ДОМАШНЕЕ ЗАДАНИЕ 3. Классификация текстовых документов

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Цель работы

Приобрести опыт решения практических задач по машинному обучению, таких как анализ и визуализация исходных данных, обучение, выбор и оценка качества моделей предсказания, посредством языка программирования Python.

Вариант 3

Набор рецензий на фильмы (reviews) Файл: data/reviews.tsv

In [2]:
```
surname = "Овчинникова" # Ваша фамилия

alp = 'абвгдеёжзийклмнопрстуфхцчшщъыьэюя'
w = [4, 42, 21, 21, 34,  1, 44, 26, 18, 43, 38, 26, 18, 43,  3, 49, 45,
        7, 42, 25,  4,  9, 36, 33, 31, 29,  5, 31,  4, 19, 24, 27, 33]
d = dict(zip(alp, w))
variant =  sum([d[el] for el in surname.lower()]) % 3 + 1
print("Ваш вариант - ", variant)
```

```
Ваш вариант -  3
```

In [3]:
```
%%html
<link href="css/style.css" rel="stylesheet" type="text/css">
```

In [4]:
```
globalRS = 123
```

Задание 1. Оценка качества классификации текстовых данных (2 балла)

In [5]:
```
%load_ext autoreload
%autoreload 2
```

In [6]:
```
import numpy as np
import pandas as pd

import matplotlib.pyplot as plt
%matplotlib inline
```

In [7]:
```
from sklearn.model_selection import train_test_split

from sklearn.metrics import classification_report, confusion_matrix
```

```
import sys
sys.path.insert(0, "../lib/")

from plot_confusion_matrix import plot_confusion_matrix
```

Загрузка исходных данных

In [8]:

```
FILE_PATH = "../data/reviews.tsv"
```

In [9]:

```
# No header for reviews table
reviews_ds = pd.read_csv(FILE_PATH, sep = '\t', header = None)
```

In [10]:

```
reviews_ds
```

Out[10]:

	0	1
0	0	unless bob crane is someone of particular inte...
1	1	finds a way to tell a simple story , perhaps t...
2	0	ill-considered , unholy hokum .
3	0	nijinsky says , 'i know how to suffer' and if ...
4	1	the auteur's ear for the way fears and slights...
...	...	...
10657	0	it's mildly sentimental , unabashedly consumer...
10658	0	so verbally flatfooted and so emotionally pred...
10659	0	alternative medicine obviously has its merits ...
10660	0	a by-the-numbers patient/doctor pic that cover...
10661	0	according to the script , grant and bullock's ...

10662 rows × 2 columns

In [11]:

```
reviews_ds[0] = ["recommend" if r == 1 else "not recommend" for r in rev
reviews_ds
```

Out[11]:

	0	1
0	not recommend	unless bob crane is someone of particular inte...
1	recommend	finds a way to tell a simple story , perhaps t...
2	not recommend	ill-considered , unholy hokum .
3	not recommend	nijinsky says , 'i know how to suffer' and if ...
4	recommend	the auteur's ear for the way fears and slights...
...	...	...
10657	not recommend	it's mildly sentimental , unabashedly consumer...
10658	not recommend	so verbally flatfooted and so emotionally pred...
10659	not recommend	alternative medicine obviously has its merits ...

10660	not recommend	a by-the-numbers patient/doctor pic that cover...
10661	not recommend	according to the script , grant and bullock's ...

10662 rows × 2 columns

In [12]:

```
# Separating the positive/negative information
recomms = np.asarray(reviews_ds[0])
recomms
```

Out[12]:

```
array(['not recommend', 'recommend', 'not recommend', ...,
       'not recommend', 'not recommend', 'not recommend'], dtype=object)
```

In [13]:

```
# Separating the reviews
reviews = reviews_ds[1]
reviews = np.asarray(reviews)
reviews
```

Out[13]:

```
array(["unless bob crane is someone of particular interest to you , this 
film's impressive performances and adept direction aren't likely to leave 
a lasting impression . ",
       'finds a way to tell a simple story , perhaps the simplest story o
f all , in a way that seems compelling and even original . ',
       'ill-considered , unholy hokum . ', ...,
       'alternative medicine obviously has its merits . . . but ayurveda 
does the field no favors . ',
       'a by-the-numbers patient/doctor pic that covers all the usual gro
und',
       "according to the script , grant and bullock's characters are made 
for each other . but you'd never guess that from the performances . "],
      dtype=object)
```

Разбиение загруженных данных

In [14]:

```
# Splitting the test/train
x_train, x_test, y_train, y_test = train_test_split(reviews, recomms, te
```

Перевод текстовых данных в векторный вид.

Для этого воспользуйтесь средствами sklearn для трансформации текстовых документов в векторы TF-IDF (настроить на обучающем подмножестве, n-gram=1, слова в нижний регистр).

In [15]:

```
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer
```

In [16]:

```
count_vectorizer = CountVectorizer(analyzer = "word", ngram_range = (1,1
                                   stop_words = None, lowercase = True,
                                   binary = False, strip_accents = None)
count_vectorizer
```

Out[16]:

```
CountVectorizer()
```

In [17]:
```
train_count_v = count_vectorizer.fit_transform(x_train)
test_count_v = count_vectorizer.transform(x_test)
```

In [18]:
```
vectorizer = TfidfVectorizer(lowercase=True, stop_words=None,
                             use_idf=True, ngram_range=(1,1),
                             smooth_idf=False)
vectorizer
```

Out[18]:
```
TfidfVectorizer(smooth_idf=False)
```

In [19]:
```
tfidf_train_v = vectorizer.fit_transform(x_train)
tfidf_test_v = vectorizer.transform(x_test)
```

In [20]:
```
tfidf_train_v
```

Out[20]:
```
<8529x16494 sparse matrix of type '<class 'numpy.float64'>'
	with 143664 stored elements in Compressed Sparse Row format>
```

In [21]:
```
# Not needed for this
# tfidf_transformer = TfidfTransformer(norm=None, use_idf=True, smooth_i
# tfidf_transformer
```

Построение K-ближайших соседей ($n=5$)

In [22]:
```
from sklearn.neighbors import KNeighborsClassifier
```

In [23]:
```
knn_rev = KNeighborsClassifier(n_neighbors = 5)
knn_rev.fit(tfidf_train_v, y_train)
```

