Import Packages

In [1]:

```python
import os

import editdistance
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import xgboost as xgb

from gensim.models.doc2vec import Doc2Vec, TaggedDocument
from gensim.models.word2vec import Word2Vec
from joblib import dump, load
from math import sin, cos, sqrt, atan2, radians
from nltk import pos_tag
from nltk.corpus import stopwords
from nltk.stem.snowball import RussianStemmer
from nltk.tokenize import word_tokenize
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.metrics import accuracy_score, mean_absolute_error, roc_auc_score
from sklearn.metrics.pairwise import cosine_similarity
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from tqdm import tqdm_notebook
```

```
C:\Users\admin\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarni
ng: detected Windows; aliasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

Data Exploration and Data Cleaning

Read CSV

In [2]:

```python
data = pd.read_csv('./csv/ItemInfo_train.csv')
data = data.drop(columns=['images_array'])
item_pairs = pd.read_csv('./csv/ItemPairs_train.csv')
location = pd.read_csv('./csv/Location.csv')
category = pd.read_csv('./csv/Category.csv')
```

In [3]:

```python
location_region = dict(zip(location['locationID'], location['regionID']))
data['regionID'] = data['locationID'].map(location_region)
```

In [4]:

```python
category_parentcategory = dict(zip(category['categoryID'], category['parentCategoryID']))
data['parentCategoryID'] = data['categoryID'].map(category_parentcategory)
```

In [5]:

```python
data['attrsJSON'] = data['attrsJSON'].replace(to_replace='[{}:",]', value=' ', regex=True)
```

In [6]:

```python
data.head()
```

Out[6]:

	itemID	categoryID	title	description	attrsJSON	price	locationID	metroID	
0	1	81	Продам Камаз 6520	Продам Камаз 6520 20 тонн	Вид техники Грузовики	300000.0	648140	NaN	64
1	3	14	Yamaha r6	Весь в тюнинге.	Вид техники Мотоциклы Вид мотоцикла С...	300000.0	639040	NaN	55
2	4	84	iPhone 3gs 8gb	Телефон в хорошем состоянии, трещин и сколов н...	Вид телефона iPhone	3500.0	640650	NaN	56
3	7	84	Xiaomi Mi4 3гб RAM + 16гб ROM белый	Отличный подарок на новый год от "китайской ар...	Вид телефона Другие марки	13500.0	662210	NaN	55
4	8	39	Лыжные ботинки	Лыжные ботинки в хорошем состоянии, 34 размер	Вид товара Зимние виды спорта	500.0	624360	NaN	55

Fix missing data

In [7]:

```python
def check_missing(data):
    for key in data.keys():
        nan_count = data[key].isna().sum()
        if nan_count > 0:
            print('{} : {}'.format(key, nan_count))

is_noun = lambda pos: pos[:2] == 'NN'
def extract_nouns(text):
    if isinstance(text, str):
        tokenized = word_tokenize(text)
        nouns = [word for (word, pos) in pos_tag(tokenized) if is_noun(pos)]
        return nouns
    else:
        return []
```

In [8]:

```
check_missing(data)
```

```
title : 1
description : 105
attrsJSON : 103988
price : 322126
metroID : 2243818
```

Fix missing title

Using nouns of attrsJSON and description.

In [9]:

```python
# data['title'] = data['title'].fillna('')

missing_title = np.where(data['title'].isnull())[0]
for i in tqdm_notebook(missing_title):
    attrsJSON_text = data.at[i, 'attrsJSON']
    nouns = extract_nouns(attrsJSON_text)
    description_text = data.at[i, 'description']
    nouns.extend(extract_nouns(description_text))
    nouns = set(nouns)

    data.at[i, 'title'] = ' '.join(nouns)
```

In [10]:

```
check_missing(data)
```

```
description : 105
attrsJSON : 103988
price : 322126
metroID : 2243818
```

Fix missing description

Using nouns of attrsJSON and title.

In [11]:

```python
# data['description'] = data['description'].fillna('')

missing_description = np.where(data['description'].isnull())[0]
for i in tqdm_notebook(missing_description):
    attrsJSON_text = data.at[i, 'attrsJSON']
    nouns = extract_nouns(attrsJSON_text)
    title_text = data.at[i, 'title']
    nouns.extend(extract_nouns(title_text))
    nouns = set(nouns)

    data.at[i, 'description'] = ' '.join(nouns)
```

In [12]:

```python
check_missing(data)
```

```
attrsJSON : 103988
price : 322126
metroID : 2243818
```

Fix missing attrsJSON

Using nouns of title.

In [13]:

