recruitML

June 7, 2024

0.1 : ML

[1]:

```
!pip install diffprivlib
```

```
Requirement already satisfied: diffprivlib in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (0.6.4)
Requirement already satisfied: numpy>=1.21.6 in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (from diffprivlib)
(1.26.4)
Requirement already satisfied: scikit-learn>=0.24.2 in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (from diffprivlib)
(1.4.2)
Requirement already satisfied: scipy>=1.7.3 in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (from diffprivlib)
(1.13.0)
Requirement already satisfied: joblib>=0.16.0 in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (from diffprivlib)
(1.4.2)
Requirement already satisfied: setuptools>=49.0.0 in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (from diffprivlib)
(69.5.1)
Requirement already satisfied: threadpoolctl>=2.0.0 in
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-packages (from scikit-
learn>=0.24.2->diffprivlib) (3.5.0)
```

[2]:

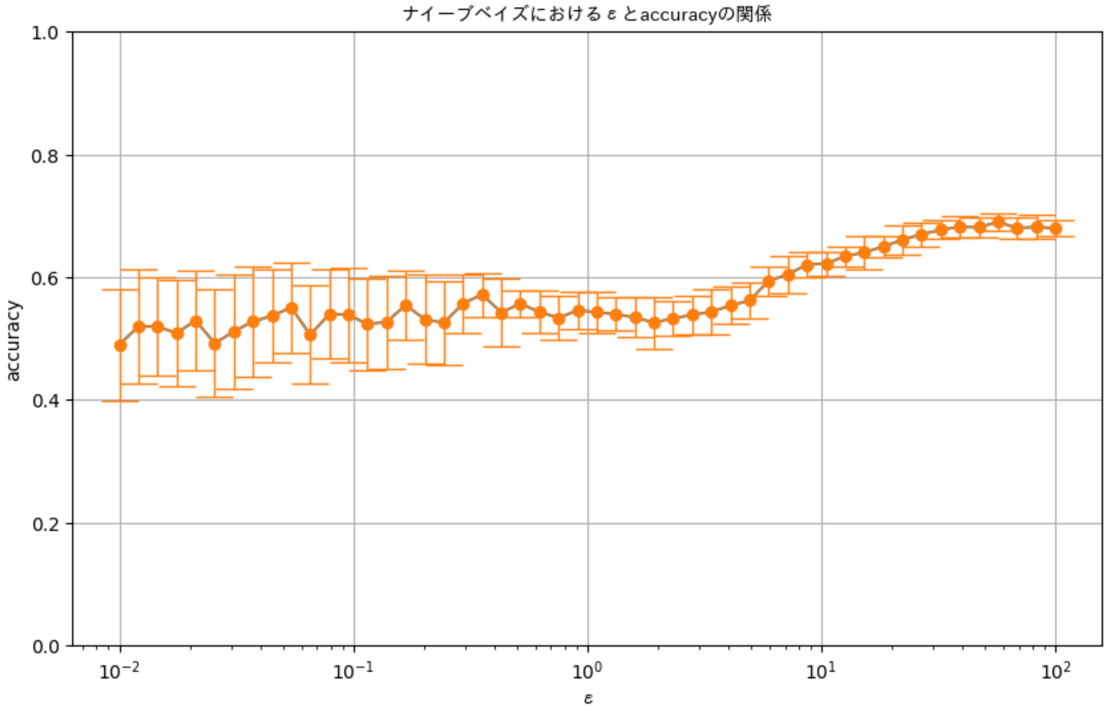
```
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB as SklearnGaussianNB
import numpy as np
import spacy
from typing import List, Tuple
import itertools
import matplotlib.pyplot as plt
from diffprivlib.models import GaussianNB as DPGaussianNB
import matplotlib.font_manager as fm

#
```

```
data_path = './data/reviews_with_sentiment.csv'
df = pd.read_csv(data_path)
font_path = '/usr/share/fonts/truetype/fonts-japanese-gothic.ttf'  #
font_prop = fm.FontProperties(fname=font_path)
# spaCy
nlp = spacy.load('ja_ginza')

#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#     BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in␣
 ↪parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:
 ↪MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF,␣
 ↪max_features=NUM_VOCAB)
bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()

#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = bow.tolist()

X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"],␣
 ↪test_size=0.2)
X_train = [list(x) for x in X_train]
X_test = [list(x) for x in X_test]

#
clf = SklearnGaussianNB()
clf.fit(X_train, y_train)
print("Non-DP accuracy: ", clf.score(X_test, y_test))

#
epsilons = np.logspace(-2, 2, 50)
dim = np.array(X_train).shape[1]
lowers = np.zeros(dim)
uppers = np.ones(dim)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for _ in range(20):
        dp_clf = DPGaussianNB(bounds=(lowers, uppers), epsilon=epsilon)
        dp_clf.fit(X_train, y_train)
        accuracy.append(dp_clf.score(X_test, y_test))
    accuracies[epsilon] = accuracy

#
x = epsilons
y = [np.mean(accuracies[eps]) for eps in epsilons]
e = [np.std(accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ', fontproperties=font_prop)
plt.ylabel('accuracy')
plt.ylim(0, 1)
plt.title('       accuracy  ', fontproperties=font_prop)
plt.grid(True)
plt.show()
```

```
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/torch/cuda/__init__.py:118: UserWarning: CUDA initialization: CUDA
```

```
unknown error - this may be due to an incorrectly set up environment, e.g.
changing env variable CUDA_VISIBLE_DEVICES after program start. Setting the
available devices to be zero. (Triggered internally at
../c10/cuda/CUDAFunctions.cpp:108.)
  return torch._C._cuda_getDeviceCount() > 0
/tmp/ipykernel_948393/3754234034.py:46: UserWarning: [W008] Evaluating
Token.similarity based on empty vectors.
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```

```
Non-DP accuracy:  0.6444644464446445
```



0.2

```
[3]: from sklearn.linear_model import LogisticRegression
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB as SklearnGaussianNB
import numpy as np
import spacy
from typing import List, Tuple
import itertools
import matplotlib.pyplot as plt
```

