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Neural Monkey: A Natural Language Processing Toolkit

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NLP Toolkit Overview

Why do we need NLP toolkits?

- No need to re-implement everything from scratch.
- Re-use of published (trained) components.
- Often difficult design decisions already made.
- Usually, published results indicate the reliability of the toolkit.

NLP Toolkit Overview

NLP research libraries and toolkits can be categorized as:

- Math libraries (matrix- or tensor-level, usually symbolic)
  - TensorFlow, (py)Torch, Theano.
- Neural Network abstraction APIs (handle individual NN layers)
  - Keras
- Higher-level toolkits (work with encoders, decoders, etc.)
  - **Neural Monkey**, AllenNLP, Sockeye
- Specialized applications
  - Marian or tensor2tensor for NMT, Kaldi for ASR, etc.

Neural Monkey

- Open-source toolkit for NLP tasks
- Suited for research and education
- Three (overlapping) user groups considered:
  - Students
  - Researchers
  - Newcomers to deep learning

Development

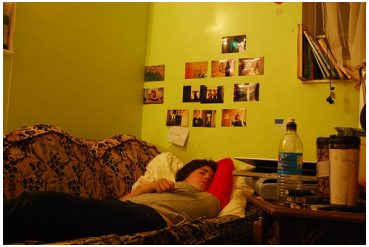
- Implemented in Python 3.6 using TensorFlow
- Thanks to TensorFlow GPU support using CUDA, cuDNN
- Actively developed using GitHub as the main communication platform

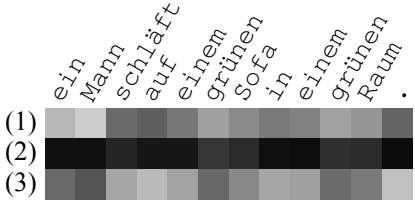
Source code here:

`https://github.com/ufal/neuralmonkey`

Used in Research

- Multimodal translation
  (Charles University, ACL 2017, WMT 2018)
- Bandit learning
  (Heidelberg University, ACL 2017)
- Graph Convolutional Encoders
  (University of Amsterdam, EMNLP 2017)
- Non-autoregressive translation
  (Charles University, EMNLP 2018)





Goals

1. Code readability

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2. Modularity along research concepts

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1. Code readability
2. Modularity along research concepts
3. Up-to-date building blocks
4. Fast prototyping

Usage

- Neural Monkey experiments defined in INI configuration files
- Once config is ready, run with:

  ```
  neuralmonkey-train config.ini
  ```

- Inference from a trained model uses a second config for data:

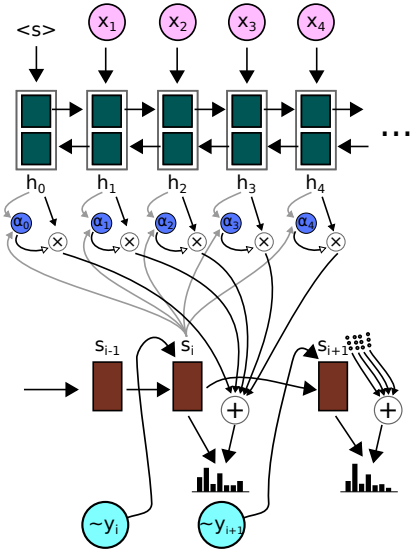
  ```
  neuralmonkey-run config.ini data.ini
  ```

Abstractions in Neural Monkey

- Compositional design
  - High-level abstractions derived from low-level ones
- (High-level) abstractions aligned with literature
  - Encoder, decoder, etc.
- Separation between model definition and usage
  - "Model parts" define the network architecture
  - "Graph executors" define what to compute in the TF session

Example Use-Case: Machine Translation

- Bahdanau et al., 2015
- Encoder: Bidirectional GRU
- Decoder: GRU with single-layer feed-forward attention



