Graph4NLP

Graph4NLP : A Library for Deep Learning on Graphs for NLP

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DLG4NLP@NAACL'22

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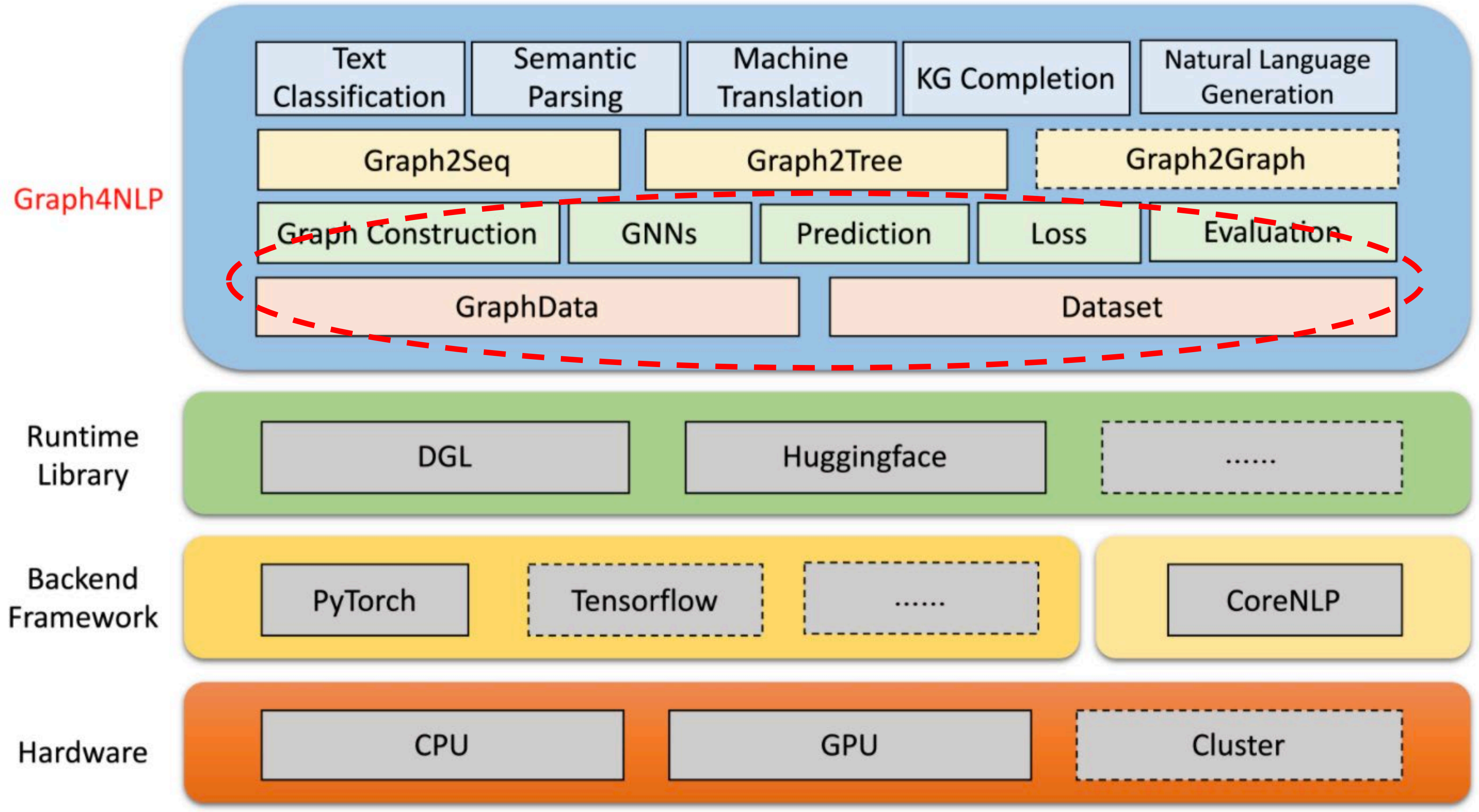
Graph4NLP

Graph4NLP: A Library for Deep Learning on Graphs for NLP

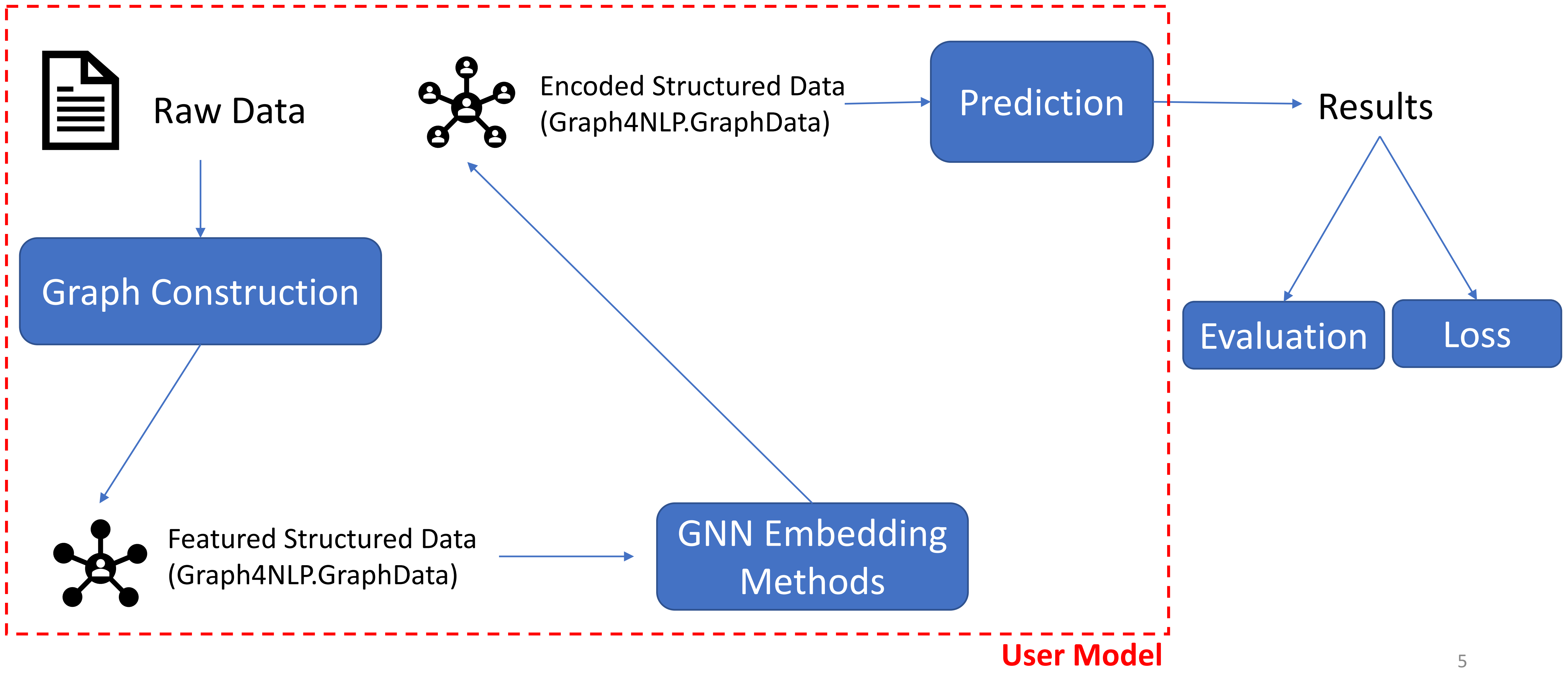
Library GitHub: https://github.com/graph4ai/graph4nlp Graph4nlp Website: https://dlg4nlp.github.io/index.html

