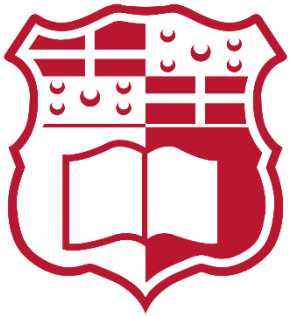
A Dependency Parser for the Maltese Language using Deep Neural Networks



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Master of Science in Artificial Intelligence
June 2018

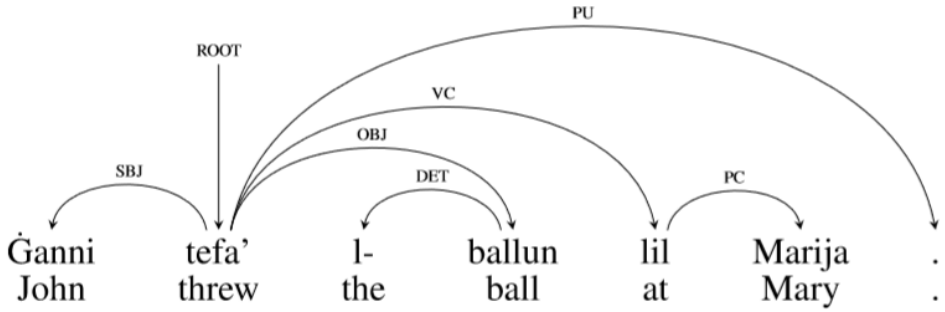
2. Dependency Parsing and NLP

A functionality that allows us to analyse the structure of a sentence and to check whether it is expressed according to a specified grammar.

Question & Answering

Sentiment Analysis

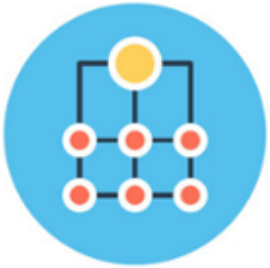
Information Retrieval



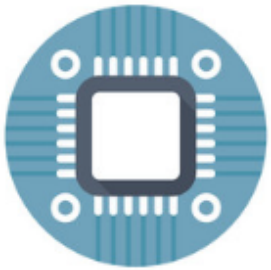
3. Motivation

Maltese Language

- computationally low resourced,
- low researched,
- no dependency parser available.



Maltese UD Treebank



Deep Learning Techniques

Active Research

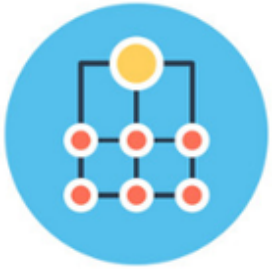
4. Aims and Objectives

To contribute to the increase in computational resources for the Maltese language and also to dependency parsing research area.

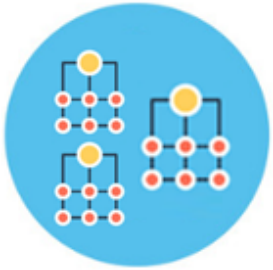
Parser for Maltese

Maltese word embeddings

Visualization



Maltese UD Treebank



Multi-source Treebank

Compare & Contrast

5. Methodology – Word Embeddings

To represent words in a description that can be used by a neural network architecture.

In word embeddings words are represented as vectors.