Simple MT Configuration Example

```
[main]
output="output_dir"
batch_size=64
epochs=20
train_dataset=<train_data>
val_dataset=<val_data>
trainer=<my_trainer>
runners=[<my_runner>]
evaluation=[("target", evaluators.BLEU)]
logging_period=500
validation_period=5000

[en_vocabulary]
class=vocabulary.from_wordlist
path="en_vocab.tsv"

[de_vocabulary]
class=vocabulary.from_wordlist
path="de_vocab.tsv"
```

```
[train_data]
class=dataset.load
series=["source, target"]
data=["data/train.en", "data/train.de"]

[val_data]
class=dataset.load
series=["source, target"]
data=["data/val.en", "data/val.de"]

[my_encoder]
class=encoders.SentenceEncoder
rnn_size=500
embedding_size=600
data_id="source"
vocabulary=<en_vocabulary>

[my_attention]
class=attention.Attention
encoder=<my_encoder>
state_size=500
```

```
[my_decoder]
class=decoders.Decoder
encoders=[<my_encoder>]
attentions=[<my_attention>]
max_output_len=20
rnn_size=1000
embedding_size=600
data_id="target"
vocabulary=<de_vocabulary>

[my_trainer]
class=trainers.CrossEntropyTrainer
decoders=[<my_decoder>]
clip_norm=1.0

[my_runner]
class=runners.GreedyRunner
decoder=<my_decoder>
output_series="target"
```

Simple MT Configuration Example

General training configuration:

```
[main]
output="output_dir"
batch_size=64
epochs=20
train_dataset=<train_data>
val_dataset=<val_data>
trainer=<my_trainer>
runners=[<my_runner>]
evaluation=[("target", evaluators.BLEU)]
logging_period=500
validation_period=5000
```

Simple MT Configuration Example

```
[main]
output="output_dir"
batch_size=64
epochs=20
train_dataset=<train_data>
val_dataset=<val_data>
trainer=<my_trainer>
runners=[<my_runner>]
evaluation=[("target", eva
logging_period=500
validation_period=5000

[en_vocabulary]
class=vocabulary.from_word
path="en_vocab.tsv"

[de_vocabulary]
class=vocabulary.from_wordlist
path="de_vocab.tsv"
```

```
[train_data]
class=dataset.load
                    encoder=<my_encoder>
                    state_size=500
```

```
[my_decoder]
class=decoders.Decoder
                    _encoder>]
                    my_attention>]
                    n=20
                    e=600
                    et"
                    e_vocabulary>

                    s.CrossEntropyTrainer
                    _decoder>]

                    .GreedyRunner
                    decoder=<my_decoder>
                    output_series="target"
```

Loading vocabularies:

```
[en_vocabulary]
class=vocabulary.from_wordlist
path="en_vocab.tsv"

[de_vocabulary]
class=vocabulary.from_wordlist
path="de_vocab.tsv"
```

Simple MT Configuration Example

```
[main]
output="output_dir"
batch_size=64
epochs=20
train_dataset=<train_data>
val_dataset=<val_data>
trainer=<my_trainer>
runners=[<my_runner>]
evaluation=[("target", eva
logging_period=500
validation_period=5000

[en_vocabulary]
class=vocabulary.from_word
path="en_vocab.tsv"

[de_vocabulary]
class=vocabulary.from_word
path="de_vocab.tsv"
```

Loading training and validation data:

```
[train_data]
class=dataset.load
series=["source, target"]
data=["data/train.en", "data/train.de"]

[val_data]
class=dataset.load
series=["source, target"]
data=["data/val.en", "data/val.de"]
```

```
s.Decoder
_encoder>]
my_attention>]
n=20

e=600
et"
e_vocabulary>

s.CrossEntropyTrainer
_decoder>]

.GreedyRunner
ecoder>
="target"

state_size=500
```

