Graph4NLP

Graph4NLP Library and Demo

Yu (Hugo) Chen
Research Scientist at Meta AI

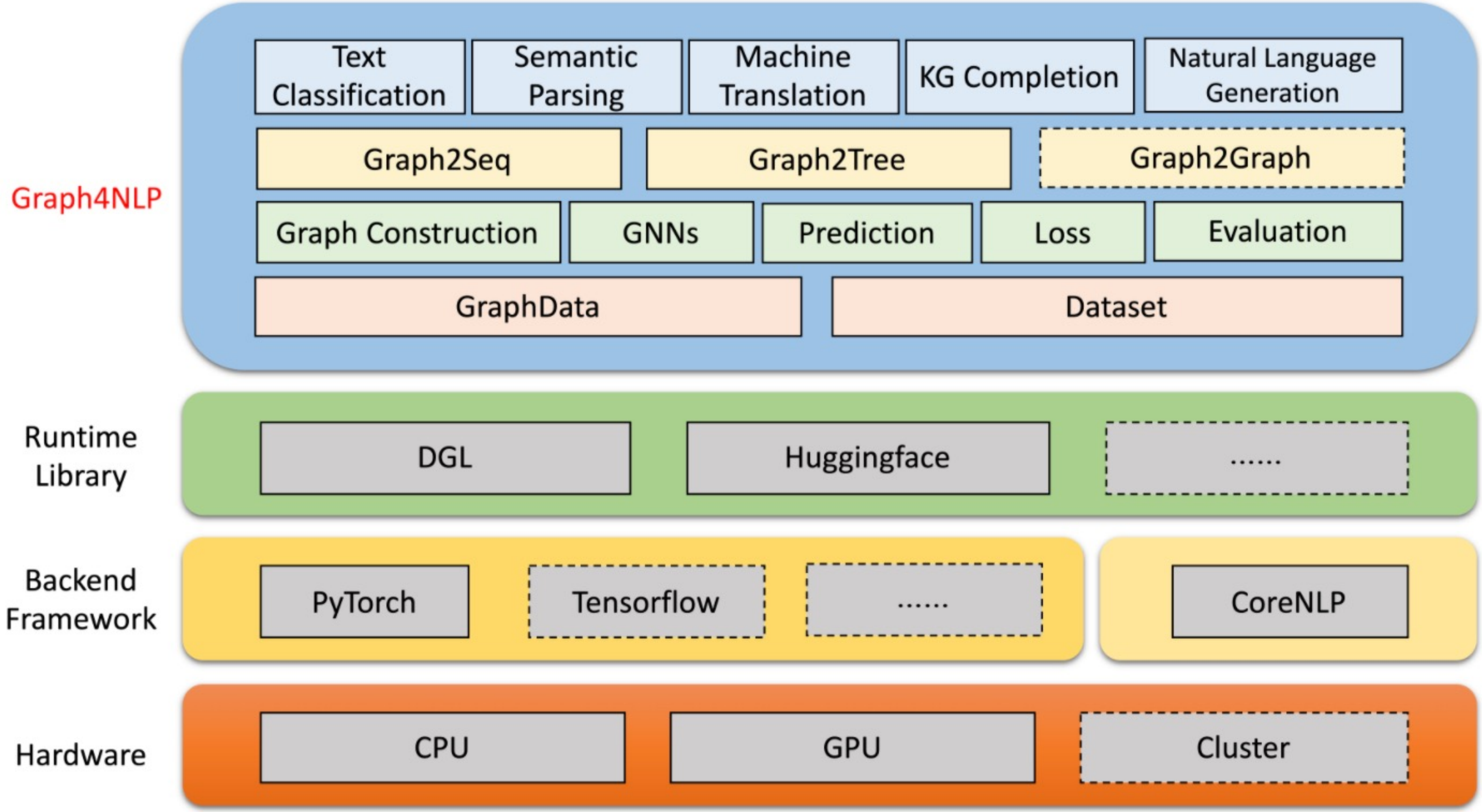
Joint Work with Graph4NLP Team

CLIQ-ai November Meetup
Nov 19th, 2021

Graph4NLP: A Library for Deep Learning on Graphs for NLP

Graph4NLP

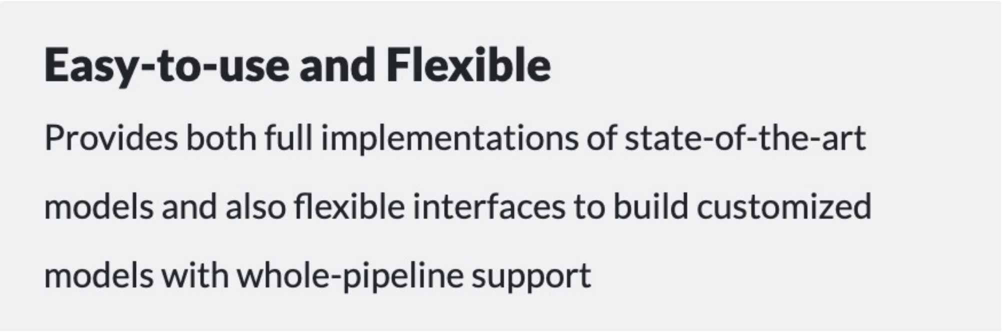
Overall Architecture of Graph4NLP Library



Graph4NLP: https://github.com/graph4ai/graph4nlp, DGL: https://github.com/dmlc/dgl, Huggingface Transformers: https://github.com/huggingface/transformers

Graph4NLP

Key Features

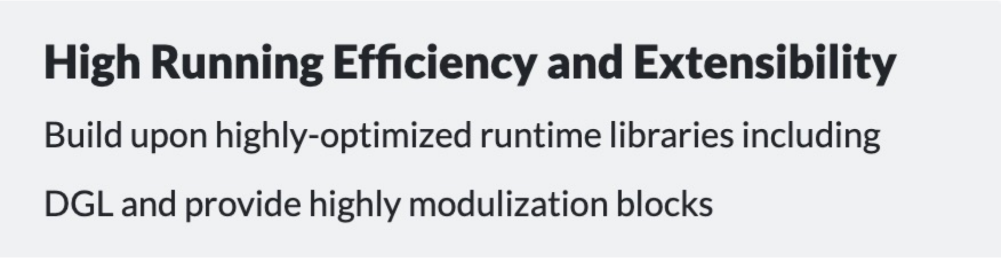


Easy-to-use and Flexible

Provides both full implementations of state-of-the-art models and also flexible interfaces to build customized models with whole-pipeline support

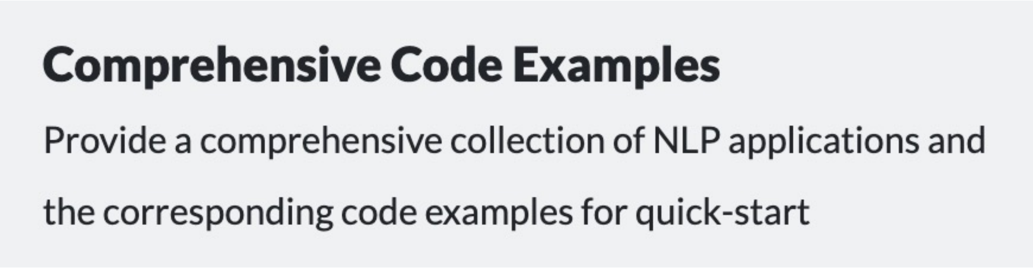
Rich Set of Learning Resources

Provide a variety of learning materials including code demos, code documentations, research tutorials and videos, and paper survey



High Running Efficiency and Extensibility

Build upon highly-optimized runtime libraries including DGL and provide highly modulization blocks

