Dependency and Span, Cross-Style Semantic Role Labeling on PropBank and NomBank

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Main Work

- The latest developments in neural semantic role labeling (SRL), including both **dependency** and **span** representation formalisms.
- we define a new **cross-style** semantic role label convention and propose a new **cross-style joint optimization model**
- Additionally,we propose a syntax aided method to enhance the learning of both dependency and span representations uniformly
- Experiments show that the proposed methods are effective on both span (CoNLL-2005) and dependency (CoNLL-2009) SRL benchmarks

For example, given an input text *The bill would have lifted the minimum wage of working to $ 4.55 an hour by late 1991*, one of the predicate is *lifted*. In the span-based SRL, the **ARG1** argument is [***the*** *minimum wage of* ***working***], while in the dependency-based SRL, the argument is (***wage***) which is the dependency head of the argument span in span-based SRL.

S: $\textit{lifted}_{\textbf{PRED}}$ $[$***the*** *minimum wage of* ***working***$]_{\textbf{ARG1}}$,

D: $\textit{lifted}_{\textbf{PRED}}$ $($***wage***$)_{\textbf{ARG1}}$,

U: $\textit{lifted}_{\textbf{PRED}}$ $[$***the*** *minimum wage of* ***working***$]($***wage***$)_{\textbf{ARG1}}$.