Maltese word embeddings

fastText

6. Methodology – Word Embeddings

MLRS sentence structure

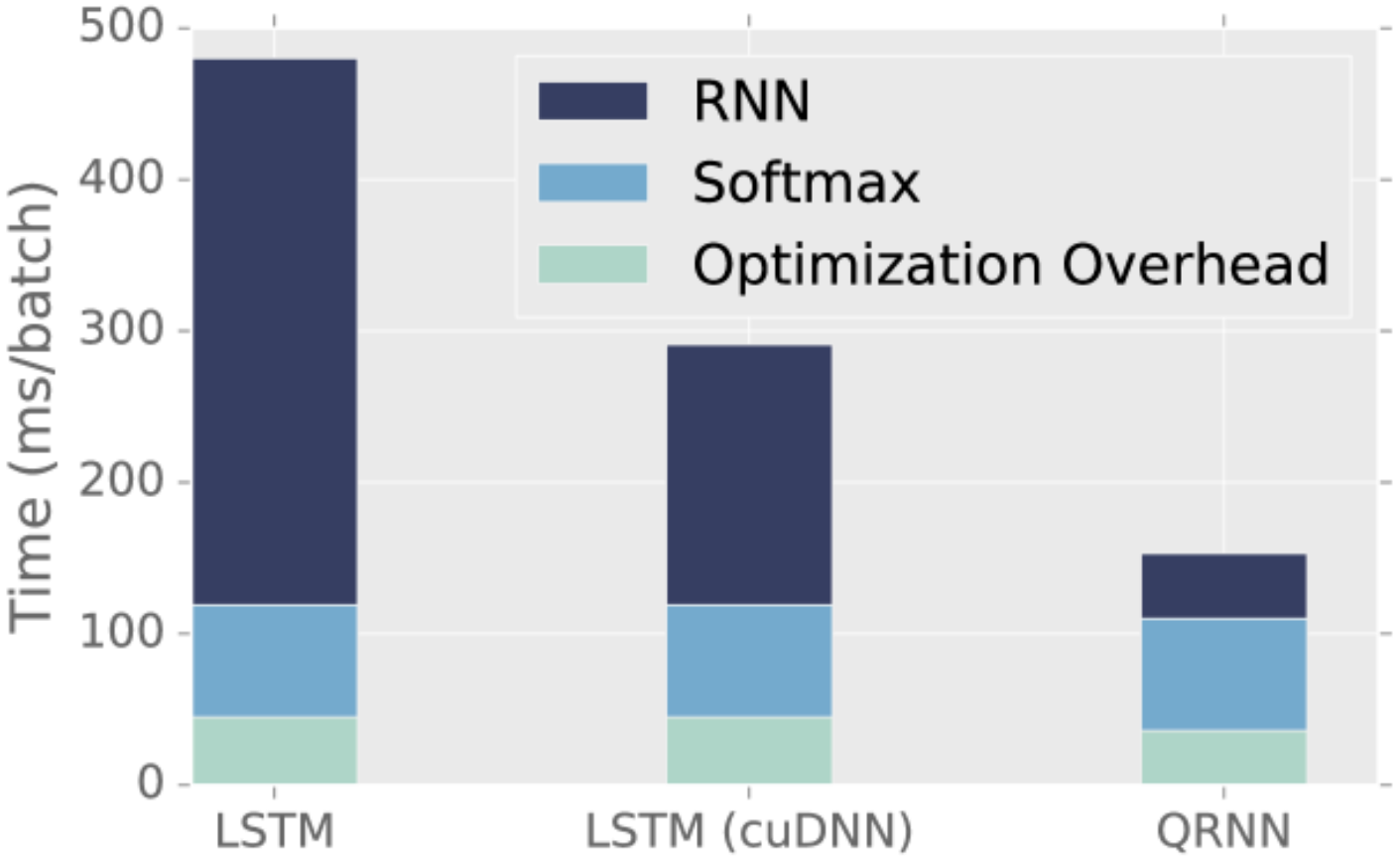
Word	Tag	Lemma	Root
Libset	VERB	null	null
iż-	DEF	il-	null
żarbun	NOUN	żarbun	ż-r-b-n
tat-	GEN-DEF	ta'	null
takkuna	NOUN	null	null
għolja	ADJ	null	null
u	CONJ-CORD	u	null
rqiqa	ADJ	rqiq	r-q-q
u	CONJ-CORD	u	null
għamlet	VERB	għamel	għ-m-l
żewġ	NUM-CRD	żewġ	null
passi	NOUN	passa	p-s-j
.	X-PUN	.	null

```
Libset iż- il- żarbun tat- ta' takkuna għolja u
rqiqa u għamlet għamel żewġ passi passa.
```