Overall Architecture of Graph4NLP Library



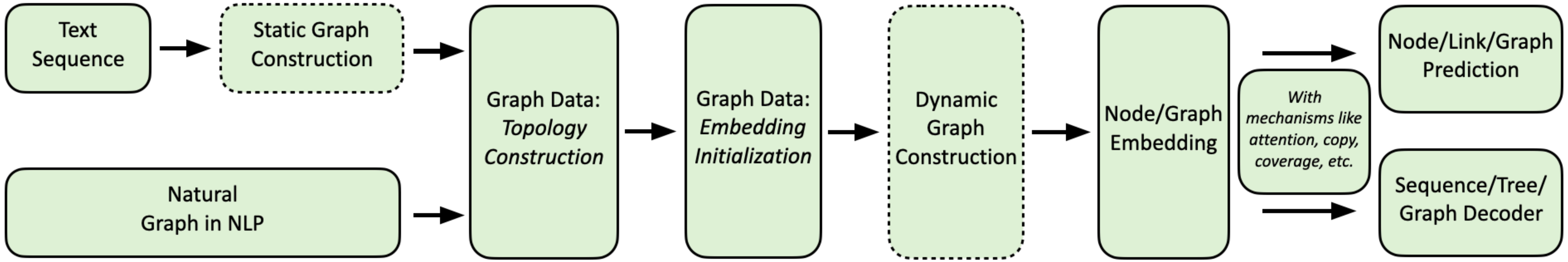
DGL: https://github.com/dmlc/dgl, DIG: https://github.com/divelab/DIG, Huggingface: https://github.com/huggingface/transformers

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: *Topology Construction*
Graph Data: *Embedding Initialization*
Dynamic Graph Construction
Node/Graph Embedding
With mechanisms like attention, copy, coverage, etc.
Node/Link/Graph Prediction
Sequence/Tree/ Graph Decoder

Key Features and Future Releases

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

Future Releases (coming soon!)

- **V0.6 new features: new configuration system, relational GNN support, etc.**
- **Future to do: Native multi-GPU support, better support for customized graph construction, etc.**

Graph4NLP

Performance of Built-in NLP Tasks

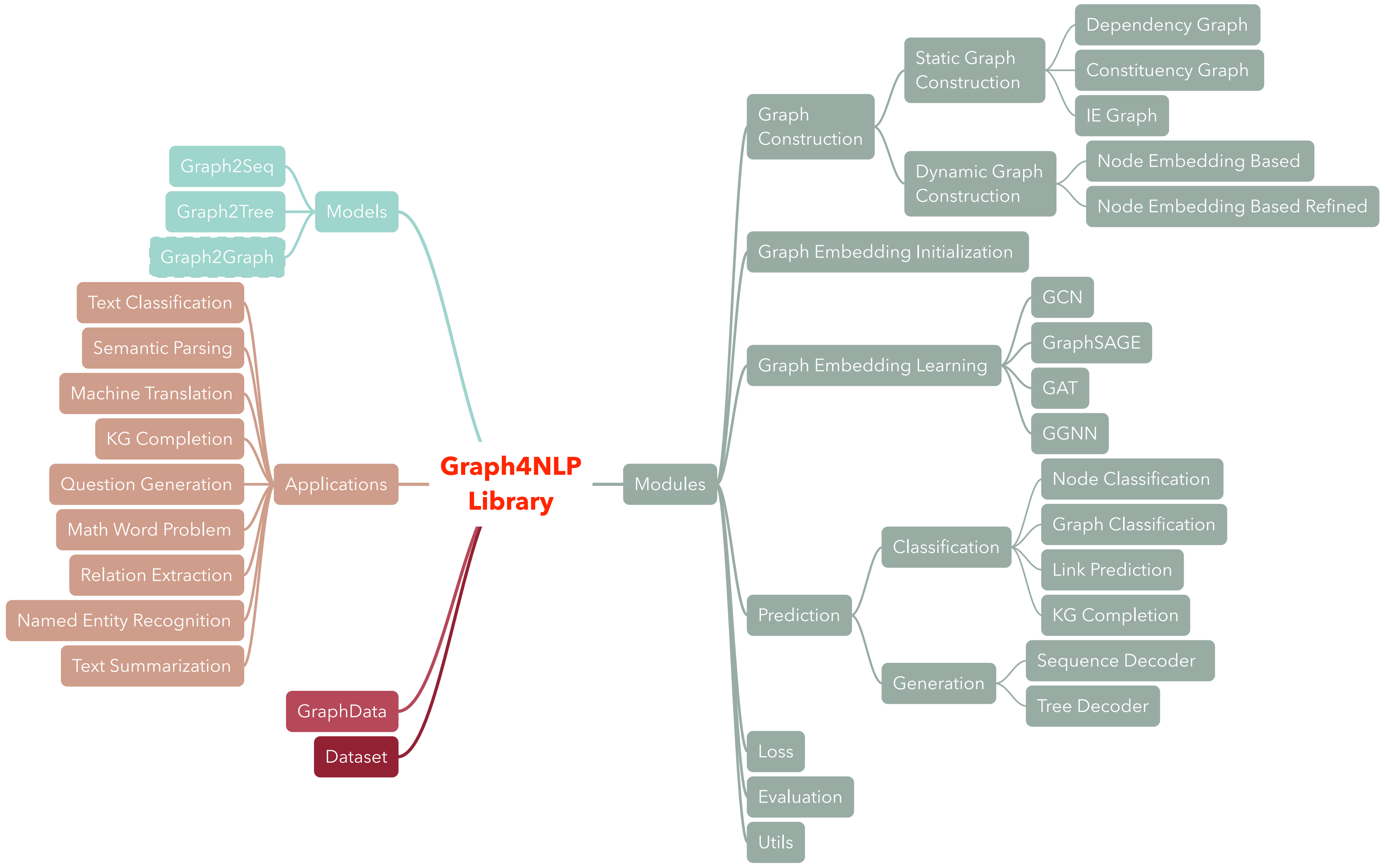
Task	Dataset	GNN Model	Graph construction	Evaluation	Performance
Text classification	TRECT CAirline CNSST	GAT	Dependency	Accuracy	0.948 0.769 0.538
Semantic Parsing	JOBS	SAGE	Constituency	Execution accuracy	0.936
Question generation	SQuAD	GGNN	Dependency	BLEU-4	0.15175
Machine translation	IWSLT14	GCN	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

