FRDS_Project

May 27, 2025

[1]:
```
!pip -q install pandas numpy scikit-learn textblob textstat tqdm

import nltk, json, os, pathlib
nltk.download('brown', quiet=True)
nltk.download('punkt', quiet=True)
nltk.download('wordnet', quiet=True)
```

```
                         175.3/175.3 kB
5.6 MB/s eta 0:00:00
                         939.4/939.4 kB
19.9 MB/s eta 0:00:00
                         2.1/2.1 MB
16.9 MB/s eta 0:00:00
```

[1]:
```
True
```

[2]:
```
kaggle_json = {"username": "YOUR_USERNAME", "key": "YOUR_API_KEY"}

home = pathlib.Path("~/.kaggle").expanduser()
home.mkdir(parents=True, exist_ok=True)
with open(home / "kaggle.json", "w") as f:
    json.dump(kaggle_json, f)
os.chmod(home / "kaggle.json", 0o600)

!kaggle datasets download -d mexwell/fake-reviews-dataset -q
!unzip -o fake-reviews-dataset.zip -d data > /dev/null
```

```
Dataset URL: https://www.kaggle.com/datasets/mexwell/fake-reviews-dataset
License(s): Attribution 4.0 International (CC BY 4.0)
```

[3]:
```
import pandas as pd, numpy as np
import matplotlib.pyplot as plt, seaborn as sns
from tqdm.notebook import tqdm
from textblob import TextBlob
import textstat, re, string, itertools

from sklearn.model_selection import train_test_split
from sklearn.metrics import (
```

```
    f1_score, confusion_matrix, ConfusionMatrixDisplay
)
from sklearn.pipeline import Pipeline
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.linear_model import LogisticRegression
from sklearn.svm import LinearSVC
from sklearn.ensemble import RandomForestClassifier

RANDOM_STATE = 42
plt.style.use("default")
```

[4]:
```
df = pd.read_csv("data/fake reviews dataset.csv")
display(df.head())
print("Shape:", df.shape, "\nClass counts:\n", df["label"].value_counts())
```

```
             category  rating label  \
0  Home_and_Kitchen_5     5.0    CG
1  Home_and_Kitchen_5     5.0    CG
2  Home_and_Kitchen_5     5.0    CG
3  Home_and_Kitchen_5     1.0    CG
4  Home_and_Kitchen_5     5.0    CG

                                               text_
0  Love this!  Well made, sturdy, and very comfor…
1  love it, a great upgrade from the original.  I…
2  This pillow saved my back. I love the look and…
3  Missing information on how to use it, but it i…
4  Very nice set. Good quality. We have had the s…
```

```
Shape: (40432, 4)
Class counts:
 label
CG    20216
OR    20216
Name: count, dtype: int64
```

[5]:
```
def clean_text(txt: str) -> str:
    if pd.isna(txt):
        return ""
    txt = txt.lower()
    txt = re.sub(r"[^\w\s]", " ", txt)
    return re.sub(r"\s+", " ", txt).strip()

df["clean_text"] = df["text_"].apply(clean_text)



df[["text_","clean_text"]].head()
```

[5]:
```
                                                text_  \
0  Love this!  Well made, sturdy, and very comfor…
1  love it, a great upgrade from the original.  I…
2  This pillow saved my back. I love the look and…
3  Missing information on how to use it, but it i…
4  Very nice set. Good quality. We have had the s…

                                          clean_text
0  love this well made sturdy and very comfortabl…
1  love it a great upgrade from the original i ve…
2  this pillow saved my back i love the look and …
3  missing information on how to use it but it is…
4  very nice set good quality we have had the set…
```

[6]:
```python
def base_features(txt: str):
    if not txt:
        return 0, 0, 0, 0
    blob = TextBlob(txt)
    sent = (blob.sentiment.polarity + 1) / 2        # 0-1
    subj = blob.sentiment.subjectivity
    read = np.clip(textstat.flesch_reading_ease(txt) / 100, 0, 1)
    leng = np.clip(len(txt.split()) / 300, 0, 1)
    return sent, subj, read, leng

tqdm.pandas(desc="Extracting features")
df[["sent", "subj", "read", "leng"]] = df["clean_text"].progress_apply(
    lambda t: pd.Series(base_features(t))
)

def tone_mismatch(row) -> int:
    star = row["rating"]          # 1-5
    tone = row["sent"]            # 0-1
    return int((star >= 4 and tone < 0.4) or (star <= 2 and tone > 0.6))

df["mismatch"] = df.apply(tone_mismatch, axis=1)


df.head()
```

```
Extracting features:   0%|          | 0/40432 [00:00<?, ?it/s]
```

