0.918865       train-auc:0.977625
[89]    eval-auc:0.919029       train-auc:0.97817
[90]    eval-auc:0.918954       train-auc:0.978305
[91]    eval-auc:0.918856       train-auc:0.978581
[92]    eval-auc:0.918894       train-auc:0.978676
[93]    eval-auc:0.918684       train-auc:0.978837
[94]    eval-auc:0.918525       train-auc:0.978995
[95]    eval-auc:0.918468       train-auc:0.979489
[96]    eval-auc:0.918707       train-auc:0.979805
[97]    eval-auc:0.919011       train-auc:0.980142
[98]    eval-auc:0.919109       train-auc:0.980201
[99]    eval-auc:0.919104       train-auc:0.980199
[100]   eval-auc:0.919457       train-auc:0.980567
[101]   eval-auc:0.919472       train-auc:0.981132
[102]   eval-auc:0.919627       train-auc:0.981391
[103]   eval-auc:0.919673       train-auc:0.981657
[104]   eval-auc:0.919748       train-auc:0.981915
[105]   eval-auc:0.91965        train-auc:0.982071
[106]   eval-auc:0.920076       train-auc:0.982203
[107]   eval-auc:0.920622       train-auc:0.982273
[108]   eval-auc:0.920507       train-auc:0.982462
[109]   eval-auc:0.920455       train-auc:0.982735
[110]   eval-auc:0.920455       train-auc:0.982735
[111]   eval-auc:0.920455       train-auc:0.982735
Stopping. Best iteration:
[109]   eval-auc:0.920455       train-auc:0.982735
```

In [68]:

```
dtest = xgb.DMatrix(X_test)
predict = bst.predict(dtest)
```

In [69]:
```
submissions = pd.DataFrame({"Id" : test_id, "PredValue" : predict, 'CarIn
surance' : test_carInsurance})
```

In [70]:
```
submissions.to_csv("./submissions.csv", index=False)
```

In [71]:

```
def make_model_optuna(trial):
    from sklearn.preprocessing import LabelEncoder
    from sklearn.model_selection import train_test_split
    import xgboost as xgb
    import sklearn.datasets
    import sklearn.metrics

    le = LabelEncoder()
    for col in cat_cols:
        train[col] = le.fit_transform(train[col])
        test[col] = le.fit_transform(test[col])

    X = train.drop(['Id', 'CarInsurance'], axis=1)
    y = train.CarInsurance
    X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                        test_size=0.3, ra
ndom_state=0)

    dtrain = xgb.DMatrix(X_train, y_train)
    dval = xgb.DMatrix(X_test, y_test)
    # eval_list = [(dval, 'eval'), (dtrain, 'train')]

    n_round = trial.suggest_int('n_round', 1, 9)
    param = {'silent': 1,
             'objective': 'binary:logistic',
             'booster': trial.suggest_categorical('booster', ['gbtree',
'gblinear', 'dart']),
             'lambda': trial.suggest_loguniform('lambda', 1e-8, 1.0),
             'alpha': trial.suggest_loguniform('alpha', 1e-8, 1.0),
             'eval_metric' : 'auc'
             }

    if param['booster'] == 'gbtree' or param['booster'] == 'dart':
        param['max_depth'] = trial.suggest_int('max_depth', 1, 9)
        param['ets'] = trial.suggest_loguniform('eta', 1e-8, 1.0)
        param['gamma'] = trial.suggest_loguniform('gamma', 1e-8, 1.0)
        param['grow_policy'] = trial.suggest_categorical('grow_policy', [
'depthwise', 'lossguide'])

    if param['booster'] == 'dart':
        param['sample_type'] = trial.suggest_categorical('sample_type', [
```

```
'uniform', 'weighted'])
        param['normalize_type'] = trial.suggest_categorical('normalize_ty
pe', ['tree', 'forest'])
        param['rate_drop'] = trial.suggest_loguniform('rate_drop', 1e-8,
1.0)
        param['skip_drop'] = trial.suggest_loguniform('skip_drop', 1e-8,
1.0)

    # bst = xgb.train(param, dtrain, n_round, eval_list)
    bst = xgb.train(param, dtrain, n_round)

    bst.eval(dval)
    return 0.6
```

In [72]:

```
"""
import optuna
study = optuna.create_study()
study.optimize(make_model_optuna, n_trials=100)
"""
```

Out[72]:

```
'\nimport optuna\nstudy = optuna.create_study()\nstudy.optimize(make_mode
l_optuna, n_trials=100)\n'
```