Out[23]:
```
KNeighborsClassifier()
```

Логистическая регрессия

In [24]:
```
from sklearn.linear_model import LogisticRegression
```

In [25]:
```
y_train
```

Out[25]:
```
array(['recommend', 'not recommend', 'not recommend', ..., 'recommend',
       'recommend', 'not recommend'], dtype=object)
```

In [70]:
```
# В замечании к заданию random_state = 12345
lin_rev = LogisticRegression(penalty = "l2", fit_intercept = True, max_i
                                solver = "lbfgs", random_state = 12345)
lin_rev.fit(tfidf_train_v, y_train)
```

Out[70]:
```
LogisticRegression(C=1, max_iter=500, random_state=12345)
```

Наивный Байес: модель Бернулли ($\alpha=1$)

In [27]:
```
from sklearn.naive_bayes import BernoulliNB
```

In [28]:
```
bnb_rev = BernoulliNB(alpha = 1, binarize = None)
bnb_rev.fit(train_count_v, y_train)
```

Out[28]:
```
BernoulliNB(alpha=1, binarize=None)
```

Наивный Байес: полиномиальная модель ($\alpha=1$)

In [29]:
```
from sklearn.naive_bayes import MultinomialNB
```

In [30]:
```
mnb_rev = MultinomialNB(alpha = 1)
mnb_rev.fit(tfidf_train_v, y_train)
```

Out[30]:
```
MultinomialNB(alpha=1)
```

Определение качества классификации на тестовом подмножестве

Balanced-Accuracy, R, P, F1 for KNN

In [31]:
```
from sklearn.metrics import balanced_accuracy_score
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
from sklearn.metrics import f1_score
```

In [32]:
```
y_pred = knn_rev.predict(tfidf_test_v)
knn_bal_acc = balanced_accuracy_score(y_test, y_pred)
knn_recall = recall_score(y_test, y_pred, pos_label = 'not recommend')
knn_prec = precision_score(y_test, y_pred, pos_label = 'not recommend')
knn_f1 = f1_score(y_test, y_pred, pos_label = 'not recommend')

print('Balanced-Accuracy: ', round(knn_bal_acc, 3), '\n',
      'Recall: ', round(knn_recall, 3), '\n',
      'Precision: ', round(knn_prec, 3), '\n',
      'F1 Score: ', round(knn_f1, 3), '\n')
```

```
Balanced-Accuracy:  0.726
 Recall:  0.705
 Precision:  0.735
 F1 Score:  0.72
```

Balanced-Accuracy, R, P, F1 for Logistic Regression

In [33]:
```
y_pred = lin_rev.predict(tfidf_test_v)
lin_bal_acc = balanced_accuracy_score(y_test, y_pred)
lin_recall = recall_score(y_test, y_pred, pos_label = 'not recommend')
lin_prec = precision_score(y_test, y_pred, pos_label = 'not recommend')
```

```
lin_f1 = f1_score(y_test, y_pred, pos_label = 'not recommend')

print('Balanced-Accuracy: ', round(lin_bal_acc, 3), '\n',
      'Recall: ', round(lin_recall, 3), '\n',
      'Precision: ', round(lin_prec, 3), '\n',
      'F1 Score: ', round(lin_f1, 3), '\n')
```

```
Balanced-Accuracy:  0.77
 Recall:  0.747
 Precision:  0.782
 F1 Score:  0.764
```

Balanced-Accuracy, R, P, F1 for Bernoulli Model

In [34]:

```
y_pred = bnb_rev.predict(tfidf_test_v)
bnb_bal_acc = balanced_accuracy_score(y_test, y_pred)
bnb_recall = recall_score(y_test, y_pred, pos_label = 'not recommend')
bnb_prec = precision_score(y_test, y_pred, pos_label = 'not recommend')
bnb_f1 = f1_score(y_test, y_pred, pos_label = 'not recommend')

print('Balanced-Accuracy: ', round(bnb_bal_acc, 3), '\n',
      'Recall: ', round(bnb_recall, 3), '\n',
      'Precision: ', round(bnb_prec, 3), '\n',
      'F1 Score: ', round(bnb_f1, 3), '\n')
```

```
Balanced-Accuracy:  0.771
 Recall:  0.836
 Precision:  0.739
 F1 Score:  0.784
```

Balanced-Accuracy, R, P, F1 for Multinomial Model

In [35]:

```
y_pred = lin_rev.predict(tfidf_test_v)
mnb_bal_acc = balanced_accuracy_score(y_test, y_pred)
mnb_recall = recall_score(y_test, y_pred, pos_label = 'not recommend')
mnb_prec = precision_score(y_test, y_pred, pos_label = 'not recommend')
mnb_f1 = f1_score(y_test, y_pred, pos_label = 'not recommend')

print('Balanced-Accuracy: ', round(mnb_bal_acc, 3), '\n',
      'Recall: ', round(mnb_recall, 3), '\n',
      'Precision: ', round(mnb_prec, 3), '\n',
      'F1 Score: ', round(mnb_f1, 3), '\n')
```

```
Balanced-Accuracy:  0.77
 Recall:  0.747
 Precision:  0.782
 F1 Score:  0.764
```

Определение времени обучения и предсказания

In [36]:

```
knn_train_time = %timeit -qo knn_rev.fit(tfidf_train_v, y_train)
print('KNN Train:', '\n', f" t = {knn_train_time.average}s")

knn_predict_time = %timeit -qo knn_rev.predict(tfidf_test_v)
print('KNN Predict:', '\n', f" t = {knn_predict_time.average}s")
```

```
KNN Train:
  t = 0.006508213571428639s
KNN Predict:
  t = 0.6754368571428456s
```

In [37]:

```
knn_train_time = %timeit -qo  knn_rev.fit(tfidf_train_v, y_train)
print('KNN Train:', '\n', f" t = {knn_train_time.average}s")

knn_predict_time = %timeit -qo knn_rev.predict(tfidf_test_v)
print('KNN Predict:', '\n', f" t = {knn_predict_time.average}s")
```

```
KNN Train:
  t = 0.006838332428571415s
KNN Predict:
  t = 0.6736828142857202s
```

In [38]:

```
lr_train_time = %timeit -qo  lin_rev.fit(tfidf_train_v, y_train)
print('LR Train:', '\n', f" t = {lr_train_time.average}s")

lr_predict_time = %timeit -qo lin_rev.predict(tfidf_test_v)
print('LR Predict:', '\n', f" t = {lr_predict_time.average}s")
```

```
LR Train:
  t = 0.10821485428571447s
LR Predict:
  t = 0.00016051872857141398s
```