[6]:
```
              category  rating label  \
0  Home_and_Kitchen_5     5.0    CG
1  Home_and_Kitchen_5     5.0    CG
2  Home_and_Kitchen_5     5.0    CG
3  Home_and_Kitchen_5     1.0    CG
4  Home_and_Kitchen_5     5.0    CG
```

```
                                                text_  \
0  Love this!  Well made, sturdy, and very comfor…
1  love it, a great upgrade from the original.  I…
2  This pillow saved my back. I love the look and…
3  Missing information on how to use it, but it i…
4  Very nice set. Good quality. We have had the s…

                                          clean_text      sent  subj  \
0  love this well made sturdy and very comfortabl…  0.730625   0.8
1  love it a great upgrade from the original i ve…  0.779167   0.7
2  this pillow saved my back i love the look and …  0.625000   0.3
3  missing information on how to use it but it is…  0.650000   0.4
4  very nice set good quality we have had the set…  0.870000   0.8

       read      leng  mismatch
0  0.634862  0.043333         0
1  0.800976  0.056667         0
2  0.959393  0.046667         0
3  0.800976  0.056667         1
4  0.898650  0.060000         0
```

[7]:
```
X_text = df["text_"].values
X_rate = df["rating"].values
y      = (df["label"].str.upper() == "CG").astype(int).values

Xtr_txt, Xte_txt, Xtr_rt, Xte_rt, y_tr, y_te = train_test_split(
    X_text, X_rate, y, test_size=0.20, random_state=RANDOM_STATE, stratify=y
)
print("Train:", Xtr_txt.shape, "  Test:", Xte_txt.shape)
```

```
Train: (32345,)   Test: (8087,)
```

[10]:
```
def train_eval(model, name):
    pipe = Pipeline([
        ("tfidf", TfidfVectorizer(stop_words="english", max_features=40_000)),
        ("clf"  , model)
    ])
    pipe.fit(Xtr_txt, y_tr)
    f1 = f1_score(y_te, pipe.predict(Xte_txt))
    print(f"{name:10s}  F1 = {f1:.4f}")
    return f1

f1_lr  = train_eval(LogisticRegression(max_iter=400, n_jobs=-1), "LogReg")
f1_svm = train_eval(LinearSVC(),                                 "SVM")
f1_rf  = train_eval(RandomForestClassifier(
                    n_estimators=300, n_jobs=-1,
                    class_weight="balanced"),                    "RandForest")
```

```
LogReg       F1 = 0.8702
SVM          F1 = 0.8750
RandForest   F1 = 0.8621
```

[8]:
```python
# triangular membership functions
def low(x):  return np.clip(1 - 2*x,            0, 1)
def high(x): return np.clip(2*x - 1,            0, 1)
def med(x):  return np.clip(1 - 2*np.abs(x-0.5), 0, 1)

# initial weights (will be tuned)
PROB = {"low": 0.15, "med": 0.50, "high": 0.80}
MISMATCH_W = 0.60

def rule_strengths(s, u, r, l, m):
    yield min(s["high"], u["high"], r["low"]),  "high"
    yield min(s["high"], u["high"], l["high"]), "high"
    yield min(s["low"] , u["low"] , r["high"]), "low"
    yield min(r["low"] , l["high"]),            "high"
    yield min(s["med"] , u["med"] , r["med"]),  "med"
    yield min(s["low"] , u["high"]),            "med"
    yield min(s["high"], r["high"]),            "low"
    yield min(u["low"] , r["low"]),             "med"
    yield min(l["low"] , r["high"]),            "low"
    # mismatch → gentle boost
    yield (m * MISMATCH_W),                     "high"

def frds_prob(text: str, rating: float) -> float:
    s_val, u_val, r_val, l_val = base_features(clean_text(text))
    m_flag = tone_mismatch({"rating": rating, "sent": s_val})

    s = {"low": low(s_val),  "med": med(s_val),  "high": high(s_val)}
    u = {"low": low(u_val),  "med": med(u_val),  "high": high(u_val)}
    r = {"low": low(r_val),  "med": med(r_val),  "high": high(r_val)}
    l = {"low": low(l_val),  "med": med(l_val),  "high": high(l_val)}

    num = den = 0.0
    for strength, lbl in rule_strengths(s, u, r, l, m_flag):
        num += strength * PROB[lbl]
        den += strength
    return num / den if den else 0.5
```