Simple MT Configuration Example

```
[main]
output="output_dir"
batch_size=64
epochs=20
train_dataset=<train_data>
val_dataset=<val_data>
trainer=<my_trainer>
runners=[<my_runner>]
evaluation=[("target", eva
logging_period=500
validation_period=5000

[en_vocabulary]
class=vocabulary.from_word
path="en_vocab.tsv"

[de_vocabulary]
class=vocabulary.from_wordlist
path="de_vocab.tsv"
```

```
[train_data]
class=dataset.load
```

```
class=attention.Attention
encoder=<my_encoder>
state_size=500
```

```
[my_decoder]
class=decoders.Decoder
_encoder>]
my_attention>]
n=20
e=600
et"
e_vocabulary>

s.CrossEntropyTrainer
_decoder>]

.GreedyRunner
decoder=<my_decoder>
output_series="target"
```

GRU Encoder configuration:

```
[my_encoder]
class=encoders.SentenceEncoder
rnn_size=500
embedding_size=600
data_id="source"
vocabulary=<en_vocabulary>
```

Simple MT Configuration Example

GRU Decoder and Attention configuration:

```
[my_attention]
class=attention.Attention
encoder=<my_encoder>
state_size=500

[my_decoder]
class=decoders.Decoder
encoders=[<my_encoder>]
attentions=[<my_attention>]
max_output_len=20
rnn_size=1000
embedding_size=600
data_id="target"
vocabulary=<de_vocabulary>
```

Simple MT Configuration Example

```
[main]
output="output_dir"
batch_size=64
epochs=20
train_dataset=<train_data>
val_dataset=<val_data>
trainer=<my_trainer>
runners=[<my_runner>]
evaluation=[("target", eva
logging_period=500
validation_period=5000

[en_vocabulary]
class=vocabulary.from_word
path="en_vocab.tsv"

[de_vocabulary]
class=vocabulary.from_word
path="de_vocab.tsv"
```

Trainer and runner:

```
[my_trainer]
class=trainers.CrossEntropyTrainer
decoders=[<my_decoder>]
clip_norm=1.0

[my_runner]
class=runners.GreedyRunner
decoder=<my_decoder>
output_series="target"
```

```
s.Decoder
_encoder>]
my_attention>]
n=20

e=600
et"
e_vocabulary>

s.CrossEntropyTrainer
_decoder>]

.GreedyRunner
ecoder>
="target"

state_size=500
```

Configuration of Captioning

Define how to load images:

```
[imagenet_reader]
class=readers.image_reader.imagenet_reader
prefix="/home/test/data/flickr30k-images"
target_width=229
target_height=229
zero_one_normalization=True
```

And replace encoder with ImageNet network:

```
[imagenet_resnet]
class=encoders.ImageNet
name="imagenet"
data_id="images"
network_type="resnet_v2_50"
spatial_layer="resnet_v2_50/block4/unit_3/bottleneck_v2/conv3"
slim_models_path="tensorflow-models/research/slim"
```

Sentence Classification

Keep the encoder and replace the decoder (and update the rest)

```
[my_classifier]
class=decoders.Classifier
data_id="labels"
encoders=[<my_encoder>]
vocabulary=<label_vocabulary>
layers=[200]
```

```
[my_runner]
class=runners.PlainRunner
decoder=<my_classifier>
```

```
[my_trainer]
class=trainers.CrossEntropyTrainer
decoders=[<my_classifier>]
clip_norm=1.0
```

