Sudan Crisis 3

July 11, 2025

Human Rights Monitoring and Protection of Population in Sudan Using Twitter Data

```
[1]: !java -version
```

```
openjdk version "11.0.27" 2025-04-15
OpenJDK Runtime Environment (build 11.0.27+6-post-Ubuntu-0ubuntu122.04)
OpenJDK 64-Bit Server VM (build 11.0.27+6-post-Ubuntu-0ubuntu122.04, mixed mode,
sharing)
```

```
[2]: %pip install kafka-python pandas geopandas matplotlib seaborn nltk spacy torch␣
     ↪transformers pyspark findspark scikit-learn shapely geopy tensorflow==2.15.0␣
     ↪tensorflow-hub==0.15.0 tensorflow-text==2.15.0 keras==2.15.0 numpy
```

```
Requirement already satisfied: kafka-python in
/home/hadoop/py311env/lib/python3.11/site-packages (2.2.10)
Requirement already satisfied: pandas in
/home/hadoop/py311env/lib/python3.11/site-packages (2.2.3)
Requirement already satisfied: geopandas in
/home/hadoop/py311env/lib/python3.11/site-packages (1.0.1)
Requirement already satisfied: matplotlib in
/home/hadoop/py311env/lib/python3.11/site-packages (3.10.3)
Requirement already satisfied: seaborn in
/home/hadoop/py311env/lib/python3.11/site-packages (0.13.2)
Requirement already satisfied: nltk in
/home/hadoop/py311env/lib/python3.11/site-packages (3.9.1)
Requirement already satisfied: spacy in
/home/hadoop/py311env/lib/python3.11/site-packages (3.8.7)
Requirement already satisfied: torch in
/home/hadoop/py311env/lib/python3.11/site-packages (2.7.0)
Requirement already satisfied: transformers in
/home/hadoop/py311env/lib/python3.11/site-packages (4.53.1)
Requirement already satisfied: pyspark in
/home/hadoop/py311env/lib/python3.11/site-packages (4.0.0)
Requirement already satisfied: findspark in
/home/hadoop/py311env/lib/python3.11/site-packages (2.0.1)
Requirement already satisfied: scikit-learn in
/home/hadoop/py311env/lib/python3.11/site-packages (1.6.1)
Requirement already satisfied: shapely in
/home/hadoop/py311env/lib/python3.11/site-packages (2.1.1)
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Requirement already satisfied: geopy in
/home/hadoop/py311env/lib/python3.11/site-packages (2.4.1)
Requirement already satisfied: tensorflow==2.15.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (2.15.0)
Requirement already satisfied: tensorflow-hub==0.15.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (0.15.0)
Requirement already satisfied: tensorflow-text==2.15.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (2.15.0)
Requirement already satisfied: keras==2.15.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (2.15.0)
Requirement already satisfied: numpy in
/home/hadoop/py311env/lib/python3.11/site-packages (1.26.4)
Requirement already satisfied: absl-py>=1.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(2.3.0)
Requirement already satisfied: astunparse>=1.6.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(1.6.3)
Requirement already satisfied: flatbuffers>=23.5.26 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(25.2.10)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(0.6.0)
Requirement already satisfied: google-pasta>=0.1.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(0.2.0)
Requirement already satisfied: h5py>=2.9.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(3.13.0)
Requirement already satisfied: libclang>=13.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(18.1.1)
Requirement already satisfied: ml-dtypes~=0.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(0.2.0)
Requirement already satisfied: opt-einsum>=2.3.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(3.4.0)
Requirement already satisfied: packaging in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(25.0)
Requirement already satisfied:
protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<5.0.0dev,>=3.20.3
in /home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(4.25.8)
Requirement already satisfied: setuptools in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
```

(65.5.0)
Requirement already satisfied: six>=1.12.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(1.17.0)
Requirement already satisfied: termcolor>=1.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(3.1.0)
Requirement already satisfied: typing-extensions>=3.6.6 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(4.13.2)
Requirement already satisfied: wrapt<1.15,>=1.11.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(1.14.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(0.37.1)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(1.71.0)
Requirement already satisfied: tensorboard<2.16,>=2.15 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(2.15.2)
Requirement already satisfied: tensorflow-estimator<2.16,>=2.15.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from tensorflow==2.15.0)
(2.15.0)
Requirement already satisfied: google-auth<3,>=1.6.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
tensorboard<2.16,>=2.15->tensorflow==2.15.0) (2.40.3)
Requirement already satisfied: google-auth-oauthlib<2,>=0.5 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
tensorboard<2.16,>=2.15->tensorflow==2.15.0) (1.2.2)
Requirement already satisfied: markdown>=2.6.8 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
tensorboard<2.16,>=2.15->tensorflow==2.15.0) (3.8)
Requirement already satisfied: requests<3,>=2.21.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
tensorboard<2.16,>=2.15->tensorflow==2.15.0) (2.32.3)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
tensorboard<2.16,>=2.15->tensorflow==2.15.0) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
tensorboard<2.16,>=2.15->tensorflow==2.15.0) (3.1.3)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from google-
auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (5.5.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from google-

auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (0.4.2)
Requirement already satisfied: rsa<5,>=3.1.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from google-
auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (4.9.1)
Requirement already satisfied: requests-oauthlib>=0.7.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from google-auth-
oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (2.0.0)
Requirement already satisfied: charset-normalizer<4,>=2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (3.4.2)
Requirement already satisfied: idna<4,>=2.5 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (2.4.0)
Requirement already satisfied: certifi>=2017.4.17 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (2025.4.26)
Requirement already satisfied: pyasn1>=0.1.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from rsa<5,>=3.1.4->google-
auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (0.6.1)
Requirement already satisfied: python-dateutil>=2.8.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from pandas) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from pandas) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in
/home/hadoop/py311env/lib/python3.11/site-packages (from pandas) (2025.2)
Requirement already satisfied: pyogrio>=0.7.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from geopandas) (0.11.0)
Requirement already satisfied: pyproj>=3.3.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from geopandas) (3.7.1)
Requirement already satisfied: contourpy>=1.0.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from matplotlib) (1.3.2)
Requirement already satisfied: cycler>=0.10 in
/home/hadoop/py311env/lib/python3.11/site-packages (from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from matplotlib) (4.58.1)
Requirement already satisfied: kiwisolver>=1.3.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from matplotlib) (1.4.8)
Requirement already satisfied: pillow>=8 in
/home/hadoop/py311env/lib/python3.11/site-packages (from matplotlib) (11.2.1)
Requirement already satisfied: pyparsing>=2.3.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from matplotlib) (3.2.3)
Requirement already satisfied: click in
/home/hadoop/py311env/lib/python3.11/site-packages (from nltk) (8.2.1)
Requirement already satisfied: joblib in
/home/hadoop/py311env/lib/python3.11/site-packages (from nltk) (1.5.1)

Requirement already satisfied: regex>=2021.8.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from nltk) (2024.11.6)
Requirement already satisfied: tqdm in
/home/hadoop/py311env/lib/python3.11/site-packages (from nltk) (4.67.1)
Requirement already satisfied: spacy-legacy<3.1.0,>=3.0.11 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (3.0.12)
Requirement already satisfied: spacy-loggers<2.0.0,>=1.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (1.0.5)
Requirement already satisfied: murmurhash<1.1.0,>=0.28.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (1.0.13)
Requirement already satisfied: cymem<2.1.0,>=2.0.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (2.0.11)
Requirement already satisfied: preshed<3.1.0,>=3.0.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (3.0.10)
Requirement already satisfied: thinc<8.4.0,>=8.3.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (8.3.4)
Requirement already satisfied: wasabi<1.2.0,>=0.9.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (1.1.3)
Requirement already satisfied: srsly<3.0.0,>=2.4.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (2.5.1)
Requirement already satisfied: catalogue<2.1.0,>=2.0.6 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (2.0.10)
Requirement already satisfied: weasel<0.5.0,>=0.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (0.4.1)
Requirement already satisfied: typer<1.0.0,>=0.3.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (0.16.0)
Requirement already satisfied: pydantic!=1.8,!=1.8.1,<3.0.0,>=1.7.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (2.11.5)
Requirement already satisfied: jinja2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (3.1.6)
Requirement already satisfied: langcodes<4.0.0,>=3.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from spacy) (3.5.0)
Requirement already satisfied: language-data>=1.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
langcodes<4.0.0,>=3.2.0->spacy) (1.3.0)
Requirement already satisfied: annotated-types>=0.6.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
pydantic!=1.8,!=1.8.1,<3.0.0,>=1.7.4->spacy) (0.7.0)
Requirement already satisfied: pydantic-core==2.33.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
pydantic!=1.8,!=1.8.1,<3.0.0,>=1.7.4->spacy) (2.33.2)
Requirement already satisfied: typing-inspection>=0.4.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
pydantic!=1.8,!=1.8.1,<3.0.0,>=1.7.4->spacy) (0.4.1)
Requirement already satisfied: blis<1.3.0,>=1.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
thinc<8.4.0,>=8.3.4->spacy) (1.2.1)
Requirement already satisfied: confection<1.0.0,>=0.0.1 in