Graph4NLP

Graph4NLP: Dive into the Library

Library GitHub: https://github.com/graph4ai/graph4nlp   Graph4nlp Website: https://dlg4nlp.github.io/index.html

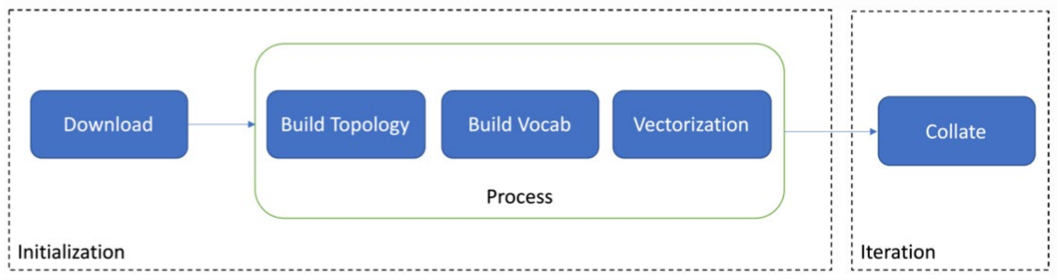
Specific components of Graph4NLP Library



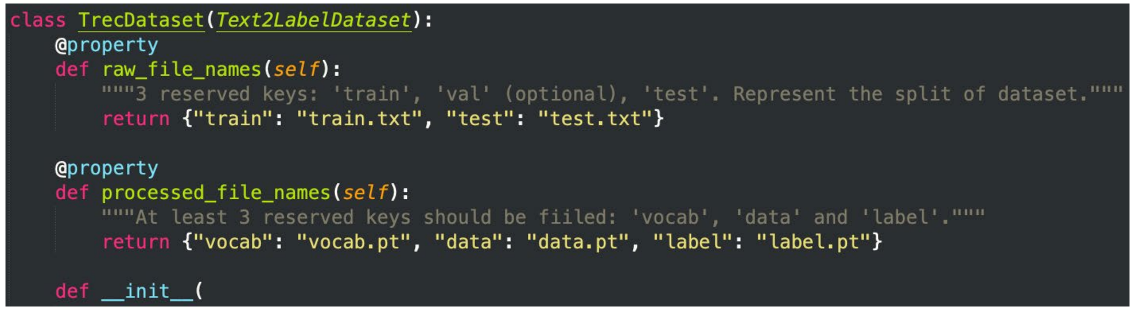
Graph4NLP

Dataset

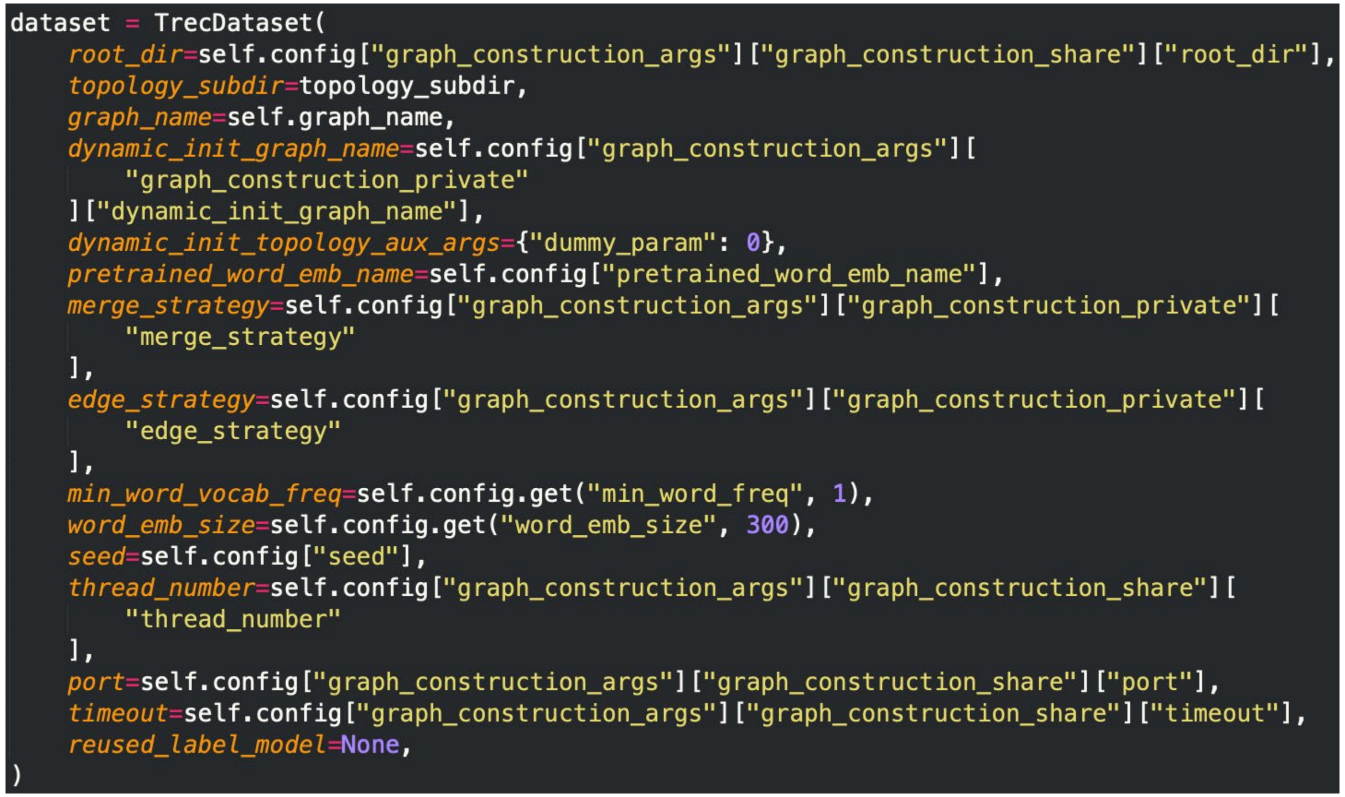
- Built-in dataset types
  - Text2TextDataset
  - TextToTreeDataset
  - Text2LabelDataset
  - SequenceLabelingDataset
  - DoubleText2TextDataset



