# Massive Choice, Ample Tasks (MaChAmp): A Toolkit for Multi-task Learning in NLP

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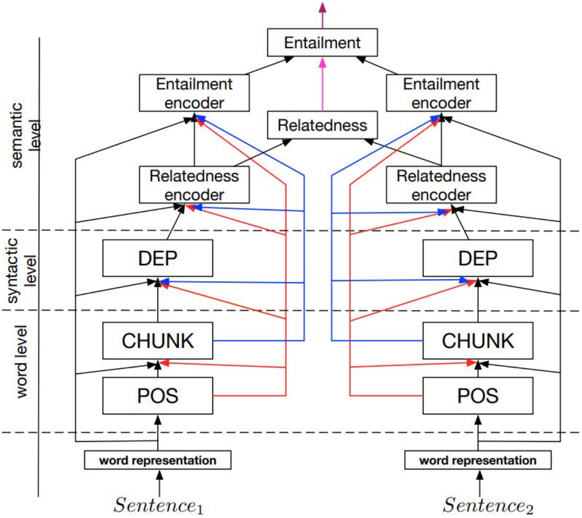
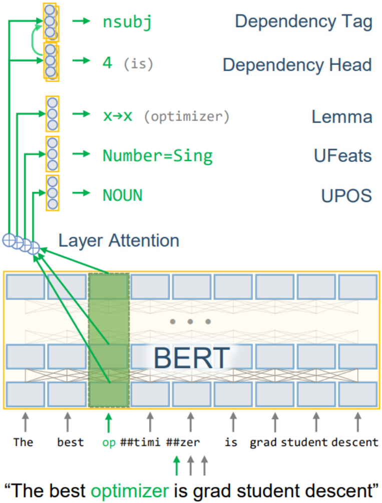
# Multitask Learning




Taken from: A Joint Many-Task Model: Growing a Neural Network for Multiple NLP Tasks. Kazuma Hashimoto, Caiming Xiong, Yoshimasa Tsuruoka, Richard Socher (EMNLP 2017)

# Udify

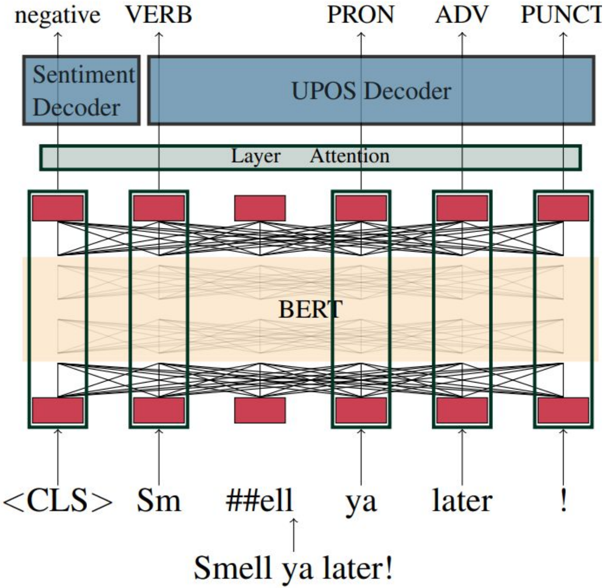



Taken from: 75 Languages, 1 Model: Parsing Universal Dependencies Universally Dan Kondratyuk and Milan Straka (EMNLP 2019)

# MaChAmp

*One arm alone can move mountains.*

# MaChAmp


negative
VERB
PRON
ADV
PUNCT
Sentiment Decoder
UPOS Decoder
Layer Attention
BERT
<CLS>
Sm
##ell
ya
later
!
Smell ya later!

# Original research questions

- Can it still be beneficial to process tasks sequentially (and embed previous predictions)?
- What would the best order be?