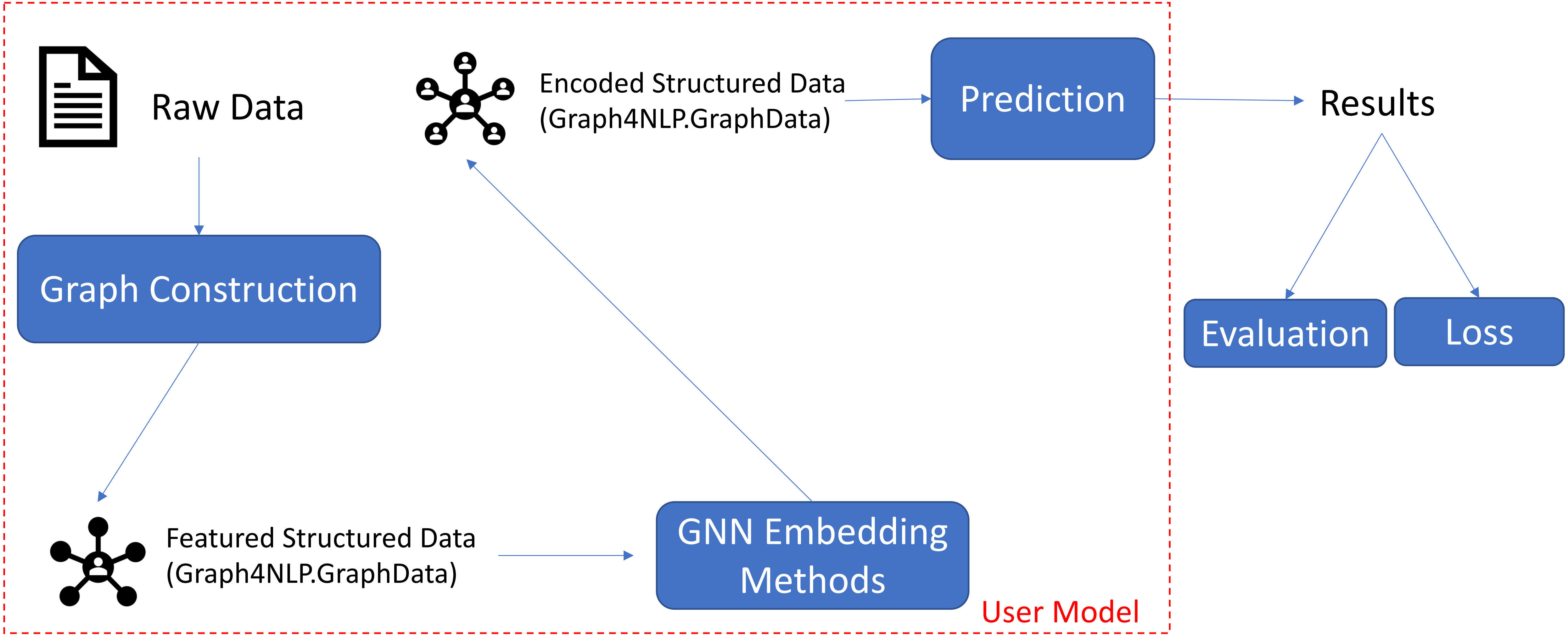


Comprehensive Code Examples

Provide a comprehensive collection of NLP applications and the corresponding code examples for quick-start

DLG4NLP website: https://dlg4nlp.github.io, Graph4NLP documentation: https://graph4ai.github.io/graph4nlp/

Data Flow of Graph4NLP



Raw Data

Graph Construction

Featured Structured Data (Graph4NLP.GraphData)

GNN Embedding Methods

Encoded Structured Data (Graph4NLP.GraphData)