Dataset Workflow



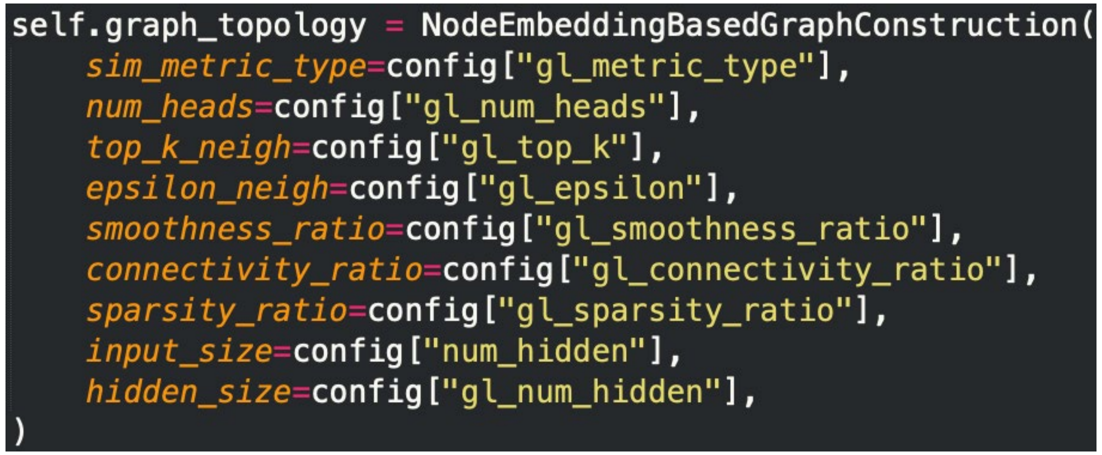
```
class TrecDataset(Text2LabelDataset):
    @property
    def raw_file_names(self):
        """3 reserved keys: 'train', 'val' (optional), 'test'. Represent the split of dataset."""
        return {"train": "train.txt", "test": "test.txt"}

    @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__(
```



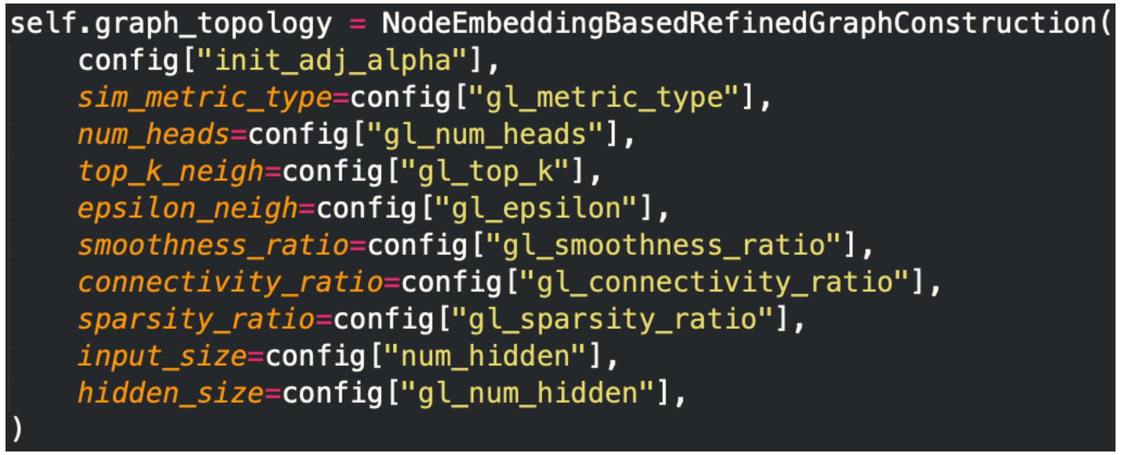
```
dataset = TrecDataset(
    root_dir=self.config["graph_construction_args"]["graph_construction_share"]["root_dir"],
    topology_subdir=topology_subdir,
    graph_name=self.graph_name,
    dynamic_init_graph_name=self.config["graph_construction_args"][
        "graph_construction_private"
    ]["dynamic_init_graph_name"],
    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,
)
```

Graph Construction Module

- 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)



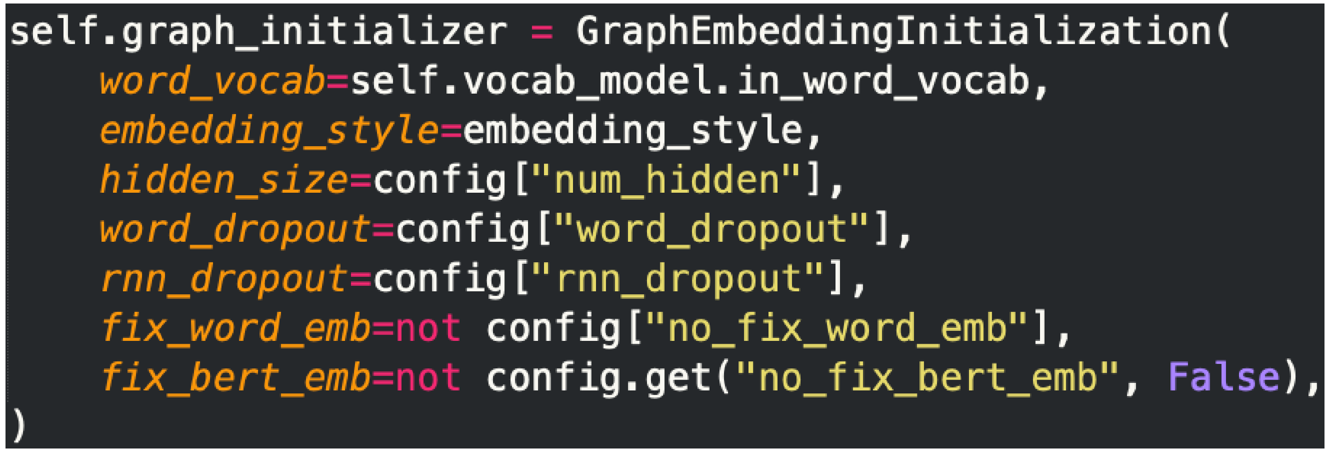
```
self.graph_topology = NodeEmbeddingBasedGraphConstruction(
    sim_metric_type=config["gl_metric_type"],
    num_heads=config["gl_num_heads"],
    top_k_neigh=config["gl_top_k"],
    epsilon_neigh=config["gl_epsilon"],
    smoothness_ratio=config["gl_smoothness_ratio"],
    connectivity_ratio=config["gl_connectivity_ratio"],
    sparsity_ratio=config["gl_sparsity_ratio"],
    input_size=config["num_hidden"],
    hidden_size=config["gl_num_hidden"],
)
```



