

COMP 3225

Natural Language Processing

Applications of NLP: Semantic Role Labelling

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Overview

- Semantic Roles
- PropBank
- FrameNet
- <break - discussion point>
- Semantic Role Labelling

Semantic Roles

- A **semantic role** is the role that arguments of a predicate take in an event
- Datasets >> PropBank, FrameNet
- **Semantic role labelling** is the task of assigning roles to spans of text in sentences
- A **thematic role** captures the semantic commonality around participants of event
 - No single definition - common examples below (typically around 12 roles)

Thematic Role	Definition	Example
AGENT	The volitional causer of an event	<i>The waiter</i> spilled the soup.
EXPERIENCER	The experiencer of an event	<i>John</i> has a headache.
FORCE	The non-volitional causer of the event	<i>The wind</i> blows debris from the mall into our yards.
THEME	The participant most directly affected by an event	Only after Benjamin Franklin broke <i>the ice</i> ...
RESULT	The end product of an event	The city built a <i>regulation-size baseball diamond</i> ...
CONTENT	The proposition or content of a propositional event	Mona asked “ <i>You met Mary Ann at a supermarket?</i> ”
INSTRUMENT	An instrument used in an event	He poached catfish, stunning them <i>with a shocking device</i> ...
BENEFICIARY	The beneficiary of an event	Whenever Ann Callahan makes hotel reservations <i>for her boss</i> .
SOURCE	The origin of the object of a transfer event	I flew in <i>from Boston</i> .
GOAL	The destination of an object of a transfer event	I drove <i>to Portland</i> .

AGENT → ARG [The waiter] PREDICATE[spilled] ARG[the soup]

Semantic Roles

- Problem with thematic roles
 - Lots of different themes/events lead to a lot of thematic roles
- Generalized semantic roles
 - Semantic roles are abstracted over many thematic roles
 - option 1
 - >> semantic roles are defined heuristically, such as 'agent-like' = PROTO-AGENT or 'patient-like' = PROTO-PATIENT
 - >> PropBank
 - option 2
 - >> define roles specific to groups of verbs or nouns
 - >> FrameNet

PropBank

- Semantic role annotations
 - English PropBank >> Penn TreeBank
 - Chinese PropBank = Penn Chinese TreeBank
 - etc.
- Semantic roles are tied to specific verb sense predicates
- **NomBank** does same for noun predicates

PropBank

- Each verb has N arguments
 - arg0 = PROTO-AGENT (usually)
 - arg1 = PROTO-PATIENT (usually)
 - arg2..N = depends on verb

(19.11) **agree.01**

Arg0: Agreeer

Arg1: Proposition

Arg2: Other entity agreeing

Ex1: [Arg0 The group] *agreed* [Arg1 it wouldn't make an offer].

Ex2: [ArgM-TMP Usually] [Arg0 John] *agrees* [Arg2 with Mary]
[Arg1 on everything].

(19.12) **fall.01**

Arg1: Logical subject, patient, thing falling

Arg2: Extent, amount fallen

Arg3: start point

Arg4: end point, end state of arg1

Ex1: [Arg1 Sales] *fell* [Arg4 to \$25 million] [Arg3 from \$27 million].

Ex2: [Arg1 The average junk bond] *fell* [Arg2 by 4.2%].

PropBank

- Each verb has N arguments
 - arg0 = PROTO-AGENT (usually)
 - arg1 = PROTO-PATIENT (usually)
 - arg2..N = depends on verb
- Arguments have argument modifiers
 - ArgM = ArgM-TMP, ArgM-LOC etc

TMP	when?	yesterday evening, now
LOC	where?	at the museum, in San Francisco
DIR	where to/from?	down, to Bangkok
MNR	how?	clearly, with much enthusiasm
PRP/CAU	why?	because ... , in response to the ruling
REC		themselves, each other
ADV	miscellaneous	
PRD	secondary predication	...ate the meat raw

FrameNet

- Semantic roles are associated with 'frames' not verb predicates
- A **frame** is a background knowledge structure that unites a set of words
- **Frame elements** (or semantic roles) are a set of semantic roles and the predicates that use these roles

FrameNet ID

change_position_on_a_scale ← **Frame**

Frame element

FrameNet desc

This frame consists of words that indicate the change of an Item's position on a scale (the **Attribute**) from a starting point (**Initial_value**) to an end point (**Final_value**).

The direction (**Path**) of the movement can be indicated as well as the magnitude of the change (**Difference**).