Prediction

Results

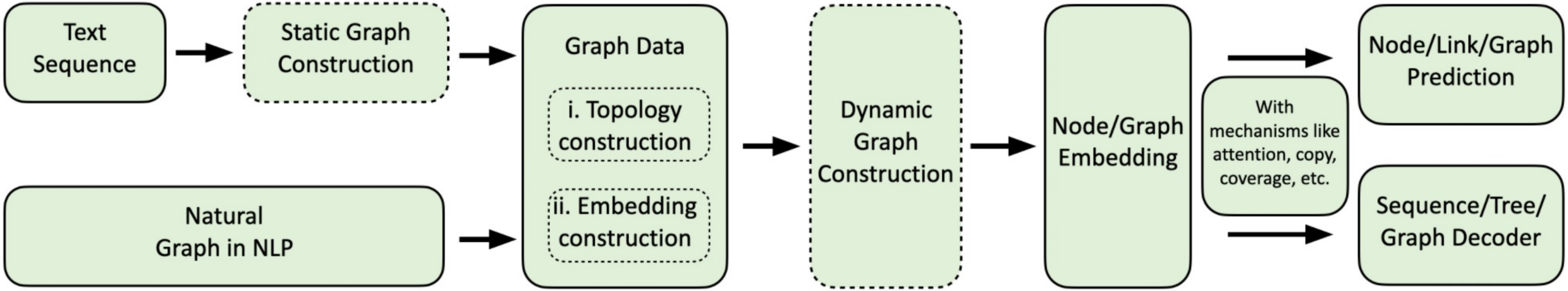
Evaluation

Loss

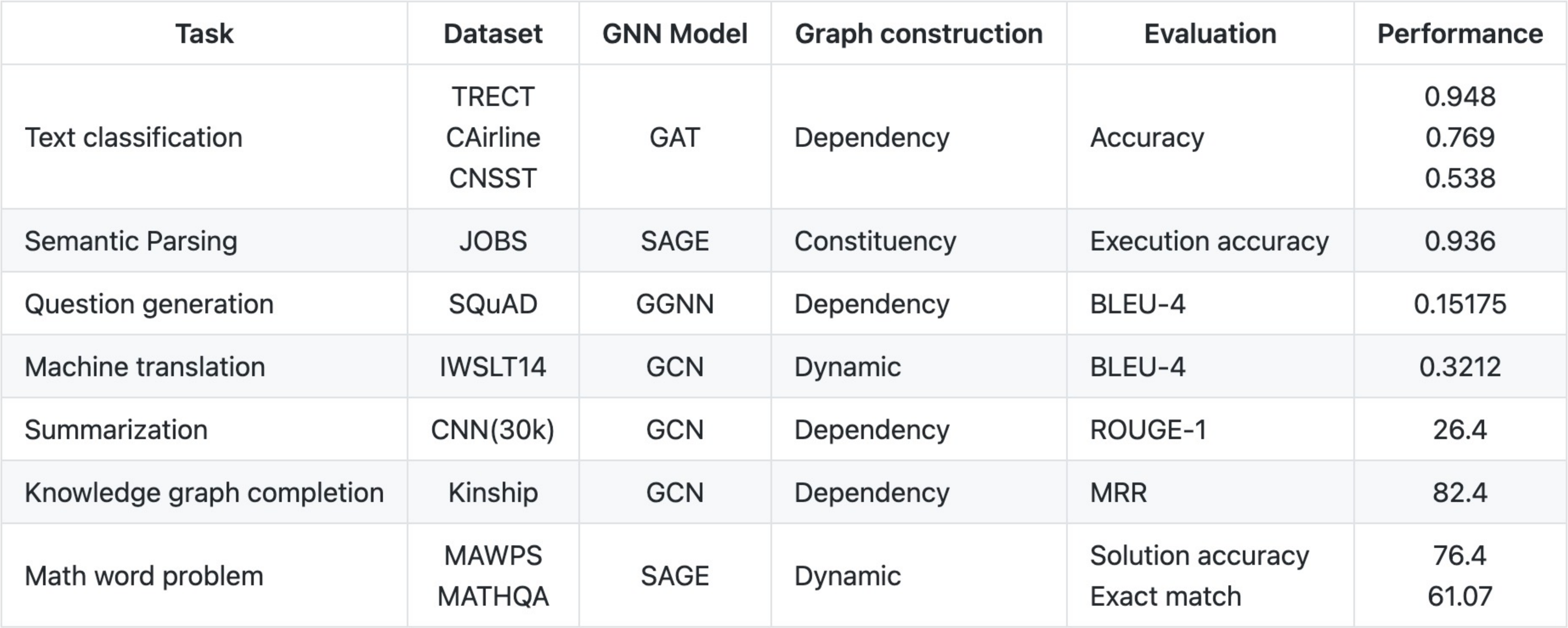
User Model

Graph4NLP

Computing Flow of Graph4NLP

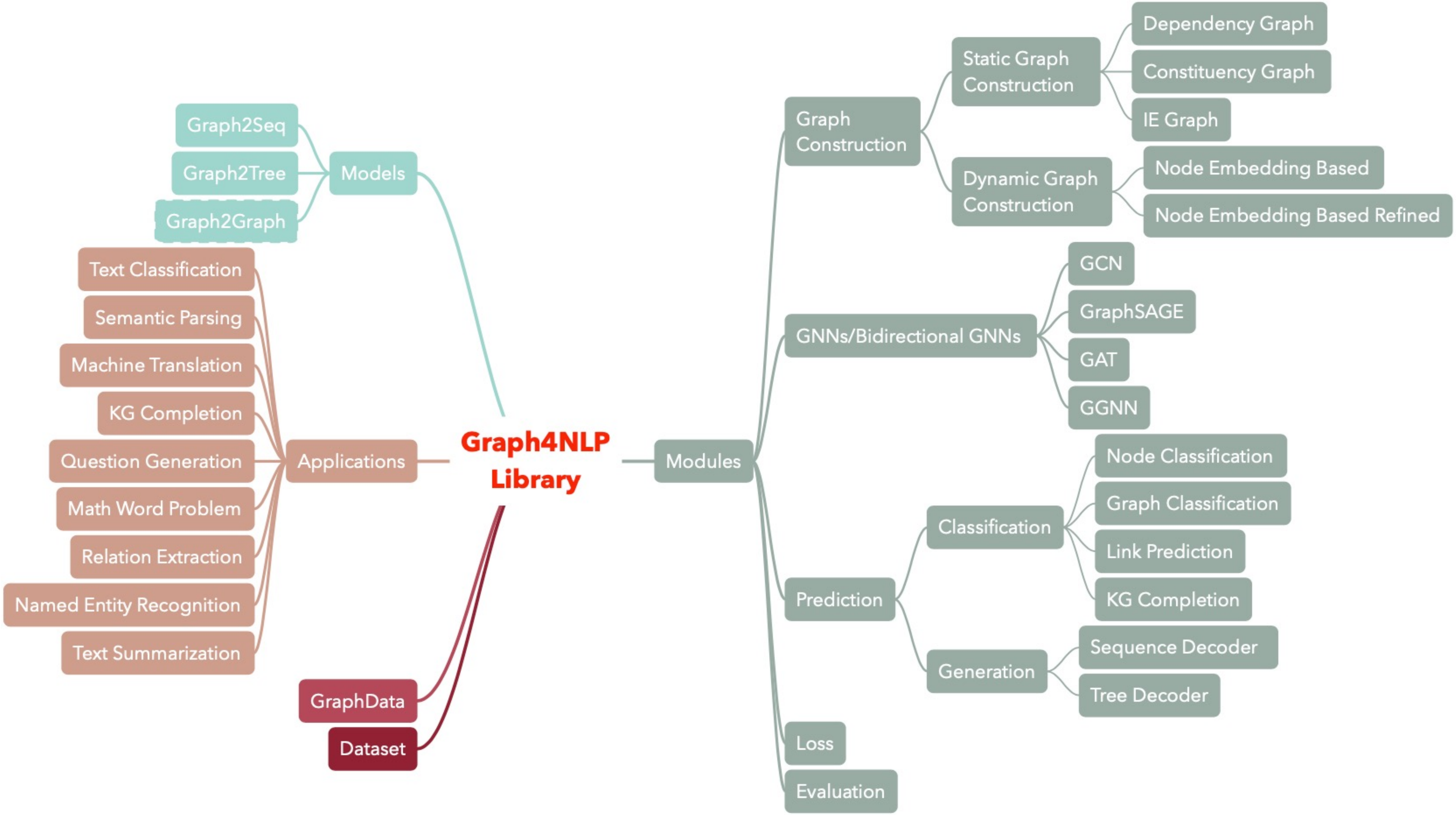

Text Sequence
Static Graph Construction
Natural Graph in NLP
Graph Data
i. Topology construction
ii. Embedding construction
Dynamic Graph Construction
Node/Graph Embedding
With mechanisms like attention, copy, coverage, etc.
Node/Link/Graph Prediction
Sequence/Tree/ Graph Decoder

Performance of Built-in NLP Tasks



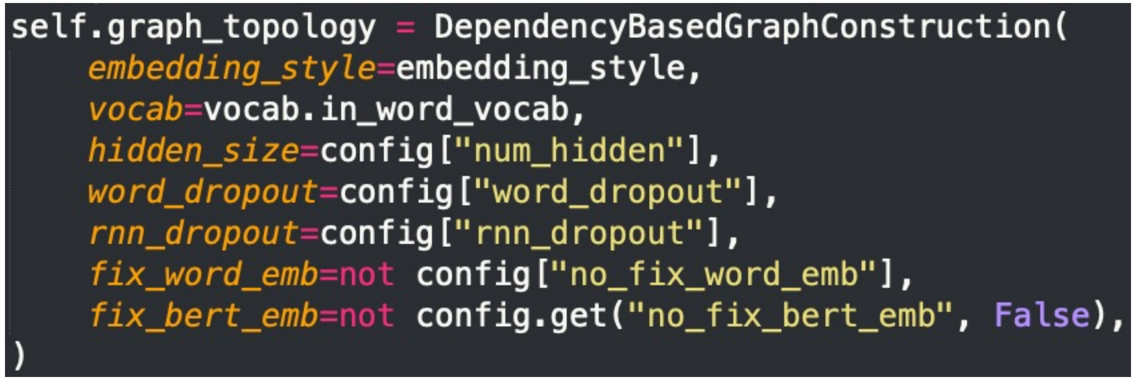
Task	Dataset	GNN Model	Graph construction	Evaluation	Performance
Text classification	TRECT CAirline CNSST	GAT	Dependency	Accuracy	0.948 0.769 0.538
Semantic Parsing	JOBS	SAGE	Constituency	Execution accuracy	0.936
Question generation	SQuAD	GGNN	Dependency	BLEU-4	0.15175
Machine translation	IWSLT14	GCN	Dynamic	BLEU-4	0.3212
Summarization	CNN(30k)	GCN	Dependency	ROUGE-1	26.4
Knowledge graph completion	Kinship	GCN	Dependency	MRR	82.4
Math word problem	MAWPS MATHQA	SAGE	Dynamic	Solution accuracy Exact match	76.4 61.07

Dive Into Graph4NLP Library



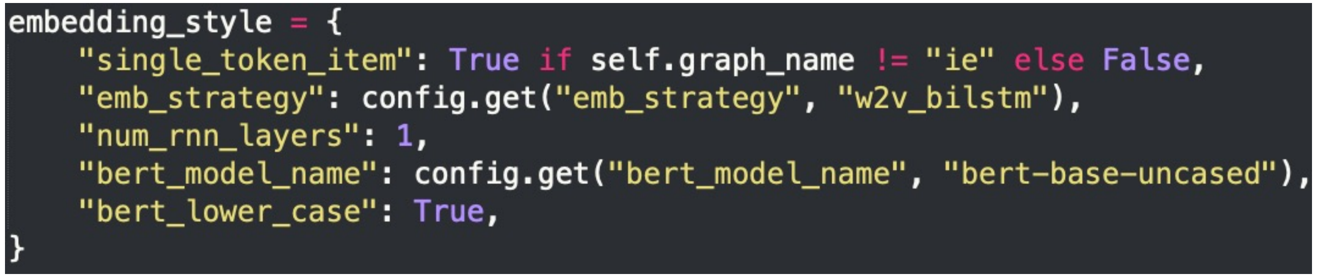
Graph Construction Module

- Topology construction
  - Static graph construction
    - Dependency graph construction
    - Constituency graph construction
    - IE graph construction
  - Dynamic graph construction
    - Node embedding based
    - Node embedding based refined (i.e., static & dynamic hybrid)



```
self.graph_topology = DependencyBasedGraphConstruction(
    embedding_style=embedding_style,
    vocab=vocab.in_word_vocab,
    hidden_size=config["num_hidden"],
    word_dropout=config["word_dropout"],
    rnn_dropout=config["rnn_dropout"],
    fix_word_emb=not config["no_fix_word_emb"],
    fix_bert_emb=not config.get("no_fix_bert_emb", False),
)
```