In [39]:

```
bnb_train_time = %timeit -qo  bnb_rev.fit(tfidf_train_v, y_train)
print('KNN Train:', '\n', f" t = {bnb_train_time.average}s")

bnb_predict_time = %timeit -qo bnb_rev.predict(tfidf_test_v)
print('KNN Predict:', '\n', f" t = {bnb_predict_time.average}s")
```

```
KNN Train:
  t = 0.017761605428571393s
KNN Predict:
  t = 0.0008880559428571522s
```

In [40]:

```
mnb_train_time = %timeit -qo  mnb_rev.fit(tfidf_train_v, y_train)
print('KNN Train:', '\n', f" t = {mnb_train_time.average}s")

mnb_predict_time = %timeit -qo mnb_rev.predict(tfidf_test_v)
print('KNN Predict:', '\n', f" t = {mnb_predict_time.average}s")
```

```
KNN Train:
  t = 0.01759262385714286s
KNN Predict:
  t = 0.0004005205142857l234s
```

Значения в датафрейме

In [41]:

```
metrics = [
            (knn_bal_acc, knn_recall, knn_prec, knn_f1, knn_train_time, k
            (lin_bal_acc, lin_recall, lin_prec, lin_f1, lr_train_time, l
            (bnb_bal_acc, bnb_recall, bnb_prec, bnb_f1, bnb_train_time, b
            (mnb_bal_acc, mnb_recall, mnb_prec, mnb_f1, mnb_train_time, m
          ]

models = ['KNN', 'Logistic Regression', 'Bernoulli', 'Multinomial Bernoul
```

```
metr_names = ['Balanced Accuracy', 'Recall', 'Precision', 'F1 Score', 'T

df = pd.DataFrame.from_records(metrics, columns = metr_names, index = mo
df
```

Out[41]:

	Balanced Accuracy	Recall	Precision	F1 Score	Train time	Predict time
KNN	0.725710	0.705164	0.734834	0.719693	6.84 ms ± 220 µs per loop (mean ± std. dev. of...	674 ms ± 38.9 ms per loop (mean ± std. dev. of...
Logistic Regression	0.769776	0.747418	0.781925	0.764282	108 ms ± 7.81 ms per loop (mean ± std. dev. of...	161 µs ± 14.2 µs per loop (mean ± std. dev. of...
Bernoulli	0.770837	0.835681	0.739203	0.784487	17.8 ms ± 728 µs per loop (mean ± std. dev. of...	888 µs ± 38 µs per loop (mean ± std. dev. of 7...
Multinomial Bernulli	0.769776	0.747418	0.781925	0.764282	17.6 ms ± 381 µs per loop (mean ± std. dev. of...	401 µs ± 26.4 µs per loop (mean ± std. dev. of...

Задание 2. Оценка качества классификации текстовых данных посредством кросс-валидации (2 балла)

Повторите решение первого задания с использованием стратифицированной кросс-валидации k-folds (k=4) для разделения исходных данных

In [42]:

```
# Random_state is needed for shuffle option, left it out
from sklearn.model_selection import StratifiedKFold
kf = StratifiedKFold(n_splits = 4)
```

In [43]:

```
def kf_mod(model_name, X = reviews, y = recomms,
                trans_type = 'tfidf', _pos_label = 'not recommend'):

    _accs = []
    _precs = []
    _recalls = []
    _f1s = []
    _train_times = []
    _predict_times = []

    for i_train, i_test in kf.split(X, y):

        x_train = [X[i] for i in i_train]
        x_test = [X[i] for i in i_test]

        y_train = [y[i] for i in i_train]
        y_test = [y[i] for i in i_test]

        if trans_type == 'tfidf':
            v_train = vectorizer.fit_transform(x_train)
            v_test = vectorizer.transform(x_test)
        else :
            v_train = count_vectorizer.fit_transform(x_train)
```

```
            v_test  = count_vectorizer.transform(x_test)

        model_name.fit(v_train, y_train)

        # Measuring the quality by Balanced-Accuracy, R, P, F1

        y_pred = model_name.predict(v_test)
        k_acc = balanced_accuracy_score(y_test, y_pred)
        k_rec = recall_score(y_test, y_pred, pos_label = _pos_label)
        k_prec = precision_score(y_test, y_pred, pos_label = _pos_label)
        k_f1 = f1_score(y_test, y_pred, pos_label = _pos_label)

        # Calculating the time

        ttk = %timeit -qo model_name.fit(v_train, y_train)
        ptk = %timeit -qo model_name.predict(v_test)

        ttk = ttk.average
        ptk = ptk.average

        # Filling up the lists to find the average + finding the average
        _accs.append(k_acc)
        _recalls.append(k_rec)
        _precs.append(k_prec)
        _f1s.append(k_f1)
        _train_times.append(ttk)
        _predict_times.append(ptk)

        acc = sum(_accs) / len(_accs)
        rec = sum(_recalls) / len(_recalls)
        prec = sum(_precs) / len(_precs)
        f1 = sum(_f1s) / len(_f1s)
        tt = sum(_train_times) / len(_train_times)
        pt = sum(_predict_times) / len(_predict_times)


    print('For', model_name, ':', '\n')
    print('Balanced Accuracy: ', round(acc, 4) )
    print('Recall: ', round(rec, 4) )
    print('Precision: ', round(prec, 4) )
    print('F1: ', round(f1, 4) )
    print('TT: ', round(tt, 4) )
    print('PT: ', round(pt, 4) )
```

In [44]:

```
# Previously added classifications' names: count_vectorizer vectorizer k
kf_mod(knn_rev)
```

```
For KNeighborsClassifier() :

Balanced Accuracy:  0.7091
Recall:  0.6909
Precision:  0.7171
F1:  0.7036
TT:  0.0048
PT:  0.8007
```

In [45]:

```
kf_mod(lin_rev)
```

```
For LogisticRegression(C=1, random_state=12345) :
```

```
Balanced Accuracy:  0.7591
Recall:  0.7515
Precision:  0.7631
F1:  0.7572
TT:  0.1196
PT:  0.0002
```

In [46]:

```
kf_mod(bnb_rev)
```

```
For BernoulliNB(alpha=1, binarize=None) :

Balanced Accuracy:  0.7775
Recall:  0.7892
Precision:  0.7713
F1:  0.7801
TT:  0.0105
PT:  0.001
```

In [47]:

```
kf_mod(mnb_rev)
```

```
For MultinomialNB(alpha=1) :

Balanced Accuracy:  0.7776
Recall:  0.788
Precision:  0.772
F1:  0.7799
TT:  0.0105
PT:  0.0005
```