```python
# data['attrsJSON'] = data['attrsJSON'].fillna('')

missing_attrsJSON = np.where(data['attrsJSON'].isnull())[0]
for i in tqdm_notebook(missing_attrsJSON):
    title_text = data.at[i, 'title']
    nouns = extract_nouns(title_text)
    nouns = set(nouns)

    data.at[i, 'attrsJSON'] = ' '.join(nouns)
```

In [14]:

```python
check_missing(data)
```

```
price : 322126
metroID : 2243818
```

Fix missing price

Using price median of their respective categoryID.

In [15]:

```python
# data['price'] = data['price'].fillna(0)

price_median = data.groupby('categoryID')[['price']].median()
price_median_dict = price_median['price'].to_dict()
data['price'] = data['categoryID'].map(price_median_dict)
```

In [16]:

```python
check_missing(data)
```

metroID : 2243818

Fix missing metroID

Using K-Nearest Neighbours with locationID, lat and lon.

In [17]:

```python
clf = None
if os.path.isfile('knn_model'):
    clf = load('knn_model')
else:
    metroID_train_X = data[['locationID', 'lat', 'lon']][data['metroID'].notnull()].val
ues
    metroID_train_y = data['metroID'][data['metroID'].notnull()].values

    clf = KNeighborsClassifier(n_neighbors=5)
    clf.fit(metroID_train_X, metroID_train_y)

    dump(clf, 'knn_model')
```

In [18]:

```python
missing_metroID = data[['locationID', 'lat', 'lon']][data['metroID'].isnull()].values
prediction = clf.predict(missing_metroID)
```

In [19]:

```python
prediction_index = 0
missing_metroID_index = np.where(data['metroID'].isnull())[0]
for i in tqdm_notebook(missing_metroID_index):
    data.at[i, 'metroID'] = prediction[prediction_index]
    prediction_index += 1
```

In [20]:

```python
check_missing(data)
```

Splitting the data

Convert DataFrame to Dictionary for faster processing

In [21]:

```
data_dict = data.set_index('itemID')
data_dict = data_dict.to_dict('index')
```

Text normalisation on title, description and attrsJSON

In [22]:

```
# stemmer = RussianStemmer()
# stop_words = set(stopwords.words('russian'))
# def normalize(text):
#     word_tokens = word_tokenize(text)
#     filtered_text = [stemmer.stem(word) for word in word_tokens if not word in stop_w
ords]
#     return ' '.join(filtered_text)
```

In [23]:

```
# for key in tqdm_notebook(data_dict.keys()):
#     data_dict[key]['title'] = normalize(data_dict[key]['title'])
#     data_dict[key]['description'] = normalize(data_dict[key]['description'])
#     data_dict[key]['attrsJSON'] = normalize(data_dict[key]['attrsJSON'])
```

Split the data into item_ID1 and item_ID2 for easier comparison

In [24]:

```
item_pairs_list = list(zip(item_pairs['itemID_1'], item_pairs['itemID_2']))
```

In [25]:

```
item_ID1_list = []
item_ID2_list = []
for item_pair in tqdm_notebook(item_pairs_list):
    item_ID1 = item_pair[0]
    item_ID2 = item_pair[1]
    item_ID1_list.append(data_dict[item_ID1])
    item_ID2_list.append(data_dict[item_ID2])
```

In [26]:

```
# item_ID1_list = item_ID1_list[:10000]
# item_ID2_list = item_ID2_list[:10000]

item_ID1_df = pd.DataFrame(item_ID1_list)
item_ID2_df = pd.DataFrame(item_ID2_list)
```

Save item_ID1 and item_ID2 to csv

In [27]:

```python
item_ID1_df.to_csv('./csv/item_ID1.csv', index=False)
item_ID2_df.to_csv('./csv/item_ID2.csv', index=False)
```

Generate mask for train and test set

In [28]:

```python
np.random.seed(0)
training_mask = np.random.rand(len(item_ID1_df)) > 0.2
test_mask = ~training_mask
```

Feature Engineering

In [29]:

```python
title_1_corpus = item_ID1_df['title'][training_mask]
title_2_corpus = item_ID2_df['title'][training_mask]
description_1_corpus = item_ID1_df['description'][training_mask]
description_2_corpus = item_ID2_df['description'][training_mask]
attrsJSON_1_corpus = item_ID1_df['attrsJSON'][training_mask]
attrsJSON_2_corpus = item_ID2_df['attrsJSON'][training_mask]

corpus = pd.concat([title_1_corpus, title_2_corpus, \
                    description_1_corpus, description_2_corpus, \
                    attrsJSON_1_corpus, attrsJSON_2_corpus])
corpus = list(corpus)
```

In [30]:

```python
vectorizer = None
if os.path.isfile('tfidf_model'):
    vectorizer = load('tfidf_model')
else:
    stop_words = set(stopwords.words('russian'))
    vectorizer = TfidfVectorizer(stop_words=stop_words, tokenizer=word_tokenize)
    vectorizer.fit(corpus)

    dump(vectorizer, 'tfidf_model')
```

In [31]:

```python
word2vec_model = None
if os.path.isfile('word2vec_model'):
    word2vec_model = Word2Vec.load('word2vec_model')
else:
    sentences = [word_tokenize(sentence) for sentence in corpus]
    word2vec_model = Word2Vec(sentences, size=300, min_count=10, window=3,
                              sample=1e-3, workers=8, seed=1)

    word2vec_model.save('word2vec_model')
```

In [32]:

```python
doc2vec_model = None
if os.path.isfile('doc2vec_model'):
    doc2vec_model = Doc2Vec.load('doc2vec_model')
else:
    documents = [TaggedDocument(word_tokenize(doc), [i]) for i, doc in enumerate(corpus
)]
    doc2vec_model = Doc2Vec(documents, vector_size=300, min_count=10, window=3,
                            sample=1e-3, workers=8, epochs=10, seed=1)

    doc2vec_model.save('doc2vec_model')
```

Generating features

In [33]:

```python
def compare_ID(item_ID1, item_ID2):
    # categoryID, parentCategoryID, locationID, regionID and metroID
    return 1 if item_ID1 == item_ID2 else 0

def calculate_price_ratio(item_ID1, item_ID2):
    return min(item_ID1, item_ID2) / max(item_ID1, item_ID2)

def compare_price(item_ID1, item_ID2):
    if item_ID1 == item_ID2:
        return 2 # same
    elif min(item_ID1, item_ID2) / max(item_ID1, item_ID2) >= 0.7:
        return 1 # similar
    else:
        return 0 # dissimilar

def calculate_distance(item_ID1_lat, item_ID1_lon, item_ID2_lat, item_ID2_lon):
    R = 6373.0

    lat1 = radians(item_ID1_lat)
    lon1 = radians(item_ID1_lon)
    lat2 = radians(item_ID2_lat)
    lon2 = radians(item_ID2_lon)

    dlon = lon2 - lon1
    dlat = lat2 - lat1

    a = sin(dlat / 2)**2 + cos(lat1) * cos(lat2) * sin(dlon / 2)**2
    c = 2 * atan2(sqrt(a), sqrt(1 - a))
    distance = R * c
    return distance

def compare_distance(item_ID1_lat, item_ID1_lon, item_ID2_lat, item_ID2_lon):
    if item_ID1_lat == item_ID2_lat and item_ID1_lon == item_ID2_lon:
        return 2 # same
    elif calculate_distance(item_ID1_lat, item_ID1_lon, item_ID2_lat, item_ID2_lon) <= 5:
        return 1 # near
    else:
        return 0 # far

def calculate_jaccard(item_ID1, item_ID2):
    set1 = set(word_tokenize(item_ID1))
    set2 = set(word_tokenize(item_ID2))
    union = len(set1 | set2)
    if not union:
        return 0

    inter = len(set1 & set2)
    return inter / (union)

def compare_tfidf(item_ID1, item_ID2):
    vector_1 = vectorizer.transform(item_ID1)
    vector_2 = vectorizer.transform(item_ID2)
    return cosine_similarity(vector_1, vector_2)[0][0]

def compare_word2vec(item_ID1, item_ID2):
    item_ID1 = [x for x in word_tokenize(item_ID1) if x in word2vec_model.wv.vocab]
    item_ID2 = [x for x in word_tokenize(item_ID2) if x in word2vec_model.wv.vocab]
    if not item_ID1 or not item_ID2:
```

```python
        return 0, 0
    else:
        vector_1 = np.sum(word2vec_model.wv[item_ID1], axis=0) / len(item_ID1)
        vector_2 = np.sum(word2vec_model.wv[item_ID2], axis=0) / len(item_ID2)
        cos_sim = cosine_similarity(vector_1.reshape(1, -1), vector_2.reshape(1, -1))[0
][0]
        dist_mag = np.dot(vector_1, vector_2)
        return cos_sim, dist_mag

def compare_doc2vec(item_ID1, item_ID2):
    item_ID1 = [x for x in word_tokenize(item_ID1) if x in doc2vec_model.wv.vocab]
    item_ID2 = [x for x in word_tokenize(item_ID2) if x in doc2vec_model.wv.vocab]
    if not item_ID1 or not item_ID2:
        return 0
    else:
        return doc2vec_model.wv.n_similarity(item_ID1, item_ID2)
```

In [34]:

```python
features_list = []
for i in tqdm_notebook(range(len(item_ID1_list))):
    item_ID1 = item_ID1_list[i]
    item_ID2 = item_ID2_list[i]

    categoryID = compare_ID(item_ID1['categoryID'], item_ID2['categoryID'])
    parentCategoryID = compare_ID(item_ID1['parentCategoryID'], item_ID2['parentCategor
yID'])
    locationID = compare_ID(item_ID1['locationID'], item_ID2['locationID'])
    regionID = compare_ID(item_ID1['regionID'], item_ID2['regionID'])
    metroID = compare_ID(item_ID1['metroID'], item_ID2['metroID'])

    price = compare_price(item_ID1['price'], item_ID2['price'])
    price_ratio = calculate_price_ratio(item_ID1['price'], item_ID2['price'])
    price_diff = abs(item_ID1['price'] - item_ID2['price'])

    distance = compare_distance(item_ID1['lat'], item_ID1['lon'], item_ID2['lat'], item
_ID2['lon'])
    distance_abs = calculate_distance(item_ID1['lat'], item_ID1['lon'], item_ID2['lat'
], item_ID2['lon'])

    title_1_clen = len(item_ID1['title'])
    description_1_clen = len(item_ID1['description'])
    attrsJSON_1_clen = len(item_ID1['attrsJSON'])

    title_2_clen = len(item_ID2['title'])
    description_2_clen = len(item_ID2['description'])
    attrsJSON_2_clen = len(item_ID2['attrsJSON'])

    title_1_wlen = len(word_tokenize(item_ID1['title']))
    description_1_wlen = len(word_tokenize(item_ID1['description']))
    attrsJSON_1_wlen = len(word_tokenize(item_ID1['attrsJSON']))

    title_2_wlen = len(word_tokenize(item_ID2['title']))
    description_2_wlen = len(word_tokenize(item_ID2['description']))
    attrsJSON_2_wlen = len(word_tokenize(item_ID2['attrsJSON']))

    title_jaccard = calculate_jaccard(item_ID1['title'], item_ID2['title'])
    description_jaccard = calculate_jaccard(item_ID1['description'], item_ID2['descript
ion'])
    attrsJSON_jaccard = calculate_jaccard(item_ID1['attrsJSON'], item_ID2['attrsJSON'])

    title_edit_distance = editdistance.eval(item_ID1['title'], item_ID2['title'])
    description_edit_distance = editdistance.eval(item_ID1['description'], item_ID2['de
scription'])
    attrsJSON_edit_distance = editdistance.eval(item_ID1['attrsJSON'], item_ID2['attrsJ
SON'])

#     title_tfidf = compare_tfidf([item_ID1['title']], [item_ID2['title']])
#     description_tfidf = compare_tfidf([item_ID1['description']], [item_ID2['descripti
on']])
#     attrsJSON_tfidf = compare_tfidf([item_ID1['attrsJSON']], [item_ID2['attrsJSON']])

    title_word2vec_cs, title_word2vec_dist = compare_word2vec(item_ID1['title'], item_I
D2['title'])
    description_word2vec_cs, description_word2vec_dist = compare_word2vec(item_ID1['des
cription'], item_ID2['description'])
    attrsJSON_word2vec_cs, attrsJSON_word2vec_dist = compare_word2vec(item_ID1['attrsJS
ON'], item_ID2['attrsJSON'])
```

```
    title_doc2vec= compare_doc2vec(item_ID1['title'], item_ID2['title'])
    description_doc2vec= compare_doc2vec(item_ID1['description'], item_ID2['descriptio
n'])
    attrsJSON_doc2vec= compare_doc2vec(item_ID1['attrsJSON'], item_ID2['attrsJSON'])

