End-to-End Discriminative Training for Machine Translation

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Dan Klein

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UC Berkeley

Computer Science Division

Discriminative machine translation

$\mathbf{x}$: le parlement adopte la résolution législative

$\mathbf{y}$: parliament adopted the legislative resolution

Discriminative machine translation

$\mathbf{x}$: le parlement adopte la résolution législative

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Training examples

$\mathbf{x}_1$: mr barn crespo wishes to make a comment .
$\mathbf{y}_1$: m. barn crespo veut intervenir .

$\mathbf{x}_2$: i consider it very important to continue this work .
$\mathbf{y}_2$: à mon avis , il est très important de continuer dans cette voie-là .

$\mathbf{x}_3$: this all augurs well , and represents real progress .
$\mathbf{y}_3$: tout cela est de bon augure et constitue un réel progrès .

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Discriminative machine translation

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NN JJ $\rightarrow$ JJ NN 1

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Lang. model	-4.253	1.7
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That's it.

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That's it. Well, actually. . .

Why is this hard?

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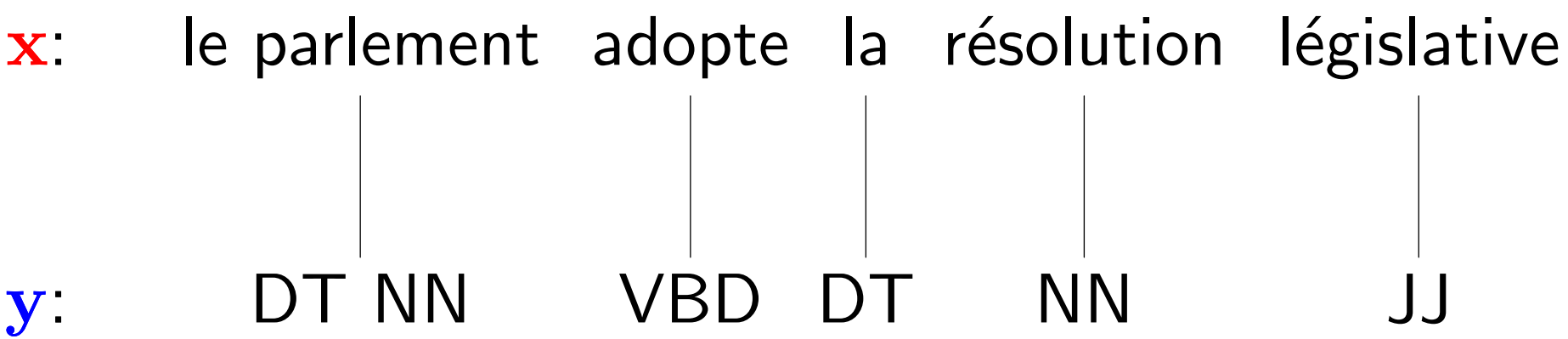

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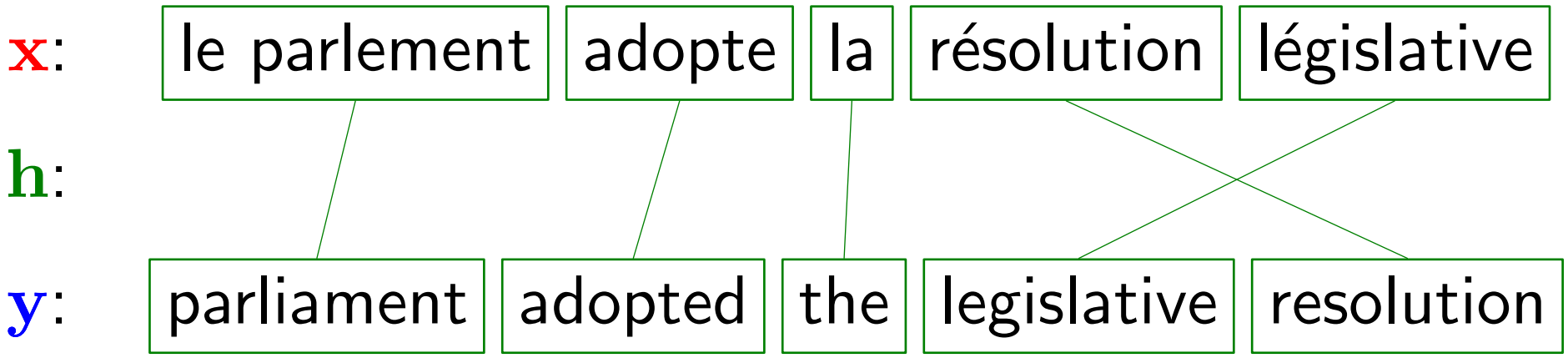