```
from diffprivlib.models import GaussianNB as DPGaussianNB
import matplotlib.font_manager as fm

#
data_path = './data/reviews_with_sentiment.csv'
df = pd.read_csv(data_path)
font_path = '/usr/share/fonts/truetype/fonts-japanese-gothic.ttf'  #
font_prop = fm.FontProperties(fname=font_path)
# spaCy
nlp = spacy.load('ja_ginza')

#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#    BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in␣
 ↪parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:
 ↪MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF,␣
 ↪max_features=NUM_VOCAB)
bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()
```

```
#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = bow.tolist()

X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"],␣
 ↪test_size=0.2)
X_train = [list(x) for x in X_train]
X_test = [list(x) for x in X_test]
#
clf = LogisticRegression(random_state=0).fit(X_train, y_train.to_numpy())
print("Non-DP accuracy: ", clf.score(X_test, y_test.to_numpy()))
```

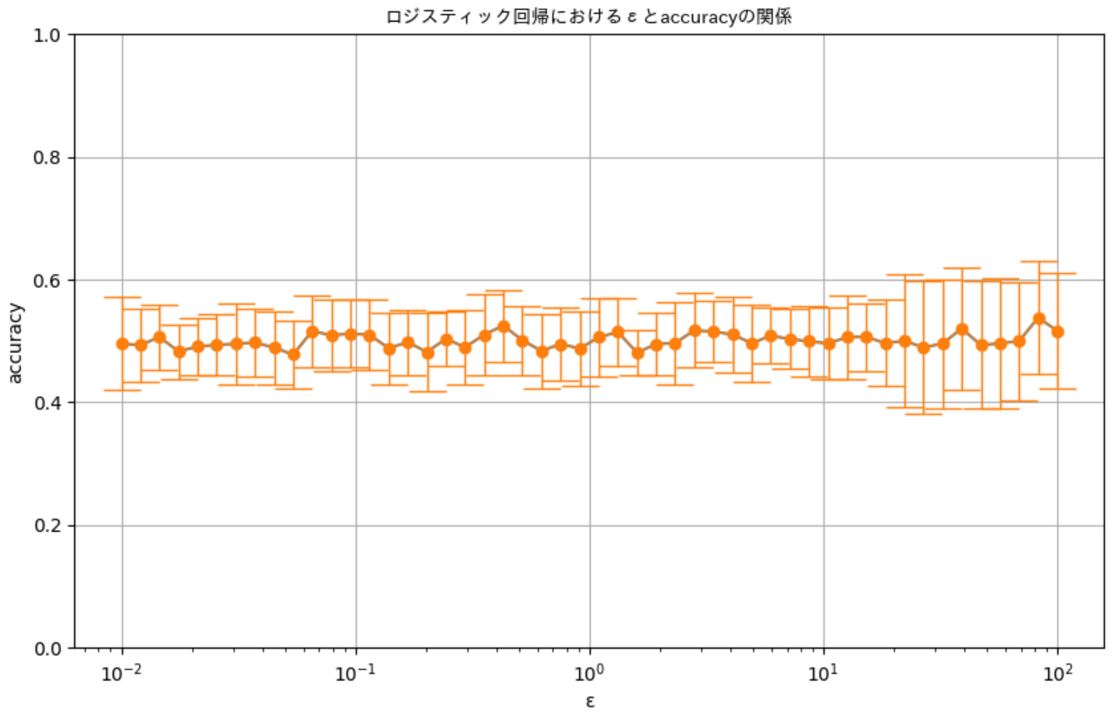
```
/tmp/ipykernel_948393/1424478305.py:47: UserWarning: [W008] Evaluating
Token.similarity based on empty vectors.
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```

```
Non-DP accuracy:  0.7155715571557155
```

[4]:

```
# from sklearn.linear_model import LogisticRegression
# clf = LogisticRegression(random_state=0).fit(X_train, y_train.to_numpy())
# print(&quot;accuracy: &quot;, clf.score(X_test, y_test.to_numpy()))
import math
import numpy as np
import matplotlib.pyplot as plt
from diffprivlib.models import LogisticRegression as DPLR

epsilons = np.logspace(-2, 2, 50)
dim = np.array(X_train).shape[1]
data_norm = math.sqrt(dim)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for i in range(20):
        clf = DPLR(data_norm=data_norm, epsilon=epsilon).fit(X_train, y_train.
 ↪to_numpy())
        accuracy.append(clf.score(X_test, y_test.to_numpy()))
    accuracies[epsilon] = accuracy

#
x = epsilons
```

```
y = [np.mean(accuracies[eps]) for eps in epsilons]
e = [np.std(accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ')
plt.ylabel('accuracy')
plt.ylim(0, 1)
plt.title('        accuracy  ', fontproperties=font_prop)
plt.grid(True)
plt.show()

# import math
# import numpy as np
# import matplotlib.pyplot as plt
# from diffprivlib.models import LogisticRegression
# epsilons = np.logspace(-2, 2, 50)
# dim = np.array(X_train).shape[1]
# data_norm = math.sqrt(dim)
# accuracies = {}
# for epsilon in epsilons:
#   accuracy = []
#   for i in range(20):
#     clf = LogisticRegression(data_norm=data_norm, epsilon=epsilon).
 ↪fit(X_train, y_train.to_numpy())
#     accuracy.append(clf.score(X_test, y_test.to_numpy()))
#   accuracies[epsilon] = accuracy
```



0.3

[3]:

```python
from sklearn.linear_model import LogisticRegression
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.naive_bayes import GaussianNB as SklearnGaussianNB
import numpy as np
import spacy
from typing import List, Tuple
import itertools
import matplotlib.pyplot as plt
from diffprivlib.models import LogisticRegression as DPLR
import matplotlib.font_manager as fm

#
data_path = './data/reviews_with_sentiment.csv'
df = pd.read_csv(data_path)
font_path = '/usr/share/fonts/truetype/fonts-japanese-gothic.ttf'  #
font_prop = fm.FontProperties(fname=font_path)

# spaCy
nlp = spacy.load('ja_ginza')
```