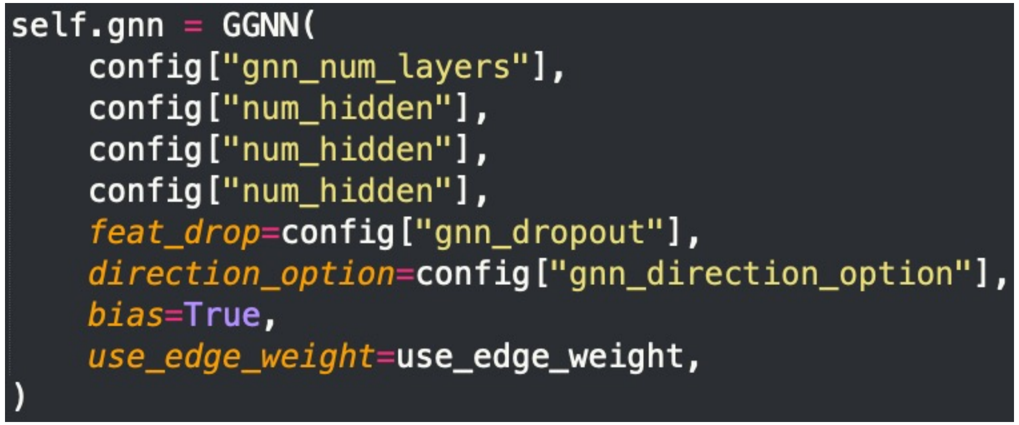
- Embedding construction (i.e., initialization)
  - Single-token & multi-token node/edge
  - Various built-in strategies for node/edge embedding initialization (non-exhaustive list)
    - ‘w2v’
    - ‘w2v_bilstm’
    - 'bert'
    - 'bert_bilstm'
    - 'w2v_bert’
    - 'w2v_bert_bilstm'



```
embedding_style = {
    "single_token_item": True if self.graph_name != "ie" else False,
    "emb_strategy": config.get("emb_strategy", "w2v_bilstm"),
    "num_rnn_layers": 1,
    "bert_model_name": config.get("bert_model_name", "bert-base-uncased"),
    "bert_lower_case": True,
}
```

Graph Embedding Module

- Common GNN variants
  - GCN
  - GAT
  - GraphSAGE
  - GGNN
- direction_option
  - ‘undirected’
  - ‘bi_fuse’
  - ‘bi_sep’
- use_edge_weight

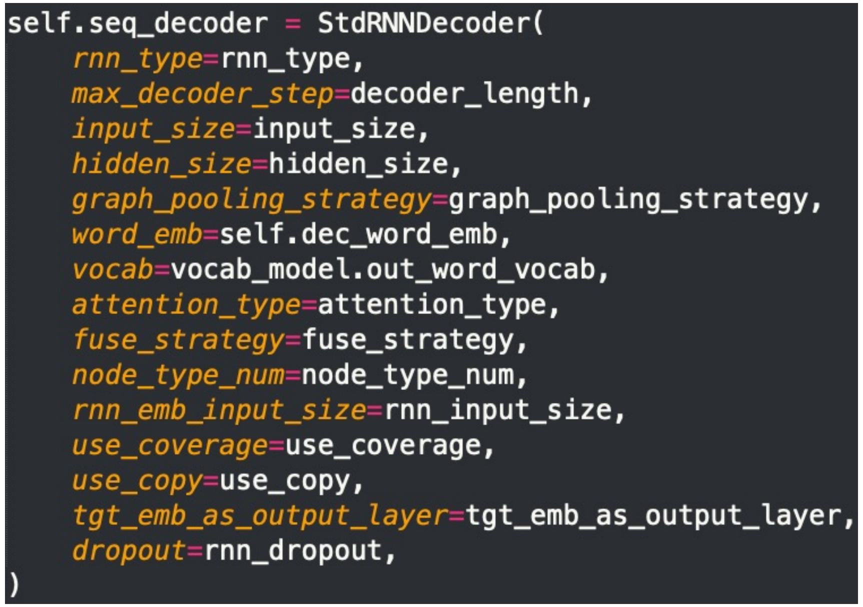


```
self.gnn = GGNN(
    config["gnn_num_layers"],
    config["num_hidden"],
    config["num_hidden"],
    config["num_hidden"],
    feat_drop=config["gnn_dropout"],
    direction_option=config["gnn_direction_option"],
    bias=True,
    use_edge_weight=use_edge_weight,
)
```

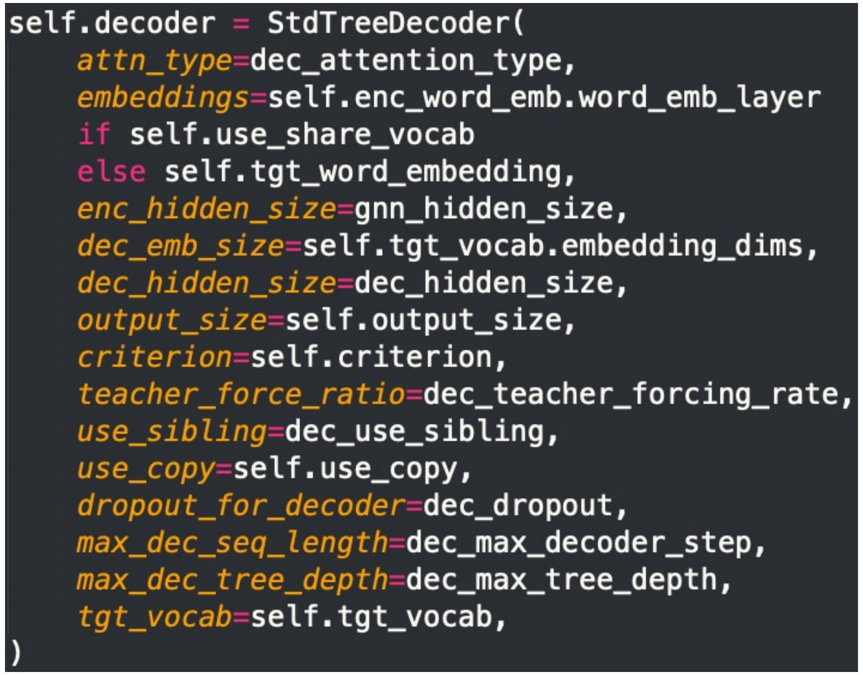
Prediction Module

- Classification
  - Node classification
  - Graph classification
  - Link prediction
  - KG completion
  - Pooling: avg_pool, max_pool

- Generation
  - Sequence decoder
  - Tree decoder
  - Attention, copy, coverage mechanisms



```
self.seq_decoder = StdRNNDecoder(
    rnn_type=rnn_type,
    max_decoder_step=decoder_length,
    input_size=input_size,
    hidden_size=hidden_size,
    graph_pooling_strategy=graph_pooling_strategy,
    word_emb=self.dec_word_emb,
    vocab=vocab_model.out_word_vocab,
    attention_type=attention_type,
    fuse_strategy=fuse_strategy,
    node_type_num=node_type_num,
    rnn_emb_input_size=rnn_input_size,
    use_coverage=use_coverage,
    use_copy=use_copy,
    tgt_emb_as_output_layer=tgt_emb_as_output_layer,
    dropout=rnn_dropout,
)
```