The rate of change of the value (**Speed**) is optionally indicated. Another scale (**Correlated_variable**), which the values are correlated with, is indicated if it is not the default correlate (namely, absolute time).

https://framenet2.icsi.berkeley.edu/fnReports/data/frameIndex.xml?frame=Change_position_on_a_scale

FrameNet

- Core roles are frame specific
- Non-core roles are general properties like time, location etc

(19.20) [ITEM Oil] *rose* [ATTRIBUTE in price] [DIFFERENCE by 2%].

(19.21) [ITEM It] has *increased* [FINAL_STATE to having them 1 day a month].

(19.22) [ITEM Microsoft shares] *fell* [FINAL_VALUE to 7 5/8].

(19.23) [ITEM Colon cancer incidence] *fell* [DIFFERENCE by 50%] [GROUP among men].

(19.24) a steady *increase* [INITIAL_VALUE from 9.5] [FINAL_VALUE to 14.3] [ITEM in dividends]

(19.25) a [DIFFERENCE 5%] [ITEM dividend] *increase...*

Core Roles	
ATTRIBUTE	The ATTRIBUTE is a scalar property that the ITEM possesses.
DIFFERENCE	The distance by which an ITEM changes its position on the scale.
FINAL_STATE	A description that presents the ITEM's state after the change in the ATTRIBUTE's value as an independent predication.
FINAL_VALUE	The position on the scale where the ITEM ends up.
INITIAL_STATE	A description that presents the ITEM's state before the change in the ATTRIBUTE's value as an independent predication.
INITIAL_VALUE	The initial position on the scale from which the ITEM moves away.
ITEM	The entity that has a position on the scale.
VALUE_RANGE	A portion of the scale, typically identified by its end points, along which the values of the ATTRIBUTE fluctuate.
Some Non-Core Roles	
DURATION	The length of time over which the change takes place.
SPEED	The rate of change of the VALUE.
GROUP	The GROUP in which an ITEM changes the value of an ATTRIBUTE in a specified way.

Break

- Panopto Quiz - discussion point
- Lookup the frame for 'Animal' in FrameNet. What core roles does it have?

<https://framenet2.icsi.berkeley.edu/fnReports/data/frameIndex.xml>

Animal

Characteristic, Descriptor, Origin

Animal, Organism

Break

- Panopto Quiz - discussion point
- Lookup the frame for 'Animal' in FrameNet. What core roles does it have?