Pre-trained model parts

Parameters of model parts can be fixed using the gradient blocking module

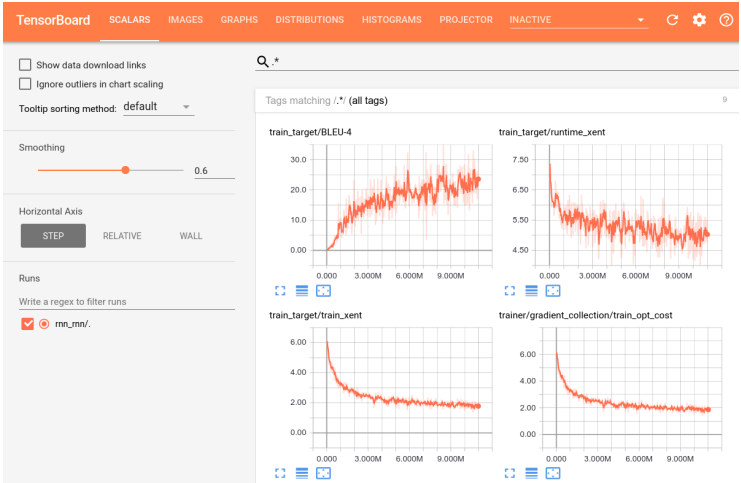
Supported Features

- Recurrent encoder and decoder with attention
- Beam search decoding with model ensembling
- Deep convolutional encoder
- Self-attentive encoder and decoder (a.k.a. *Transformer*)
- Wrappers for ImageNet networks
- Custom CNNs for image processing
- ConvNets for sequence classification
- Self-attentive embeddings for sentence classification
- Hierarchical attention over multiple source sequences
- Generic sequence labeler
- Connectionist temporal classification