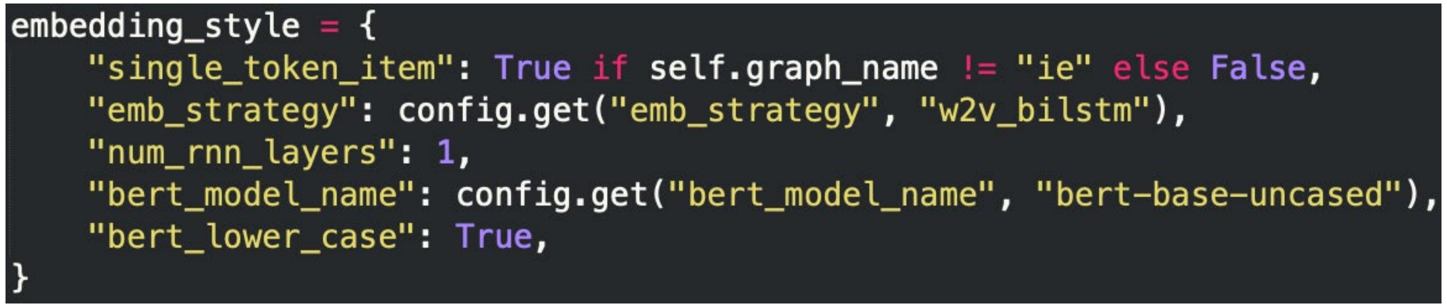
```
self.graph_topology = NodeEmbeddingBasedRefinedGraphConstruction(
    config["init_adj_alpha"],
    sim_metric_type=config["gl_metric_type"],
    num_heads=config["gl_num_heads"],
    top_k_neigh=config["gl_top_k"],
    epsilon_neigh=config["gl_epsilon"],
    smoothness_ratio=config["gl_smoothness_ratio"],
    connectivity_ratio=config["gl_connectivity_ratio"],
    sparsity_ratio=config["gl_sparsity_ratio"],
    input_size=config["num_hidden"],
    hidden_size=config["gl_num_hidden"],
)
```

Graph Embedding Initialization Module

- 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'



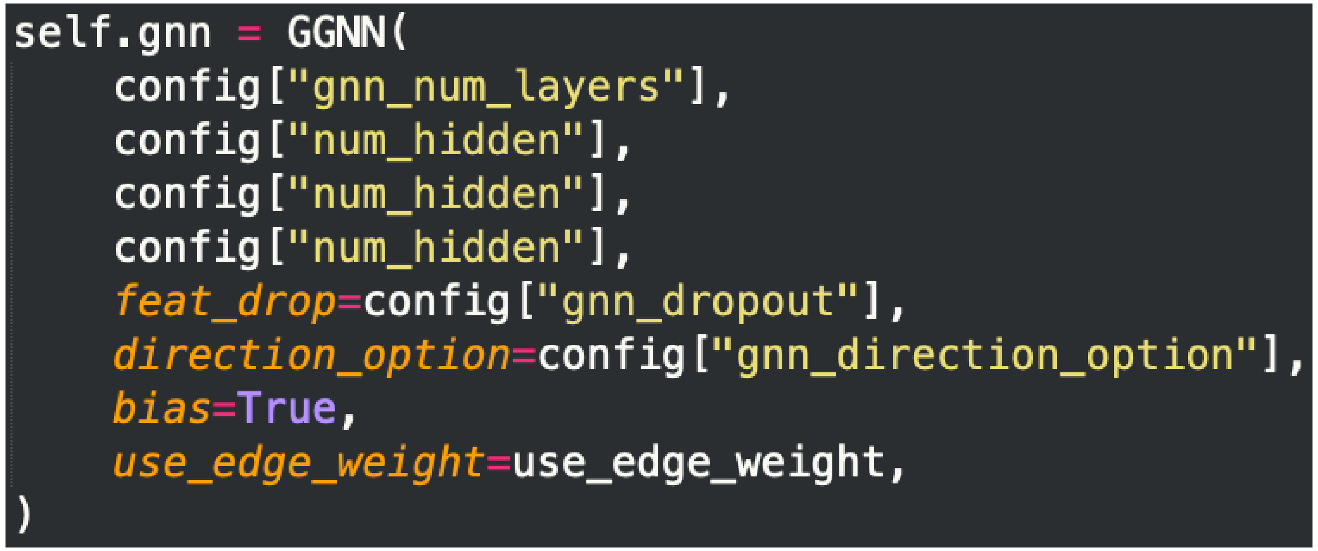
```
self.graph_initializer = GraphEmbeddingInitialization(
    word_vocab=self.vocab_model.in_word_vocab,
    embedding_style=embedding_style,
    hidden_size=config["num_hidden"],
    word_dropout=config["word_dropout"],
    rnn_dropout=config["rnn_dropout"],
    fix_word_emb=not config["no_fix_word_emb"],
    fix_bert_emb=not config.get("no_fix_bert_emb", False),
)
```



```
embedding_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 Learning Module

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

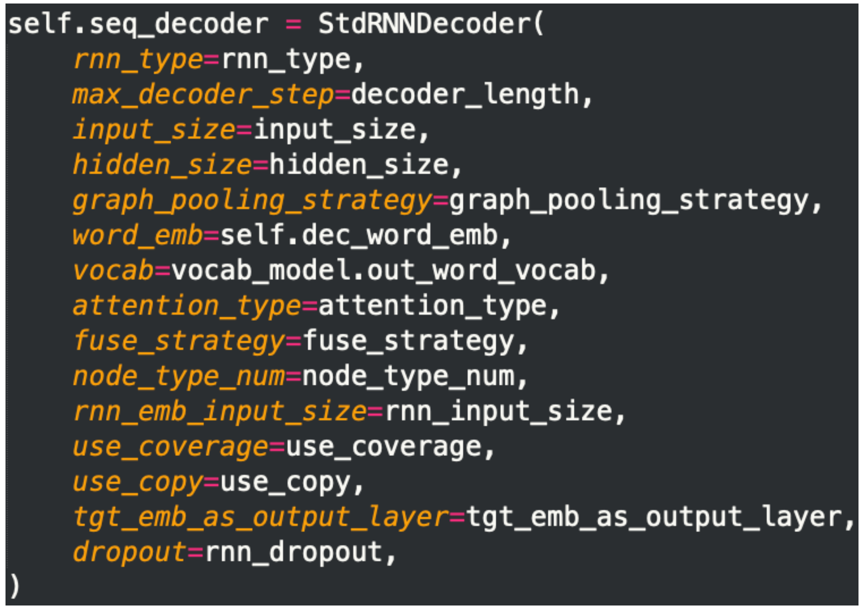