7. Methodology – Word Embeddings

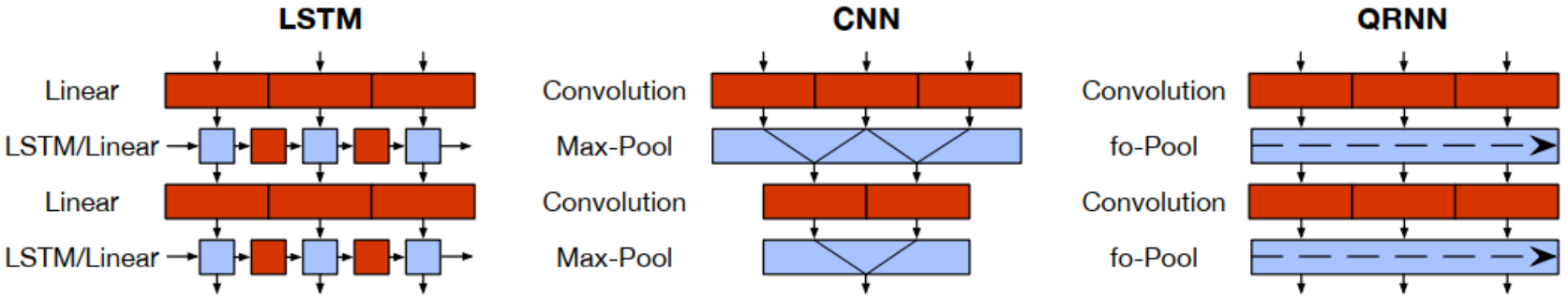
8. Methodology - QRNN

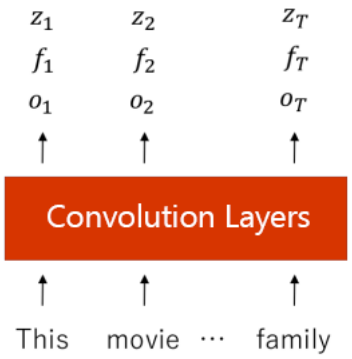
Bradbury et al performed language modelling, sentiment classification and machine translation experiments.



9. Methodology - QRNN

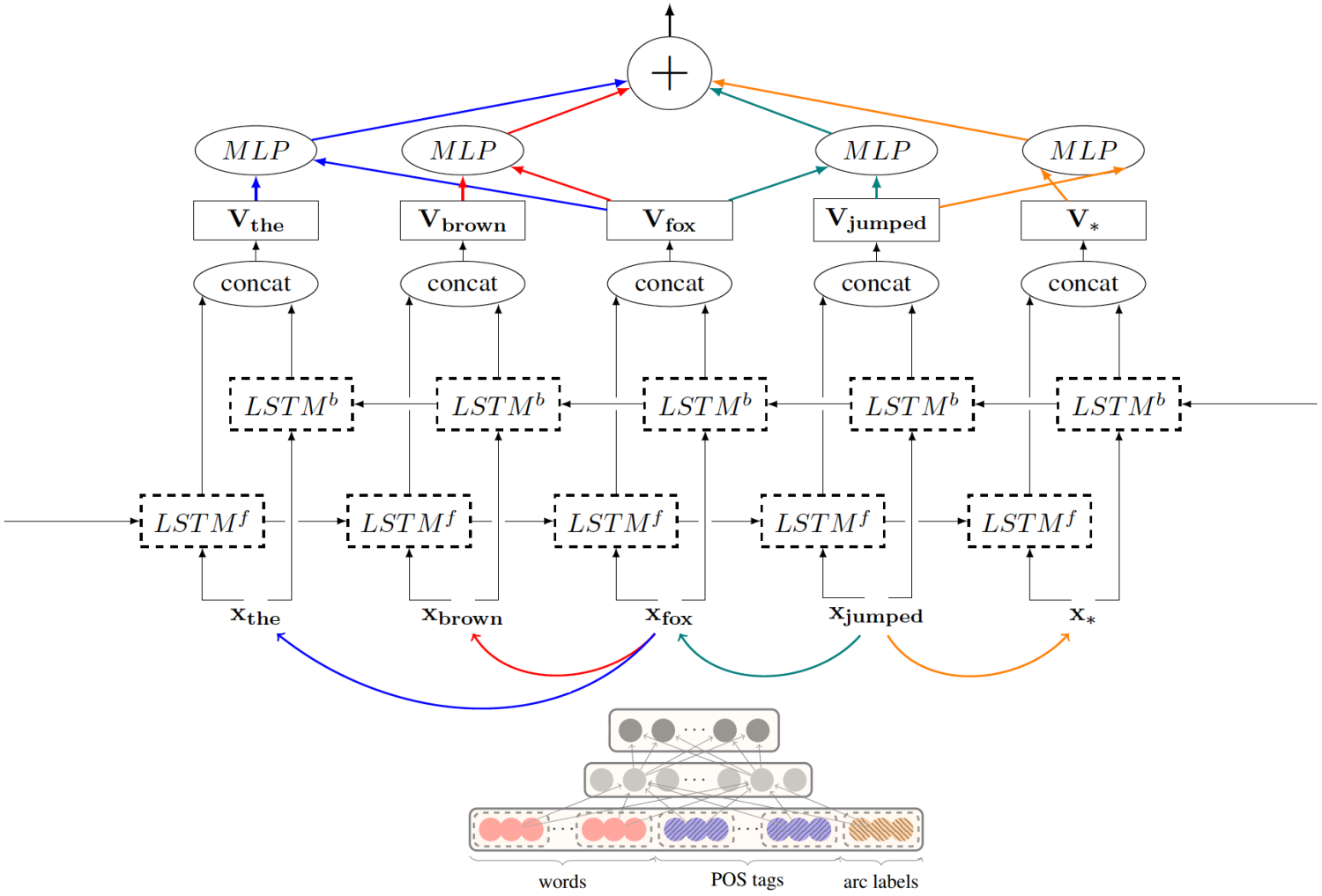
Comparing Deep Learning architectures.