# Input to decoder

Normal case:
$\vec{b}$

# Input to decoder

Normal case:
$\vec{b}$

Add information from previous task prediction:
$\vec{b} \cdot \vec{l}$

# Input to decoder

Normal case:
$\vec{b}$

Add information from previous task prediction:
$\vec{b} \cdot \vec{l}$

Weighted average from previous prediction:
$$\vec{b} \cdot \sum_{i=0}^{n} p_i * \vec{l_i}$$

# Training MaChAmp

```
{
    "UD": {
        "train_data_path": "data/ewt.train",
        "validation_data_path": "data/ewt.dev",
        "word_idx": 1,
        "tasks": {
            "upos": {
                "task_type": "seq",
                "column_idx": 3
            }
        }
    }
}
```

# Training MaChAmp

Training can be as easy as:

```
python3 train.py --dataset_config upos.json
```

# Training MaChAmp

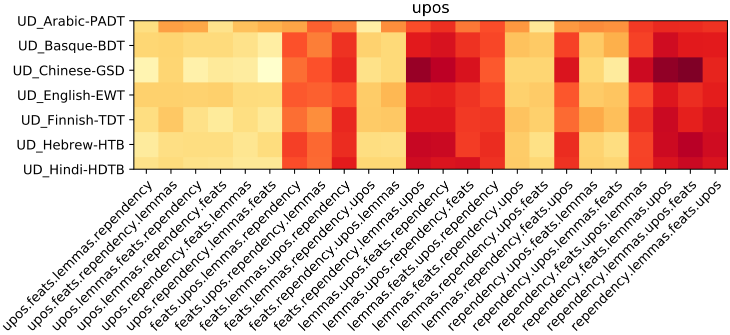
Training can also be done like:

```
python3 train.py --dataset_config upos.json --name \
EWT.upos --device -1 --parameters_config newParams.json
```

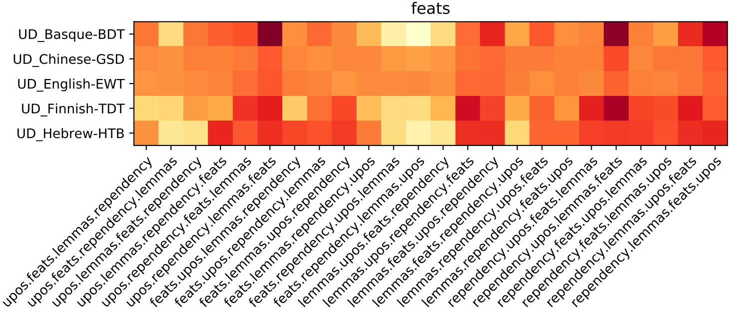
# Training MaChAmp

```
{
    "UD": {
        "train_data_path": "data/ewt.train",
        "validation_data_path": "data/ewt.dev",
        "word_idx": 1,
        "tasks": {
            "upos": {
                "task_type": "seq",
                "column_idx": 3
            },
            "xpos": {
                "task_type": "seq",
                "column_idx": 4,
                "prev_task_embed_dim":32,
                "order":2
            }
        }
    }
```

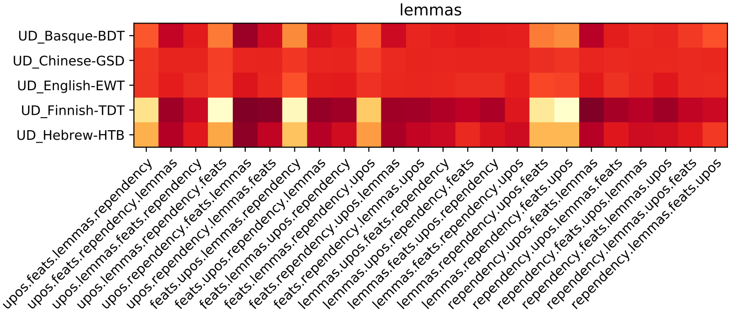
# Multiple languages (UPOS)