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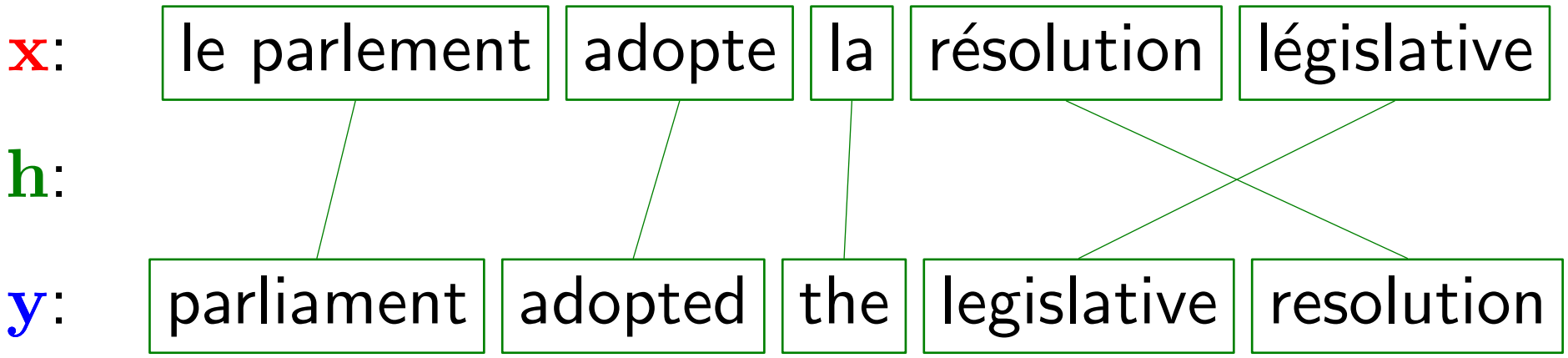

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- Hidden correspondence is abused

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h:

y: parliament has adopted the resolution

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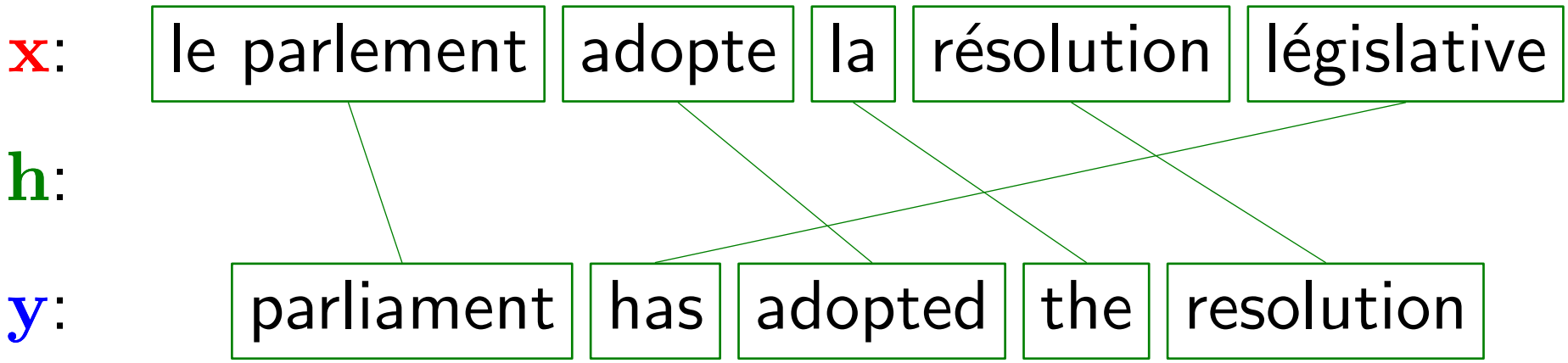