```
self.gnn = GGNN(
    config["gnn_num_layers"],
    config["num_hidden"],
    config["num_hidden"],
    config["num_hidden"],
    feat_drop=config["gnn_dropout"],
    direction_option=config["gnn_direction_option"],
    bias=True,
    use_edge_weight=use_edge_weight,
)
```

Graph4NLP

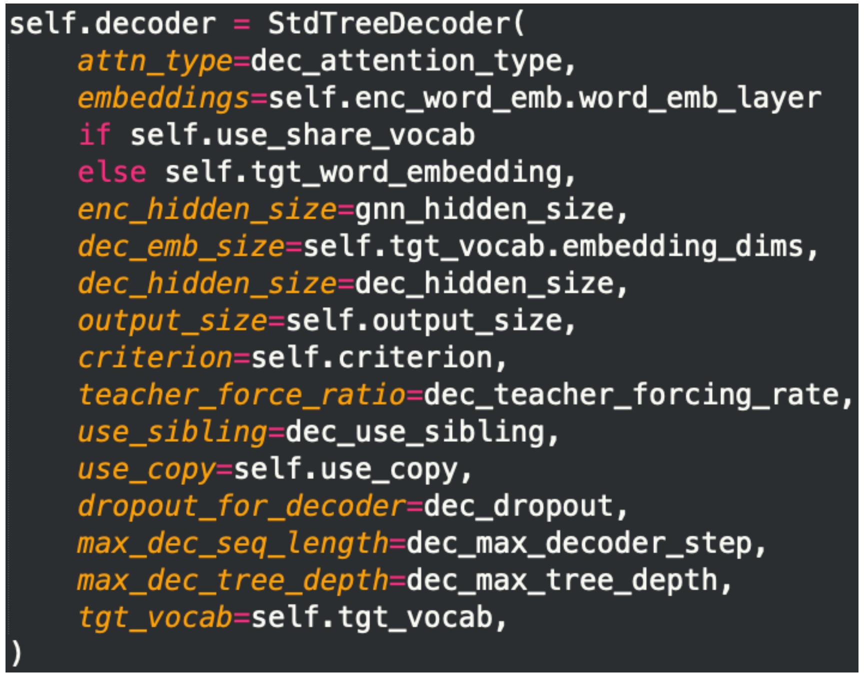
Prediction Module

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



```
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,
)
```

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

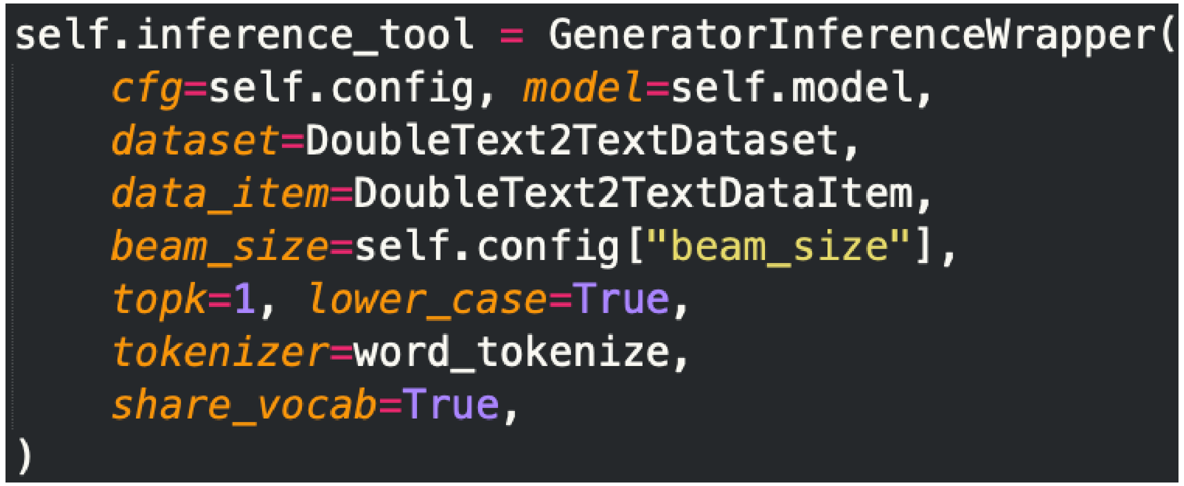


```
self.decoder = StdTreeDecoder(
    attn_type=dec_attention_type,
    embeddings=self.enc_word_emb.word_emb_layer
    if self.use_share_vocab
    else self.tgt_word_embedding,
    enc_hidden_size=gnn_hidden_size,
    dec_emb_size=self.tgt_vocab.embedding_dims,
    dec_hidden_size=dec_hidden_size,
    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,
)
```

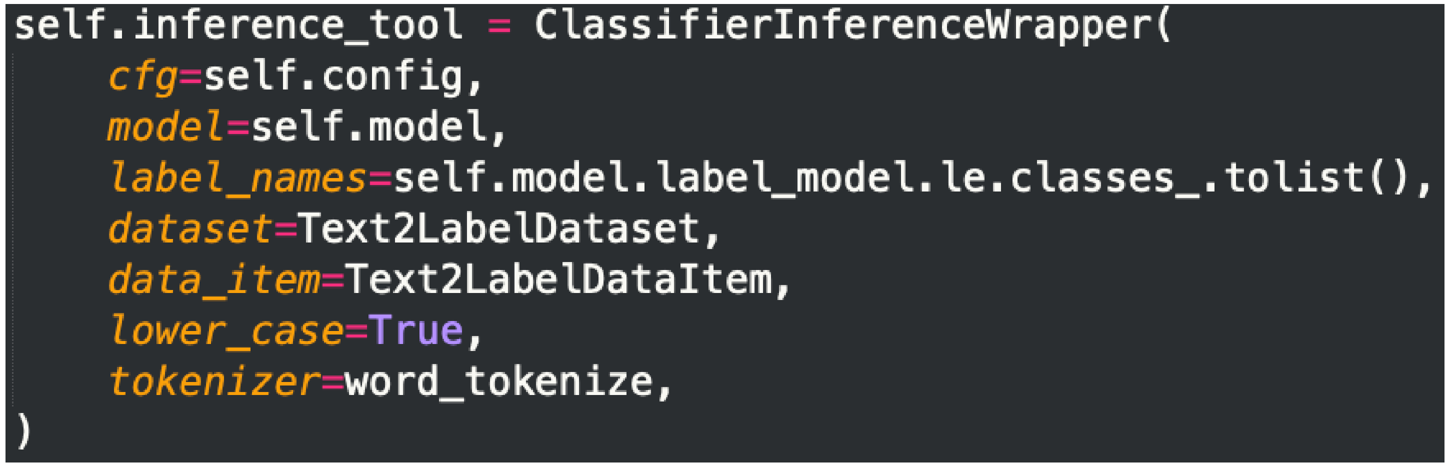
Built-in high-level Graph2Seq, Graph2Tree APIs. Config in, model out.

Inference

- Inference wrapper
  - classifier_inference_wrapper
  - generator_inference_wrapper
  - generator_inference_wrapper_for_tree