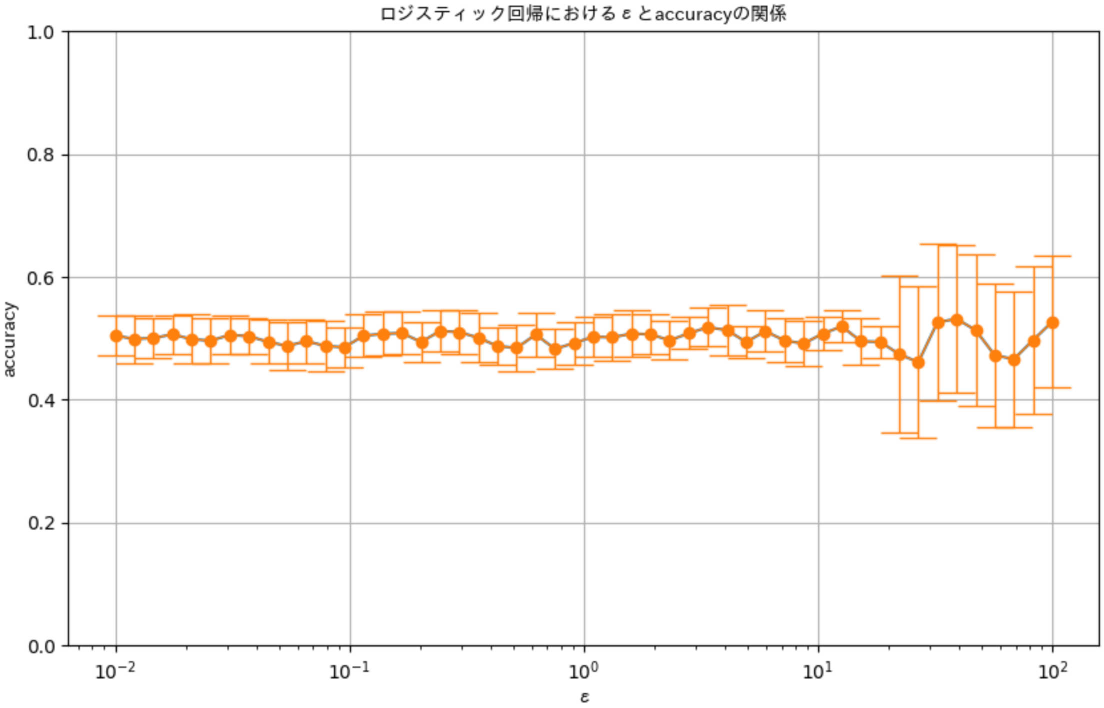
```python
#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#    BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF, max_features=NUM_VOCAB)
bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()

#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = bow.tolist()
```

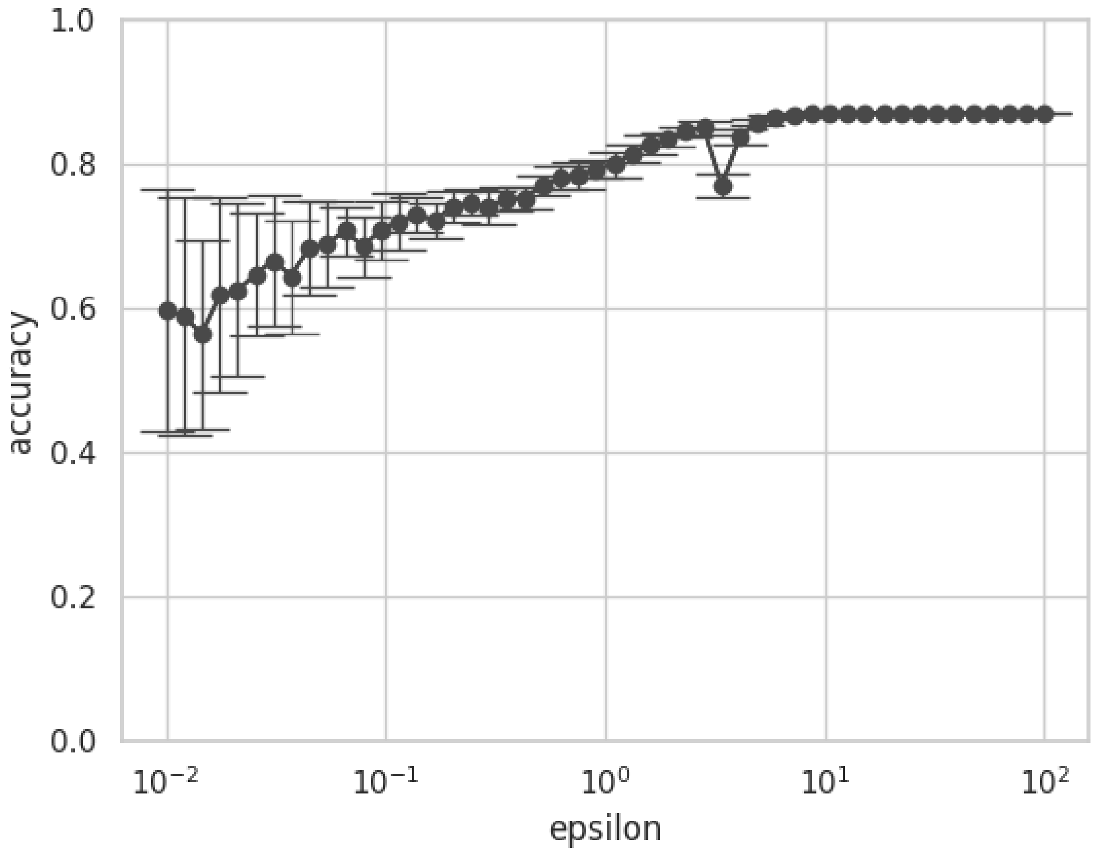
```
X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"], test_size=0.2)
X_train = np.array(X_train.tolist())
X_test = np.array(X_test.tolist())

#
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

#
clf = LogisticRegression(random_state=0).fit(X_train_scaled, y_train.to_numpy())
print("Non-DP accuracy: ", clf.score(X_test_scaled, y_test.to_numpy()))

#
import math

epsilons = np.logspace(-2, 2, 50)
dim = np.array(X_train_scaled).shape[1]
data_norm = math.sqrt(dim)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for i in range(20):
        clf = DPLR(data_norm=data_norm, epsilon=epsilon).fit(X_train_scaled, y_train.to_numpy())
        accuracy.append(clf.score(X_test_scaled, y_test.to_numpy()))
    accuracies[epsilon] = accuracy

#
x = epsilons
y = [np.mean(accuracies[eps]) for eps in epsilons]
e = [np.std(accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ', fontproperties=font_prop)
plt.ylabel('accuracy', fontproperties=font_prop)
plt.ylim(0, 1)
plt.title('        accuracy  ', fontproperties=font_prop)
plt.grid(True)
plt.show()
```

```
/tmp/ipykernel_984731/2882912114.py:49: UserWarning: [W008] Evaluating
Token.similarity based on empty vectors.
```

```
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```