<https://framenet2.icsi.berkeley.edu/fnReports/data/frameIndex.xml>

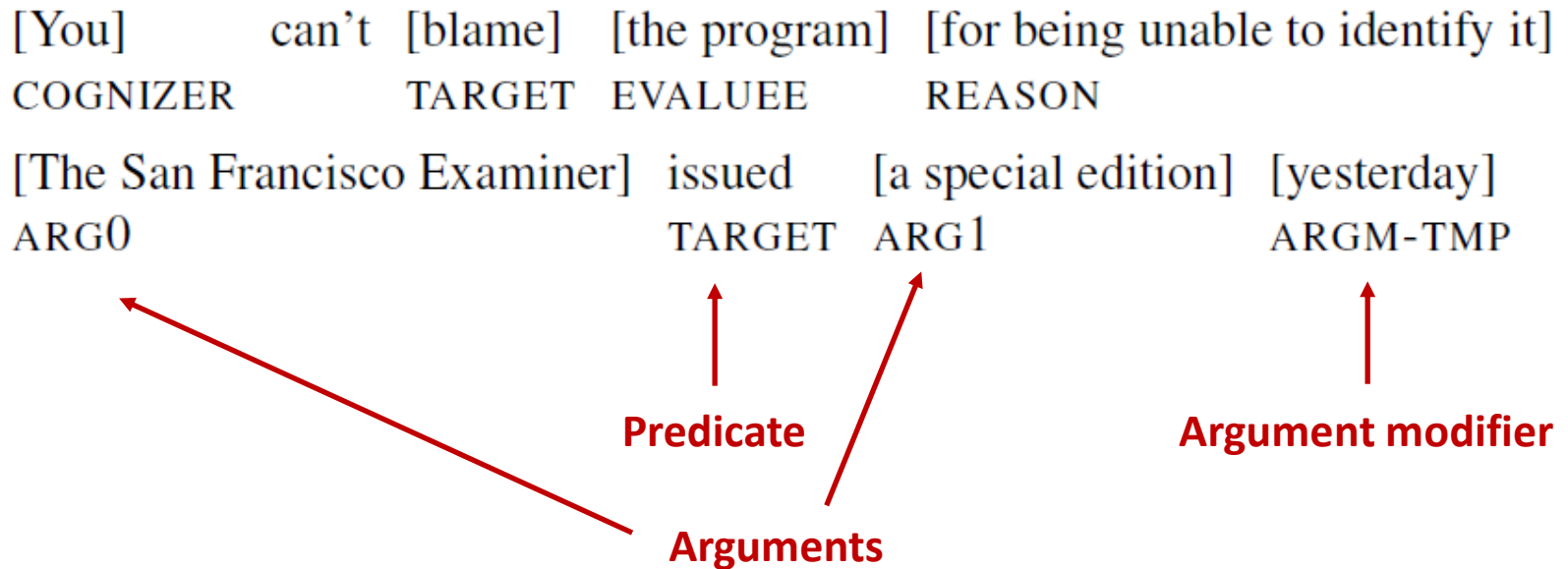
Animal

Characteristic, Descriptor, Origin >> non-core roles

Animal, Organism >> organism is an inherited core role

Semantic Role Labelling

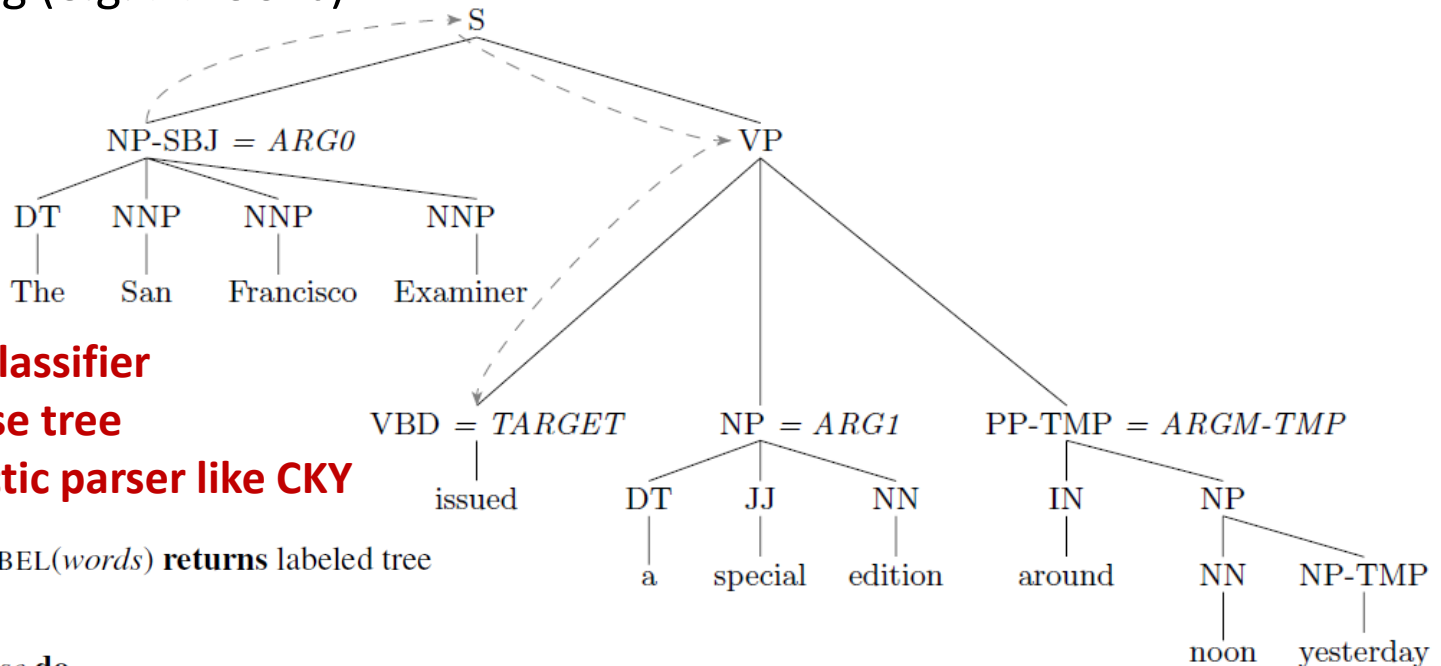
- Semantic Role Labelling (SRL) is the task of finding semantic roles for each argument of a given predicate



Semantic Role Labelling

- Feature-based SRL

- Training set = PropBank or FrameNet = sent + parse tree
- Node = node of parse tree
- Supervised classifier (e.g. CRF) to predict SRL for a node
- X = feature template for a specific (node, predicate) in parse tree
- Y = SRL tag (e.g. NP-SUBJ)