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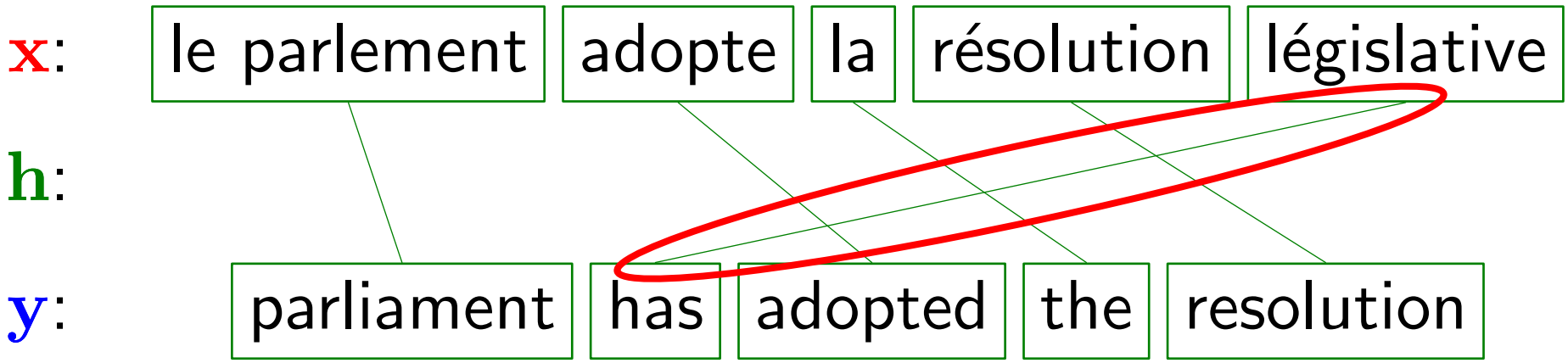

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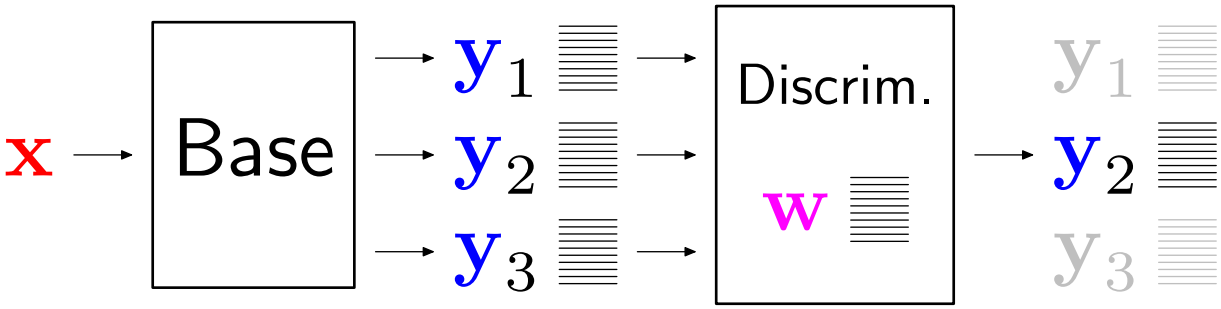
Discriminative approaches

Reranking [Shen, et al. '04; Och, et al. '04]