```
Non-DP accuracy:  0.7020702070207021
```





0.4

[4]:

```
from sklearn.linear_model import LogisticRegression
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
import numpy as np
import spacy
from typing import List, Tuple
import itertools
import matplotlib.pyplot as plt
from diffprivlib.models import LogisticRegression as DPLR
import matplotlib.font_manager as fm

#
data_path = './data/reviews_with_sentiment.csv'
df = pd.read_csv(data_path)
font_path = '/usr/share/fonts/truetype/fonts-japanese-gothic.ttf'  #
font_prop = fm.FontProperties(fname=font_path)

# spaCy
```

```
nlp = spacy.load('ja_ginza')

#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#    BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in␣
 ↪parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:
 ↪MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF,␣
 ↪max_features=NUM_VOCAB)
bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()

#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = bow.tolist()
```

```
X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"],␣
 ↪test_size=0.2)
X_train = np.array(X_train.tolist())
X_test = np.array(X_test.tolist())

#
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

#
clf = LogisticRegression(random_state=0).fit(X_train_scaled, y_train.to_numpy())
print("Non-DP accuracy: ", clf.score(X_test_scaled, y_test.to_numpy()))

#
import math

#
epsilons = np.logspace(-2, 3, 100)
dim = np.array(X_train_scaled).shape[1]
data_norm = math.sqrt(dim)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for i in range(20):
        clf = DPLR(data_norm=data_norm, epsilon=epsilon).fit(X_train_scaled,␣
 ↪y_train.to_numpy())
        accuracy.append(clf.score(X_test_scaled, y_test.to_numpy()))
    accuracies[epsilon] = accuracy

#
x = epsilons
y = [np.mean(accuracies[eps]) for eps in epsilons]
e = [np.std(accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ', fontproperties=font_prop)
plt.ylabel('accuracy', fontproperties=font_prop)
plt.ylim(0, 1)
plt.title('        accuracy  ', fontproperties=font_prop)
plt.grid(True)
plt.show()
```

```
/tmp/ipykernel_984731/728075650.py:48: UserWarning: [W008] Evaluating
```

```
Token.similarity based on empty vectors.
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```

```
Non-DP accuracy:  0.7083708370837084
```

```
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
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```

```
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
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ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
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/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
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  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
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  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
```

```
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
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packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
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  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
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lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
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  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
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packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
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  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
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/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/diffprivlib/models/logistic_regression.py:423: ConvergenceWarning:
lbfgs failed to converge. Increase the number of iterations.
  warnings.warn("lbfgs failed to converge. Increase the number of iterations.",
ConvergenceWarning)
```
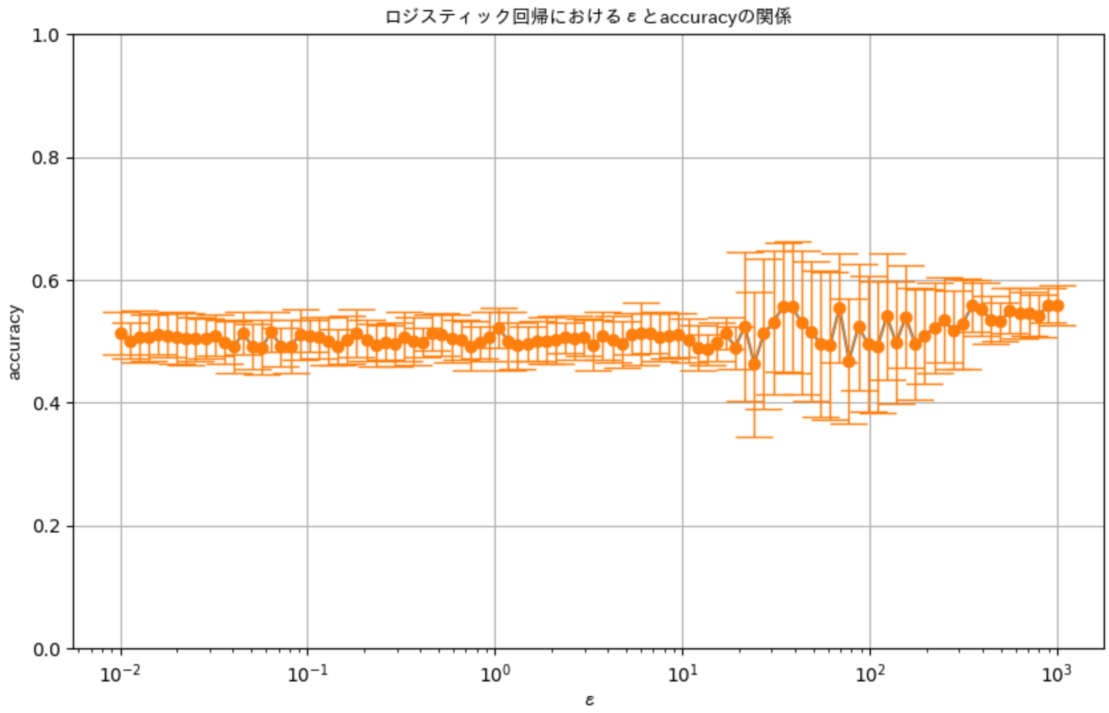



0.5 TF-IDF

[5]:

```
#
data_path = './data/reviews_with_sentiment.csv'
df = pd.read_csv(data_path)

#
print(df.isnull().sum())

#
df = df.dropna()

# spaCy
nlp = spacy.load('ja_ginza')

#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#    BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in␣
  ↪parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:
  ↪MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF,␣
  ↪max_features=NUM_VOCAB)
tfidf_bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()

#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = tfidf_bow.tolist()

#
print(df.isnull().sum())

#
df = df.dropna()

X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"],␣
  ↪test_size=0.2)
X_train = [list(x) for x in X_train]
X_test = [list(x) for x in X_test]
```

```python
#
clf = LogisticRegression(random_state=0).fit(X_train, y_train.to_numpy())
print("Non-DP accuracy: ", clf.score(X_test, y_test.to_numpy()))
```

```
review       0
sentiment    0
dtype: int64
```

```
/tmp/ipykernel_984731/346474164.py:39: UserWarning: [W008] Evaluating
Token.similarity based on empty vectors.
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```

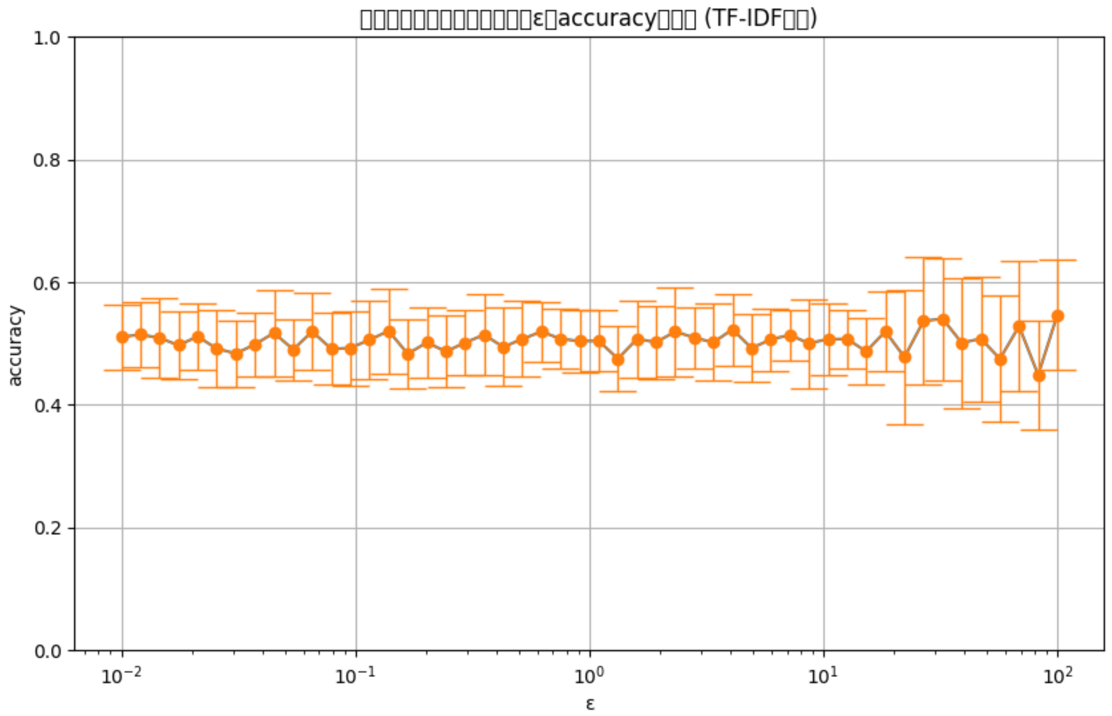
```
review       0
sentiment    0
bow          0
dtype: int64
Non-DP accuracy:  0.7155715571557155
```

[6]:

```python
import math
import numpy as np
import matplotlib.pyplot as plt
from diffprivlib.models import LogisticRegression as DPLR

epsilons = np.logspace(-2, 2, 50)
dim = np.array(X_train).shape[1]
data_norm = math.sqrt(dim)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for i in range(20):
        clf = DPLR(data_norm=data_norm, epsilon=epsilon).fit(X_train, y_train.
 ↪to_numpy())
        accuracy.append(clf.score(X_test, y_test.to_numpy()))
    accuracies[epsilon] = accuracy

#
x = epsilons
y = [np.mean(accuracies[eps]) for eps in epsilons]
e = [np.std(accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ')
plt.ylabel('accuracy')
plt.ylim(0, 1)
plt.title('        accuracy   (TF-IDF )')
plt.grid(True)
plt.show()
```

```
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12525 (\N{KATAKANA
LETTER RO}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12472 (\N{KATAKANA
LETTER ZI}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12473 (\N{KATAKANA
LETTER SU}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12486 (\N{KATAKANA
LETTER TE}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12451 (\N{KATAKANA
LETTER SMALL I}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12483 (\N{KATAKANA
LETTER SMALL TU}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12463 (\N{KATAKANA
LETTER KU}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 22238 (\N{CJK
UNIFIED IDEOGRAPH-56DE}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 24112 (\N{CJK
UNIFIED IDEOGRAPH-5E30}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12395 (\N{HIRAGANA
LETTER NI}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12362 (\N{HIRAGANA
LETTER O}) missing from current font.
```

```
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12369 (\N{HIRAGANA
LETTER KE}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12427 (\N{HIRAGANA
LETTER RU}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12392 (\N{HIRAGANA
LETTER TO}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 12398 (\N{HIRAGANA
LETTER NO}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 38306 (\N{CJK
UNIFIED IDEOGRAPH-95A2}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 20418 (\N{CJK
UNIFIED IDEOGRAPH-4FC2}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 20351 (\N{CJK
UNIFIED IDEOGRAPH-4F7F}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
/home/jun/.pyenv/versions/3.11.8/lib/python3.11/site-
packages/IPython/core/pylabtools.py:170: UserWarning: Glyph 29992 (\N{CJK
UNIFIED IDEOGRAPH-7528}) missing from current font.
  fig.canvas.print_figure(bytes_io, **kw)
```