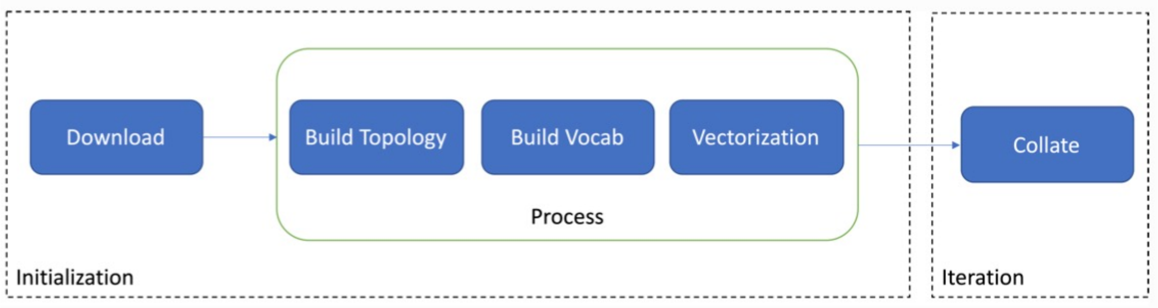


```
self.decoder = StdTreeDecoder(
    attn_type=dec_attention_type,
    embeddings=self.enc_word_emb.word_emb_layer
    if self.use_share_vocab
    else self.tgt_word_embedding,
    enc_hidden_size=gnn_hidden_size,
    dec_emb_size=self.tgt_vocab.embedding_dims,
    dec_hidden_size=dec_hidden_size,
    output_size=self.output_size,
    criterion=self.criterion,
    teacher_force_ratio=dec_teacher_forcing_rate,
    use_sibling=dec_use_sibling,
    use_copy=self.use_copy,
    dropout_for_decoder=dec_dropout,
    max_dec_seq_length=dec_max_decoder_step,
    max_dec_tree_depth=dec_max_tree_depth,
    tgt_vocab=self.tgt_vocab,
)
```

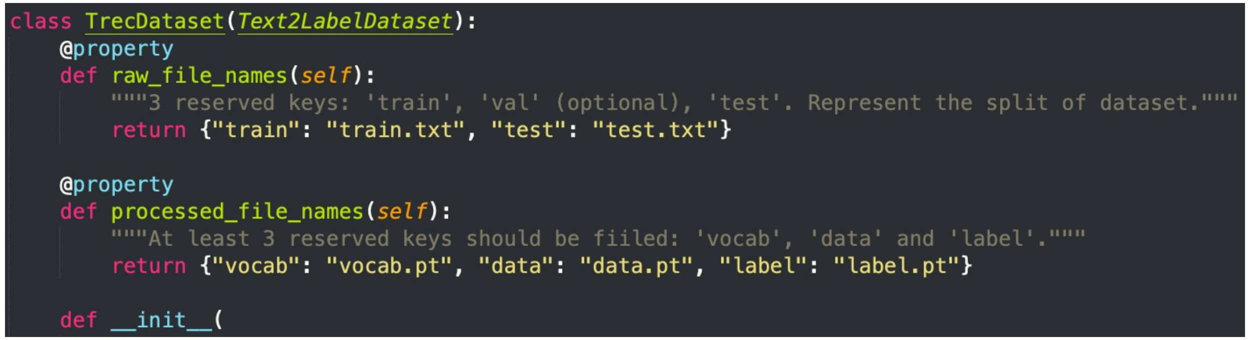
Built-in high-level Graph2Seq, Graph2Tree APIs. Config in, model out.

Dataset

- Built-in dataset types
  - Text2TextDataset
  - TextToTreeDataset
  - Text2LabelDataset
  - SequenceLabelingDataset
  - DoubleText2TextDataset



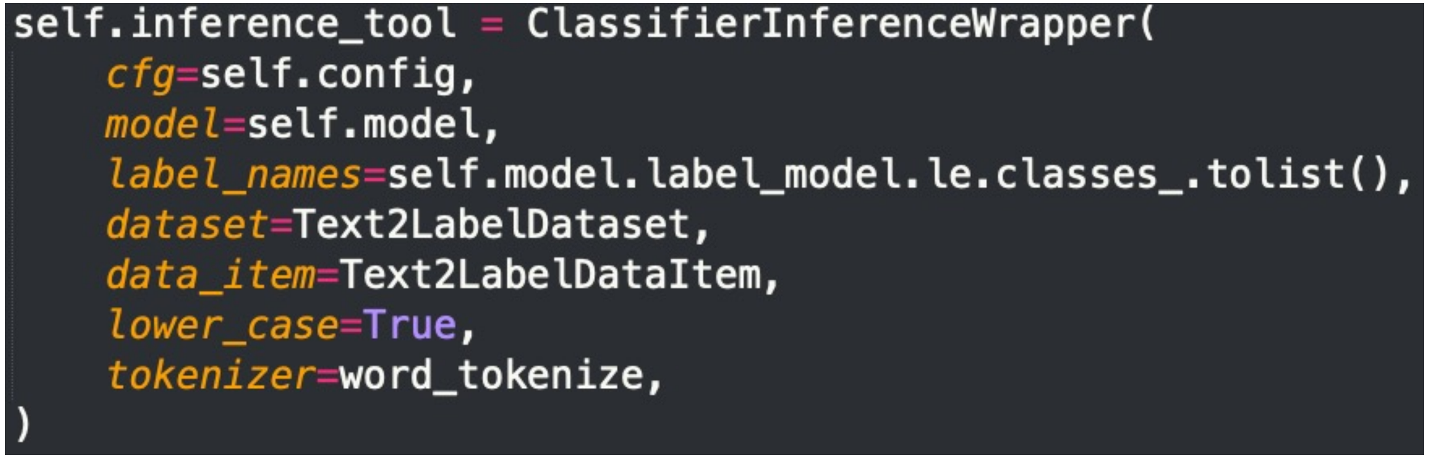
Dataset Workflow



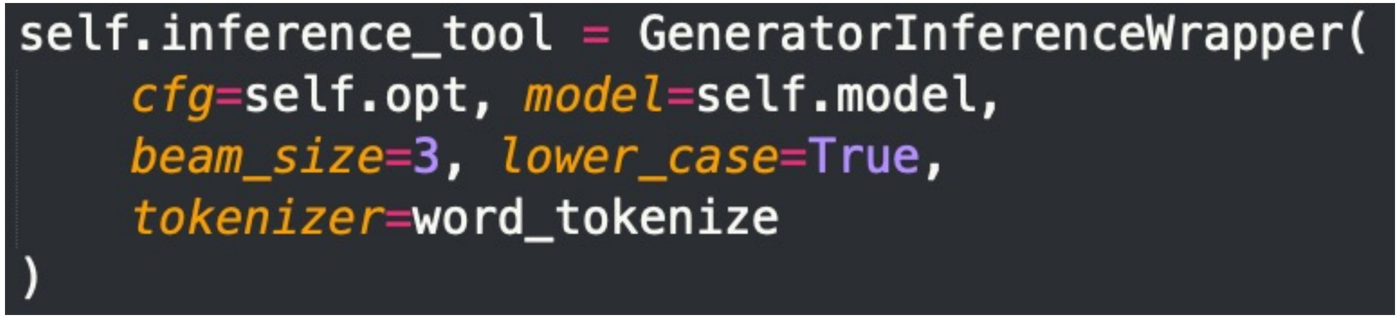
```
class TrecDataset(Text2LabelDataset):
    @property
    def raw_file_names(self):
        """3 reserved keys: 'train', 'val' (optional), 'test'. Represent the split of dataset."""
        return {"train": "train.txt", "test": "test.txt"}

    @property
    def processed_file_names(self):
        """At least 3 reserved keys should be fiiled: 'vocab', 'data' and 'label'."""
        return {"vocab": "vocab.pt", "data": "data.pt", "label": "label.pt"}

    def __init__(
```

Inference

- Inference wrapper
  - classifier_inference_wrapper.py
  - generator_inference_wrapper.py



```
self.inference_tool = ClassifierInferenceWrapper(
    cfg=self.config,
    model=self.model,
    label_names=self.model.label_model.le.classes_.tolist(),
    dataset=Text2LabelDataset,
    data_item=Text2LabelDataItem,
    lower_case=True,
    tokenizer=word_tokenize,
)
```