/home/hadoop/py311env/lib/python3.11/site-packages (from
thinc<8.4.0,>=8.3.4->spacy) (0.1.5)
Requirement already satisfied: shellingham>=1.3.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
typer<1.0.0,>=0.3.0->spacy) (1.5.4)
Requirement already satisfied: rich>=10.11.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
typer<1.0.0,>=0.3.0->spacy) (14.0.0)
Requirement already satisfied: cloudpathlib<1.0.0,>=0.7.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
weasel<0.5.0,>=0.1.0->spacy) (0.21.1)
Requirement already satisfied: smart-open<8.0.0,>=5.2.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
weasel<0.5.0,>=0.1.0->spacy) (7.1.0)
Requirement already satisfied: filelock in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (3.18.0)
Requirement already satisfied: sympy>=1.13.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (1.14.0)
Requirement already satisfied: networkx in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (3.5)
Requirement already satisfied: fsspec in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (2025.3.0)
Requirement already satisfied: nvidia-cuda-nvrtc-cu12==12.6.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.6.77)
Requirement already satisfied: nvidia-cuda-runtime-cu12==12.6.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.6.77)
Requirement already satisfied: nvidia-cuda-cupti-cu12==12.6.80 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.6.80)
Requirement already satisfied: nvidia-cudnn-cu12==9.5.1.17 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (9.5.1.17)
Requirement already satisfied: nvidia-cublas-cu12==12.6.4.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.6.4.1)
Requirement already satisfied: nvidia-cufft-cu12==11.3.0.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (11.3.0.4)
Requirement already satisfied: nvidia-curand-cu12==10.3.7.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (10.3.7.77)
Requirement already satisfied: nvidia-cusolver-cu12==11.7.1.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (11.7.1.2)
Requirement already satisfied: nvidia-cusparse-cu12==12.5.4.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.5.4.2)
Requirement already satisfied: nvidia-cusparselt-cu12==0.6.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (0.6.3)
Requirement already satisfied: nvidia-nccl-cu12==2.26.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (2.26.2)
Requirement already satisfied: nvidia-nvtx-cu12==12.6.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.6.77)
Requirement already satisfied: nvidia-nvjitlink-cu12==12.6.85 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (12.6.85)

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Requirement already satisfied: nvidia-cufile-cu12==1.11.1.6 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (1.11.1.6)
Requirement already satisfied: triton==3.3.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch) (3.3.0)
Requirement already satisfied: huggingface-hub<1.0,>=0.30.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from transformers) (0.32.3)
Requirement already satisfied: pyyaml>=5.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from transformers) (6.0.2)
Requirement already satisfied: tokenizers<0.22,>=0.21 in
/home/hadoop/py311env/lib/python3.11/site-packages (from transformers) (0.21.1)
Requirement already satisfied: safetensors>=0.4.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from transformers) (0.5.3)
Requirement already satisfied: hf-xet<2.0.0,>=1.1.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from huggingface-
hub<1.0,>=0.30.0->transformers) (1.1.2)
Requirement already satisfied: py4j==0.10.9.9 in
/home/hadoop/py311env/lib/python3.11/site-packages (from pyspark) (0.10.9.9)
Requirement already satisfied: scipy>=1.6.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from scikit-learn) (1.15.3)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from scikit-learn) (3.6.0)
Requirement already satisfied: geographiclib<3,>=1.52 in
/home/hadoop/py311env/lib/python3.11/site-packages (from geopy) (2.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
astunparse>=1.6.0->tensorflow==2.15.0) (0.45.1)
Requirement already satisfied: marisa-trie>=1.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from language-
data>=1.2->langcodes<4.0.0,>=3.2.0->spacy) (1.2.1)
Requirement already satisfied: oauthlib>=3.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from requests-
oauthlib>=0.7.0->google-auth-
oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (3.3.1)
Requirement already satisfied: markdown-it-py>=2.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
rich>=10.11.0->typer<1.0.0,>=0.3.0->spacy) (3.0.0)
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
rich>=10.11.0->typer<1.0.0,>=0.3.0->spacy) (2.19.1)
Requirement already satisfied: mdurl~=0.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from markdown-it-
py>=2.2.0->rich>=10.11.0->typer<1.0.0,>=0.3.0->spacy) (0.1.2)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from sympy>=1.13.3->torch)
(1.3.0)
Requirement already satisfied: MarkupSafe>=2.1.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
werkzeug>=1.0.1->tensorboard<2.16,>=2.15->tensorflow==2.15.0) (3.0.2)
```

Note: you may need to restart the kernel to use updated packages.

[3]: ```
%pip install seqeval torchcrf
```