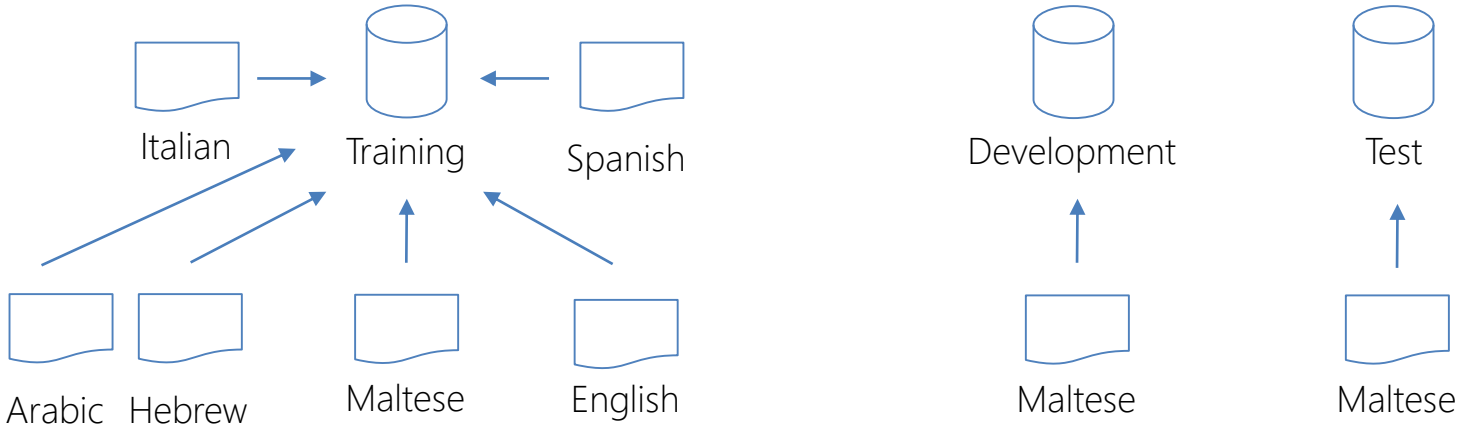
10. Methodology - Parser

Graph-based parser based on the work of Kiperwasser and Goldberg.



11. Methodology – Multi-source Treebank

2000 annotated sentences by Dr Slavomír Čéplö based on the Universal Dependencies framework. A first for Maltese language!



12. Methodology – Evaluation Process

CoNLL 2017 evaluation standard using official script. Ensures that results can be compared with those achieved during CoNLL 2017 participants.

Evaluation metrics:

- Labeled Attachment Score (LAS) - standard evaluation metric for dependency parsing. The percentage of words that are assigned both the correct head and dependency label.

- Unlabeled Attachment Score (UAS) - the percentage of words that are assigned only the correct head.