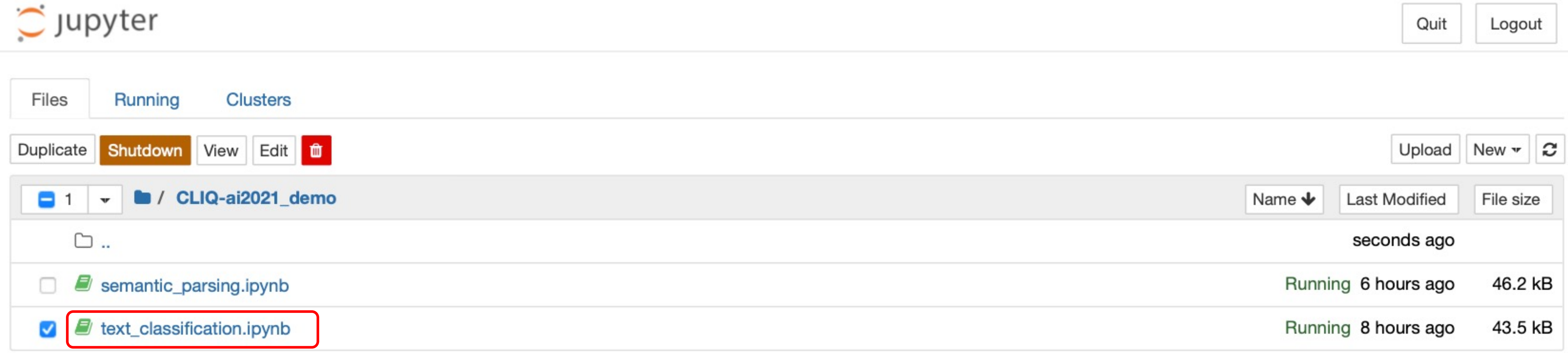


```
self.inference_tool = GeneratorInferenceWrapper(
    cfg=self.opt, model=self.model,
    beam_size=3, lower_case=True,
    tokenizer=word_tokenize
)
```

Graph4NLP Demo

Demo 1: Building a Text Classification Application

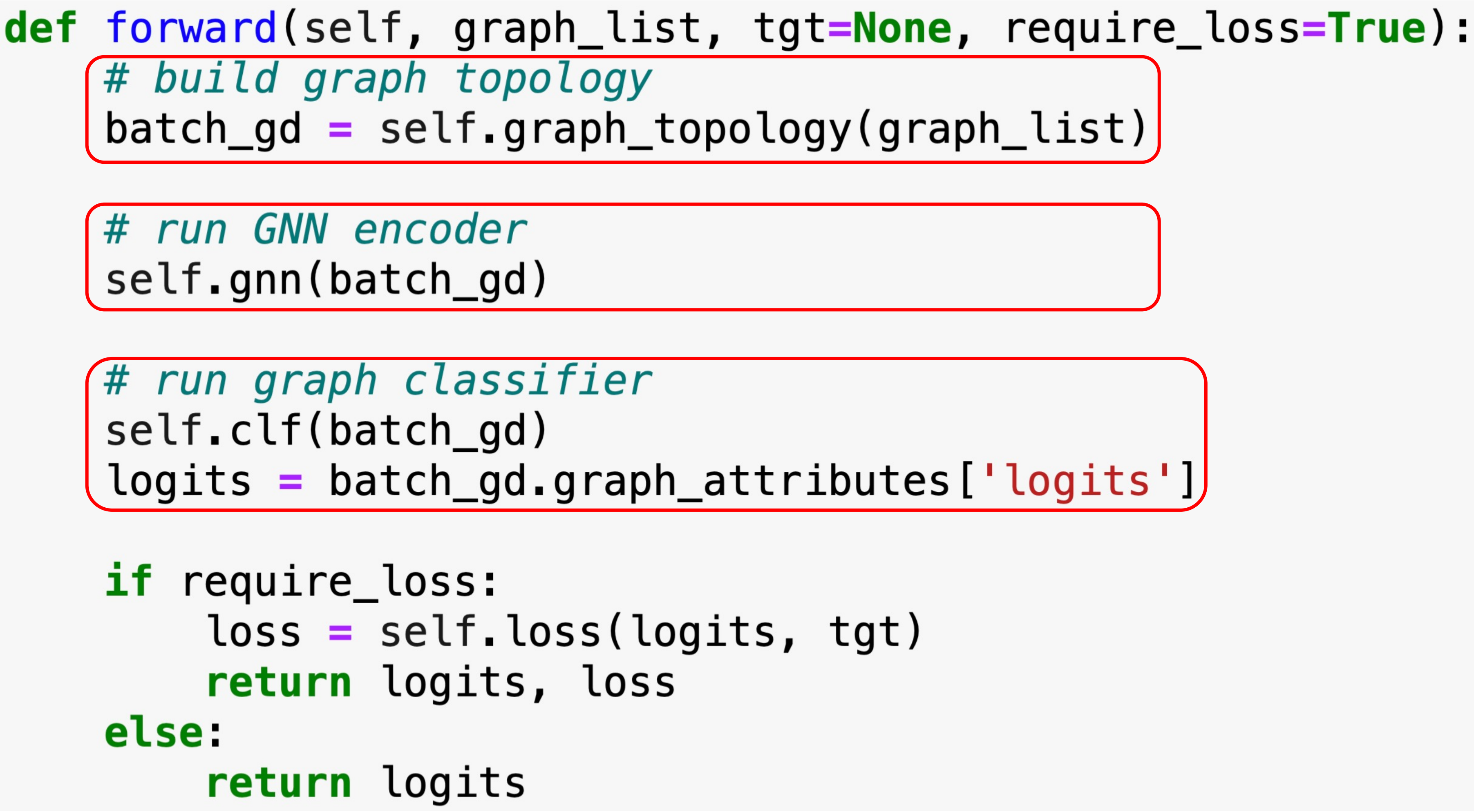
1) git clone https://github.com/graph4ai/graph4nlp_demo
2) follow Get Started instructions in README



/ CLIQ-ai2021_demo

	Name		Last Modified	File size
	..		seconds ago	
□	semantic_parsing.ipynb	Running	6 hours ago	46.2 kB
☑	text_classification.ipynb	Running	8 hours ago	43.5 kB

Demo 1: Building a Text Classification Application



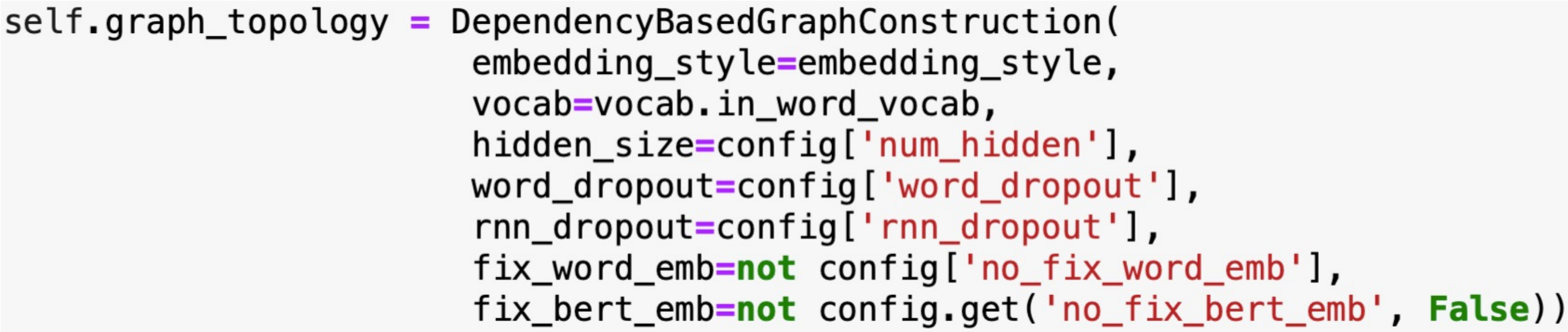
```
def forward(self, graph_list, tgt=None, require_loss=True):
    # build graph topology
    batch_gd = self.graph_topology(graph_list)

    # run GNN encoder
    self.gnn(batch_gd)

    # run graph classifier
    self.clf(batch_gd)
    logits = batch_gd.graph_attributes['logits']

    if require_loss:
        loss = self.loss(logits, tgt)
        return logits, loss
    else:
        return logits
```