Requirement already satisfied: seqeval in
/home/hadoop/py311env/lib/python3.11/site-packages (1.2.2)
Requirement already satisfied: torchcrf in
/home/hadoop/py311env/lib/python3.11/site-packages (1.1.0)
Requirement already satisfied: numpy>=1.14.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from seqeval) (1.26.4)
Requirement already satisfied: scikit-learn>=0.21.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from seqeval) (1.6.1)
Requirement already satisfied: torch>=1.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torchcrf) (2.7.0)
Requirement already satisfied: scipy>=1.6.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from scikit-
learn>=0.21.3->seqeval) (1.15.3)
Requirement already satisfied: joblib>=1.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from scikit-
learn>=0.21.3->seqeval) (1.5.1)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from scikit-
learn>=0.21.3->seqeval) (3.6.0)
Requirement already satisfied: filelock in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(3.18.0)
Requirement already satisfied: typing-extensions>=4.10.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(4.13.2)
Requirement already satisfied: sympy>=1.13.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(1.14.0)
Requirement already satisfied: networkx in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(3.5)
Requirement already satisfied: jinja2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(3.1.6)
Requirement already satisfied: fsspec in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(2025.3.0)
Requirement already satisfied: nvidia-cuda-nvrtc-cu12==12.6.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.6.77)
Requirement already satisfied: nvidia-cuda-runtime-cu12==12.6.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.6.77)
Requirement already satisfied: nvidia-cuda-cupti-cu12==12.6.80 in

```
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.6.80)
Requirement already satisfied: nvidia-cudnn-cu12==9.5.1.17 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(9.5.1.17)
Requirement already satisfied: nvidia-cublas-cu12==12.6.4.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.6.4.1)
Requirement already satisfied: nvidia-cufft-cu12==11.3.0.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(11.3.0.4)
Requirement already satisfied: nvidia-curand-cu12==10.3.7.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(10.3.7.77)
Requirement already satisfied: nvidia-cusolver-cu12==11.7.1.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(11.7.1.2)
Requirement already satisfied: nvidia-cusparse-cu12==12.5.4.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.5.4.2)
Requirement already satisfied: nvidia-cusparselt-cu12==0.6.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(0.6.3)
Requirement already satisfied: nvidia-nccl-cu12==2.26.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(2.26.2)
Requirement already satisfied: nvidia-nvtx-cu12==12.6.77 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.6.77)
Requirement already satisfied: nvidia-nvjitlink-cu12==12.6.85 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(12.6.85)
Requirement already satisfied: nvidia-cufile-cu12==1.11.1.6 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(1.11.1.6)
Requirement already satisfied: triton==3.3.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from torch>=1.0.0->torchcrf)
(3.3.0)
Requirement already satisfied: setuptools>=40.8.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
triton==3.3.0->torch>=1.0.0->torchcrf) (65.5.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
sympy>=1.13.3->torch>=1.0.0->torchcrf) (1.3.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
jinja2->torch>=1.0.0->torchcrf) (3.0.2)
Note: you may need to restart the kernel to use updated packages.
```

```
[4]: %pip install --upgrade jupyter ipywidgets
```

Requirement already satisfied: jupyter in
/home/hadoop/py311env/lib/python3.11/site-packages (1.1.1)
Requirement already satisfied: ipywidgets in
/home/hadoop/py311env/lib/python3.11/site-packages (8.1.7)
Requirement already satisfied: notebook in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter) (7.4.3)
Requirement already satisfied: jupyter-console in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter) (6.6.3)
Requirement already satisfied: nbconvert in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter) (7.16.6)
Requirement already satisfied: ipykernel in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter) (6.29.5)
Requirement already satisfied: jupyterlab in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter) (4.4.3)
Requirement already satisfied: comm>=0.1.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipywidgets) (0.2.2)
Requirement already satisfied: ipython>=6.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipywidgets) (9.2.0)
Requirement already satisfied: traitlets>=4.3.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipywidgets) (5.14.3)
Requirement already satisfied: widgetsnbextension~=4.0.14 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipywidgets) (4.0.14)
Requirement already satisfied: jupyterlab_widgets~=3.0.15 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipywidgets) (3.0.15)
Requirement already satisfied: decorator in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (5.2.1)
Requirement already satisfied: ipython-pygments-lexers in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (1.1.1)
Requirement already satisfied: jedi>=0.16 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (0.19.2)
Requirement already satisfied: matplotlib-inline in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (0.1.7)
Requirement already satisfied: pexpect>4.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (4.9.0)
Requirement already satisfied: prompt_toolkit<3.1.0,>=3.0.41 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (3.0.51)
Requirement already satisfied: pygments>=2.4.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (2.19.1)

Requirement already satisfied: stack_data in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (0.6.3)
Requirement already satisfied: typing_extensions>=4.6 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets) (4.13.2)
Requirement already satisfied: wcwidth in
/home/hadoop/py311env/lib/python3.11/site-packages (from
prompt_toolkit<3.1.0,>=3.0.41->ipython>=6.1.0->ipywidgets) (0.2.13)
Requirement already satisfied: parso<0.9.0,>=0.8.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
jedi>=0.16->ipython>=6.1.0->ipywidgets) (0.8.4)
Requirement already satisfied: ptyprocess>=0.5 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
pexpect>4.3->ipython>=6.1.0->ipywidgets) (0.7.0)
Requirement already satisfied: debugpy>=1.6.5 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(1.8.14)
Requirement already satisfied: jupyter-client>=6.1.12 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(8.6.3)
Requirement already satisfied: jupyter-core!=5.0.*,>=4.12 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(5.8.1)
Requirement already satisfied: nest-asyncio in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(1.6.0)
Requirement already satisfied: packaging in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(25.0)
Requirement already satisfied: psutil in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(7.0.0)
Requirement already satisfied: pyzmq>=24 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(26.4.0)
Requirement already satisfied: tornado>=6.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from ipykernel->jupyter)
(6.5.1)
Requirement already satisfied: python-dateutil>=2.8.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
client>=6.1.12->ipykernel->jupyter) (2.9.0.post0)
Requirement already satisfied: platformdirs>=2.5 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
core!=5.0.*,>=4.12->ipykernel->jupyter) (4.3.8)
Requirement already satisfied: six>=1.5 in
/home/hadoop/py311env/lib/python3.11/site-packages (from python-
dateutil>=2.8.2->jupyter-client>=6.1.12->ipykernel->jupyter) (1.17.0)