Model

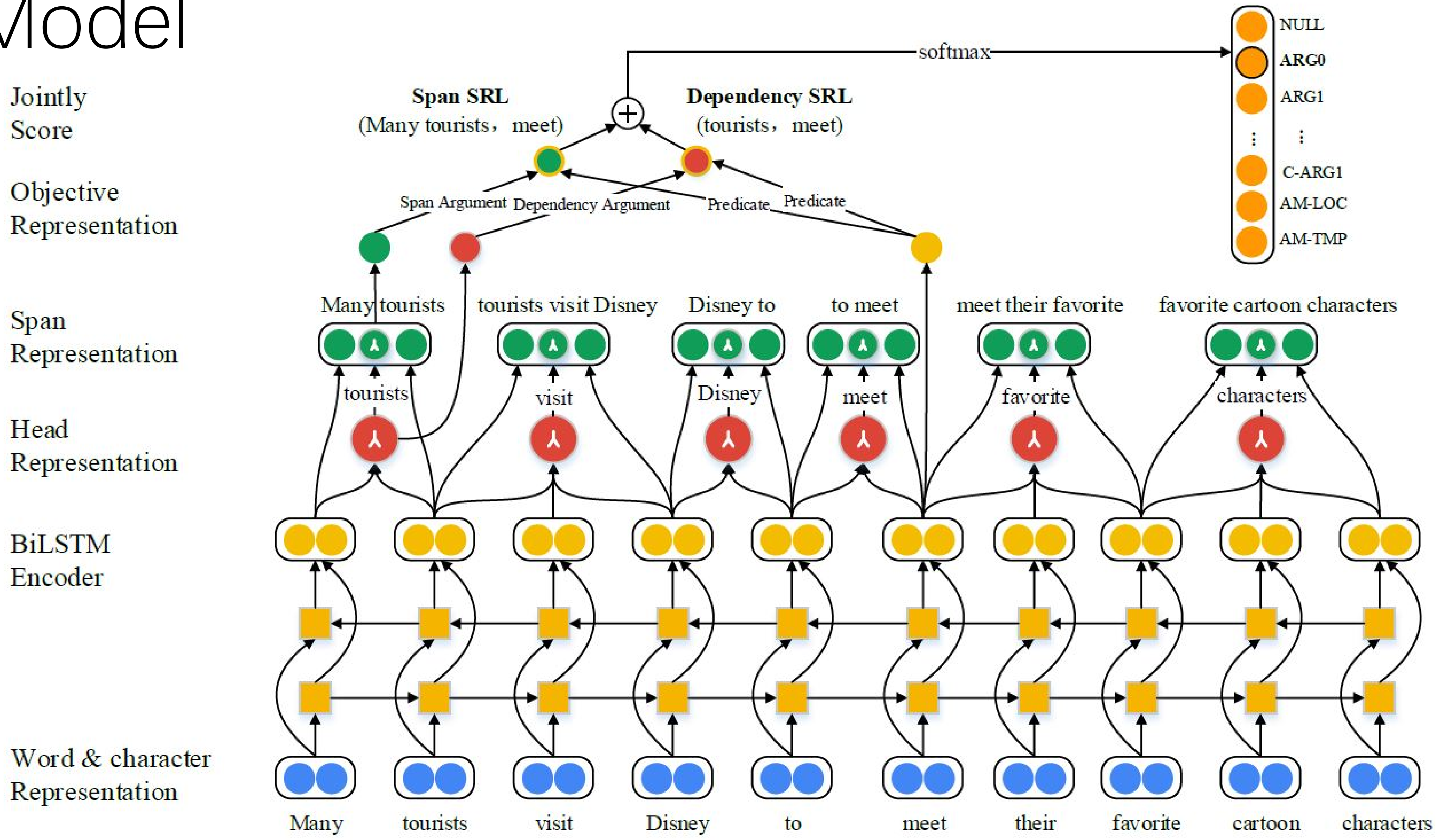


Figure 4: Overall architecture of our proposed SRL model.

Encoder

- Contextualized representation x_i

$$x_i = BiLSTM([e_i^{word}; e_i^{char}; e_i^{lm}])$$

- Objective Representation Layer

$$x_{arg} = [x_{\textsc{Start}(a)}; x_{\textsc{End}(a)}; x_{span}; e^{width}]$$

$$\alpha_{span} = \textbf{softmax}(\mathbf{w}_s^T x_{\textsc{Start}(a):\textsc{End}(a)})$$

$$x_{span} = x_{\textsc{Start}(a):\textsc{End}(a)} \cdot \alpha_{span}$$

Semantic Aided

- Dependency Syntax Aided (DSA)

To utilize such dependency tree structures, for each candidate span $span = \{w_j, w_{j+1}, ..., w_{j+\mathcal{L}}\}$, we get the dependency syntax heads set $headset = \{w_h\}, h \in [j : j + \mathcal{L}]$ from the span by the heuristic defined in previous section. We define an indicator embedding e^{dsa} on the dependency syntax heads set $headset_t$ input to the calculate the span representation x_{span} and head position h.

$$e_t^{dsa} = \begin{cases} 1, & w_t \in headset \\ 0, & w_t \notin headset \end{cases} \quad (6)$$

After we add the indicator embedding e^{dsa} into Eq. (3), the equation becomes:

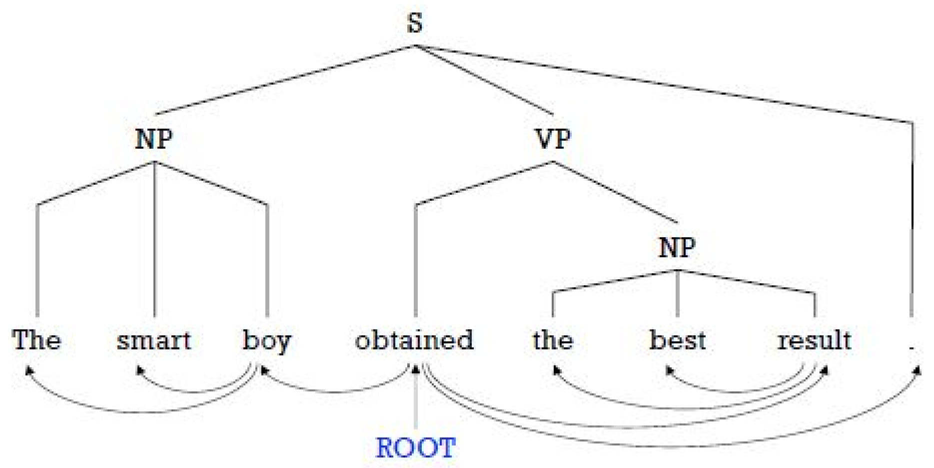
$$\alpha_{span} = \mathbf{softmax}(\mathbf{w}_s^T [x_{\text{START}(a):\text{END}(a)}; e^{dsa}_{\text{START}(a):\text{END}(a)}])$$

Semantic Aided

- Constituency Syntax Aided (CSA)