Model arch

https://github.com/graph4ai/graph4nlp_demo/tree/main/CLIQ-ai2021_demo

Demo 1: Building a Text Classification Application

Graph construction API, various built-in options, can be customized

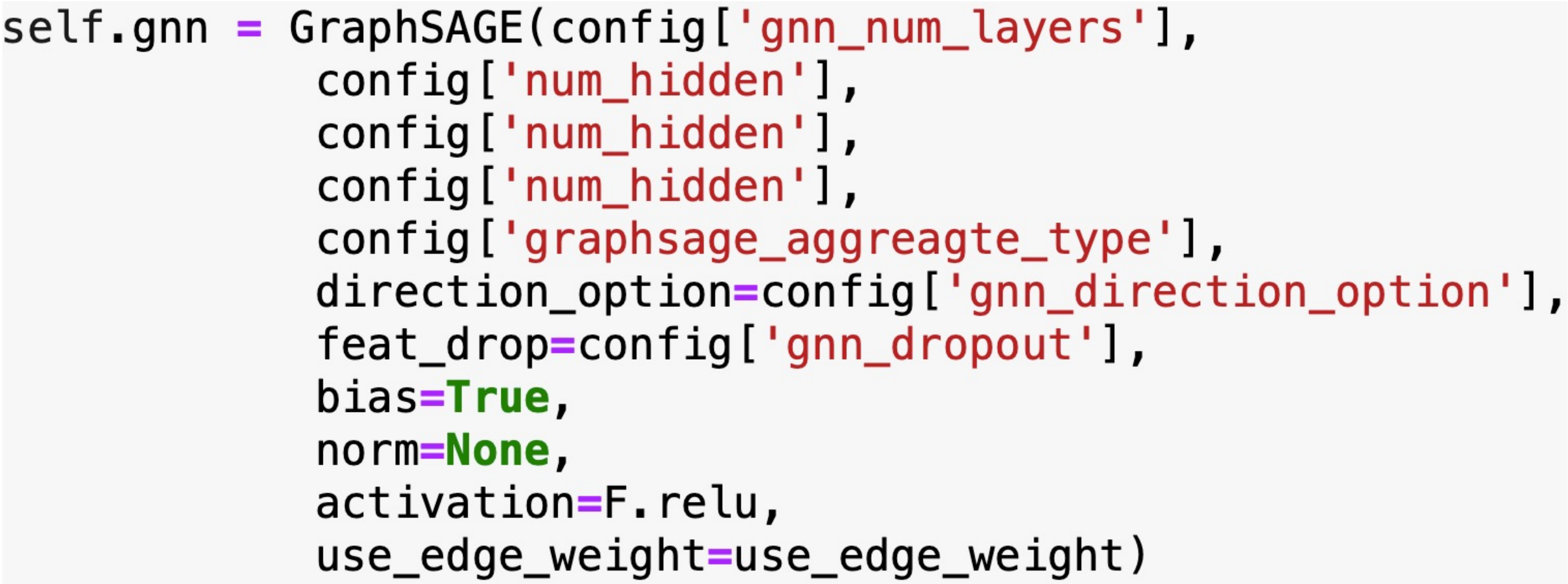


```
self.graph_topology = DependencyBasedGraphConstruction(
                        embedding_style=embedding_style,
                        vocab=vocab.in_word_vocab,
                        hidden_size=config['num_hidden'],
                        word_dropout=config['word_dropout'],
                        rnn_dropout=config['rnn_dropout'],
                        fix_word_emb=not config['no_fix_word_emb'],
                        fix_bert_emb=not config.get('no_fix_bert_emb', False))
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/CLIQ-ai2021_demo

Demo 1: Building a Text Classification Application

GNN API, various built-in options, can be customized

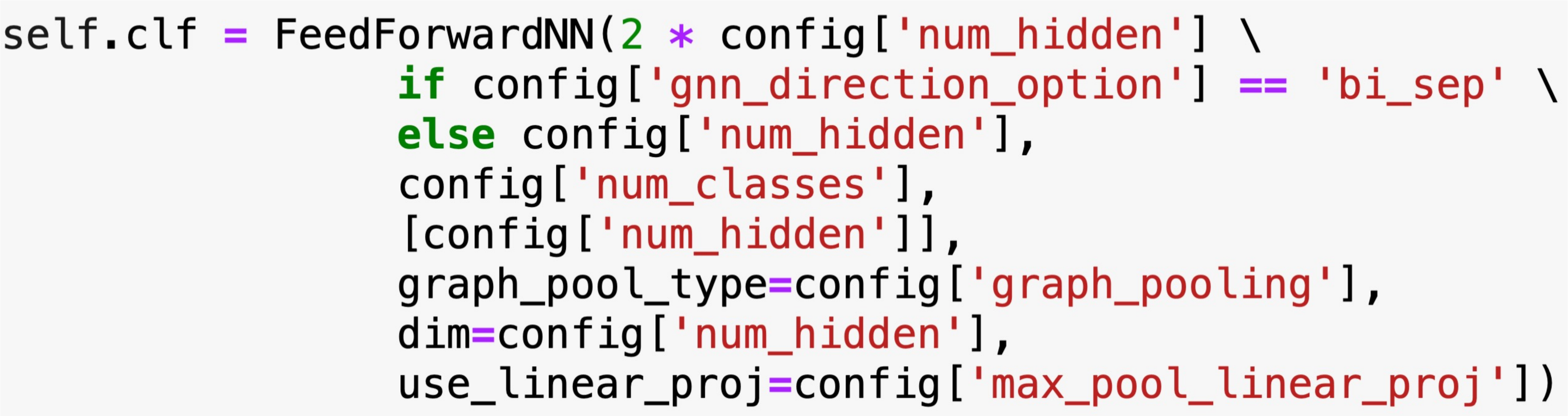


```
self.gnn = GraphSAGE(config['gnn_num_layers'],
            config['num_hidden'],
            config['num_hidden'],
            config['num_hidden'],
            config['graphsage_aggreagte_type'],
            direction_option=config['gnn_direction_option'],
            feat_drop=config['gnn_dropout'],
            bias=True,
            norm=None,
            activation=F.relu,
            use_edge_weight=use_edge_weight)
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/CLIQ-ai2021_demo