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Requirement already satisfied: async-lru>=1.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(2.0.5)
Requirement already satisfied: httpx>=0.25.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(0.28.1)
Requirement already satisfied: jinja2>=3.0.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(3.1.6)
Requirement already satisfied: jupyter-lsp>=2.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(2.2.5)
Requirement already satisfied: jupyter-server<3,>=2.4.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(2.16.0)
Requirement already satisfied: jupyterlab-server<3,>=2.27.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(2.27.3)
Requirement already satisfied: notebook-shim>=0.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(0.2.4)
Requirement already satisfied: setuptools>=41.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab->jupyter)
(65.5.0)
Requirement already satisfied: anyio>=3.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (4.9.0)
Requirement already satisfied: argon2-cffi>=21.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (23.1.0)
Requirement already satisfied: jupyter-events>=0.11.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (0.12.0)
Requirement already satisfied: jupyter-server-terminals>=0.4.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (0.5.3)
Requirement already satisfied: nbformat>=5.3.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (5.10.4)
Requirement already satisfied: overrides>=5.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (7.7.0)
Requirement already satisfied: prometheus-client>=0.9 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (0.22.0)
Requirement already satisfied: send2trash>=1.8.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (1.8.3)
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Requirement already satisfied: terminado>=0.8.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (0.18.1)
Requirement already satisfied: websocket-client>=1.7 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (1.8.0)
Requirement already satisfied: babel>=2.10 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab-
server<3,>=2.27.1->jupyterlab->jupyter) (2.17.0)
Requirement already satisfied: json5>=0.9.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab-
server<3,>=2.27.1->jupyterlab->jupyter) (0.12.0)
Requirement already satisfied: jsonschema>=4.18.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab-
server<3,>=2.27.1->jupyterlab->jupyter) (4.24.0)
Requirement already satisfied: requests>=2.31 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyterlab-
server<3,>=2.27.1->jupyterlab->jupyter) (2.32.3)
Requirement already satisfied: idna>=2.8 in
/home/hadoop/py311env/lib/python3.11/site-packages (from anyio>=3.1.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (3.10)
Requirement already satisfied: sniffio>=1.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from anyio>=3.1.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (1.3.1)
Requirement already satisfied: argon2-cffi-bindings in
/home/hadoop/py311env/lib/python3.11/site-packages (from
argon2-cffi>=21.1->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (21.2.0)
Requirement already satisfied: certifi in
/home/hadoop/py311env/lib/python3.11/site-packages (from
httpx>=0.25.0->jupyterlab->jupyter) (2025.4.26)
Requirement already satisfied: httpcore==1.* in
/home/hadoop/py311env/lib/python3.11/site-packages (from
httpx>=0.25.0->jupyterlab->jupyter) (1.0.9)
Requirement already satisfied: h11>=0.16 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
httpcore==1.*->httpx>=0.25.0->jupyterlab->jupyter) (0.16.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
jinja2>=3.0.3->jupyterlab->jupyter) (3.0.2)
Requirement already satisfied: attrs>=22.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->jupyter) (25.3.0)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->jupyter)
(2025.4.1)
Requirement already satisfied: referencing>=0.28.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from

jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->jupyter) (0.36.2)
Requirement already satisfied: rpds-py>=0.7.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->jupyter) (0.25.1)
Requirement already satisfied: python-json-logger>=2.0.4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
events>=0.11.0->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (3.3.0)
Requirement already satisfied: pyyaml>=5.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
events>=0.11.0->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (6.0.2)
Requirement already satisfied: rfc3339-validator in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
events>=0.11.0->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (0.1.4)
Requirement already satisfied: rfc3986-validator>=0.1.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jupyter-
events>=0.11.0->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (0.1.1)
Requirement already satisfied: fqdn in
/home/hadoop/py311env/lib/python3.11/site-packages (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.11.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (1.5.1)
Requirement already satisfied: isoduration in
/home/hadoop/py311env/lib/python3.11/site-packages (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.11.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (20.11.0)
Requirement already satisfied: jsonpointer>1.13 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.11.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (3.0.0)
Requirement already satisfied: uri-template in
/home/hadoop/py311env/lib/python3.11/site-packages (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.11.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (1.3.0)
Requirement already satisfied: webcolors>=24.6.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.11.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (24.11.1)
Requirement already satisfied: beautifulsoup4 in
/home/hadoop/py311env/lib/python3.11/site-packages (from nbconvert->jupyter)
(4.13.4)
Requirement already satisfied: bleach!=5.0.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
bleach[css]!=5.0.0->nbconvert->jupyter) (6.2.0)
Requirement already satisfied: defusedxml in
/home/hadoop/py311env/lib/python3.11/site-packages (from nbconvert->jupyter)
(0.7.1)
Requirement already satisfied: jupyterlab-pygments in
/home/hadoop/py311env/lib/python3.11/site-packages (from nbconvert->jupyter)
(0.3.0)