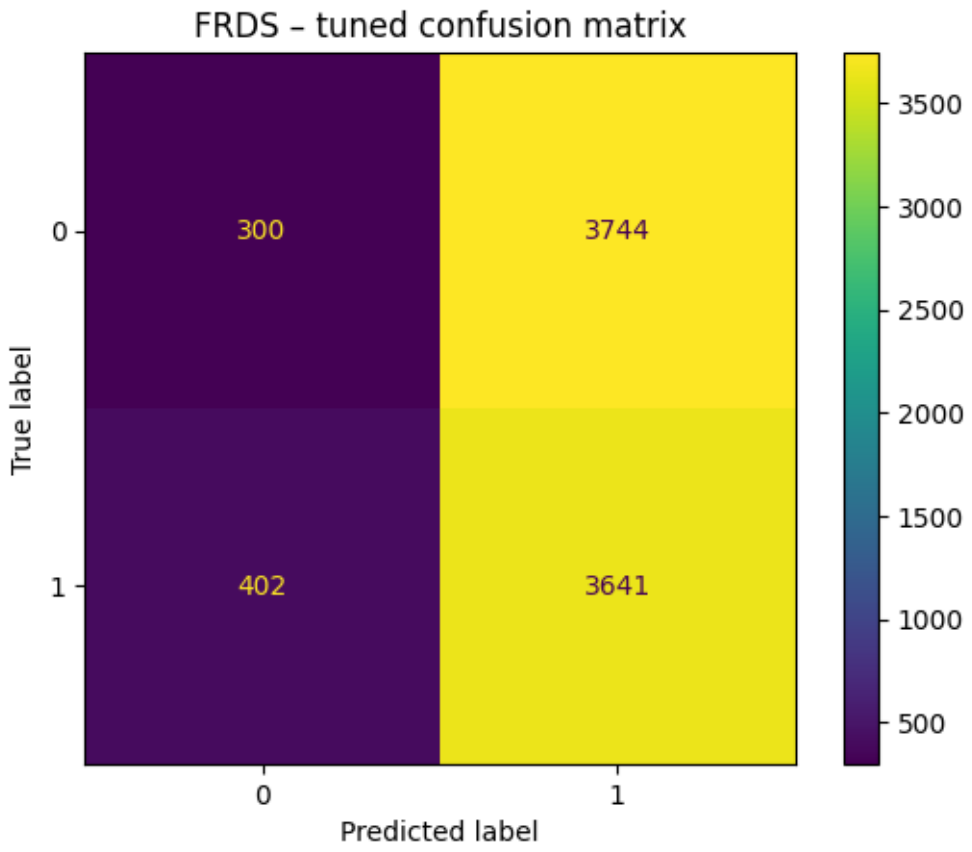
[9]:
```python
grid_low       = [0.12, 0.15, 0.18]
grid_med       = [0.48, 0.52, 0.56]
grid_high      = [0.78, 0.82, 0.86]
grid_mismatchW = [0.40, 0.55, 0.70]
grid_thresh    = np.linspace(0.20, 0.70, 11)   # step 0.05
```

```
best_cfg = None
best_f1  = 0

probs_all = np.array([
    frds_prob(t, r) for t, r in tqdm(
        zip(Xte_txt, Xte_rt),
        total=len(Xte_txt),
        desc="FRDS inference")
])

for lo, me, hi, mw in itertools.product(
        grid_low, grid_med, grid_high, grid_mismatchW):
    PROB.update({"low": lo, "med": me, "high": hi})
    MISMATCH_W = mw
    for t in grid_thresh:
        f1_val = f1_score(y_te, (probs_all >= t).astype(int))
        if f1_val > best_f1:
            best_f1  = f1_val
            best_cfg = (lo, me, hi, mw, t)

lo, me, hi, mw, best_t = best_cfg
PROB.update({"low": lo, "med": me, "high": hi})
MISMATCH_W = mw
y_pred_frds = (probs_all >= best_t).astype(int)

print(
    f"Best configuration  PROB=({lo:.2f},{me:.2f},{hi:.2f}), "
    f"MISMATCH_W={mw:.2f}, threshold={best_t:.2f}\n"
    f"FRDS F1 = {best_f1:.4f}"
)
```