```
self.inference_tool = GeneratorInferenceWrapper(
    cfg=self.config, model=self.model,
    dataset=DoubleText2TextDataset,
    data_item=DoubleText2TextDataItem,
    beam_size=self.config["beam_size"],
    topk=1, lower_case=True,
    tokenizer=word_tokenize,
    share_vocab=True,
)
```



```
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,
)
```

Graph4NLP

Graph4NLP: A Brief History and Future

Year June/2021
Graph4NLP v0.4.1 Released, first library for promoting easy use of GNN for NLP

Year September/2021
Our **DLG4NLP website** launched: survey, library, tutorial, workshop and many more.

Year September/2021
Graph4NLP v0.5.1 released, Lint the codes, support testing with users 'own data, and fix many reported bugs.

Year January/2022
Graph4NLP v0.5.5 released, Support model.predict API by introducing wrapper functions, separate graph Topology and graph Embedding and many more...

Year April/2022
- DLG4NLP@ICLR2022 workshop

Year July/2022 (ongoing)
- DLG4NLP@NAACL 2022 workshop

Year July 2022 (planning)
-**Graph4NLP** v0.6.1 will be released, new configuration system, relational GNN
-Release a New Graph4NLP book by Cambridge Press

Graph4NLP

Thanks!
Q&A

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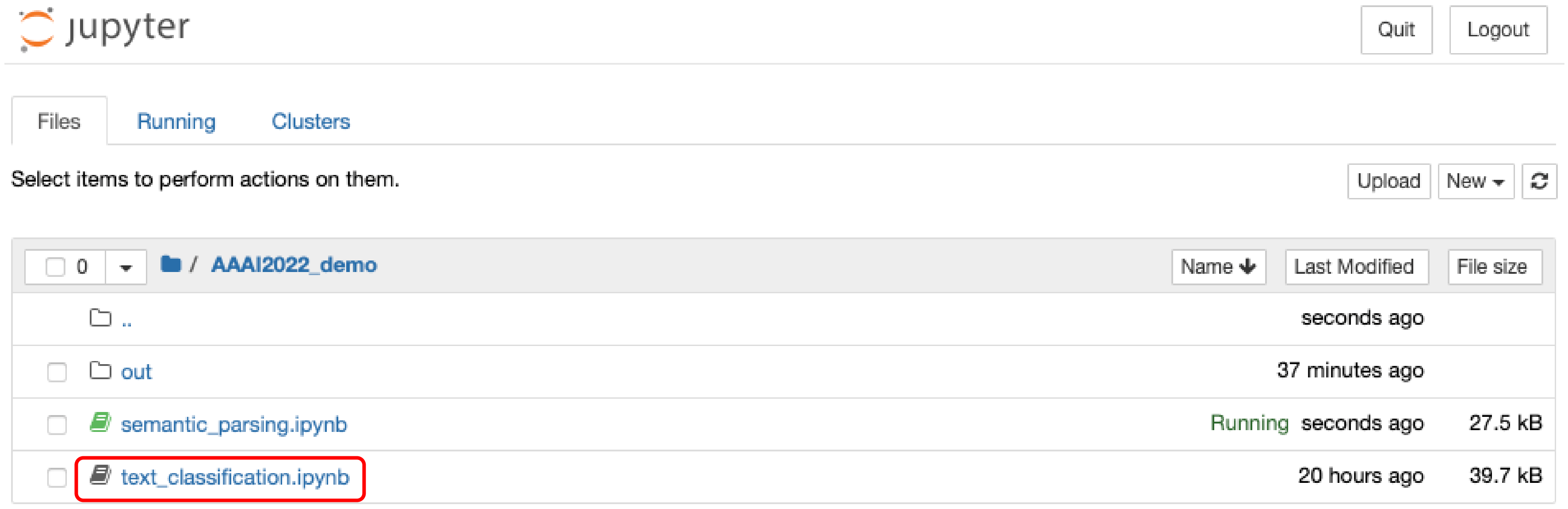
Web: https://sites.google.com/view/xiaojie-guo-personal-site

Graph4NLP: Live Demo

Library GitHub: https://github.com/graph4ai/graph4nlp Graph4nlp Website: https://dlg4nlp.github.io/index.html

Demo 1: Text Classification Application

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



Select items to perform actions on them.

/ AAAI2022_demo

Name	Last Modified	File size
..	seconds ago	
out	37 minutes ago	
semantic_parsing.ipynb	Running seconds ago	27.5 kB
text_classification.ipynb	20 hours ago	39.7 kB

Graph4NLP

Demo 1: Building a Text Classification Application

```python
def forward(self, graph_list, tgt=None, require_loss=True):
    # graph embedding initialization
    batch_gd = self.graph_initializer(graph_list)

    # run dynamic graph construction if turned on
    if hasattr(self, "graph_topology") and hasattr(self.graph_topology, "dynamic_topology"):
        batch_gd = self.graph_topology.dynamic_topology(batch_gd)

    # run GNN
    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
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/AAAI2022_demo

Graph4NLP

Demo 1: Building a Text Classification Application

Graph embedding initialization API, various built-in options, can be customized

```
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,
}

self.graph_initializer = GraphEmbeddingInitialization(
    word_vocab=self.vocab_model.in_word_vocab,
    embedding_style=embedding_style,
    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/AAAI2022_demo

Demo 1: Building a Text Classification Application

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

```
self.graph_topology = NodeEmbeddingBasedGraphConstruction(
    sim_metric_type=config["gl_metric_type"],
    num_heads=config["gl_num_heads"],
    top_k_neigh=config["gl_top_k"],
    epsilon_neigh=config["gl_epsilon"],
    smoothness_ratio=config["gl_smoothness_ratio"],
    connectivity_ratio=config["gl_connectivity_ratio"],
    sparsity_ratio=config["gl_sparsity_ratio"],
    input_size=config["num_hidden"],
    hidden_size=config["gl_num_hidden"],
)
```

https://github.com/graph4ai/graph4nlp_demo/tree/main/AAAI2022_demo

Graph4NLP

Demo 1: Building a Text Classification Application

Graph embedding learning 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/AAAI2022_demo

Demo 1: Building a Text Classification Application

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