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Requirement already satisfied: mistune<4,>=2.0.3 in
/home/hadoop/py311env/lib/python3.11/site-packages (from nbconvert->jupyter)
(3.1.3)
Requirement already satisfied: nbclient>=0.5.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from nbconvert->jupyter)
(0.10.2)
Requirement already satisfied: pandocfilters>=1.4.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from nbconvert->jupyter)
(1.5.1)
Requirement already satisfied: webencodings in
/home/hadoop/py311env/lib/python3.11/site-packages (from
bleach!=5.0.0->bleach[css]!=5.0.0->nbconvert->jupyter) (0.5.1)
Requirement already satisfied: tinycss2<1.5,>=1.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
bleach[css]!=5.0.0->nbconvert->jupyter) (1.4.0)
Requirement already satisfied: fastjsonschema>=2.15 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
nbformat>=5.3.0->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (2.21.1)
Requirement already satisfied: charset-normalizer<4,>=2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
requests>=2.31->jupyterlab-server<3,>=2.27.1->jupyterlab->jupyter) (3.4.2)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
requests>=2.31->jupyterlab-server<3,>=2.27.1->jupyterlab->jupyter) (2.4.0)
Requirement already satisfied: cffi>=1.0.1 in
/home/hadoop/py311env/lib/python3.11/site-packages (from argon2-cffi-
bindings->argon2-cffi>=21.1->jupyter-server<3,>=2.4.0->jupyterlab->jupyter)
(1.17.1)
Requirement already satisfied: pycparser in
/home/hadoop/py311env/lib/python3.11/site-packages (from
cffi>=1.0.1->argon2-cffi-bindings->argon2-cffi>=21.1->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (2.22)
Requirement already satisfied: soupsieve>1.2 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
beautifulsoup4->nbconvert->jupyter) (2.7)
Requirement already satisfied: arrow>=0.15.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
isoduration->jsonschema[format-nongpl]>=4.18.0->jupyter-events>=0.11.0->jupyter-
server<3,>=2.4.0->jupyterlab->jupyter) (1.3.0)
Requirement already satisfied: types-python-dateutil>=2.8.10 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
arrow>=0.15.0->isoduration->jsonschema[format-nongpl]>=4.18.0->jupyter-
events>=0.11.0->jupyter-server<3,>=2.4.0->jupyterlab->jupyter) (2.9.0.20250516)
Requirement already satisfied: executing>=1.2.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
stack_data->ipython>=6.1.0->ipywidgets) (2.2.0)
Requirement already satisfied: asttokens>=2.1.0 in
/home/hadoop/py311env/lib/python3.11/site-packages (from
```

```
stack_data->ipython>=6.1.0->ipywidgets) (3.0.0)
Requirement already satisfied: pure-eval in
/home/hadoop/py311env/lib/python3.11/site-packages (from
stack_data->ipython>=6.1.0->ipywidgets) (0.2.3)
Note: you may need to restart the kernel to use updated packages.
```

[5]: `!jupyter nbextension enable --py widgetsnbextension`

```
usage: jupyter [-h] [--version] [--config-dir] [--data-dir] [--runtime-dir]
               [--paths] [--json] [--debug]
               [subcommand]

Jupyter: Interactive Computing

positional arguments:
  subcommand     the subcommand to launch

options:
  -h, --help     show this help message and exit
  --version      show the versions of core jupyter packages and exit
  --config-dir   show Jupyter config dir
  --data-dir     show Jupyter data dir
  --runtime-dir  show Jupyter runtime dir
  --paths        show all Jupyter paths. Add --json for machine-readable
                 format.
  --json         output paths as machine-readable json
  --debug        output debug information about paths

Available subcommands: console dejavu events execute kernel kernelspec lab
labextension labhub migrate nbconvert notebook run server troubleshoot trust

Jupyter command `jupyter-nbextension` not found.
```

[6]:
```python
import os
os.environ["JAVA_HOME"] = "/usr/lib/jvm/java-11-openjdk-amd64"
os.environ["SPARK_HOME"] = "/opt/spark/spark-3.5.6-bin-hadoop3"
os.environ["HADOOP_HOME"] = "/usr/local/hadoop"
os.environ["TF_USE_LEGACY_KERAS"] = "1"
```

[7]:
```python
import findspark
findspark.init()
import pyspark
```

[8]:
```python
#Import necessary libraries
```