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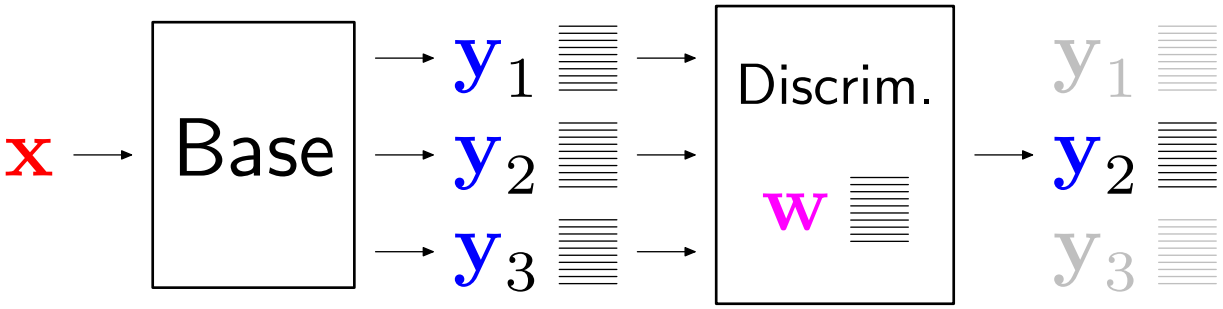
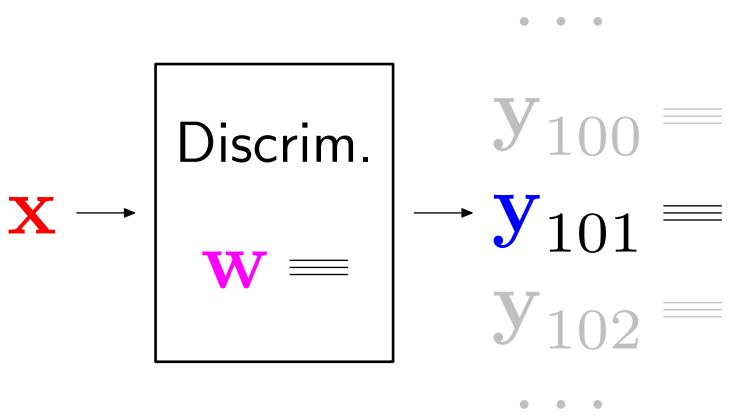


MERT [Och '03]



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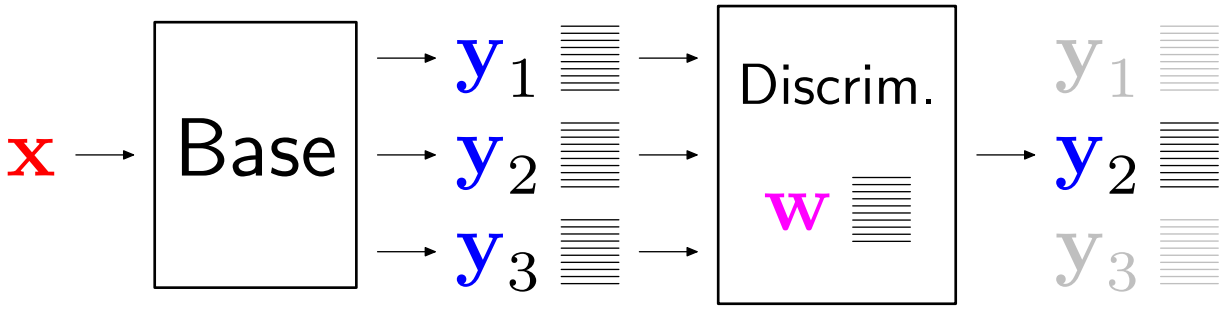

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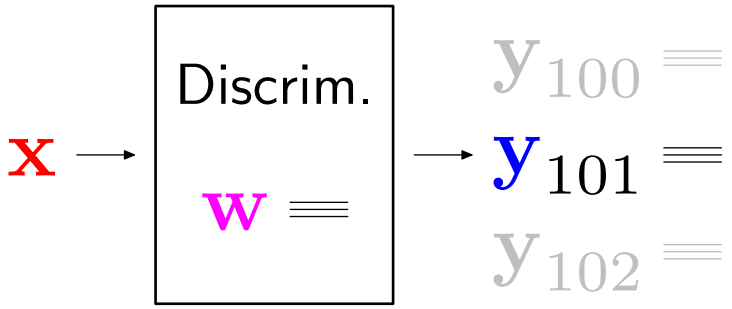
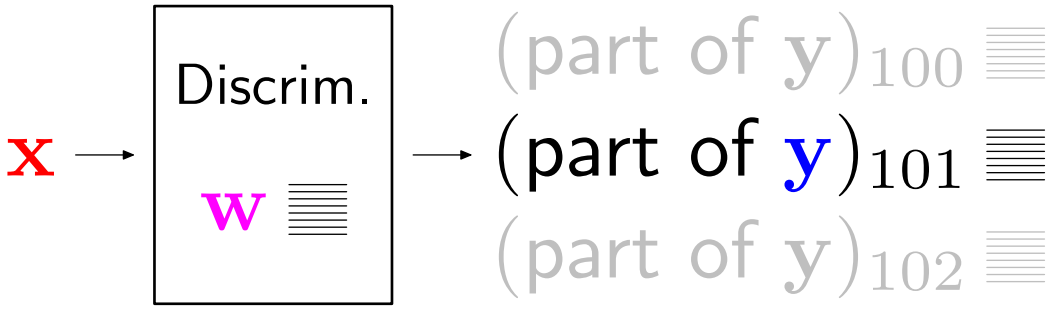