Задание 3. Выбор модели (4 баллов)

In [48]:

```
from sklearn.model_selection import StratifiedKFold
```

In [49]:

```
recomms_bl = [1 if r == "recommend" else 0 for r in recomms]
recomms_bl
```

Out[49]:

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In [50]:

```
y = recomms_bl
X
```

Out[50]:

```
array(["unless bob crane is someone of particular interest to you , this film's impressive performances and adept direction aren't likely to leave a lasting impression . ",
       'finds a way to tell a simple story , perhaps the simplest story of all , in a way that seems compelling and even original . ',
       'ill-considered , unholy hokum . ', ...,
       'alternative medicine obviously has its merits . . . but ayurveda does the field no favors . ',
       'a by-the-numbers patient/doctor pic that covers all the usual ground',
       "according to the script , grant and bullock's characters are made for each other . but you'd never guess that from the performances . "],
      dtype=object)
```

In [51]:

```
X_train, X_test, y_train, y_test = train_test_split(reviews, recomms_bl,
```

In [52]:

```
y = np.array(y)
```

Разбиение обучающего подмножества (train) посредством стратифицированной кросс-валидации с kfolds

In [53]:
```
skf = StratifiedKFold(n_splits = 4)

splits = skf.split(X_train, y_train)
i = 0
for train_index, test_index in splits:
    print("Split", i + 1)
    print("\tindices:\t{}{}".format(train_index, test_index))
    print("\ty:\t\t{}{}".format(y[train_index], y[test_index]))
    i += 1
```

```
Split 1
        indices:        [2122 2125 2126 ... 8526 8527 8528][   0    1
2 ... 2143 2144 2145]
        y:              [0 0 0 ... 0 1 1][0 1 0 ... 0 1 0]
Split 2
        indices:        [   0    1    2 ... 8526 8527 8528][2122 2125 212
6 ... 4262 4264 4265]
        y:              [0 1 0 ... 0 1 1][0 0 0 ... 0 1 1]
Split 3
        indices:        [   0    1    2 ... 8526 8527 8528][4263 4266 426
7 ... 6408 6413 6415]
        y:              [0 1 0 ... 0 1 1][1 0 1 ... 0 0 1]
Split 4
        indices:        [   0    1    2 ... 6408 6413 6415][6374 6377 638
0 ... 8526 8527 8528]
        y:              [0 1 0 ... 0 0 1][1 0 0 ... 0 1 1]
```

Обучение и тестирование на разбитом обучающем подмножестве классификаторов с заданными параметрами

In [54]:
```
# количество соседей: np.arange(1, 150, 20), параметр регуляризации: np.
# сглаживающий параметр: np.logspace(-4, 1, 8, base=10)
```

In [79]:
```
nbr = np.arange(1, 150, 20)
regul = np.logspace(-2, 10, 8, base = 10)
par = np.logspace(-4, 1, 8, base=10)
```

In [55]:
```
from sklearn.model_selection import GridSearchCV
from sklearn.pipeline import Pipeline
from sklearn.metrics import mean_squared_error
```

In [56]:
```
def calc_knn ():
    knn_mod = KNeighborsClassifier()
    nbr = np.arange(1, 150, 20)
    pipeline = Pipeline([
        ("TfIDF", vectorizer),
        ("knn_model", knn_mod)
    ])

    parameters = {
        "knn_model__n_neighbors": nbr
    }

# Training parameters

    grid_class_parameters = {
```

```
        "estimator": pipeline,
        "param_grid": parameters,
        "cv": skf
    }

# Training
    grid_search = GridSearchCV(**grid_class_parameters)
    grid_search.fit(X_train, y_train)

    return grid_search

# # Средние проверочные ошибки для каждой степени
# mses_avg = np.abs(grid_search.cv_results_["mean_test_score"])

# for indx, mse_avg in enumerate(mses_avg):
#     print("{}) Test MSE for degree {}: {}".format(indx+1, nbr[indx], m

# print("Best parameters:", grid_search.best_params_["knn_model__n_neigh

# # Предсказания для тестового множества
# y_test__pred = grid_search.predict(X_test)

# pipeline.get_params().keys()

# mse_test = mean_squared_error(y_test, y_test__pred)

# print("Test MSE:", mse_test)


# Plotting

# df = pd.DataFrame(grid_search.cv_results_)
# df = df[['mean_fit_time', 'mean_score_time', 'mean_test_score', 'rank_
```

In [67]:

```
def calc_LR():
    regul = np.logspace(-2, 10, 8, base = 10)
    pipeline = Pipeline([
        ("TfIDF", vectorizer),
        ("linear_model", lin_rev)
    ])

# pipeline.get_params().keys()

    parameters = {
        "linear_model__C": regul
    }

# Training parameters

    grid_class_parameters = {
        "estimator": pipeline,
        "param_grid": parameters,
        "cv": skf
    }

    # Training
    grid_search = GridSearchCV(**grid_class_parameters)
    grid_search.fit(X_train, y_train)
    return grid_search
```

In [66]:

```python
def calc_bnb():

    bnb_mod = BernoulliNB(binarize = None)

    par = np.logspace(-4, 1, 8, base=10)

    pipeline = Pipeline([
        ("TfIDF", count_vectorizer),
        ("bernoulli_model", bnb_mod)
    ])

    pipeline.get_params().keys()

    parameters = {
        "bernoulli_model__alpha": par
    }

    # Training parameters

    grid_class_parameters = {
        "estimator": pipeline,
        "param_grid": parameters,
        "cv": skf
    }

    # Training
    grid_search = GridSearchCV(**grid_class_parameters)
    grid_search.fit(X_train, y_train)

    return grid_search
```

In [68]:

```python
def calc_mnb():

    mnb_reg = MultinomialNB()

    par = np.logspace(-4, 1, 8, base=10)

    pipeline = Pipeline([
        ("TfIDF", count_vectorizer),
        ("multinomial_model", mnb_reg)
    ])

    pipeline.get_params().keys()

    parameters = {
        "multinomial_model__alpha": par
    }

    # Training parameters

    grid_class_parameters = {
        "estimator": pipeline,
        "param_grid": parameters,
        "cv": skf
    }

    # Training
    grid_search = GridSearchCV(**grid_class_parameters)
    grid_search.fit(X_train, y_train)

    return grid_search
```