```python
import pandas as pd    # Pandas is an open source, BSD-licensed library
    # providing high-performance, easy-to-use data structures and data analysis
    # tools for the Python programming language. Pandas Series is a
    # one-dimensional labeled array capable of holding any data type with axis
    # labels or index
import geopandas as gpd
import time
import matplotlib.pyplot as plt
import numpy as np
import logging
import hashlib
from geopy.geocoders import Nominatim
from geopy.extra.rate_limiter import RateLimiter
from pyspark.sql import functions as func
from pyspark.sql.types import IntegerType, StringType, FloatType,
    TimestampType, BinaryType
from pyspark.sql.functions import col, count, when, mean, stddev, abs, sum,
    row_number
from pyspark.ml.feature import VectorAssembler, StandardScaler, StringIndexer,
    OneHotEncoder
from pyspark.ml import Pipeline
from pyspark.ml.classification import RandomForestClassifier
from pyspark.ml.tuning import CrossValidator, ParamGridBuilder
from pyspark.ml.evaluation import MulticlassClassificationEvaluator,
    BinaryClassificationEvaluator
from sklearn.metrics import precision_recall_curve
from pyspark.sql import Window
from transformers import pipeline, AutoTokenizer,
    AutoModelForSequenceClassification
from shapely.geometry import Point
from tqdm import tqdm
import torch
```

2025-07-11 02:03:11.205537: E
external/local_xla/xla/stream_executor/cuda/cuda_dnn.cc:9261] Unable to register
cuDNN factory: Attempting to register factory for plugin cuDNN when one has
already been registered
2025-07-11 02:03:11.206243: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:607] Unable to register
cuFFT factory: Attempting to register factory for plugin cuFFT when one has
already been registered
2025-07-11 02:03:11.387831: E
external/local_xla/xla/stream_executor/cuda/cuda_blas.cc:1515] Unable to
register cuBLAS factory: Attempting to register factory for plugin cuBLAS when
one has already been registered
2025-07-11 02:03:11.760537: I tensorflow/core/platform/cpu_feature_guard.cc:182]
This TensorFlow binary is optimized to use available CPU instructions in

17

performance-critical operations.
To enable the following instructions: AVX2 FMA, in other operations, rebuild
TensorFlow with the appropriate compiler flags.
2025-07-11 02:03:14.732444: W
tensorflow/compiler/tf2tensorrt/utils/py_utils.cc:38] TF-TRT Warning: Could not
find TensorRT

```
[9]: # Start SparkSession
     from pyspark.sql import SparkSession
     spark=SparkSession.builder.appName("Sudan Crisis Analysis").config("spark.
      ↪driver.memory", "4g").getOrCreate()
     spark
```

25/07/11 02:03:26 WARN Utils: Your hostname, julius-virtual-machine resolves to
a loopback address: 127.0.1.1; using 192.168.145.130 instead (on interface
ens33)
25/07/11 02:03:26 WARN Utils: Set SPARK_LOCAL_IP if you need to bind to another
address
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use
setLogLevel(newLevel).
25/07/11 02:03:27 WARN NativeCodeLoader: Unable to load native-hadoop library
for your platform… using builtin-java classes where applicable

```
[9]: <pyspark.sql.session.SparkSession at 0x762bb9a3dc90>
```

```
[10]: #Load the data and handle missing values
      df_pyspark = spark.read.csv("Sudan_Twitter_Data_June_2025latlong.csv",␣
       ↪header=True, inferSchema=True).cache()
      df_pyspark.show(5)
```

25/07/11 02:03:40 WARN SparkStringUtils: Truncated the string representation of
a plan since it was too large. This behavior can be adjusted by setting
'spark.sql.debug.maxToStringFields'.
[Stage 2:===================>   (1 + 2) / 3]

```
+--------+-----------+-------------+-------------+------------------+------
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----+-----------+----+-------+------------------+------------------+------
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+-------+--------+--------+------------------+------------------+--------+-----
------+------------+---------+----------+----------+
|     _id|     userId|     userName|        alias|     profilePicture|
userCreatedAt|
bio|followers|following|lists|statusesCount|verified|userLocation|lang|   type|
text|         createdAt|          mentions|totalRetweets|favorites|replies|l
inks|firstLink|images|impressions|isImage|firstImage| location|
url|noteTweetText|inReplyTo|inReplyToId|inReplyToUserId|reportName|   Latitude|
```

Longitude|
+-------+----------+------------+-------------+-----------------+------------------+------+----------+-------------------+--------+----------+----+------------+------------------+---------+---------+----+-------+----------------+------------------+------+----------+----+-------+----------------+------+-----+--------+------+----------+-------+---------+------------+--------------------+-----------+---------+----------+----------+
|1.93E+18|2.43752092E8| Damascene|
nanssolo|https://pbs.twimg…|2011-01-27T18:51:…|Syrian* blunt and…|
941| 754| 2| 182403| FALSE| NULL| en|retweet|RT
@BSonblast: Pl…|2025-06-17T03:32:…| "[""@bsonblast""]"| 0|
0| 0| []| NULL| []| 0| FALSE| NULL|Abyei
PCA|https://x.com/use…| NULL| FALSE| NULL| NULL|
NULL|9.594021206|28.43772416|
|1.93E+18| 1.45E18| nana nano|
hydrowanter|https://pbs.twimg…|2021-10-05T06:07:…|she/her | Indones…|
156| 46| 1| 37124| FALSE| NULL| en|retweet|RT
@BSonblast: Pl…|2025-06-17T03:31:…| "[""@bsonblast""]"| 0|
0| 0| []| NULL| []| 0| FALSE| NULL|Abyei
PCA|https://x.com/use…| NULL| FALSE| NULL| NULL|
NULL|9.594021206|28.43772416|
|1.93E+18| 1.06E18| bean |
Charlixxx_|https://pbs.twimg…|2018-11-13T12:11:…| pan   pirate …|
152| 327| 0| 35414| FALSE| NULL| en|retweet|RT
@BSonblast: Pl…|2025-06-17T03:30:…| "[""@bsonblast""]"| 0|
0| 0| []| NULL| []| 0| FALSE| NULL|Abyei
PCA|https://x.com/use…| NULL| FALSE| NULL| NULL|
NULL|9.594021206|28.43772416|
|1.93E+18| 7.16E17| Pastel
 |soIguessIexist|https://pbs.twimg…|2016-04-01T01:12:…|24 | black | nonb…|
488| 554| 2| 36040| FALSE| NULL| en|retweet|RT
@blkdesertfair…|2025-06-17T03:30:…|"[""@blkdesertfai…| 0|
0| 0| []| NULL| []| 0| FALSE| NULL|Abyei
PCA|https://x.com/use…| NULL| FALSE| NULL| NULL|
NULL|9.594021206|28.43772416|
|1.93E+18| 1.21E18| u i |
02A4D3|https://pbs.twimg…|2019-12-22T17:21:…| NULL| 14|
204| 0| 2549| FALSE| NULL| en|retweet|RT @BSonblast:
Pl…|2025-06-17T03:29:…| "[""@bsonblast""]"| 0| 0| 0|
[]| NULL| []| 0| FALSE| NULL|Abyei
PCA|https://x.com/use…| NULL| FALSE| NULL| NULL|
NULL|9.594021206|28.43772416|
+-------+----------+------------+-------------+-----------------+------------------+------+----------+-------------------+--------+----------+----+------------+------------------+---------+---------+----+-------+----------------+------------------+------+----------+----+-------+----------------+------+-----+--------+------+----------+-------+---------+------------+--------------------+-----------+---------+----------+----------+

only showing top 5 rows