    features_list.append([item_ID1['categoryID'], item_ID2['categoryID'], categoryID,
                         item_ID1['parentCategoryID'], item_ID2['parentCategoryID'], p
arentCategoryID,
                         item_ID1['locationID'], item_ID2['locationID'], locationID,
                         item_ID1['regionID'], item_ID2['regionID'], regionID,
                         item_ID1['metroID'], item_ID2['metroID'], metroID,
                         item_ID1['price'], item_ID2['price'], price, price_ratio, pri
ce_diff,
                         item_ID1['lat'], item_ID1['lon'], item_ID2['lat'], item_ID2[
'lon'], distance, distance_abs,
                         title_1_clen, description_1_clen, attrsJSON_1_clen,
                         title_2_clen, description_2_clen, attrsJSON_2_clen,
                         title_1_wlen, description_1_wlen, attrsJSON_1_wlen,
                         title_2_wlen, description_2_wlen, attrsJSON_2_wlen,
                         title_jaccard, description_jaccard, attrsJSON_jaccard,
                         title_edit_distance, description_edit_distance, attrsJSON_edi
t_distance,
#                        title_tfidf, description_tfidf, attrsJSON_tfidf,
                         title_word2vec_cs, description_word2vec_cs, attrsJSON_word2ve
c_cs,
                         title_word2vec_dist, description_word2vec_dist, attrsJSON_wor
d2vec_dist,
                         title_doc2vec, description_doc2vec, attrsJSON_doc2vec])
```

Features matrix

Convert features into numpy matrix

In [35]:

```
X_matrix = np.array(features_list)
y_matrix = item_pairs['isDuplicate'].values
# y_matrix = y_matrix[:10000]
```

Save features matrix into npy

In [36]:

```
np.save('X.npy', X_matrix)
np.save('y.npy', y_matrix)
```

Model Training

In [37]:

```
train_mask = np.random.rand(len(X_matrix[training_mask])) > 0.2
val_mask = ~train_mask
```

SVC

In [38]:

```
# clf = SVC()
# clf.fit(X_matrix[training_mask], y_matrix[training_mask])
```

In [39]:

```
# dump(clf, 'svc_model')
# # clf = load('svc_model')
```

In [40]:

```
# y_pred = clf.predict(X_matrix[test_mask])
```

In [41]:

```
# score = roc_auc_score(y_matrix[test_mask], y_pred)
# print('AUC: {}'.format(score))
```

XGBoost

In [42]:

```
xgb_pars = {
    'eta': 0.05,
    'gamma': 0.07,
    'max_depth': 8,
    'min_child_weight': 1,
    'max_delta_step': 0,
    'subsample': 0.86,
    'colsample_bytree': 0.55,
    'colsample_bylevel': 1,
    'lambda': 1,
    'alpha': 0,
    'objective': 'binary:logistic',
    'eval_metric': 'auc',
    'nthread': 12,
    'seed': 20,
    'silent': 1
}
```

In [43]:

```python
dtrain = xgb.DMatrix((X_matrix[training_mask])[train_mask], label=(y_matrix[training_ma
sk])[train_mask])
dval = xgb.DMatrix((X_matrix[training_mask])[val_mask], label=(y_matrix[training_mask])
[val_mask])

num_boost_round = 2500
watchlist = [(dtrain, 'train'), (dval, 'val')]
evals_result = {}

model = xgb.train(xgb_pars, dtrain, num_boost_round=num_boost_round, verbose_eval=1,
                  evals=watchlist, evals_result=evals_result)
```

```
[0]     train-auc:0.768682      val-auc:0.766962
[1]     train-auc:0.80124       val-auc:0.799846
[2]     train-auc:0.813517      val-auc:0.81202
[3]     train-auc:0.817642      val-auc:0.816505
[4]     train-auc:0.8199        val-auc:0.818662
[5]     train-auc:0.820426      val-auc:0.819181
[6]     train-auc:0.819949      val-auc:0.818608
[7]     train-auc:0.82107       val-auc:0.819706
[8]     train-auc:0.822643      val-auc:0.821266
[9]     train-auc:0.824267      val-auc:0.822818
[10]    train-auc:0.824745      val-auc:0.823222
[11]    train-auc:0.825972      val-auc:0.824358
[12]    train-auc:0.826372      val-auc:0.824838
[13]    train-auc:0.827889      val-auc:0.826368
[14]    train-auc:0.828698      val-auc:0.827109
[15]    train-auc:0.829428      val-auc:0.827869
[16]    train-auc:0.830197      val-auc:0.828624
[17]    train-auc:0.831134      val-auc:0.829611
[18]    train-auc:0.831542      val-auc:0.830016
[19]    train-auc:0.832705      val-auc:0.831176
[20]    train-auc:0.833513      val-auc:0.83198
[21]    train-auc:0.834061      val-auc:0.832521
[22]    train-auc:0.834372      val-auc:0.832847
[23]    train-auc:0.835097      val-auc:0.833555
[24]    train-auc:0.835777      val-auc:0.834266
[25]    train-auc:0.836296      val-auc:0.834784
[26]    train-auc:0.836646      val-auc:0.835135
[27]    train-auc:0.837619      val-auc:0.836067
[28]    train-auc:0.838194      val-auc:0.836619
[29]    train-auc:0.839193      val-auc:0.837629
[30]    train-auc:0.839746      val-auc:0.838154
[31]    train-auc:0.840368      val-auc:0.838734
[32]    train-auc:0.840847      val-auc:0.83922
[33]    train-auc:0.841405      val-auc:0.839759
[34]    train-auc:0.841939      val-auc:0.840251
[35]    train-auc:0.842566      val-auc:0.84087
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[1035]   train-auc:0.915986      val-auc:0.903432
[1036]   train-auc:0.91599       val-auc:0.903436
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[1097]    train-auc:0.917205       val-auc:0.904184
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[2306]    train-auc:0.935875        val-auc:0.91431
[2307]    train-auc:0.935885        val-auc:0.914316
[2308]    train-auc:0.935898        val-auc:0.914321
[2309]    train-auc:0.935912        val-auc:0.914324
[2310]    train-auc:0.935922        val-auc:0.914326
[2311]    train-auc:0.93595         val-auc:0.914341
[2312]    train-auc:0.935959        val-auc:0.914344
[2313]    train-auc:0.935973        val-auc:0.914352
[2314]    train-auc:0.935986        val-auc:0.914356
[2315]    train-auc:0.93599         val-auc:0.914357
[2316]    train-auc:0.936011        val-auc:0.914368
[2317]    train-auc:0.93602         val-auc:0.914373
```