0.6 Λ +

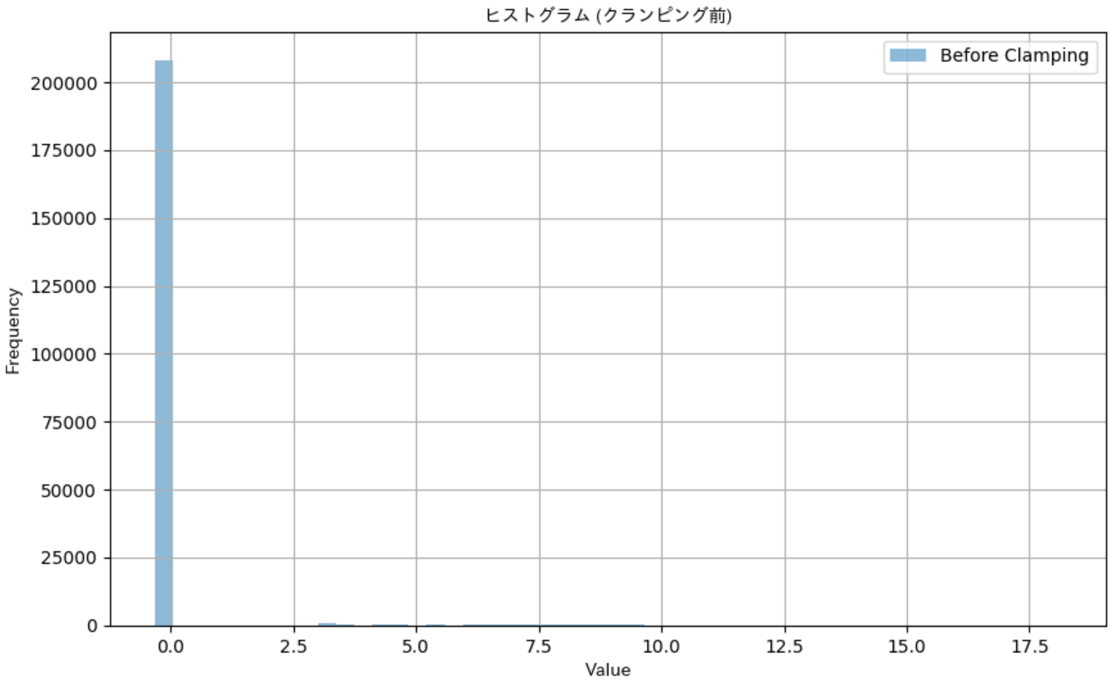
```
[7]: import math
     import numpy as np
     import pandas as pd
     import spacy
     from typing import List, Tuple
     from sklearn.linear_model import LogisticRegression as SklearnLogisticRegression
     from sklearn.model_selection import train_test_split
     from sklearn.feature_extraction.text import CountVectorizer
     from sklearn.naive_bayes import GaussianNB as SklearnGaussianNB
     from sklearn.preprocessing import StandardScaler
     import matplotlib.pyplot as plt
     from diffprivlib.models import LogisticRegression as DPLR
     import matplotlib.font_manager as fm

     #
     data_path = './data/reviews_with_sentiment.csv'
     df = pd.read_csv(data_path)
     font_path = '/usr/share/fonts/truetype/fonts-japanese-gothic.ttf'  #
     font_prop = fm.FontProperties(fname=font_path)

     # spaCy
```