```python
[11]: # Try to find the column containing tweet text
      possible_text_columns = ['text', 'Text', 'tweet', 'Tweet', 'content']
      text_col = None
      for col in possible_text_columns:
          if col in df_pyspark.columns:
              text_col = col
              break

      if text_col is None:
          raise ValueError("No text column found! Please check your CSV and set the␣
       ↪correct column name.")
```

```python
[12]: # Drop rows with missing text
      df_pyspark = df_pyspark.dropna(subset=[text_col])
```

```python
[13]: # Define Event Labels for Event Detection and Classification Matrix

      event_labels = [
          "armed conflict",
          "displacement",
          "looting",
          "sexual violence",
          "infrastructure destruction",
          "protest suppression",
          "famine"
      ]
```

```python
[14]: # Initialize Zero-Shot Classifier ---
      classifier = pipeline(
          "zero-shot-classification",
          model="facebook/bart-large-mnli",  # Change to multilingual model if needed
          device=0 if torch.cuda.is_available() else -1
      )
```

Device set to use cpu

```python
[15]: # Define Robust Event Detection Function ---

      def detect_events(text):
          try:
              result = classifier(text, event_labels, multi_label=True)
              return dict(zip(result['labels'], result['scores']))
          except Exception as e:
```

```
            print(f"Error processing text: {e}")
            return {label: None for label in event_labels}
```

[16]:
```
# Convert PySpark DataFrame to Pandas
df_pd = df_pyspark.toPandas()
```

[17]:
```
# Apply Event Detection with Progress Bar ---

tqdm.pandas()
event_scores = df_pd[text_col].astype(str).progress_apply(detect_events)
event_scores_df = pd.DataFrame(event_scores.tolist())
```

100%| | 15632/15632 [11:24:53<00:00, 2.63s/it]

[18]:
```
# Concatenate Results and export the data ---

df_pd = pd.concat([df_pd, event_scores_df], axis=1)
df_pd['Predicted_Events'] = event_scores_df.apply(
    lambda row: [label for label, score in row.items() if score is not None and↵
    ↪score > 0.5], axis=1
)
df_pd.to_csv("event_detection_results.csv", index=False)
print("Exported event detection results to event_detection_results.csv")
```

Exported event detection results to event_detection_results.csv

[19]:
```
# Preview Results ---

print(df_pd[[text_col, 'Predicted_Events'] + event_labels].head())
```

```
                                        text Predicted_Events  \
0  RT @BSonblast: Please help this young lady rea…               []
1  RT @BSonblast: Please help this young lady rea…               []
2  RT @BSonblast: Please help this young lady rea…               []
3  RT @blkdesertfairy: still $566 away from hitti…               []
4  RT @BSonblast: Please help this young lady rea…               []

   armed conflict  displacement   looting  sexual violence  \
0        0.139043      0.329689  0.002833         0.047099
1        0.139043      0.329689  0.002833         0.047099
2        0.139043      0.329689  0.002833         0.047099
3        0.076006      0.389195  0.002422         0.014389
4        0.139043      0.329689  0.002833         0.047099

   infrastructure destruction  protest suppression    famine
0                    0.015939             0.049745  0.032101
1                    0.015939             0.049745  0.032101
2                    0.015939             0.049745  0.032101
```

```
3                        0.004586                0.019459  0.146247
4                        0.015939                0.049745  0.032101
```

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