SRL >> apply node classifier

in a walk of the parse tree

Parse tree >> syntactic parser like CKY

function SEMANTICROLELABEL(*words*) **returns** labeled tree

```

parse ← PARSE(words)
for each predicate in parse do
  for each node in parse do
    featurevector ← EXTRACTFEATURES(node, predicate, parse)
    CLASSIFYNODE(node, featurevector, parse)
  
```

Semantic Role Labelling

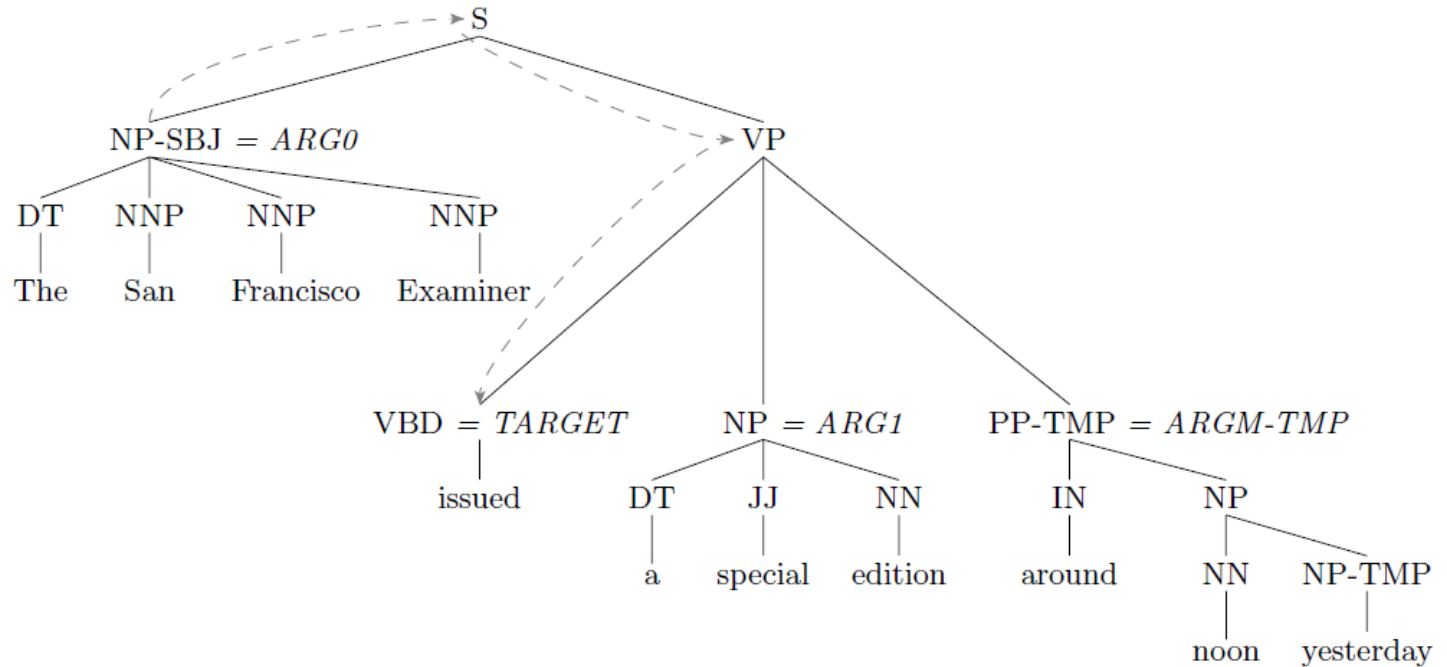
- Pipeline
 - Prune >> heuristics to remove unlikely constituents (prior to training)
 - Identify >> binary classifier (argument/not_argument) to identify nodes
 - Classify >> multi-class classifier (SRL label for argument) for nodes
- Global consistency
 - Semantic roles of constituents are not independent, so per-node (argument) local role classification is not optimal
 - Global consistency step added as a second pass
e.g. re-ranking methods

Semantic Role Labelling

- Feature templates for SRL
 - Governing predicate (e.g. verb)
 - Phrase type of the constituent (e.g. NP-SBJ)
 - Headword of the constituent (e.g. via head finding rules)
 - Headword POS tag (e.g. NNP)
 - Path in parse tree from constituent to predicate (e.g. NP↑S↓VP↓VBD)
 - Voice of the clause (e.g. active, passive)
 - Position of constituent with respect to the predicate (e.g. before, after)
 - Subcategorization of the predicate - 1 deep parse tree of parent (e.g. VP → VBD NP PP-TMP)
 - Named entity type of the constituent (e.g. LOC)
 - First and last word of the constituent