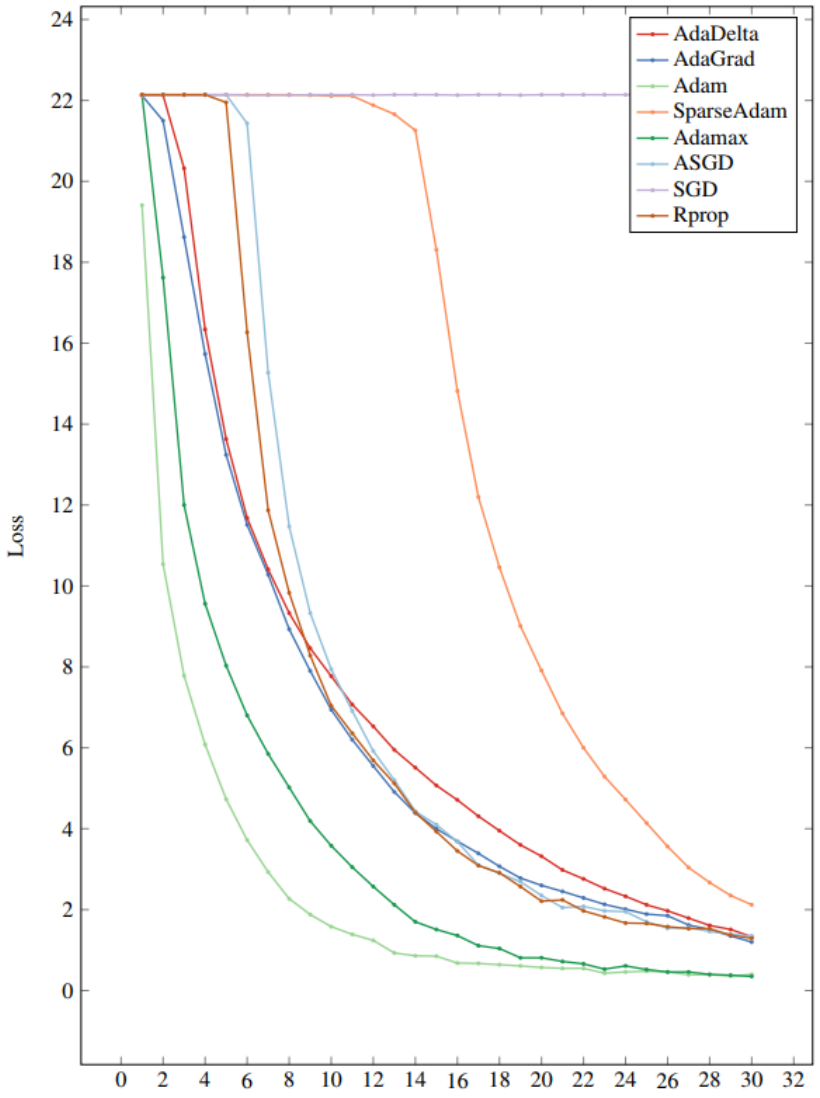
- Weighted Labeled Attachment Score (WLAS) - similar to LAS but the dependency labels are assigned a weight.

13. Experiments and Results

Five sets of experiments:

- Neural Network Optimizers
- External word embedding
- Bootstrapped multi-source treebanks
- LSTM vs QRNN
- Compare with parsers which participated in CoNLL 2017