Demo 1: Building a Text Classification Application

Prediction API, various built-in options, can be customized

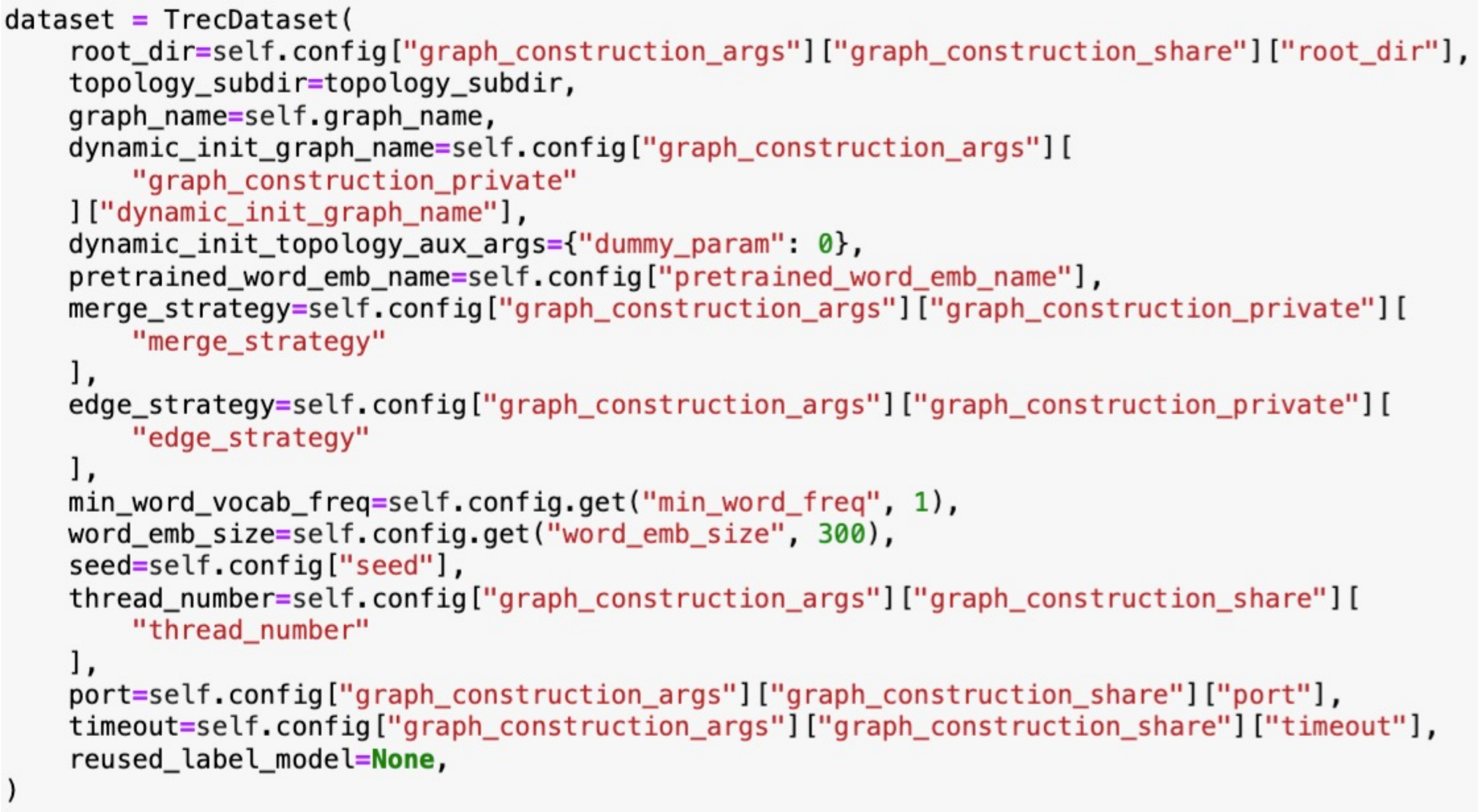


```python
self.clf = FeedForwardNN(2 * config['num_hidden'] \
                if config['gnn_direction_option'] == 'bi_sep' \
                else config['num_hidden'],
                config['num_classes'],
                [config['num_hidden']],
                graph_pool_type=config['graph_pooling'],
                dim=config['num_hidden'],
                use_linear_proj=config['max_pool_linear_proj'])
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/CLIQ-ai2021_demo

Demo 1: Building a Text Classification Application

Dataset API, various built-in options, can be customized

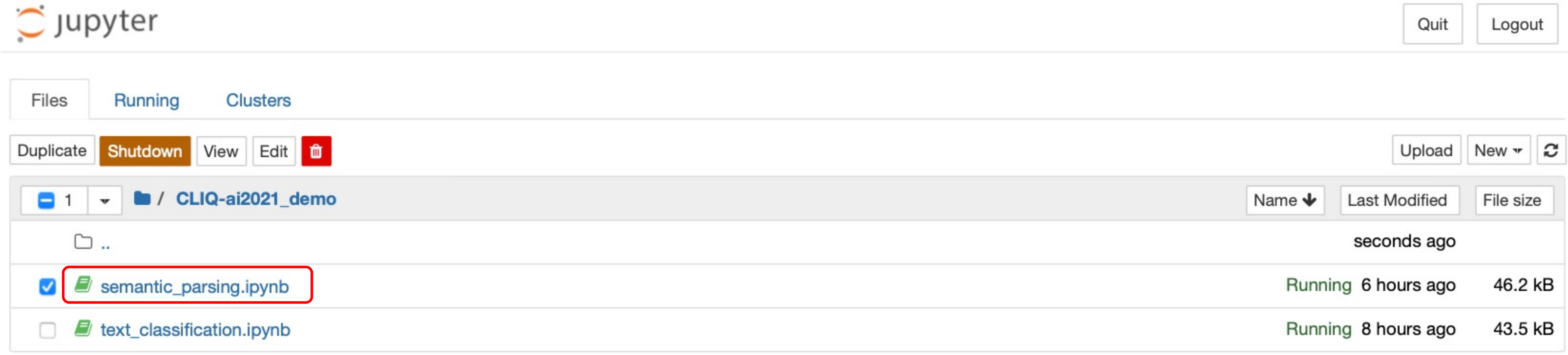


```
dataset = TrecDataset(
    root_dir=self.config["graph_construction_args"]["graph_construction_share"]["root_dir"],
    topology_subdir=topology_subdir,
    graph_name=self.graph_name,
    dynamic_init_graph_name=self.config["graph_construction_args"][
        "graph_construction_private"
    ]["dynamic_init_graph_name"],
    dynamic_init_topology_aux_args={"dummy_param": 0},
    pretrained_word_emb_name=self.config["pretrained_word_emb_name"],
    merge_strategy=self.config["graph_construction_args"]["graph_construction_private"][
        "merge_strategy"
    ],
    edge_strategy=self.config["graph_construction_args"]["graph_construction_private"][
        "edge_strategy"
    ],
    min_word_vocab_freq=self.config.get("min_word_freq", 1),
    word_emb_size=self.config.get("word_emb_size", 300),
    seed=self.config["seed"],
    thread_number=self.config["graph_construction_args"]["graph_construction_share"][
        "thread_number"
    ],
    port=self.config["graph_construction_args"]["graph_construction_share"]["port"],
    timeout=self.config["graph_construction_args"]["graph_construction_share"]["timeout"],
    reused_label_model=None,
)
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/CLIQ-ai2021_demo

Demo 2: Building a Semantic Parsing Application

1) git clone https://github.com/graph4ai/graph4nlp_demo
2) follow Get Started instructions in README

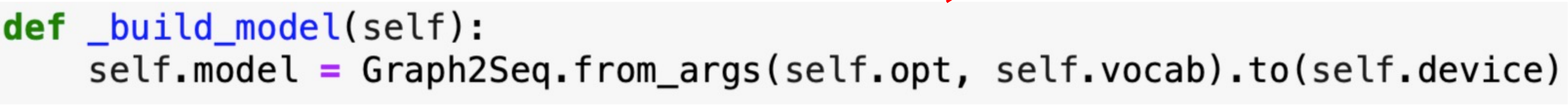


/ CLIQ-ai2021_demo

..		seconds ago	
☑ semantic_parsing.ipynb	Running	6 hours ago	46.2 kB
□ text_classification.ipynb	Running	8 hours ago	43.5 kB

Demo 2: Building a Semantic Parsing Application

Graph2Seq API



```
def _build_model(self):
    self.model = Graph2Seq.from_args(self.opt, self.vocab).to(self.device)
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/CLIQ-ai2021_demo

Resources

- Our Graph4NLP library aims to make easy use of GNNs for NLP:
  - DLG4NLP website: https://dlg4nlp.github.io/index.html
  - Survey: https://arxiv.org/abs/2106.06090
  - Graph4NLP library: https://github.com/graph4ai/graph4nlp
  - Graph4NLP documentation https://graph4ai.github.io/graph4nlp/
  - Literature list: https://github.com/graph4ai/graph4nlp_literature

Thanks!
Q&A

Yu (Hugo) Chen
Research Scientist
Meta AI,
Email: hugochan2013@gmail.com, hugochen@fb.com
Web: http://academic.hugochan.net