Semantic Role Labelling

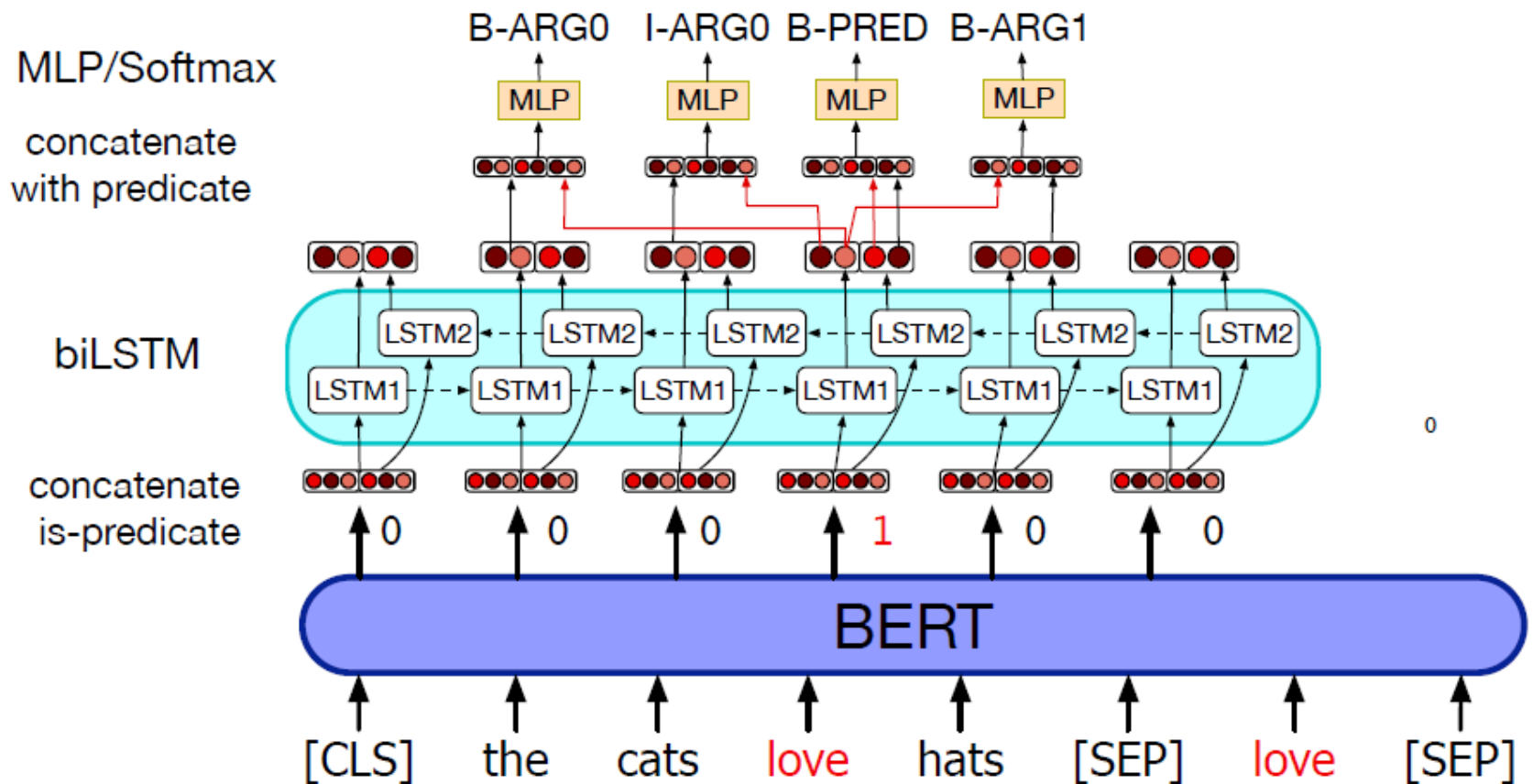
- Example for node NP-SBJ



- Node = NP-SBJ Predicate = TARGET
- X = feature value set = [issued, NP-SBJ, Examiner, NNP, NP↑S↓VP↓VBD, active, before, VP → VBD NP PP-TMP, ORG, The, Examiner]
- Y = ARG0