In [71]:

```
gs_knn11 = calc_knn()
gs_LR11 = calc_LR()
gs_bnb11 = calc_bnb()
gs_mnb11 = calc_mnb()
```

In [72]:

```
vectorizer = TfidfVectorizer(lowercase=True, stop_words=None,
                             use_idf=True, ngram_range=(2, 2),
                             smooth_idf=False)

count_vectorizer = CountVectorizer(analyzer = "word", ngram_range = (2, 
                                   stop_words = None, lowercase = True,
                                   binary = False, strip_accents = None)
```

In [73]:

```
gs_knn22 = calc_knn()
gs_LR22 = calc_LR()
gs_bnb22 = calc_bnb()
gs_mnb22 = calc_mnb()
```

In [74]:

```
vectorizer = TfidfVectorizer(lowercase=True, stop_words=None,
                             use_idf=True, ngram_range=(1, 2),
                             smooth_idf=False)

count_vectorizer = CountVectorizer(analyzer = "word", ngram_range = (1, 
                                   stop_words = None, lowercase = True,
                                   binary = False, strip_accents = None)
```

In [75]:

```
gs_knn21 = calc_knn()
gs_LR21 = calc_LR()
gs_bnb21 = calc_bnb()
gs_mnb21 = calc_mnb()
```

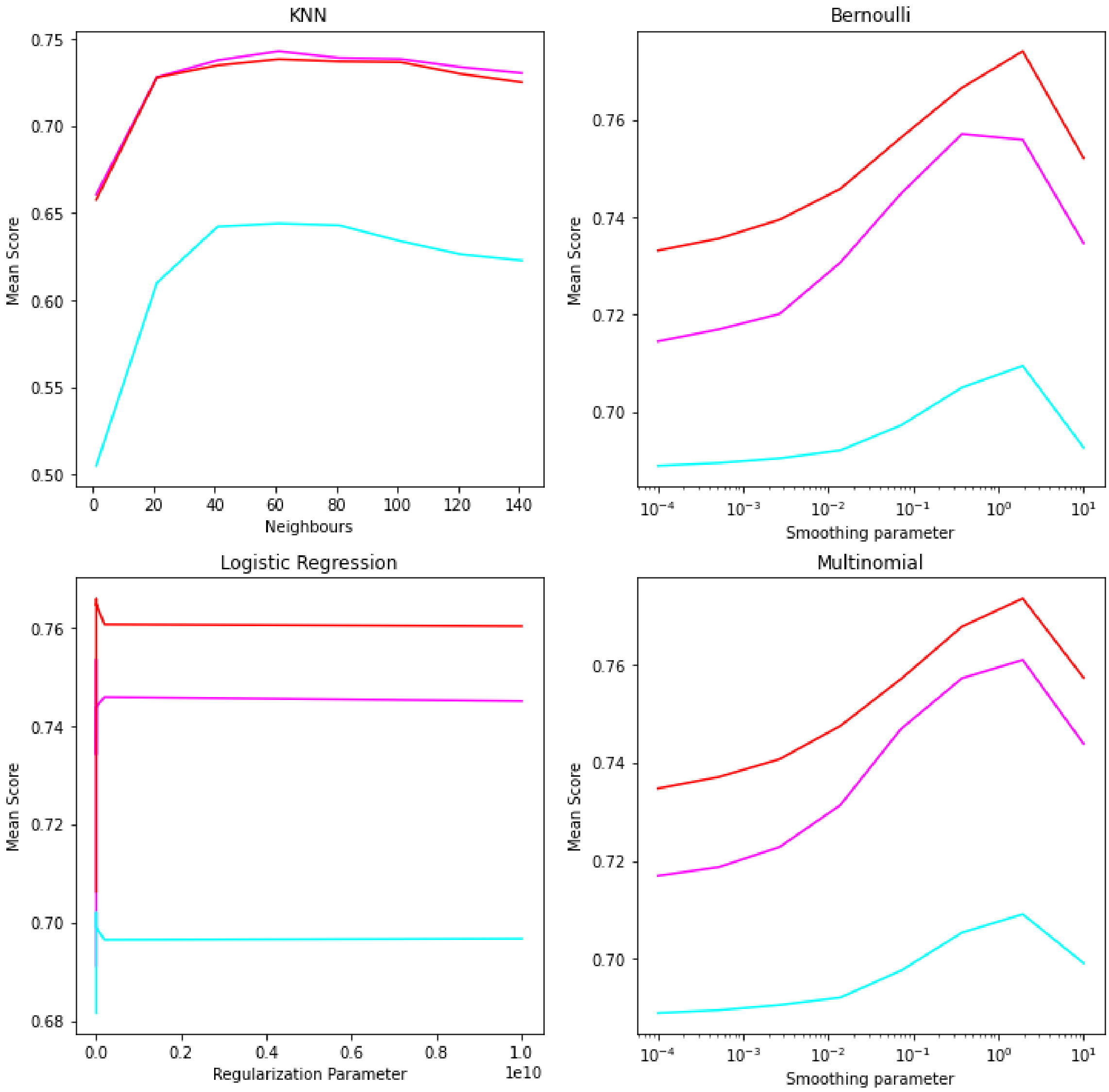
In [80]:

```
fig, axs = plt.subplots(2, 2, figsize=(12, 12))
axs[0, 0].plot(nbr, gs_knn11.cv_results_['mean_test_score'], color = 'ma
axs[0, 0].plot(nbr, gs_knn22.cv_results_['mean_test_score'], color = 'cy
axs[0, 0].plot(nbr, gs_knn21.cv_results_['mean_test_score'], color = 're
axs[0, 0].set_title("KNN")
axs[0, 0].set_ylabel("Mean Score")
axs[0, 0].set_xlabel("Neighbours")
axs[1, 0].plot(regul, gs_LR11.cv_results_['mean_test_score'], color = 'm
axs[1, 0].plot(regul, gs_LR22.cv_results_['mean_test_score'], color = 'c
axs[1, 0].plot(regul, gs_LR21.cv_results_['mean_test_score'], color = 'r
axs[1, 0].set_title("Logistic Regression")
axs[1, 0].set_ylabel("Mean Score")
axs[1, 0].set_xlabel("Regularization Parameter")
axs[0, 1].plot(par, gs_bnb11.cv_results_['mean_test_score'], color = 'ma
axs[0, 1].plot(par, gs_bnb22.cv_results_['mean_test_score'], color = 'cy
axs[0, 1].plot(par, gs_bnb21.cv_results_['mean_test_score'], color = 're
axs[0, 1].set_title("Bernoulli")
axs[0, 1].set_xscale('log')
axs[0, 1].set_ylabel("Mean Score")
axs[0, 1].set_xlabel("Smoothing parameter")
axs[1, 1].plot(par, gs_mnb11.cv_results_['mean_test_score'], color = 'ma
axs[1, 1].plot(par, gs_mnb22.cv_results_['mean_test_score'], color = 'cy
axs[1, 1].plot(par, gs_mnb21.cv_results_['mean_test_score'], color = 're
```

```
axs[1, 1].set_title("Multinomial")
axs[1, 1].set_ylabel("Mean Score")
axs[1, 1].set_xscale('log')
axs[1, 1].set_xlabel("Smoothing parameter")
```