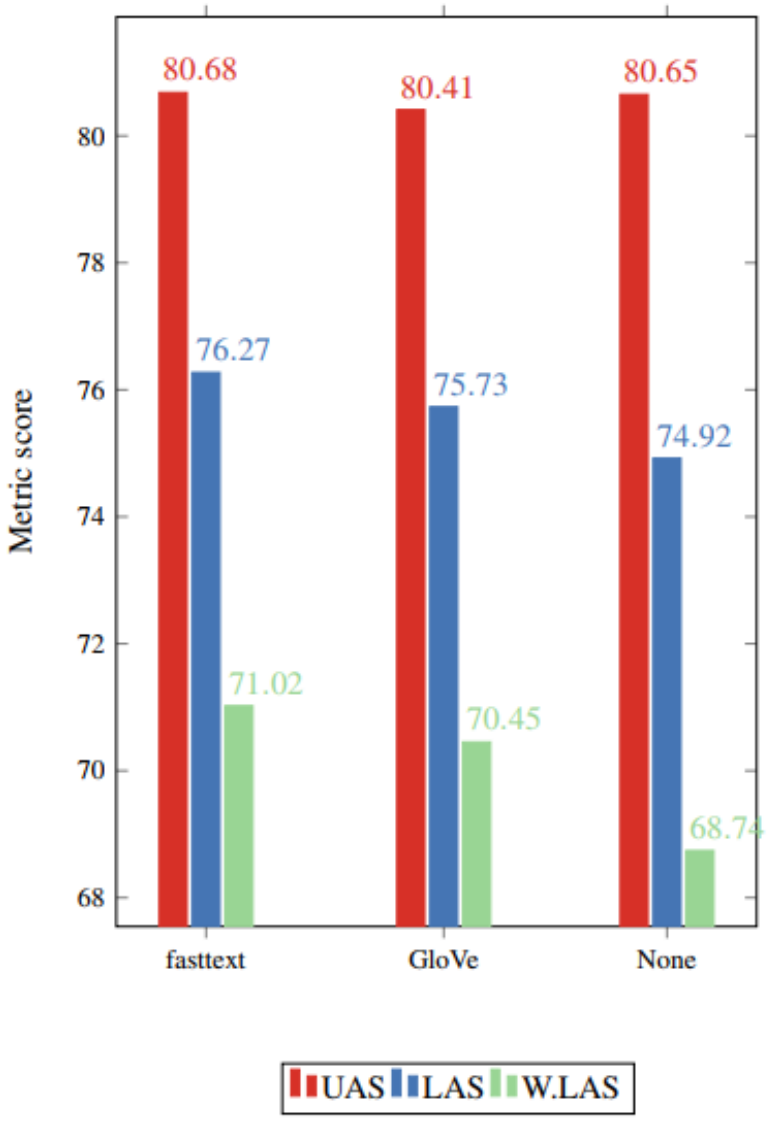
14. Experiments & Results - Optimizers



ID	Treebank	Neural Architecture	External Embedding	Optimizer
1	Maltese	QRNN	None	AdaDelta
2	Maltese	QRNN	None	AdaGrad
3	Maltese	QRNN	None	Adam
4	Maltese	QRNN	None	SparseAdam
5	Maltese	QRNN	None	Adamax
6	Maltese	QRNN	None	ASGD
7	Maltese	QRNN	None	SGD
8	Maltese	QRNN	None	Rprop

ID	Optimizer	Prediction Metrics		
		UAS	LAS	Weighted LAS
1	AdaDelta	78.09	73.03	67.05
2	AdaGrad	73.77	63.01	51.92
3	Adam	79.02	73.90	68.08
4	SparseAdam	74.39	69.46	63.49
5	**Adamax**	**79.14**	**74.16**	**68.49**
6	ASGD	77.98	73.05	67.15
7	SGD	12.49	01.84	01.85
8	Rprop	77.92	72.68	67.10

15. Experiments & Results – Word Embeddings



ID	Treebank	Neural Architecture	External Embedding	Optimizer
9	Maltese	QRNN	fasttext	Adam
10	Maltese	QRNN	GloVe	Adam
11	Maltese	QRNN	None	Adam

ID	External Word Embeddings	Prediction Metrics		
		UAS	LAS	Weighted LAS
9	fasttext	**80.68**	**76.27**	**71.02**
10	GloVe	80.41	75.73	70.45
11	None	80.65	74.92	68.74

16. Experiments & Results – Multi-sourced Treebanks

Evaluation metrics using Bootstrapped Multi-source Treebanks

ID	Treebank	External Embedding	Evaluation Metrics		
			UAS	LAS	Weighted LAS
9	Maltese	fasttext	80.68	76.27	71.02
12	Maltese & Romance	None	88.49	85.07	81.85
13	Maltese, Romance & Arabic	None	87.97	84.40	81.07
14	Maltese, Romance & Hebrew	None	87.94	84.21	80.70
15	**Maltese & Romance**	fasttext	**89.77**	**86.33**	**83.17**
16	Maltese, Romance & Arabic	fasttext	88.86	85.45	81.81
17	Maltese, Romance & Hebrew	fasttext	88.61	85.21	82.10