In order to utilize such constituent boundaries in the constituency tree and use it to help decide the argument candidates, we extract all the constituent c boundaries to form a set $boundaryset = \{(\textsc{Start}(c), \textsc{End}(c))\}$. We also define an indicator embedding e_{csa} on the constituent boundaries set $boundaryset$ input to calculate the span representation.

$$e_t^{csa} = \begin{cases} 1, & span_t \in boundaryset \\ 0, & span_t \notin boundaryset \end{cases} \tag{8}$$



After we add the indicator embedding e^{csa} into Eq. (2), the equation becomes:

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$$x_{arg} = [x_{\text{START}(a)}; x_{\text{END}(a)}; x_{span}; e^{width}; e^{csa}].$$

Train

- Scorer with biaffine attention

$$\Phi_r(p, a) = \{h_p\}^T \mathbf{W}_1 h_a + \mathbf{W}_2^T (h_p \oplus h_a) + \mathbf{b}.$$

- Training Objectives

$$P_\theta(Y|X) = \prod_{p \in \mathcal{P}, a \in \mathcal{A}} P_\theta(y_{p,a}|X),$$

$$P_\theta(y_{p,a} = r|X) = \frac{\exp(\Phi_r(p, a))}{\sum_{r' \in \mathcal{R}} \exp(\Phi_{r'}(p, a))},$$

$$\begin{aligned} \mathcal{J}(X) = & \lambda(-\log P_\theta(Y^*_{span}|X)) \\ & + (1-\lambda)(-\log P_\theta(Y^*_{dep}|X)), \end{aligned}$$

Result

Gold predicates	CoNLL05 WSJ			CoNLL05 Brown			CoNLL09 WSJ			CoNLL09 Brown		
	P	R	F_1	P	R	F_1	P	R	F_1	P	R	F_1
wo/LM												
FitzGerald et al. (2015)*	82.3	76.8	79.4	73.8	68.8	71.2	-	-	87.3	-	-	75.2
Li et al. (2019)	-	-	83.0	-	-	-	-	-	85.1	-	-	-
Ours	83.9	83.5	83.7	73.5	69.1	71.2	86.7	86.9	86.8	75.2	75.4	75.3
Ours + Predicted Syntax	85.0	86.0	85.5	74.0	70.8	72.3	87.8	88.0	87.9	77.0	76.8	76.9
Ours + Gold Syntax	88.0	86.4	87.2	76.6	71.2	73.8	89.1	88.7	88.9	78.9	76.7	77.8
w/ELMo												
Li et al. (2019)	87.9	87.5	87.7	80.6	80.4	80.5	89.6	91.2	90.4	81.7	81.4	81.5
Ours	88.2	87.6	87.9	81.0	80.8	80.9	90.0	91.2	90.6	81.7	81.5	81.6
Ours + Predicted Syntax	88.5	88.1	88.3	81.3	81.1	81.2	90.5	92.1	91.3	81.7	81.9	81.8
Ours + Gold Syntax	89.6	90.1	89.8	82.4	82.6	82.5	90.8	93.5	92.2	82.0	83.4	82.7
w/BERT												
Ours	87.9	89.7	88.8	81.4	81.6	81.5	91.2	91.4	91.3	82.8	82.2	82.5
Ours + Predicted Syntax	88.9	89.1	**89.0**	81.6	82.0	**81.8**	91.4	91.4	**91.4**	82.4	82.8	**82.6**
Ours + Gold Syntax	90.2	91.8	91.0	83.2	84.0	83.6	92.4	93.0	92.7	82.8	84.8	83.8