Local [Tillmann, Zhang '05]



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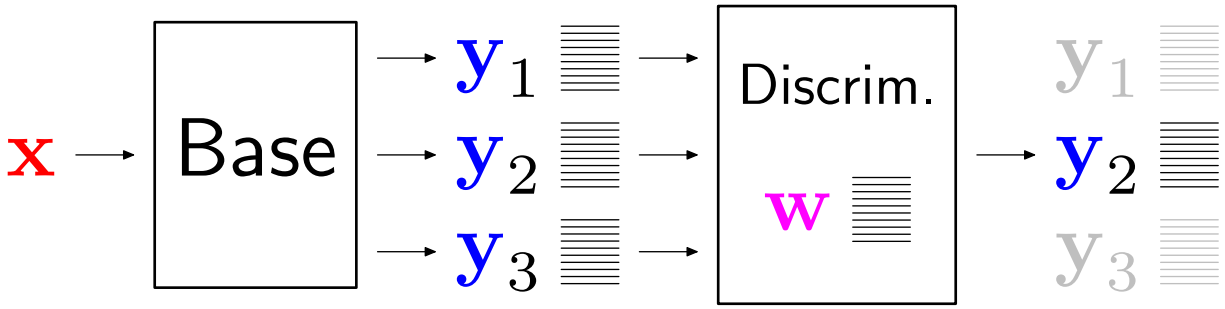

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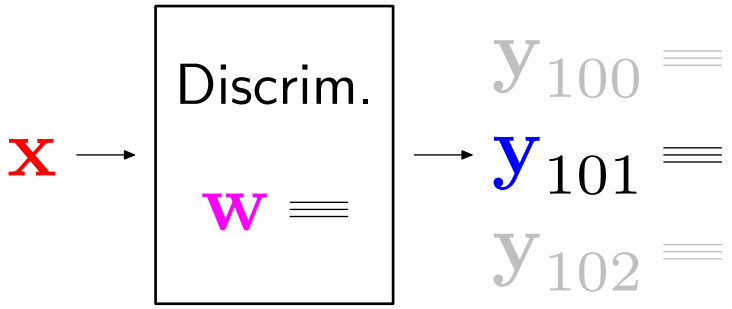