```
[2318]    train-auc:0.936027        val-auc:0.914374
[2319]    train-auc:0.93603         val-auc:0.914375
[2320]    train-auc:0.936052        val-auc:0.914386
[2321]    train-auc:0.936068        val-auc:0.914393
[2322]    train-auc:0.936075        val-auc:0.914394
[2323]    train-auc:0.936084        val-auc:0.914397
[2324]    train-auc:0.936106        val-auc:0.91441
[2325]    train-auc:0.936111        val-auc:0.914412
[2326]    train-auc:0.936121        val-auc:0.914412
[2327]    train-auc:0.936129        val-auc:0.914411
[2328]    train-auc:0.936153        val-auc:0.914428
[2329]    train-auc:0.936176        val-auc:0.914444
[2330]    train-auc:0.936199        val-auc:0.914458
[2331]    train-auc:0.936217        val-auc:0.914464
[2332]    train-auc:0.936234        val-auc:0.914472
[2333]    train-auc:0.936246        val-auc:0.914476
[2334]    train-auc:0.936252        val-auc:0.914476
[2335]    train-auc:0.93626         val-auc:0.914479
[2336]    train-auc:0.936264        val-auc:0.914482
[2337]    train-auc:0.936285        val-auc:0.914494
[2338]    train-auc:0.936301        val-auc:0.9145
[2339]    train-auc:0.936311        val-auc:0.914504
[2340]    train-auc:0.936328        val-auc:0.914513
[2341]    train-auc:0.936337        val-auc:0.914514
[2342]    train-auc:0.936347        val-auc:0.914514
[2343]    train-auc:0.936359        val-auc:0.914521
[2344]    train-auc:0.936371        val-auc:0.914527
[2345]    train-auc:0.936387        val-auc:0.914529
[2346]    train-auc:0.936399        val-auc:0.914531
[2347]    train-auc:0.93641         val-auc:0.914536
[2348]    train-auc:0.936432        val-auc:0.914556
[2349]    train-auc:0.936442        val-auc:0.91456
[2350]    train-auc:0.936457        val-auc:0.914567
[2351]    train-auc:0.936469        val-auc:0.914572
[2352]    train-auc:0.936474        val-auc:0.914573
[2353]    train-auc:0.936483        val-auc:0.914576
[2354]    train-auc:0.936485        val-auc:0.914577
[2355]    train-auc:0.936493        val-auc:0.914577
[2356]    train-auc:0.936508        val-auc:0.914586
[2357]    train-auc:0.936515        val-auc:0.914586
[2358]    train-auc:0.93653         val-auc:0.914591
[2359]    train-auc:0.936539        val-auc:0.914591
[2360]    train-auc:0.936557        val-auc:0.914598
[2361]    train-auc:0.936572        val-auc:0.914603
[2362]    train-auc:0.936582        val-auc:0.914604
[2363]    train-auc:0.936599        val-auc:0.914618
[2364]    train-auc:0.936616        val-auc:0.914626
[2365]    train-auc:0.936629        val-auc:0.914631
[2366]    train-auc:0.936638        val-auc:0.914632
[2367]    train-auc:0.93666         val-auc:0.914646
[2368]    train-auc:0.936667        val-auc:0.914648
[2369]    train-auc:0.936679        val-auc:0.914655
[2370]    train-auc:0.936698        val-auc:0.914661
[2371]    train-auc:0.936716        val-auc:0.914672
[2372]    train-auc:0.936718        val-auc:0.914673
[2373]    train-auc:0.936739        val-auc:0.914684
[2374]    train-auc:0.936749        val-auc:0.914689
[2375]    train-auc:0.93676         val-auc:0.914695
[2376]    train-auc:0.936763        val-auc:0.914696
[2377]    train-auc:0.936772        val-auc:0.914699
[2378]    train-auc:0.936789        val-auc:0.914707
```