Out[80]:

```
Text(0.5, 0, 'Smoothing parameter')
```



In [81]:

```
gs_knn11.cv_results_
```

Out[81]:

```
{'mean_fit_time': array([0.14092314, 0.15630054, 0.15113807, 0.13778365,
0.13850081,
        0.12571788, 0.12579292, 0.14908761]),
 'std_fit_time': array([0.01106385, 0.01097965, 0.01610229, 0.0096376 ,
0.01271927,
        0.00019997, 0.00042198, 0.00768678]),
 'mean_score_time': array([0.50466782, 0.6182189 , 0.60546911, 0.6024438
1, 0.61122805,
        0.59639007, 0.62803197, 0.67901742]),
 'std_score_time': array([0.01762967, 0.01495541, 0.00436012, 0.01809376,
0.0269524 ,
        0.01164257, 0.0331433 , 0.01310923]),
 'param_knn_model__n_neighbors': masked_array(data=[1, 21, 41, 61, 81, 10
1, 121, 141],
              mask=[False, False, False, False, False, False, False, Fals
e],
        fill_value='?',
```

```
            dtype=object),
 'params': [{'knn_model__n_neighbors': 1},
  {'knn_model__n_neighbors': 21},
  {'knn_model__n_neighbors': 41},
  {'knn_model__n_neighbors': 61},
  {'knn_model__n_neighbors': 81},
  {'knn_model__n_neighbors': 101},
  {'knn_model__n_neighbors': 121},
  {'knn_model__n_neighbors': 141}],
 'split0_test_score': array([0.6511955 , 0.72480075, 0.73323957, 0.746835
44, 0.75058603,
        0.75246132, 0.73933427, 0.74496015]),
 'split1_test_score': array([0.64915572, 0.72138837, 0.72185741, 0.724671
67, 0.72091932,
        0.72091932, 0.71013133, 0.71247655]),
 'split2_test_score': array([0.66275797, 0.72701689, 0.73874296, 0.735459
66, 0.73076923,
        0.73405253, 0.73217636, 0.72232645]),
 'split3_test_score': array([0.67964353, 0.73874296, 0.75703565, 0.764540
34, 0.75375235,
        0.74624765, 0.7532833 , 0.74155722]),
 'mean_test_score': array([0.66068818, 0.72798724, 0.7377189 , 0.7428767
8, 0.73900673,
        0.73842021, 0.73373132, 0.73033009]),
 'std_test_score': array([0.01211092, 0.00652545, 0.01270666, 0.01475992,
0.0136613 ,
        0.01208076, 0.01559688, 0.01344335]),
 'rank_test_score': array([8, 7, 4, 1, 2, 3, 5, 6])}
```

In [153…

```
# Training time counter by best ranking test score

gs_knn11_tt = float(gs_knn11.cv_results_['mean_fit_time'][np.where(gs_kn
gs_knn22_tt = float(gs_knn22.cv_results_['mean_fit_time'][np.where(gs_kn
gs_knn21_tt = float(gs_knn21.cv_results_['mean_fit_time'][np.where(gs_kn

gs_LR11_tt = float(gs_LR11.cv_results_['mean_fit_time'][np.where(gs_LR11
gs_LR22_tt = float(gs_LR22.cv_results_['mean_fit_time'][np.where(gs_LR22
gs_LR21_tt = float(gs_LR21.cv_results_['mean_fit_time'][np.where(gs_LR21

gs_bnb11_tt = float(gs_bnb11.cv_results_['mean_fit_time'][np.where(gs_bn
gs_bnb22_tt = float(gs_bnb22.cv_results_['mean_fit_time'][np.where(gs_bn
gs_bnb21_tt = float(gs_bnb21.cv_results_['mean_fit_time'][np.where(gs_bn

gs_mnb11_tt = float(gs_mnb11.cv_results_['mean_fit_time'][np.where(gs_mn
gs_mnb22_tt = float(gs_mnb22.cv_results_['mean_fit_time'][np.where(gs_kn
gs_mnb21_tt = float(gs_mnb21.cv_results_['mean_fit_time'][np.where(gs_kn
```

In [154…

```
# Predict time counter on test

gs_knn11_pt = %timeit -qo gs_knn11.best_estimator_.predict(x_test)
gs_knn22_pt = %timeit -qo gs_knn22.best_estimator_.predict(x_test)
gs_knn21_pt = %timeit -qo gs_knn21.best_estimator_.predict(x_test)

gs_LR11_pt = %timeit -qo gs_LR11.best_estimator_.predict(x_test)
gs_LR22_pt = %timeit -qo gs_LR22.best_estimator_.predict(x_test)
gs_LR21_pt = %timeit -qo gs_LR21.best_estimator_.predict(x_test)

gs_bnb11_pt = %timeit -qo gs_bnb11.best_estimator_.predict(x_test)
gs_bnb22_pt = %timeit -qo gs_bnb22.best_estimator_.predict(x_test)
gs_bnb21_pt = %timeit -qo gs_bnb21.best_estimator_.predict(x_test)
```

```
gs_mnb11_pt = %timeit -qo gs_mnb11.best_estimator_.predict(x_test)
gs_mnb22_pt = %timeit -qo gs_mnb22.best_estimator_.predict(x_test)
gs_mnb21_pt = %timeit -qo gs_mnb21.best_estimator_.predict(x_test)
```