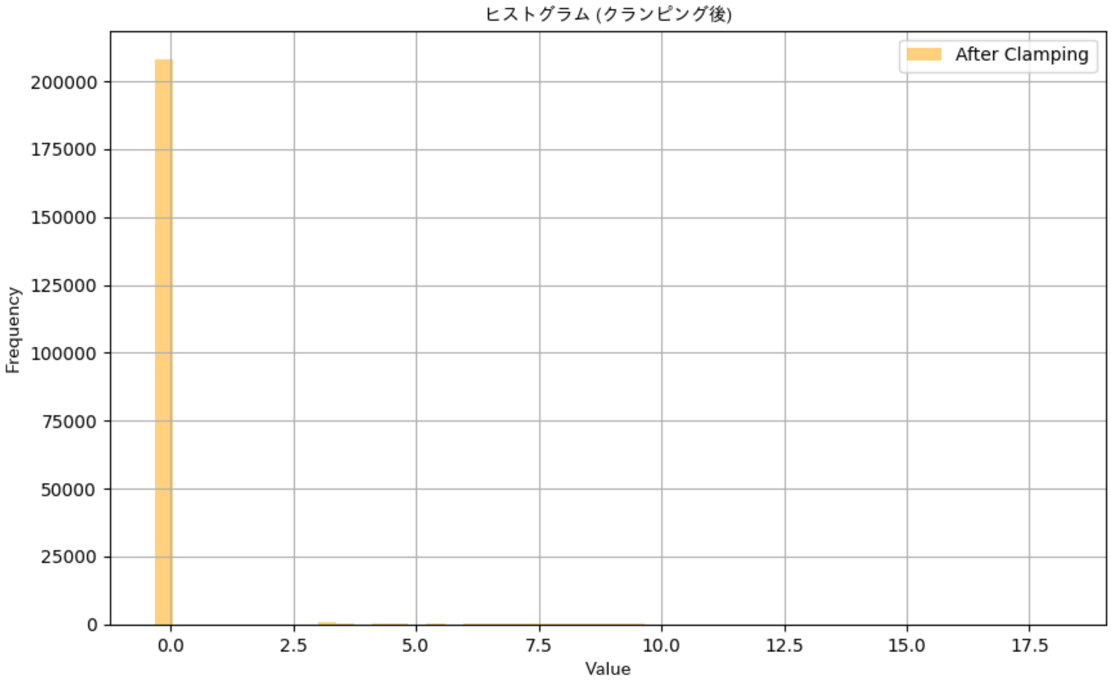
```
nlp = spacy.load('ja_ginza')

#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#    BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in␣
 ↪parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:
 ↪MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF,␣
 ↪max_features=NUM_VOCAB)
bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()

#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = bow.tolist()
```

```
X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"], test_size=0.2)
X_train = np.array(X_train.tolist())
X_test = np.array(X_test.tolist())

#
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train)
X_test_scaled = scaler.transform(X_test)

#
def clamp(data, lower, upper):
    return np.clip(data, lower, upper)

#
lower_bound = -100
upper_bound = 100

#
plt.figure(figsize=(10, 6))
plt.hist(X_train_scaled.flatten(), bins=50, alpha=0.5, label='Before Clamping')
plt.xlabel('Value', fontproperties=font_prop)
plt.ylabel('Frequency', fontproperties=font_prop)
plt.title('    (    )', fontproperties=font_prop)
plt.legend()
plt.grid(True)
plt.show()

X_train_clamped = clamp(X_train_scaled, lower_bound, upper_bound)
X_test_clamped = clamp(X_test_scaled, lower_bound, upper_bound)

#
plt.figure(figsize=(10, 6))
plt.hist(X_train_clamped.flatten(), bins=50, alpha=0.5, label='After Clamping', color='orange')
plt.xlabel('Value', fontproperties=font_prop)
plt.ylabel('Frequency', fontproperties=font_prop)
plt.title('    (    )', fontproperties=font_prop)
plt.legend()
plt.grid(True)
plt.show()

#
clf = SklearnLogisticRegression(random_state=0).fit(X_train_clamped, y_train.to_numpy())
print("Non-DP accuracy: ", clf.score(X_test_clamped, y_test.to_numpy()))
```

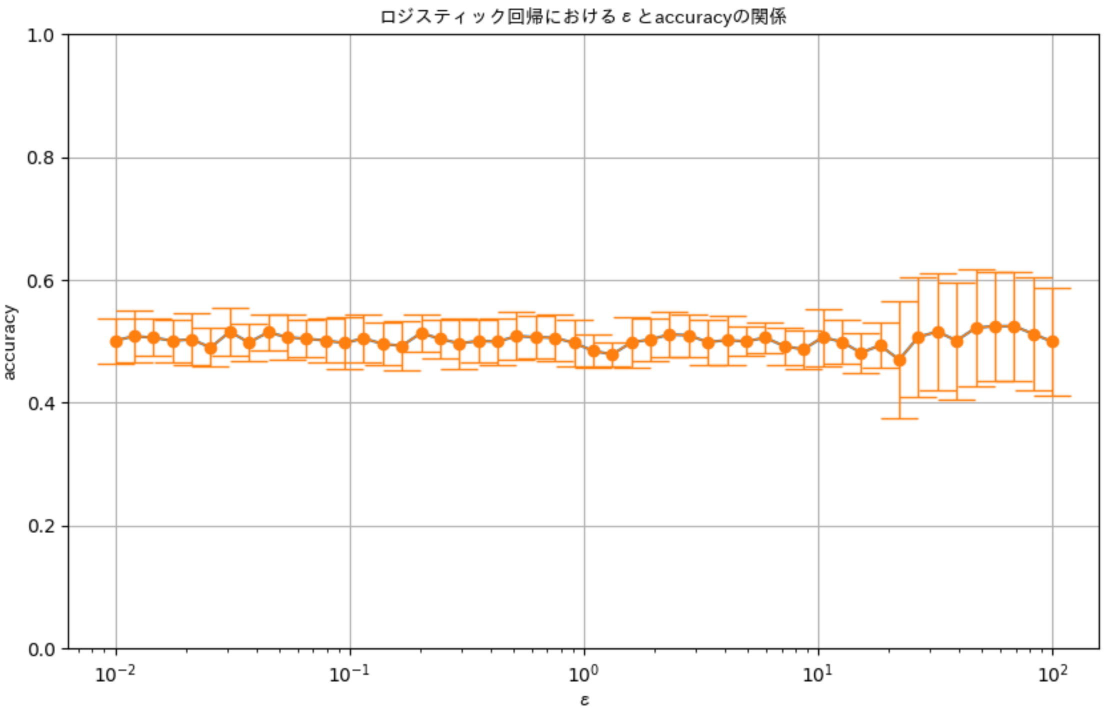
```
#
epsilons = np.logspace(-2, 2, 50)
dim = np.array(X_train_clamped).shape[1]
data_norm = math.sqrt(dim)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for i in range(20):
        clf = DPLR(data_norm=data_norm, epsilon=epsilon).fit(X_train_clamped,␣
 ↪y_train.to_numpy())
        accuracy.append(clf.score(X_test_clamped, y_test.to_numpy()))
    accuracies[epsilon] = accuracy

#
def bias_correction(accuracies, epsilons):
    corrected_accuracies = {}
    for epsilon in epsilons:
        corrected_accuracies[epsilon] = []
        for acc in accuracies[epsilon]:
            corrected_accuracies[epsilon].append(acc * (1 + (1 / epsilon)))
    return corrected_accuracies

corrected_accuracies = bias_correction(accuracies, epsilons)

#
x = epsilons
# y = [np.mean(corrected_accuracies[eps]) for eps in epsilons]
# e = [np.std(corrected_accuracies[eps]) for eps in epsilons]
y = [np.mean(accuracies[eps]) for eps in epsilons]
e = [np.std(accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ', fontproperties=font_prop)
plt.ylabel('accuracy', fontproperties=font_prop)
plt.ylim(0, 1)
plt.title('        accuracy  ', fontproperties=font_prop)
plt.grid(True)
plt.show()
```

```
/tmp/ipykernel_984731/200654788.py:49: UserWarning: [W008] Evaluating
Token.similarity based on empty vectors.
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```