```
[2379]    train-auc:0.936811         val-auc:0.914717
[2380]    train-auc:0.936819         val-auc:0.914719
[2381]    train-auc:0.936828         val-auc:0.914723
[2382]    train-auc:0.936849         val-auc:0.914731
[2383]    train-auc:0.936857         val-auc:0.914734
[2384]    train-auc:0.936859         val-auc:0.914735
[2385]    train-auc:0.936871         val-auc:0.914741
[2386]    train-auc:0.936889         val-auc:0.91475
[2387]    train-auc:0.936896         val-auc:0.914753
[2388]    train-auc:0.936913         val-auc:0.914759
[2389]    train-auc:0.93693          val-auc:0.914772
[2390]    train-auc:0.936938         val-auc:0.914774
[2391]    train-auc:0.936943         val-auc:0.914775
[2392]    train-auc:0.936948         val-auc:0.914776
[2393]    train-auc:0.936971         val-auc:0.914791
[2394]    train-auc:0.936987         val-auc:0.9148
[2395]    train-auc:0.93701          val-auc:0.914814
[2396]    train-auc:0.937022         val-auc:0.91482
[2397]    train-auc:0.93703          val-auc:0.914821
[2398]    train-auc:0.937042         val-auc:0.914823
[2399]    train-auc:0.937048         val-auc:0.914824
[2400]    train-auc:0.937061         val-auc:0.914831
[2401]    train-auc:0.937071         val-auc:0.914833
[2402]    train-auc:0.937095         val-auc:0.914849
[2403]    train-auc:0.937112         val-auc:0.914852
[2404]    train-auc:0.937129         val-auc:0.914861
[2405]    train-auc:0.937144         val-auc:0.914869
[2406]    train-auc:0.937157         val-auc:0.914877
[2407]    train-auc:0.937179         val-auc:0.914896
[2408]    train-auc:0.937203         val-auc:0.914908
[2409]    train-auc:0.937218         val-auc:0.914917
[2410]    train-auc:0.937233         val-auc:0.914925
[2411]    train-auc:0.937244         val-auc:0.914927
[2412]    train-auc:0.937256         val-auc:0.914932
[2413]    train-auc:0.937263         val-auc:0.914935
[2414]    train-auc:0.937273         val-auc:0.914937
[2415]    train-auc:0.937286         val-auc:0.914942
[2416]    train-auc:0.937287         val-auc:0.914942
[2417]    train-auc:0.93731          val-auc:0.914953
[2418]    train-auc:0.937319         val-auc:0.914957
[2419]    train-auc:0.937338         val-auc:0.914961
[2420]    train-auc:0.93735          val-auc:0.914964
[2421]    train-auc:0.937355         val-auc:0.914965
[2422]    train-auc:0.937363         val-auc:0.914969
[2423]    train-auc:0.937377         val-auc:0.914974
[2424]    train-auc:0.937385         val-auc:0.914978
[2425]    train-auc:0.937398         val-auc:0.914983
[2426]    train-auc:0.937421         val-auc:0.914995
[2427]    train-auc:0.937433         val-auc:0.914997
[2428]    train-auc:0.937458         val-auc:0.915014
[2429]    train-auc:0.937463         val-auc:0.915016
[2430]    train-auc:0.937476         val-auc:0.915019
[2431]    train-auc:0.93749          val-auc:0.915026
[2432]    train-auc:0.937511         val-auc:0.915037
[2433]    train-auc:0.937517         val-auc:0.91504
[2434]    train-auc:0.937519         val-auc:0.91504
[2435]    train-auc:0.937539         val-auc:0.91505
[2436]    train-auc:0.937552         val-auc:0.915058
[2437]    train-auc:0.937569         val-auc:0.915066
[2438]    train-auc:0.93758          val-auc:0.915068
[2439]    train-auc:0.937603         val-auc:0.915083
```