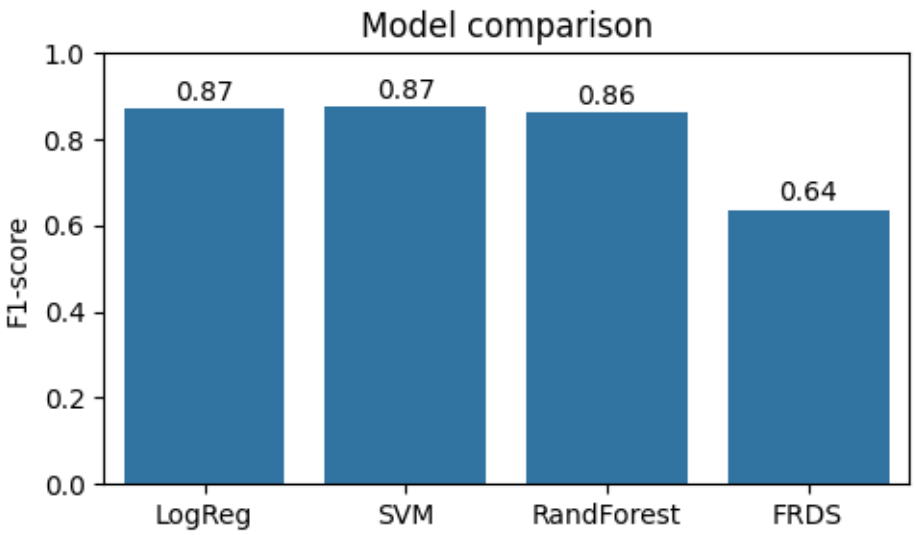
```
FRDS inference:   0%|          | 0/8087 [00:00<?, ?it/s]
```

```
Best configuration  PROB=(0.12,0.48,0.78), MISMATCH_W=0.40, threshold=0.20
FRDS F1 = 0.6372
```

[11]:
```
cm = confusion_matrix(y_te, y_pred_frds)
ConfusionMatrixDisplay(cm, display_labels=[0, 1]).plot(values_format='d')
plt.title("FRDS - tuned confusion matrix")
plt.show()
```



[12]:
```
models = ["LogReg", "SVM", "RandForest", "FRDS"]
f1s    = [f1_lr,    f1_svm, f1_rf,       best_f1]

plt.figure(figsize=(5, 3))
sns.barplot(x=models, y=f1s)
plt.ylim(0, 1)
plt.ylabel("F1-score")
plt.title("Model comparison")
for i, v in enumerate(f1s):
    plt.text(i, v + 0.02, f"{v:.2f}", ha="center")
plt.tight_layout()
plt.show()
```

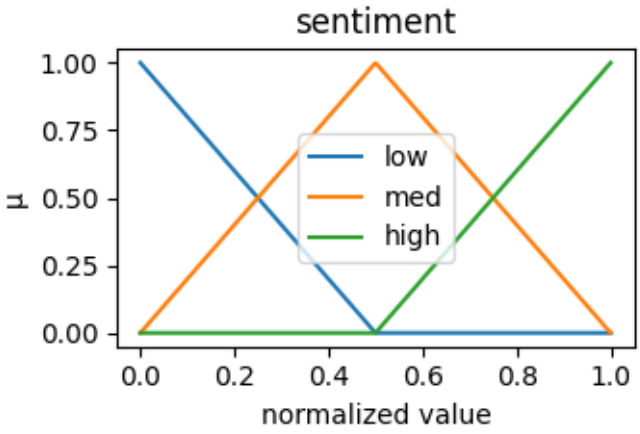


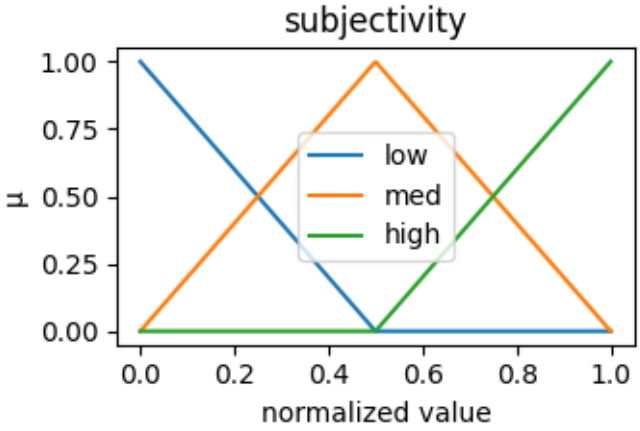
[13]:
```
def traffic(p):
    return "Green" if p <= 0.30 else "Amber" if p <= 0.60 else "Red"

demo = pd.DataFrame({"review": Xte_txt[:5], "rating": Xte_rt[:5]})
demo["P(fake)"] = demo.apply(
    lambda r: frds_prob(r["review"], r["rating"]), axis=1
)
demo["label"] = demo["P(fake)"].apply(traffic)
display(demo)
```