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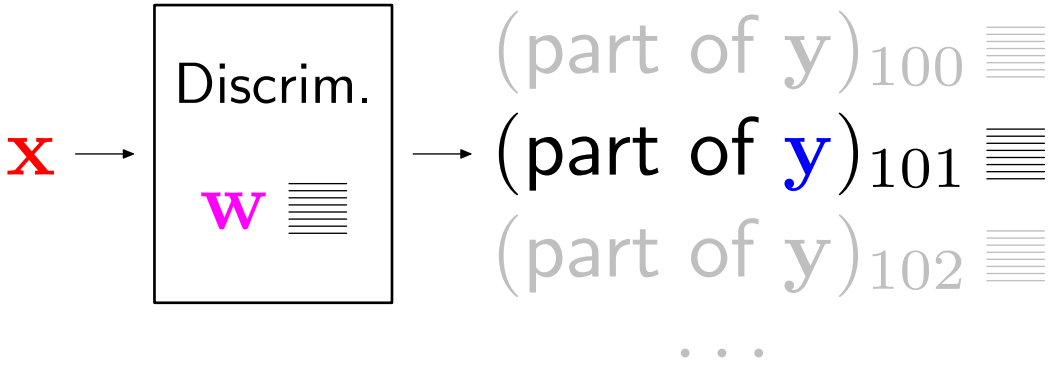
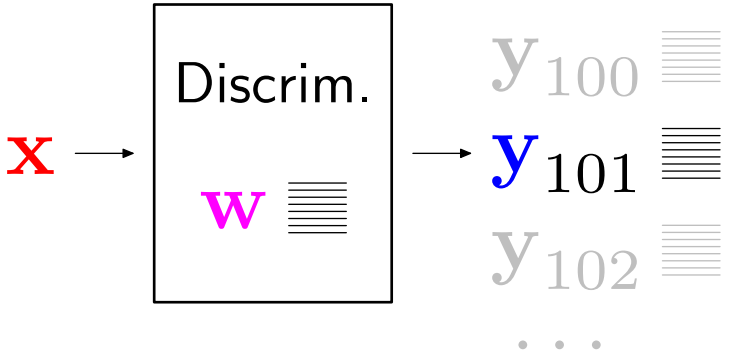


Our end-to-end approach



Experimental setup

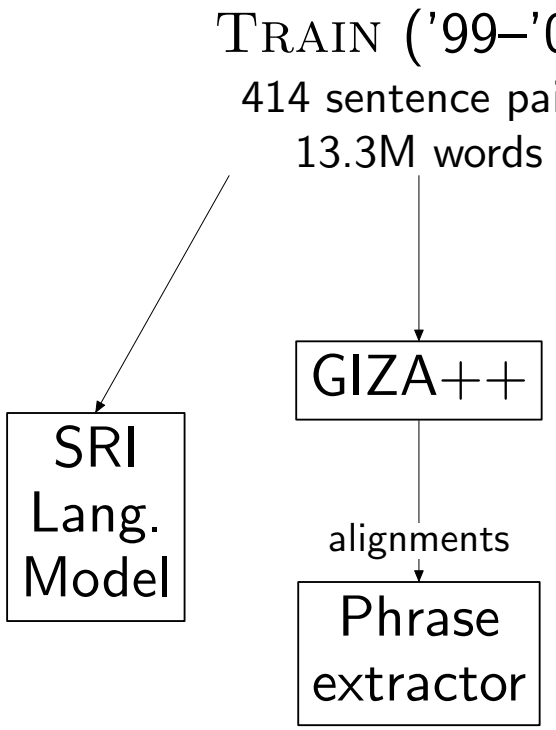
TRAIN ('99–'01)
414 sentence pairs
13.3M words

French-English Europarl corpus

DEV.5–15 ('02)
first 1K sentence pairs
10.4K words

TEST.5–15 ('03)
first 1K sentence pairs
10.8K words

Experimental setup



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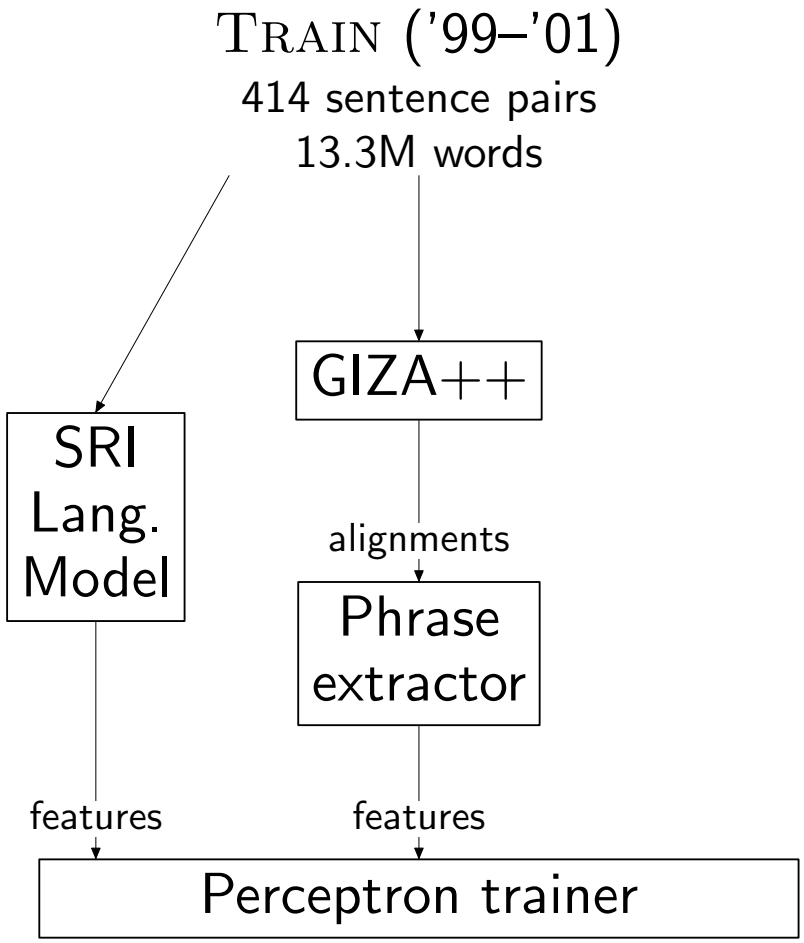