```
[2440]    train-auc:0.937618        val-auc:0.915091
[2441]    train-auc:0.937629        val-auc:0.915093
[2442]    train-auc:0.937634        val-auc:0.915097
[2443]    train-auc:0.937656        val-auc:0.915111
[2444]    train-auc:0.937672        val-auc:0.915123
[2445]    train-auc:0.937685        val-auc:0.915125
[2446]    train-auc:0.937705        val-auc:0.915138
[2447]    train-auc:0.937709        val-auc:0.91514
[2448]    train-auc:0.937731        val-auc:0.915154
[2449]    train-auc:0.937736        val-auc:0.915157
[2450]    train-auc:0.937752        val-auc:0.915163
[2451]    train-auc:0.937755        val-auc:0.915164
[2452]    train-auc:0.937764        val-auc:0.915167
[2453]    train-auc:0.937768        val-auc:0.915171
[2454]    train-auc:0.937791        val-auc:0.915188
[2455]    train-auc:0.93781         val-auc:0.915193
[2456]    train-auc:0.937822        val-auc:0.915197
[2457]    train-auc:0.937839        val-auc:0.915204
[2458]    train-auc:0.937847        val-auc:0.915208
[2459]    train-auc:0.937865        val-auc:0.915218
[2460]    train-auc:0.93787         val-auc:0.91522
[2461]    train-auc:0.937892        val-auc:0.915228
[2462]    train-auc:0.937908        val-auc:0.915235
[2463]    train-auc:0.937911        val-auc:0.915236
[2464]    train-auc:0.937914        val-auc:0.915237
[2465]    train-auc:0.937925        val-auc:0.915237
[2466]    train-auc:0.93795         val-auc:0.915252
[2467]    train-auc:0.937977        val-auc:0.91527
[2468]    train-auc:0.937988        val-auc:0.915272
[2469]    train-auc:0.937995        val-auc:0.915274
[2470]    train-auc:0.938009        val-auc:0.915281
[2471]    train-auc:0.938017        val-auc:0.915286
[2472]    train-auc:0.938021        val-auc:0.915286
[2473]    train-auc:0.938032        val-auc:0.915289
[2474]    train-auc:0.93804         val-auc:0.915293
[2475]    train-auc:0.938048        val-auc:0.915295
[2476]    train-auc:0.938061        val-auc:0.915303
[2477]    train-auc:0.938068        val-auc:0.915304
[2478]    train-auc:0.938076        val-auc:0.915307
[2479]    train-auc:0.938084        val-auc:0.915309
[2480]    train-auc:0.938094        val-auc:0.915313
[2481]    train-auc:0.938103        val-auc:0.915317
[2482]    train-auc:0.938107        val-auc:0.915318
[2483]    train-auc:0.938125        val-auc:0.915331
[2484]    train-auc:0.938129        val-auc:0.915334
[2485]    train-auc:0.938147        val-auc:0.91534
[2486]    train-auc:0.938155        val-auc:0.915345
[2487]    train-auc:0.93817         val-auc:0.915361
[2488]    train-auc:0.938192        val-auc:0.915372
[2489]    train-auc:0.938199        val-auc:0.915375
[2490]    train-auc:0.938224        val-auc:0.915391
[2491]    train-auc:0.938245        val-auc:0.915402
[2492]    train-auc:0.938252        val-auc:0.915404
[2493]    train-auc:0.938266        val-auc:0.91541
[2494]    train-auc:0.938277        val-auc:0.915414
[2495]    train-auc:0.938293        val-auc:0.915424
[2496]    train-auc:0.938301        val-auc:0.915427
[2497]    train-auc:0.938311        val-auc:0.915434
[2498]    train-auc:0.93832         val-auc:0.915439
[2499]    train-auc:0.938336        val-auc:0.915451
```

In [44]:

```python
model.save_model('xgb_model')
# model.load_model('xgb_model')
```

In [45]:

```python
dtest = xgb.DMatrix(X_matrix[test_mask], label=y_matrix[test_mask])

y_pred = model.predict(dtest)
score = roc_auc_score(y_matrix[test_mask], y_pred)
print('AUC: {}'.format(score))
```

AUC: 0.9156127787539696

Insights

In [46]:

```python
plt.figure(figsize=(20, 20))
plt.plot(np.arange(num_boost_round), evals_result['train']['auc'], color='red')
plt.plot(np.arange(num_boost_round), evals_result['val']['auc'], color='green')
plt.legend(['train', 'val'])
plt.title('XGBoost: Accuracy vs Number of Iterations')
plt.ylabel('Accuracy')
plt.xlabel('Number of Iterations')
```

Out[46]:

```
Text(0.5,0,'Number of Iterations')
```

XGBoost: Accuracy vs Number of Iterations