In [155…

```
# Best parameter

gs_knn11_best_par = int(nbr[np.where(gs_knn11.cv_results_['rank_test_sco
gs_knn22_best_par = int(nbr[np.where(gs_knn22.cv_results_['rank_test_sco
gs_knn21_best_par = int(nbr[np.where(gs_knn21.cv_results_['rank_test_sco

gs_LR11_best_par = int(nbr[np.where(gs_LR11.cv_results_['rank_test_score
gs_LR22_best_par = int(nbr[np.where(gs_LR22.cv_results_['rank_test_score
gs_LR21_best_par = int(nbr[np.where(gs_LR21.cv_results_['rank_test_score

gs_bnb11_best_par = int(nbr[np.where(gs_bnb11.cv_results_['rank_test_sco
gs_bnb22_best_par = int(nbr[np.where(gs_bnb22.cv_results_['rank_test_sco
gs_bnb21_best_par = int(nbr[np.where(gs_bnb21.cv_results_['rank_test_sco

gs_mnb11_best_par = int(nbr[np.where(gs_mnb11.cv_results_['rank_test_sco
gs_mnb22_best_par = int(nbr[np.where(gs_mnb22.cv_results_['rank_test_sco
gs_mnb21_best_par = int(nbr[np.where(gs_mnb21.cv_results_['rank_test_sco
```

Итоговые данные по всем методам для лучших моделей (метод, n-gram, значение параметра модели, время обучения, время предсказания)

In [156…

```
# KNN

n_grams_1 = "1, 1"
n_grams_2 = "2, 2"
n_grams_3 = "2, 1"
knn_metrics = [
            ('KNN', n_grams_1, gs_knn11_best_par, gs_knn11_tt, gs_kn
            ('KNN', n_grams_2, gs_knn22_best_par, gs_knn21_tt, gs_kn
            ('KNN', n_grams_3, gs_knn21_best_par, gs_knn21_tt, gs_kn

            ('Logistic Regression', n_grams_1, gs_LR11_best_par, gs_
            ('Logistic Regression', n_grams_2, gs_LR22_best_par, gs_
            ('Logistic Regression', n_grams_3, gs_LR21_best_par, gs_

            ('Bernoulli', n_grams_1, gs_bnb11_best_par, gs_bnb11_tt,
            ('Bernoulli', n_grams_2, gs_bnb22_best_par, gs_bnb21_tt,
            ('Bernoulli', n_grams_3, gs_bnb21_best_par, gs_bnb21_tt,

            ('Multinomial Bernulli', n_grams_1, gs_mnb11_best_par, g
            ('Multinomial Bernulli', n_grams_2, gs_mnb22_best_par, g
            ('Multinomial Bernulli', n_grams_3, gs_mnb21_best_par, g
          ]

metrics_labels = ["Model", "N Grams", "Parameter", "Train time", "Predic

df_f = pd.DataFrame.from_records(knn_metrics, columns = metrics_labels)
df_f
```

Out[156…

	Model	N Grams	Parameter	Train time	Predict time
0	KNN	1, 1	61	0.137784	721 ms ± 23.1 ms per loop (mean ± std. dev. of...

1	KNN	2, 2	61	0.376497	518 ms ± 12.2 ms per loop (mean ± std. dev. of...
2	KNN	2, 1	61	0.376497	761 ms ± 36 ms per loop (mean ± std. dev. of 7...
3	Logistic Regression	1, 1	41	0.500010	32.9 ms ± 1.17 ms per loop (mean ± std. dev. o...
4	Logistic Regression	2, 2	41	3.272012	48.1 ms ± 2.44 ms per loop (mean ± std. dev. o...
5	Logistic Regression	2, 1	61	3.272012	71.1 ms ± 2.52 ms per loop (mean ± std. dev. o...
6	Bernoulli	1, 1	101	0.128411	35.1 ms ± 2.18 ms per loop (mean ± std. dev. o...
7	Bernoulli	2, 2	121	0.373268	58.4 ms ± 2.77 ms per loop (mean ± std. dev. o...
8	Bernoulli	2, 1	121	0.373268	73.1 ms ± 4.81 ms per loop (mean ± std. dev. o...
9	Multinomial Bernulli	1, 1	121	0.126564	37.9 ms ± 3.43 ms per loop (mean ± std. dev. o...
10	Multinomial Bernulli	2, 2	121	0.390185	60.8 ms ± 7.83 ms per loop (mean ± std. dev. o...
11	Multinomial Bernulli	2, 1	121	0.390185	71.5 ms ± 4.46 ms per loop (mean ± std. dev. o...

Задание 4. Оценка влияния количества признаков FeatureHasher на качество классификации (2 баллов)

Как будет меняться качество классификации для обозначенных ранее методов при использовании FeatureHasher (или HashingVectorizer) из пакета sklearn перед TF-IDF преобразованием?

Количество признаков: np.logspace(1, 5, 5, base=10)

In [157…

```
feats = np.logspace(1, 5, 5, base = 10)
```

In [159…

```
from sklearn.feature_extraction.text import HashingVectorizer

hash_v = HashingVectorizer(norm=None, alternate_sign = False,
                                    lowercase = True, stop_words = None,
                                    ngram_range=(1, 1))
```

In [183…

```
def calc_knn_hv():
    knn_mod = KNeighborsClassifier()
    pipeline = Pipeline([
        ("hash_v", hash_v),
        ("TfIDF", TfidfTransformer(use_idf=True, smooth_idf=False)),
        ("knn_model", knn_mod)
    ])
```

```
    gs_knn_hv = GridSearchCV(pipeline, {"hash_v__n_features": feats.asty
    gs_knn_hv.fit(x_train, y_train)

    return gs_knn_hv
```

In [184…

```
gs_knn = calc_knn_hv()
```

```
C:\Users\blueb\anaconda3\lib\site-packages\sklearn\feature_extraction\tex
t.py:1450: RuntimeWarning: divide by zero encountered in true_divide
  idf = np.log(n_samples / df) + 1
C:\Users\blueb\anaconda3\lib\site-packages\sklearn\model_selection\_valid
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  File "C:\Users\blueb\anaconda3\lib\site-packages\sklearn\utils\metaesti
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  warnings.warn(
C:\Users\blueb\anaconda3\lib\site-packages\sklearn\model_selection\_searc
h.py:922: UserWarning: One or more of the test scores are non-finite: [0.
48938793 0.53605288 0.60687213        nan        nan]
  warnings.warn(
```

In [185…

```
knn_fit_time = gs_knn.cv_results_['mean_fit_time'][np.where(gs_knn.cv_re
knn_pred_time = %timeit -qo gs_knn.best_estimator_.predict(x_test)
knn_score = gs_knn.cv_results_['mean_test_score'][np.where(gs_knn.cv_res
```