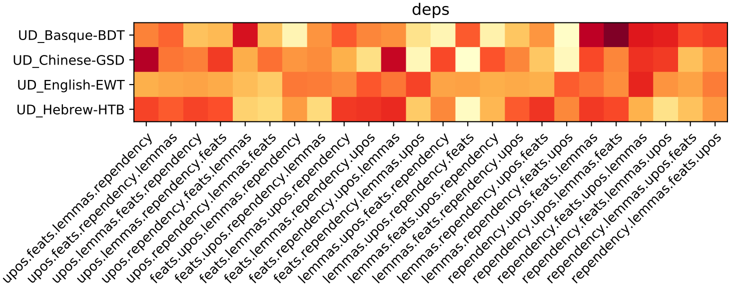
# Multiple languages (Morphological tagging)



# Multiple languages (Lemmas)



# Multiple languages (Dependency parsing)



# Comparison to previous work

| | $\text{JMT}_{\text{all}}$ | Random |
|---|---|---|
| POS | 97.88 | 97.83 |
| Chunking | 97.59 | 97.71 |
| Dependency UAS | 94.51 | 94.66 |
| Dependency LAS | 92.60 | 92.80 |
| Relatedness | 0.236 | 0.298 |
| Entailment | 84.6 | 83.2 |

Taken from: A Joint Many-Task Model: Growing a Neural Network for Multiple NLP Tasks. Kazuma Hashimoto, Caiming Xiong, Yoshimasa Tsuruoka, Richard Socher (EMNLP 2017)

# Now what?

So, how about using word-level tasks to improve phrase-level tasks?

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So, how about using word-level tasks to improve phrase-level tasks?

- Add sentence level tasks (and make it possible to use multiple datasets simultaneously)
- Make challenging: cross-lingual settings!

```
"UD": {
    "train_data_path": "data/ewt.train",
    "validation_data_path": "data/ewt.dev",
    "word_idx": 1,
    "tasks": {
        "upos": {
            "task_type": "seq",
            "column_idx": 3
        },
    }
},"RTE" {
    "train_data_path": "data/ewt.train",
    "validation_data_path": "data/ewt.dev",
    "sent_idxs": [0,1],
    "tasks": {
        "rte": {
            "task_type": "classification",
            "column_idx": 2
        },
    }
```

# Task Types

- seq
- string2string
- dependency
- multiseq
- masked_crf
- classification

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- classification

# Performance

- EWT
- PMB
- GLUE

| | EWT v2.3 | | | | | PMB v3.0 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task | dep | feats | lemma | upos | xpos | lemma | semtag | supertag | verbnet | wordnet |
| Task type | dep | seq | s2s | seq | seq | s2s | seq | seq | seq | s2s |
| Train size | | | 205k | | | | | 43k | | |
| MaChAmp$_{(ST)}$ | **89.90** | **97.18** | **98.21** | **97.01** | 96.64 | **97.52** | **98.32** | 94.87 | 94.37 | 89.15 |
| MaChAmp$_{(MT)}$ | 89.61 | 97.15 | 97.79 | **97.01** | **96.79** | 97.33 | 98.23 | **94.91** | **94.54** | **89.32** |
| UDify | 89.67 | 97.15 | 97.80 | 96.90 | – | – | – | – | – | – |

| | GLUE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | cola | mnli | mnli-mis | mrpc | qnli | qqp | rte | snli | sst-2 |
| Task type | c | c | c | c | c | c | c | c | c |
| Train size | 8.5k | 392k | 392k | 3.6k | 108k | 363k | 2.5k | 549k | 67k |
| MaChAmp$_{(ST)}$ | **78.04** | 81.99 | 82.15 | **86.03** | **88.31** | **89.75** | 72.20 | 89.58 | **90.71** |
| MaChAmp$_{(MT)}$ | 72.20 | 82.35 | **82.80** | 82.11 | 86.58 | 89.27 | **73.65** | 89.61 | 90.25 |
| BERT-base | – | **84.4** | **86.7** | – | – | – | – | **93.3** | – |

# Proportional sampling

- Downscale each task to the smallest task
- Upscale each task to the largest task
- Take the average amount of batches over all tasks for all tasks