ID	Author	Prediction Metrics		
		UAS	LAS	Weighted LAS
15	Zammit	89.77	86.33	83.17
	Tiedemann and van der Plas	71.80	63.03	
15	Performance	+17.97	+23.30	

17. Experiments & Results – QRNN vs bi-LSTM

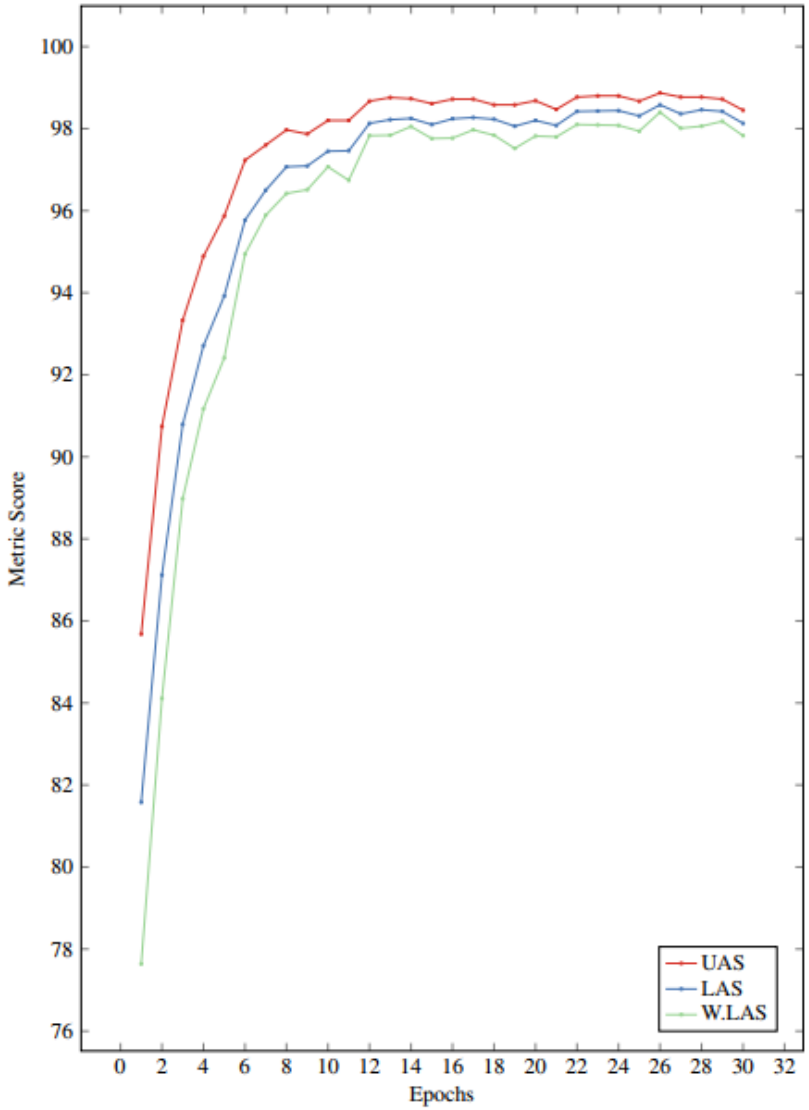
Prediction metrics using QRNN and bi-LSTM neural architectures

ID	Treebank	Neural Architecture	External Embedding	Prediction Metrics		
				UAS	LAS	Weighted LAS
20	**Maltese & Romance**	**bi-LSTM**	**fasttext**	**89.89**	**86.51**	**83.38**
15	Maltese & Romance	QRNN	fasttext	89.77	86.33	83.17
	Performance			+00.12	+00.18	+00.21

Runtime performance of QRNN and bi-LSTM neural architectures

ID	Treebank	Neural Architecture	External Embedding	Elapsed time per Epoch in minutes
20	Maltese & Romance	bi-LSTM	fasttext	122
15	**Maltese & Romance**	**QRNN**	**fasttext**	**40**