Console Logging during Training

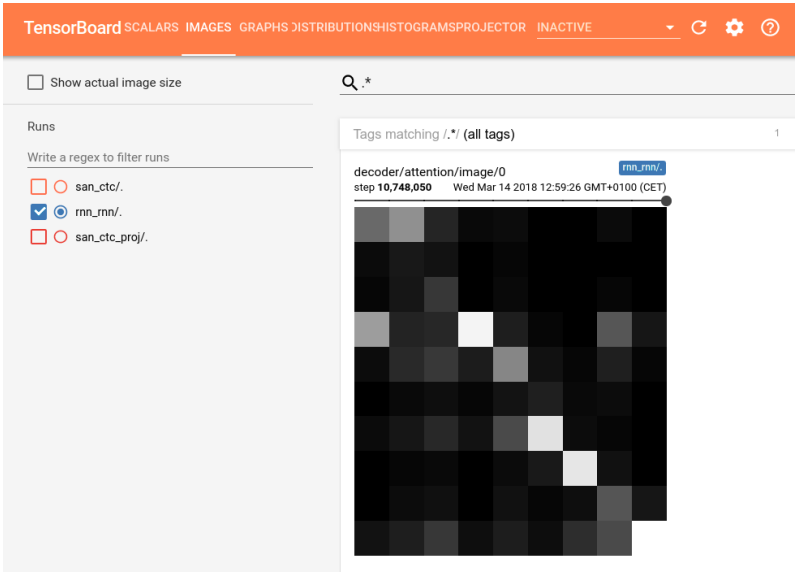
```
[11]
source: it started the French League season with two wins and two draws , and on Sunday it defeated St. Etienne 5 : 0 .
source_bpe: it started the French League season with two wins and two draws , and on Sunday it defeated St. Eti@@ enne 5 : 0 .
target_bpe: ten do se@@ z@@ ony francouzské ligy od@@ stat@@ oval dvěma výhra@@ mi a dvěma re@@ mi@@ zami , v neděli roz@@ střílel St . Eti@@ enne 5 : 0 .
target: začalo to <unk> <unk> <unk> <unk> a <unk> , a v neděli <unk> <unk> <unk> .
target (ref): ten do sezony francouzské ligy odstatoval dvěma výhrami a dvěma remízami , v neděli rozstřílel St . Etienne 5 : 0 .

[12]
source: it is putting the most pressure on AS Monaco .
source_bpe: it is putting the most pressure on AS Monaco .
target_bpe: relativně nejvíc tlačí bota klub AS Monaco .
target: <unk> <unk> tlak na <unk> AS .
target (ref): relativně nejvíc tlačí bota klub AS Monaco .

[13]
source: it so far has a balance of 1-1-2 in the league , and over the weekend it parted with Lille with a 1 : 1 tie .
source_bpe: it so far has a balance of 1-@@ 1-2 in the league , and over the weekend it parted with L@@ ille with a 1 : 1 tie .
target_bpe: ten má v lize zatím bilanci 1-@@ 1-2 a o víkendu se rozešel s L@@ ille s@@ mírně 1 : 1 .
target: v <unk> <unk> <unk> <unk> a <unk> se <unk> s <unk> <unk> <unk> .
target (ref): ten má v lize zatím bilanci 1-1-2 a o víkendu se rozešel s Lille smírně 1 : 1 .

[14]
source: today news appeared on tabloid English-language websites stating that the Queens Park Rangers may want Čech .
source_bpe: today news appeared on ta@@ blo@@ id Engli@@ sh-@@ language websites stating that the Queens Park Rangers may want Č@@ ech .
target_bpe: na bulvá@@ rních anglic@@ kých we@@ bech dnes vy@@ sko@@ čily zprávy , že by Č@@ ech@@ a mohli chtít v Queens Park Rangers .
target: dnes se objevila zpráva na internetových stránkách <unk> <unk> , které <unk> , že <unk> <unk> <unk> .
target (ref): na bulvárních anglických webech dnes vyskočily zprávy , že by Čecha mohli chtít v Queens Park Rangers .

[15]
source: however , according to English bookmakers , Čech &amp;apos;s departure from Chelsea at the last minute is not very likely .
source_bpe: however , according to English book@@ makers , Č@@ ech &@@ a@@ pos@@ ;@@ s departure from Chelsea at the last minute is not very likely .
target_bpe: podle anglic@@ kých book@@ ma@@ ker@@ Ů ale Č@@ ech@@ ův odchod z Chelsea na poslední chvíli není příliš pravděpodobný .
target: nicméně , podle <unk> <unk> , <unk> <unk> <unk> z Chelsea za poslední minutu není pravděpodobné .
target (ref): podle anglických bookmakerů ale Čechův odchod z Chelsea na poslední chvíli není příliš pravděpodobný .


2018-03-14 12:58:13: Validation (epoch 1, batch number 214960):
2018-03-14 12:58:46: Variable file saved in experiments/czeng_rnn_rnn/variables.data
2018-03-14 12:58:46: Best scores saved so far: [9.8540928005025079]
2018-03-14 12:59:06: Variables of 'encoder' saved to 'experiments/czeng_rnn_rnn/encoder.ckpt'
2018-03-14 12:59:26: Variables of 'encoder_input' saved to 'experiments/czeng_rnn_rnn/embeddings.ckpt'
2018-03-14 12:59:26: best target/BLEU-4 on validation: 9.855 (in epoch 1, after batch number 214960)
2018-03-14 12:59:26: Epoch 1/10  Instances 10748050  target/runtime_xent: 6.395    target/train_xent: 2.626    target/BLEU-4: 9.855
2018-03-14 12:59:26: Validation time: 11713.46s, inter-validation: 7391.83s, per-instance (train): 0.02s, per-instance (val): 4.41s
2018-03-14 12:59:26: Validation period setting is inefficient.

2018-03-14 13:03:11: Epoch 1/10  Instances 10748100  target/runtime_xent: 5.032    target/train_xent: 1.726    target/BLEU-4: 20.54
2018-03-14 13:15:41: Epoch 1/10  Instances 10778450  target/runtime_xent: 5.367    target/train_xent: 2.043    target/BLEU-4: 20.02
2018-03-14 13:28:07: Epoch 1/10  Instances 10808500  target/runtime_xent: 4.734    target/train_xent: 1.885    target/BLEU-4: 18.73
2018-03-14 13:40:35: Epoch 1/10  Instances 10838550  target/runtime_xent: 5.606    target/train_xent: 1.766    target/BLEU-4: 23.88
2018-03-14 13:53:03: Epoch 1/10  Instances 10868350  target/runtime_xent: 5.246    target/train_xent: 1.713    target/BLEU-4: 24.79
```

Scalar Values in TensorBoard



Losses, evaluation metrics, parameter norms, histograms of gradients

Attention in TensorBoard



Summary

Neural Monkey is:

- Actively developing open-source GitHub project
- Suited for researchers, students, and other DL enthusiasts
- Collection of features from across the NLP sub-topics
- Simple to use because of clear and readable config files
- Highly modular, therefore relatively easy to debug

https://github.com/ufal/neuralmonkey