Semantic Role Labelling

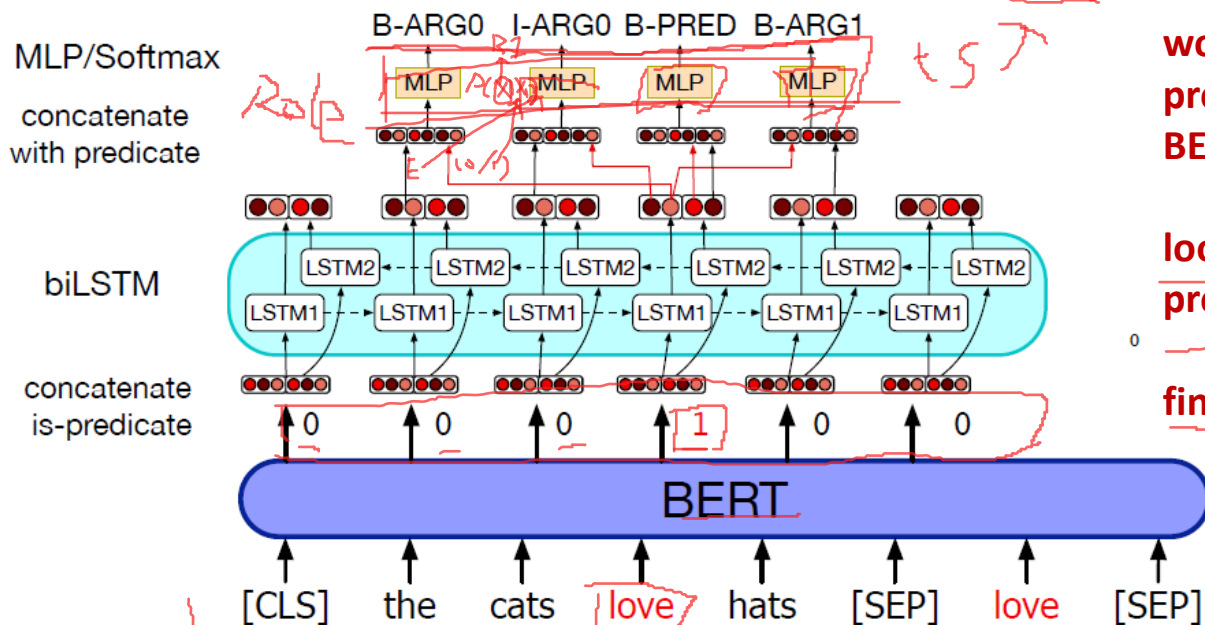
- **Neural SRL** can be formulated as a sequence labelling task
 - $X = [\text{CLS}] \text{ sent } \dots [\text{SEP}] \text{ predicate } [\text{SEP}]$
 - $Y = \text{BIO tags for SRL (e.g. B-ARG0; I-ARG-0 } \dots)$



No parse tree input >> just text

Semantic Role Labelling

- Neural SRL can be formulated as a sequence labelling task
 - $X = [\text{CLS}] \text{ sent } \dots [\text{SEP}] \text{ predicate } [\text{SEP}]$
 - $Y = \text{BIO tags for SRL from PropBank (e.g. B-ARG0; I-ARG0 ...)}$
 - BiLSTM encoder
 - Concatenate (a) BERT word embedding and (b) predicate flag embedding
 - Could use other layers than BiLSTM (e.g. Transformer)
 - MLP + Softmax decoder
 - Concatenate (a) hidden layer output for word and (b) hidden layer output for predicate
 - Could use other layers than MLP (e.g. CRF layer)



word (seq pos 4) = 'love'
predicate flag = True = 1
BERT vocab size = V

lookup BERT embedding = $\text{shape}(1, V)$
predicate value vector = $\text{shape}(1, 1)$

final input embedding = $\text{shape}(1, V+1)$

Semantic Role Labelling

- Evaluation of SRL
 - Datasets CoNLL-2005 and CoNLL-2012
 - Metric P/R/F1

Required Reading

- Information Extraction
 - Jurafsky and Martin, Speech and Language Processing, 3rd edition (online)
>> chapter 19

Questions

- Panopto Quiz - 1 minute brainstorm for interactive questions
Please write down in Panopto quiz in **1 minute** two or three questions that you would like to have answered at the next interactive session.

Do it **right now** while its fresh.

Take a screen shot of your questions and **bring them with you** at the interactive session so you have something to ask.