Result

End-to-end	WSJ			Brown		
	P	R	F_1	P	R	F_1
CoNLL-2005						
He et al. (2017)	80.2	82.3	81.2	67.6	69.6	68.5
He et al. (2018a)	84.8	87.2	86.0	73.9	78.4	76.1
Strubell et al. (2018)	87.1	86.7	86.9	79.0	77.5	78.3
Li et al. (2019)	85.2	87.5	86.3	74.7	78.1	76.4
w/ELMo						
Ours	86.7	86.1	86.4	75.3	78.1	76.7
+Predicted Syntax	86.7	86.7	86.7	76.4	78.2	77.3
+Gold Syntax	88.6	88.0	88.3	78.0	78.2	78.1
w/BERT						
Ours	88.1	86.3	87.2	79.7	79.5	79.6
+Predicted Syntax	88.1	87.5	**87.8**	79.8	80.2	**80.0**
+Gold Syntax	88.4	89.6	89.0	80.3	83.9	82.1
CoNLL-2009						
He et al. (2018b)	83.9	82.7	83.3	–	–	–
Cai et al.(2018)	84.7	85.2	85.0	–	–	72.5
Li et al. (2019)	84.5	86.1	85.3	74.6	73.8	74.2
w/ELMo						
Ours	85.0	86.2	85.6	74.6	74.0	74.3
+Predicted Syntax	86.1	85.9	86.0	75.0	74.8	74.9
+Gold Syntax	88.6	88.9	88.7	75.7	75.3	75.5
w/BERT						
Ours	87.9	86.3	87.1	77.1	74.9	76.0
+Predicted Syntax	87.8	88.0	**87.9**	77.1	75.5	**76.3**
+Gold Syntax	88.6	90.4	89.5	76.0	80.5	78.2

End-to-end	Span SRL			Depedency SRL		
	P	R	F_1	P	R	F_1
Baseline	88.1	87.5	87.8	87.8	88.0	87.9
-DSA	88.0	87.4	87.7	88.1	86.5	87.3
-CSA	87.9	86.7	87.3	88.3	86.5	87.4
-Both	88.1	86.3	87.2	87.9	86.3	87.1

YAGS

- **Dev / Test**
  -- items are TAB-separated, first two items are 0s
- -- 3rd item: number of annotations for this predicate (frame and role annotations: "2" means 1 frame and 1 role are annotated)
- -- 4th item: Frame label of predicate
- -- 5th item: lemma.POS of predicate
- -- 6th item: index of predicate word in sentence (as tokenized in *.lemma.tags file, index starting with 0), multiwords separated by "_"
- -- 7th item: predicate word
- -- 8th item: index of sentence belonging to this predicate (sentences found in *.lemma.tags file
- -- 9th/10th item (optional): first pair of role label and index of argument word in the sentence (multiword spans separated by ":")
- -- further pairs of items (optional): additional pairs of role label and index of argument word