```
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/AAAI2022_demo

Demo 1: Building a Text Classification Application

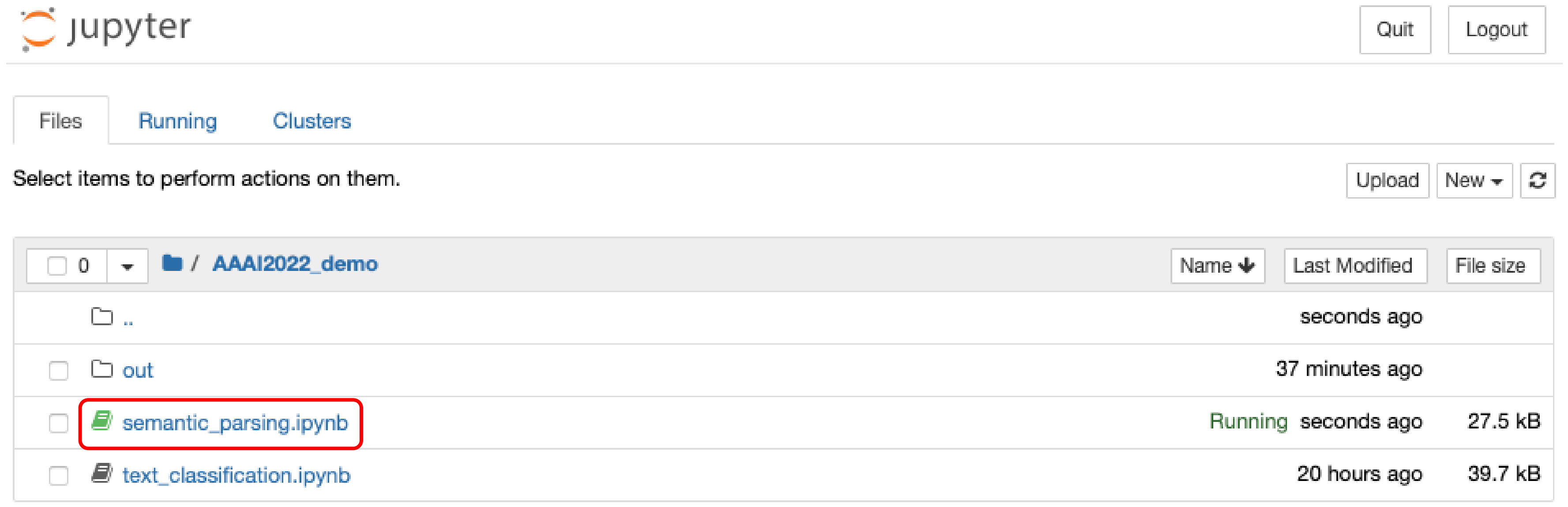
```
dataset = TrecDataset(
    root_dir=self.config["graph_construction_args"]["graph_construction_share"]["root_dir"],
    topology_subdir=topology_subdir,
    graph_name=self.graph_name,
    dynamic_init_graph_name=self.config["graph_construction_args"][
        "graph_construction_private"
    ]["dynamic_init_graph_name"],
    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,
)
```

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

https://github.com/graph4ai/graph4nlp_demo/tree/main/AAAI2022_demo

Demo 2: Building a Semantic Parsing Application

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



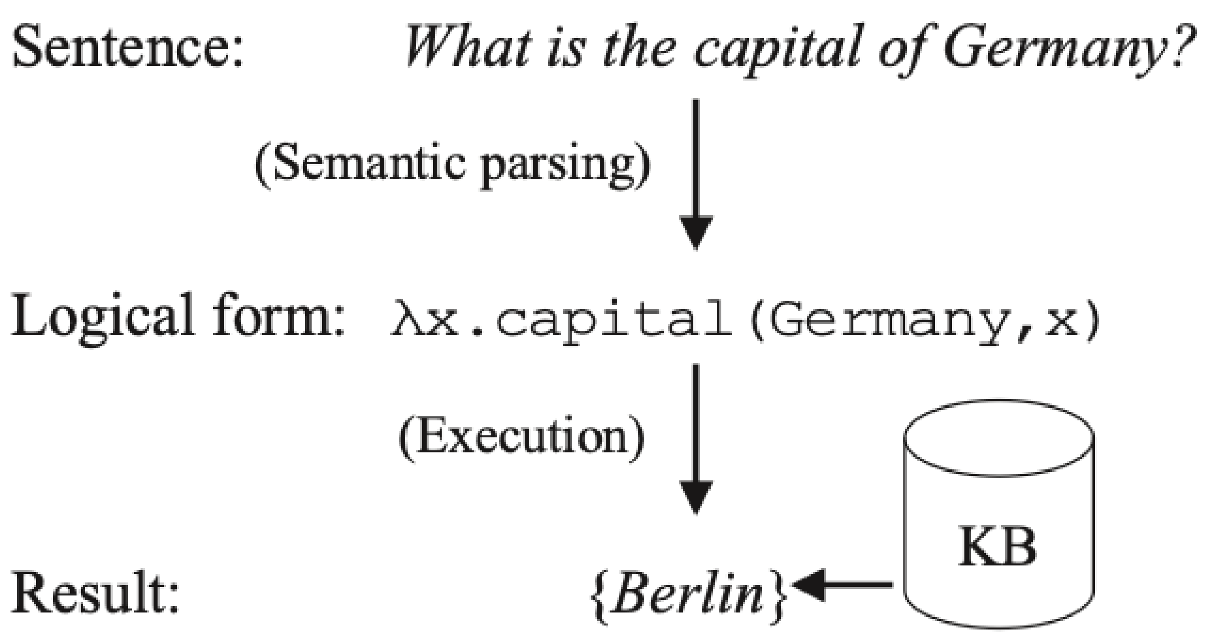
Select items to perform actions on them.

/ AAAI2022_demo

..	seconds ago	
out	37 minutes ago	
semantic_parsing.ipynb	Running seconds ago	27.5 kB
text_classification.ipynb	20 hours ago	39.7 kB

Graph4NLP

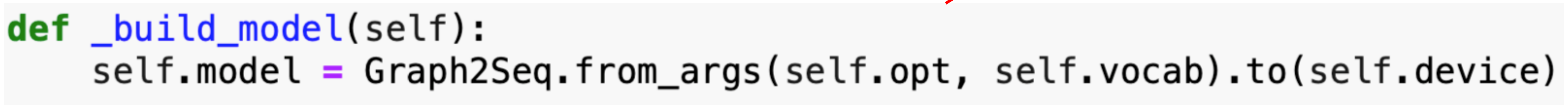
Demo 2: Building a Semantic Parsing Application



https://github.com/graph4ai/graph4nlp_demo/tree/main/AAAI2022_demo

Demo 2: Building a Semantic Parsing Application

Graph2Seq API



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

https://github.com/graph4ai/graph4nlp_demo/tree/main/AAAI2022_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