In [173…

```
def calc_LR_hv():
    pipeline = Pipeline([
        ("hash_v", hash_v),
        ("TfIDF", TfidfTransformer(use_idf=True, smooth_idf=False)),
        ("LR_model", lin_rev)
    ])
```

```
    gs_LR_hv = GridSearchCV(pipeline, {"hash_v__n_features": feats.astyp
    gs_LR_hv.fit(x_train, y_train)

    return gs_LR_hv
```

In [186…

```
gs_LR_hv = calc_LR_hv()
```

```
C:\Users\blueb\anaconda3\lib\site-packages\sklearn\feature_extraction\tex
t.py:1450: RuntimeWarning: divide by zero encountered in true_divide
  idf = np.log(n_samples / df) + 1
C:\Users\blueb\anaconda3\lib\site-packages\sklearn\model_selection\_valid
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  File "C:\Users\blueb\anaconda3\lib\site-packages\sklearn\metrics\_scorer.py", line 397, in _passthrough_scorer
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C:\Users\blueb\anaconda3\lib\site-packages\sklearn\model_selection\_search.py:922: UserWarning: One or more of the test scores are non-finite: [0.51565176 0.58447609 0.66725242        nan        nan]
  warnings.warn(
```

In [187…

```
LR_fit_time = gs_LR_hv.cv_results_['mean_fit_time'][np.where(gs_LR_hv.cv_
LR_pred_time = %timeit -qo gs_LR_hv.best_estimator_.predict(x_test)
LR_score = gs_LR_hv.cv_results_['mean_test_score'][np.where(gs_LR_hv.cv_
```

In [175…

```
def calc_bnb_hv():
    bnb_mod = BernoulliNB(binarize = None)

    pipeline = Pipeline([
        ("hash_v", hash_v),
```

```
        ("TfIDF", TfidfTransformer(use_idf=True, smooth_idf=False)),
        ("Bernoulli_model", bnb_mod)
    ])

    gs_bnb_hv = GridSearchCV(pipeline, {"hash_v__n_features": feats.asty
    gs_bnb_hv.fit(x_train, y_train)

    return gs_bnb_hv
```

In [188…

```
gs_bnb_hv = calc_bnb_hv()
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```
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h.py:922: UserWarning: One or more of the test scores are non-finite: [0.
51635576 0.58388979 0.66279706        nan        nan]
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In [189…

```
bnb_fit_time = gs_bnb_hv.cv_results_['mean_fit_time'][np.where(gs_bnb_hv
bnb_pred_time = %timeit -qo gs_bnb_hv.best_estimator_.predict(x_test)
bnb_score = gs_bnb_hv.cv_results_['mean_test_score'][np.where(gs_bnb_hv.
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In [182…

```
def calc_mnb_hv():
```

```python
    mnb_reg = MultinomialNB()

    pipeline = Pipeline([
        ("hash_v", hash_v),
        ("TfIDF", TfidfTransformer(use_idf=True, smooth_idf=False)),
        ("Multinomial_model", mnb_reg)
    ])

    gs_mnb_hv = GridSearchCV(pipeline, {"hash_v__n_features": feats.asty
    gs_mnb_hv.fit(x_train, y_train)

    return gs_mnb_hv
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  warnings.warn(
C:\Users\blueb\anaconda3\lib\site-packages\sklearn\model_selection\_searc
h.py:922: UserWarning: One or more of the test scores are non-finite: [0.
51494885 0.58506245 0.66279706        nan        nan]
  warnings.warn(
```

In [195…

```
mnb_fit_time = gs_mnb_hv.cv_results_['mean_fit_time'][np.where(gs_mnb_hv
mnb_pred_time = %timeit -qo gs_mnb_hv.best_estimator_.predict(x_test)
mnb_score = gs_mnb_hv.cv_results_['mean_test_score'][np.where(gs_mnb_hv.
```

In [180…

```
# gs_knn.cv_results_
```

Out[180…

```
{'mean_fit_time': array([0.08442497, 0.08908737, 0.0847137 , 0.08703607,
0.09421897]),
 'std_fit_time': array([0.0102591 , 0.00630516, 0.00641797, 0.00843135,
0.00099229]),
 'mean_score_time': array([0.66319054, 0.68192399, 0.52775681, 0.0287361
7, 0.0304926 ]),
 'std_score_time': array([0.01716725, 0.04637696, 0.00688731, 0.0083437 ,
0.00676056]),
 'param_hash_v__n_features': masked_array(data=[10, 100, 1000, 10000, 100
000],
              mask=[False, False, False, False, False],
        fill_value='?',
             dtype=object),
 'params': [{'hash_v__n_features': 10},
  {'hash_v__n_features': 100},
  {'hash_v__n_features': 1000},
  {'hash_v__n_features': 10000},
  {'hash_v__n_features': 100000}],
 'split0_test_score': array([0.49976559, 0.54102203, 0.59446789,        n
an,        nan]),
 'split1_test_score': array([0.48405253, 0.53142589, 0.61116323,        n
an,        nan]),
 'split2_test_score': array([0.48874296, 0.52954972, 0.60131332,        n
an,        nan]),
 'split3_test_score': array([0.48499062, 0.54221388, 0.62054409,        n
an,        nan]),
 'mean_test_score': array([0.48938793, 0.53605288, 0.60687213,        na
n,        nan]),
 'std_test_score': array([0.00624329, 0.00562029, 0.0098755 ,        nan,
nan]),
 'rank_test_score': array([3, 2, 1, 4, 5])}
```

In [193…

```
values = [
            (knn_fit_time, knn_pred_time, knn_score),
            (LR_fit_time, LR_pred_time, LR_score),
            (bnb_fit_time, bnb_pred_time, bnb_score),
            (mnb_fit_time, mnb_pred_time, mnb_score)
         ]

metrics_labels = ["Train time", "Predict time", "Balanced Accuracy"]

models = ['KNN', 'Logistic Regression', 'Bernoulli', 'Multinomial Bernul

df_hv = pd.DataFrame.from_records(values, columns = metrics_labels, inde
df_hv
```

Out[193…

	Train time	Predict time	Balanced Accuracy
KNN	0.090330	730 ms ± 40.5 ms per loop (mean ± std. dev. of...	0.606872
Logistic Regression	0.118363	31 ms ± 1.18 ms per loop (mean ± std. dev. of ...	0.667252
Bernoulli	0.096338	31.2 ms ± 1.55 ms per loop (mean ± std. dev. o...	0.662797
Multinomial Bernulli	0.082394	29.1 ms ± 1.17 ms per loop (mean ± std. dev. o...	0.662797