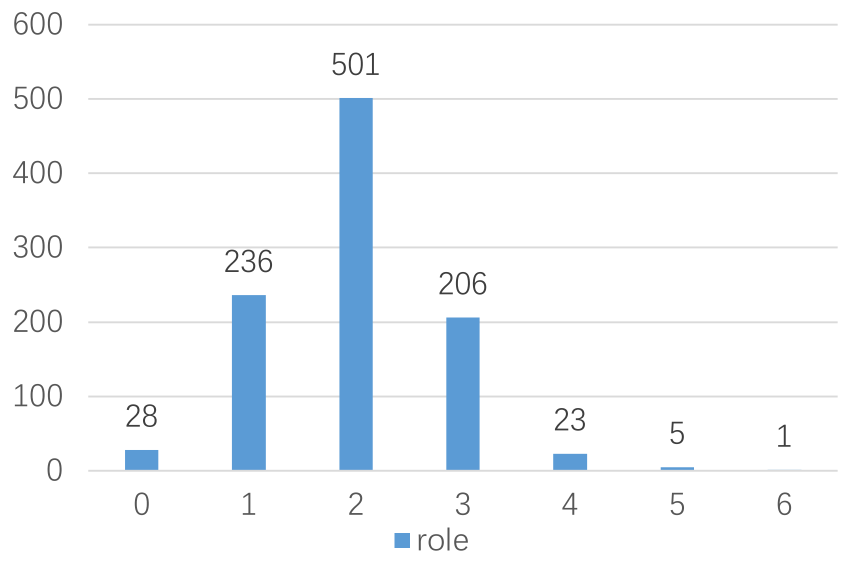
YAGS

- **Text**

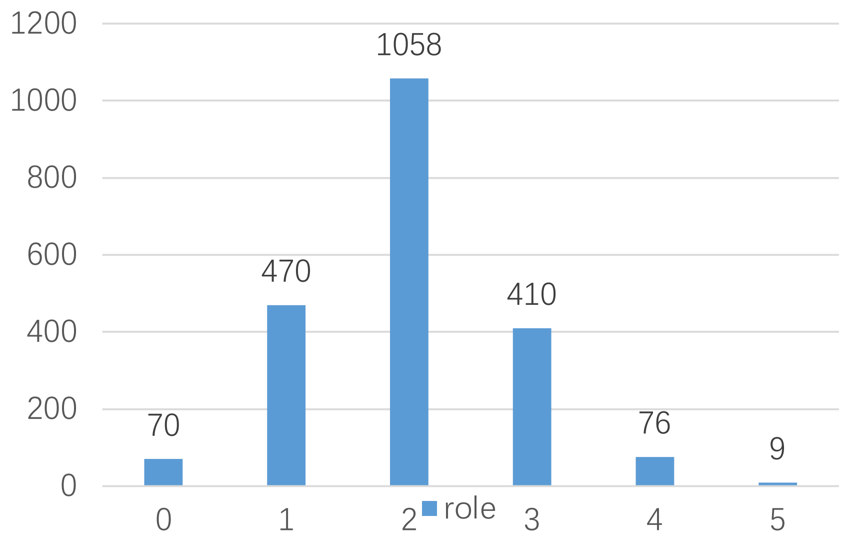
  -- the first column marks the number of tokens in a sentence (n)
- -- the next n items contain the WORDS (tokens)
- -- the next n items contain the corresponding POS tags
- -- the next n items contain the dependency labels
- -- the next n items contain the dependency heads
- -- the next n items are 0
- -- the next n items contain the LEMMA

YAGS

- **Dev**
  - **size：1000**
  - **frame：268**
  - **role_avg= 2.979**



- **Test**
  - **size：2093**
  - **frame：363**
  - **role_avg=2.98**



YAGS

- • **example**

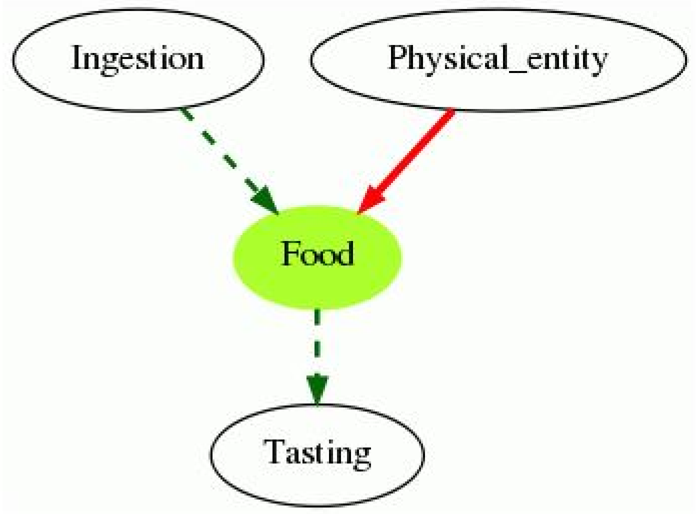
```
0	0	4	Personal_relationship	boyfriend.n 3	boyfriend	1007
0	0	4	Intentionally_act	do.v	5	did 1007	Agent	2:3 Act
0	0	4	Capability	able.a	15	able	1007	Degree	13	Event
```

YAGS

- **Frame-frame Relations:**

Frame-frame Relations:

Inherits from: Physical_entity
Is Inherited by:
Perspective on:
Is Perspectivized in:
Uses: Ingestion
Is Used by: Tasting
Subframe of:
Has Subframe(s):
Precedes:
Is Preceded by:
Is Inchoative of:
Is Causative of:



ImsituVQA

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IMAGE about cooking

QUESTION	ANSWER	FRAME ELEMENT
Who is cooking?	boy	AGENT
What does the boy cook with spatula?	meat	FOOD
What is the boy doing?	cooking	VERB
What does the boy use to cook in wok?	spatula	TOOL
Where does the boy cook meat in wok?	kitchen	PLACE

IMAGE about buying

QUESTION	ANSWER	FRAME ELEMENT
Who is buying shoes?	woman	AGENT
What is the woman doing?	buying	VERB
What item does the woman buy with credit card?	shoe	GOODS
who does the woman buy shoe from?	person	SELLER
where does the woman buy shoe?	shoe store	PLACE