```
Non-DP accuracy:  0.7065706570657065
```



0.7

[24]:

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression as SklearnLR
from diffprivlib.models import LogisticRegression as DPLR
import spacy
from typing import List, Tuple
import itertools
import math

#
data_path = './data/reviews_with_sentiment.csv'
df = pd.read_csv(data_path)

# spaCy
nlp = spacy.load('ja_ginza')

#
POS = ['ADJ', 'ADV', 'INTJ', 'PROPN', 'NOUN', 'VERB']
MAX_TERMS_IN_DOC = 5
```

```
NGRAM = 1
MAX_DF = 1.0
MIN_DF = 0.01
NUM_VOCAB = 10000

def flatten(*lists) -> list:
    res = []
    for l in list(itertools.chain.from_iterable(lists)):
        for e in l:
            res.append(e)
    return res

def remove_duplicates(l: List[Tuple[str, float]]) -> List[Tuple[str, float]]:
    d = {}
    for e in l:
        d[e[0]] = e[1]
    return list(d.items())

#    BoW
tokens = []
for doc in df["review"]:
    parsed_doc = nlp(doc)
    similarities = [(token.similarity(parsed_doc), token.lemma_) for token in␣
 ↪parsed_doc if token.pos_ in POS]
    similarities = remove_duplicates(similarities)
    similarities = sorted(similarities, key=lambda sim: sim[1], reverse=True)[:
 ↪MAX_TERMS_IN_DOC]
    tokens.append([similarity[1] for similarity in similarities])

cv = CountVectorizer(ngram_range=(1, NGRAM), max_df=MAX_DF, min_df=MIN_DF,␣
 ↪max_features=NUM_VOCAB)
bow = cv.fit_transform([" ".join(ts) for ts in tokens]).toarray()

#
m = {
    "positive": 1,
    "neutral": 0,
    "negative": 0,
}
df["sentiment"] = df["sentiment"].map(m)
df["bow"] = bow.tolist()
df
```

```
/tmp/ipykernel_984731/1391980650.py:45: UserWarning: [W008] Evaluating
Token.similarity based on empty vectors.
  similarities = [(token.similarity(parsed_doc), token.lemma_) for token in
parsed_doc if token.pos_ in POS]
```

[24]:

```
                                               review  sentiment  \
0                                                        0
1                                                          0
2                                                         1
3                                                      1
4                                                        1
…                                               …        …
5548                                      0
5549                                             0
5550                                     0
5551                                      0
5552                                      …          0

                                                    bow
0     [0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, …
1     [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
2     [0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, …
3     [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, …
4     [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, …
…                                                 …
5548  [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
5549  [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
5550  [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
5551  [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …
5552  [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, …

[5553 rows x 3 columns]
```

[ ]:

```
X_train, X_test, y_train, y_test = train_test_split(df["bow"], df["sentiment"],␣
 ↪test_size=0.2)
X_train = np.array(X_train.tolist())
X_test = np.array(X_test.tolist())

#
lower_bound = 0
upper_bound = 1.0
clamped_values = np.clip(X_train, lower_bound, upper_bound)

#
plt.figure(figsize=(10, 6))
plt.hist(X_train.flatten(), bins=50, alpha=0.5, label='Before Clamping')
plt.hist(clamped_values.flatten(), bins=50, alpha=0.5, label='After Clamping')
plt.legend()
plt.title('        ')
plt.xlabel('Value')
plt.ylabel('Frequency')
plt.grid(True)
plt.show()

#
clf = SklearnLR(random_state=0).fit(X_train, y_train)
print("Non-DP accuracy: ", clf.score(X_test, y_test))

#
epsilons = np.logspace(-2, 2, 50)
accuracies = {}

for epsilon in epsilons:
    accuracy = []
    for i in range(20):
        clf = DPLR(data_norm=upper_bound, epsilon=epsilon).fit(clamped_values,␣
 ↪y_train)
        accuracy.append(clf.score(X_test, y_test))
    accuracies[epsilon] = accuracy

#
def bias_correction(estimated_values, clamped_values, lower, upper):
    alpha1 = np.mean(estimated_values < lower)
    alpha2 = np.mean(estimated_values > upper)
    theta_T = np.mean(clamped_values[(estimated_values >= lower) &␣
 ↪(estimated_values <= upper)])
    corrected_estimates = -alpha1 * lower + (1 - alpha2 - alpha1) * theta_T +␣
 ↪alpha2 * upper
    return corrected_estimates

corrected_accuracies = {}
for eps in epsilons:
    estimated_values_for_eps = np.array(accuracies[eps])
    clamped_estimated_values = np.clip(estimated_values_for_eps, lower_bound,␣
 ↪upper_bound)
    corrected_accuracy = bias_correction(clamped_estimated_values,␣
 ↪clamped_values.flatten(), lower_bound, upper_bound)
    corrected_accuracies[eps] = corrected_accuracy

#
x = epsilons
y = [np.mean(corrected_accuracies[eps]) for eps in epsilons]
e = [np.std(corrected_accuracies[eps]) for eps in epsilons]

plt.figure(figsize=(10, 6))
plt.semilogx(x, y)
plt.errorbar(x, y, yerr=e, marker='o', capthick=1, capsize=10, lw=1)
plt.xlabel(' ')
plt.ylabel('accuracy')
plt.ylim(0, 1)
plt.title('        accuracy  ', fontproperties=font_prop)
plt.grid(True)
plt.show()
```