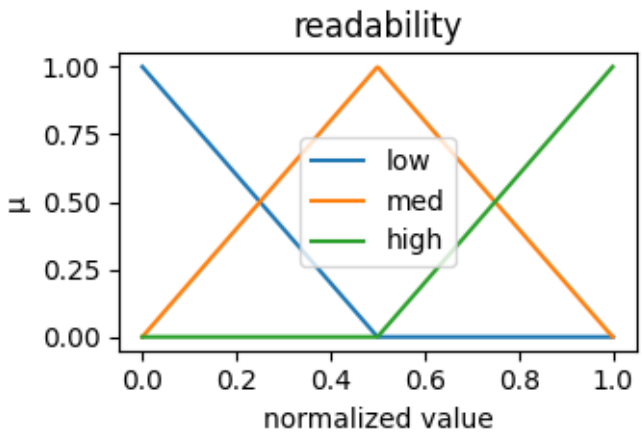
	review	rating	P(fake)	label
0	My grandson loves to experience the real world…	5.0	0.274380	Green
1	Just as advertised! Perfect for keeping on a d…	5.0	0.193664	Green
2	I take a size 10D and it fits fine. I will ke…	5.0	0.145366	Green
3	Of all the recipe books I have seen to date wh…	5.0	0.401920	Amber
4	Colors are off white & a pink red color. Retur…	2.0	0.171410	Green

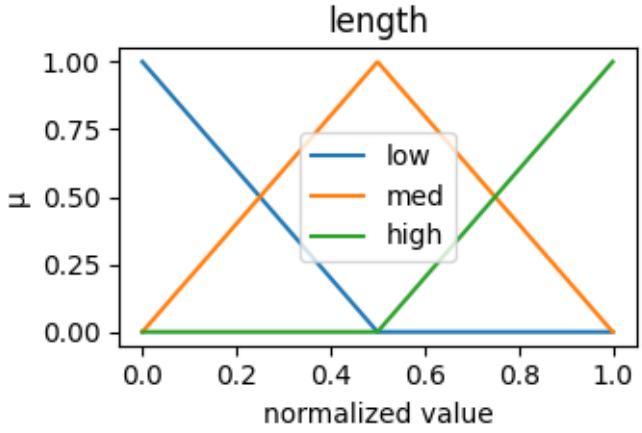
[14]:
```
def plot_mf(var_name):
    x = np.linspace(0, 1, 500)
    plt.figure(figsize=(3.5, 2.5))
    plt.plot(x, low(x),  label="low")
    plt.plot(x, med(x),  label="med")
    plt.plot(x, high(x), label="high")
    plt.title(var_name)
    plt.xlabel("normalized value")
    plt.ylabel(" ")
    plt.legend()
    plt.tight_layout()
    plt.show()
```

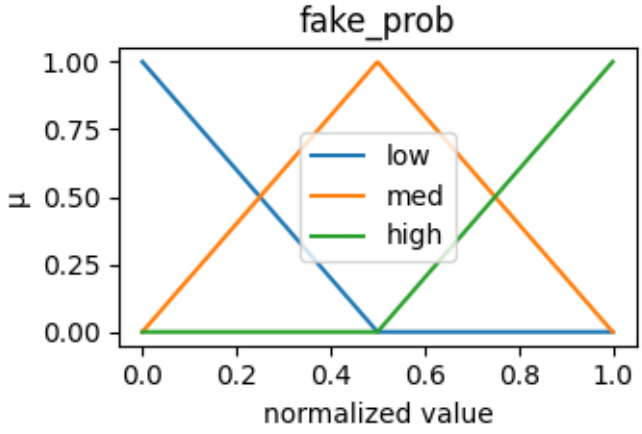
```
for name in ["sentiment", "subjectivity", "readability", "length", "fake_prob"]:
    plot_mf(name)
```






readability
1.00
0.75
0.50
0.25
0.00
μ
low
med
high
0.0
0.2
0.4
0.6
0.8
1.0
normalized value


length
1.00
0.75
0.50
0.25
0.00
μ
low
med
high
0.0
0.2
0.4
0.6
0.8
1.0
normalized value


fake_prob
1.00
0.75
0.50
0.25
0.00
μ
low
med
high
0.0
0.2
0.4
0.6
0.8
1.0
normalized value