18. Experiments & Results – QRNN vs bi-LSTM



19. Experiments & Results – Other Languages

Predicted metrics for English Language

ID	Author	Prediction Metrics		
		UAS	LAS	Weighted LAS
18	Zammit	87.12	84.58	81.63
	Dozat et al.	84.74	82.23	78.99
	Performance	+02.38	+02.35	+02.64

Predicted metrics for Spanish Language

ID	Author	Prediction Metrics		
		UAS	LAS	Weighted LAS
19	Zammit	91.99	89.23	84.28
	Dozat et al.	90.01	87.29	82.08
	Performance	+01.98	+01.94	+02.20

20. Experiments & Results – Other Languages

Predicted metrics for Uyghur Language

ID	Author	Prediction Metrics		
		UAS	LAS	Weighted LAS
20	Zammit	73.10	56.13	47.25
	Shi et al.	60.57	43.51	
	Performance	+12.53	+12.62	

Predicted metrics for Kazakh Language

ID	Author	Prediction Metrics		
		UAS	LAS	Weighted LAS
21	Zammit	53.95	34.52	27.22
	Shi et al.	44.25	25.29	
	Performance	+09.70	+09.23	

21. Conclusion

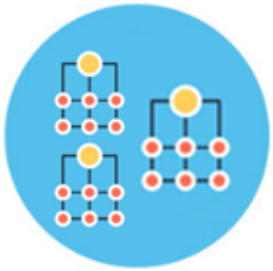
Aims and objectives set for this work were met within the scope.

Parser for Maltese

Maltese word embeddings

Visualization

QRNN as alternative



Multi-source Treebank

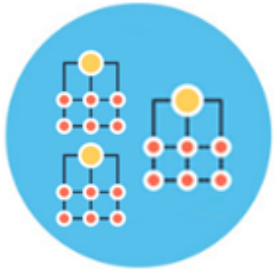
Performance of parser

22. Future Work

Opportunities to overcome the limitations and extend this work.

Bi-directional QRNN

Early stop training phase



Multi-source Treebanks

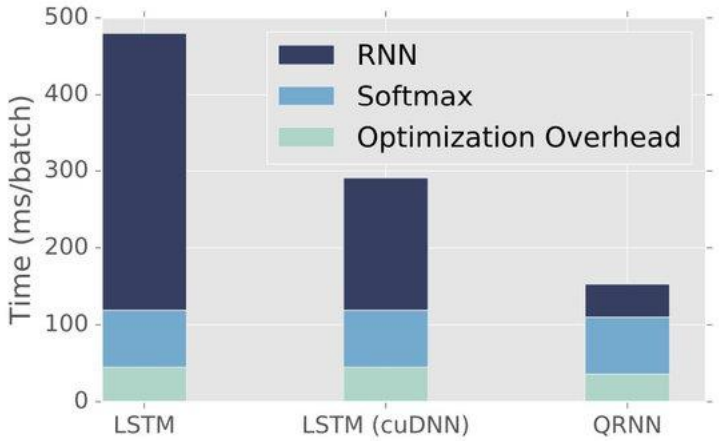
23. Final Thoughts

Thank you for the amazing experience!

24. Methodology - QRNN

Bradbury et al performed language modelling, sentiment classification and machine translation experiments.

Model	Parameters	Validation	Test
LSTM (medium) (Zaremba et al., 2014)	20M	86.2	82.7
Variational LSTM (medium) (Gal & Ghahramani, 2016)	20M	81.9	79.7
LSTM with CharCNN embeddings (Kim et al., 2016)	19M	–	78.9
Zoneout + Variational LSTM (medium) (Merity et al., 2016)	20M	84.4	80.6
Our models			
LSTM (medium)	20M	85.7	82.0
QRNN (medium)	18M	82.9	79.9
QRNN + zoneout ($p = 0.1$) (medium)	18M	82.1	78.3



		Sequence length				
		32	64	128	256	512
Batch size	8	5.5x	8.8x	11.0x	12.4x	16.9x
	16	5.5x	6.7x	7.8x	8.3x	10.8x
	32	4.2x	4.5x	4.9x	4.9x	6.4x
	64	3.0x	3.0x	3.0x	3.0x	3.7x
	128	2.1x	1.9x	2.0x	2.0x	2.4x
	256	1.4x	1.4x	1.3x	1.3x	1.3x

25. Experiments & Results – Multi-sourced Treebanks