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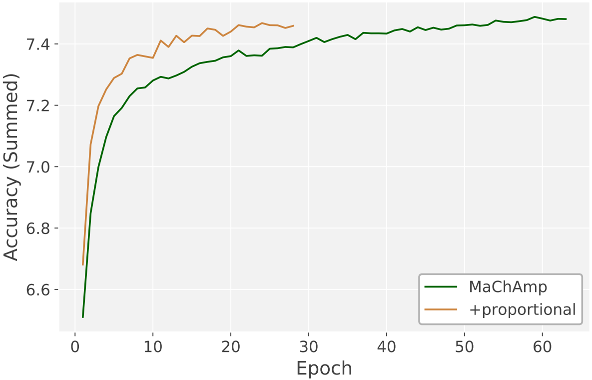

# Zero-shot learning

## Preliminary Results

| | English | Arabic | Turkish | Urdu | Vietnamese |
|---|---|---|---|---|---|
| En-XNLI | 81.84 | 65.93 | 61.52 | 58.02 | 69.08 |
| En-XNLI<br>+En-UD<br>+X-UD | - | 63.17<br>WO: 0.64/0.30 | 60.56<br>WO: 0.52/0.19 | 59.72<br>WO: 0.76/0.31 | 67.65<br>WO: 0.70/0.22 |
| En-XNLI<br>+X-UD (4 Tasks) | | 64.57<br>WO: 0.64/0.30 | 59.39<br>WO: 0.49/0.17 | 58.75<br>WO: 0.76/0.27 | 70.02<br>WO: 0.68/0.15 |

# Natural language understanding

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| set | a | reminder | to | tell | my | wife | i | love | her |
| O | O | B-Rem./NN | O | B-Rem. | I-R | I-R | I-R | I-R | I-R |

Intent: setReminder

# Natural language understanding

```
# text: Set alarm every minute for next hour
# intent: alarm/set_alarm
# slots: 10:36:datetime
1       set     alarm/set_alarm NoLabel
2       alarm   alarm/set_alarm NoLabel
3       every   alarm/set_alarm B-datetime
4       minute  alarm/set_alarm I-datetime
5       for     alarm/set_alarm I-datetime
6       next    alarm/set_alarm I-datetime
7       hour    alarm/set_alarm I-datetime
```

# Natural language understanding

```
{
    "NLU": {
        "train_data_path": "data/nlu/train-en.conllu",
        "validation_data_path": "data/nlu/eval-en.conllu",
        "word_idx": 1,
        "tasks": {
            "slot": {
                "task_type": "seq",
                "metric": "span-f1",
                "column_idx": 3
            },
            "intent": {
                "task_type": "classification",
                "column_idx": -1
            }
        }
    }
}
```

# NLU (zero-shot ES)

| model | intents | slots | exact |
|---|---|---|---|
| schuster-translate | 85.39 | 72.87 | 54.95 |
| schuster-cove | 53.34 | 22.50 | 10.56 |

# NLU (zero-shot ES)

| model | intents | slots | exact |
|---|---|---|---|
| schuster-translate | 85.39 | 72.87 | 54.95 |
| schuster-cove | 53.34 | 22.50 | 10.56 |
| MaChAmp-NLU | 84.21 | 75.01 | 56.02 |
| MaChAmp-NLU-UD-sep | 84.77 | 70.79 | 48.41 |
| MaChAmp-NLU-UD-mixed | 87.79 | 71.01 | 48.10 |

Results from: Cross-lingual Transfer Learning for Multilingual Task Oriented Dialog. Sebastian Schuster, Sonal Gupta, Rushin Shah, and Mike Lewis (NAACL 2019)

Other things this framework has been used for:

- POS tagging for code-switched data
- Biomedical event extraction
- Rik: effect of PMB predictions on Boxer performance
- Inspect BERT layer performances for UD tasks
- Nested named entity tagging for Danish
- ~~Lexical normalization~~

Smell you later!

# Multiple languages (UPOS)