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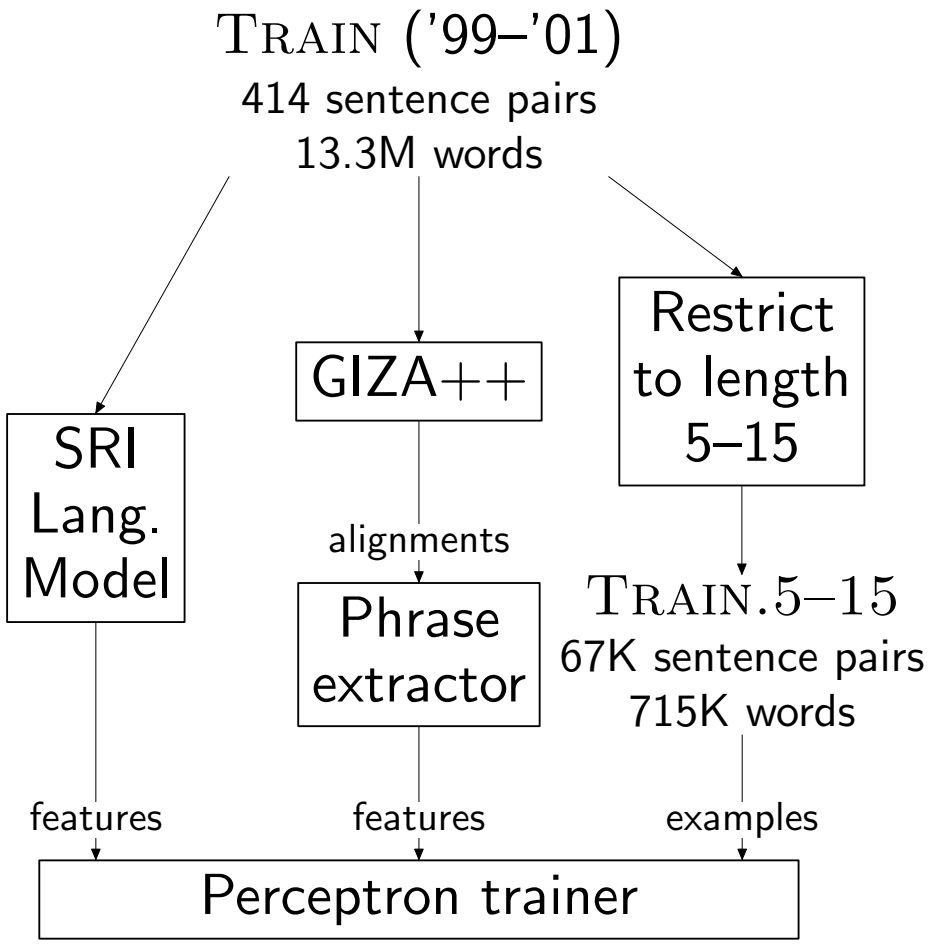

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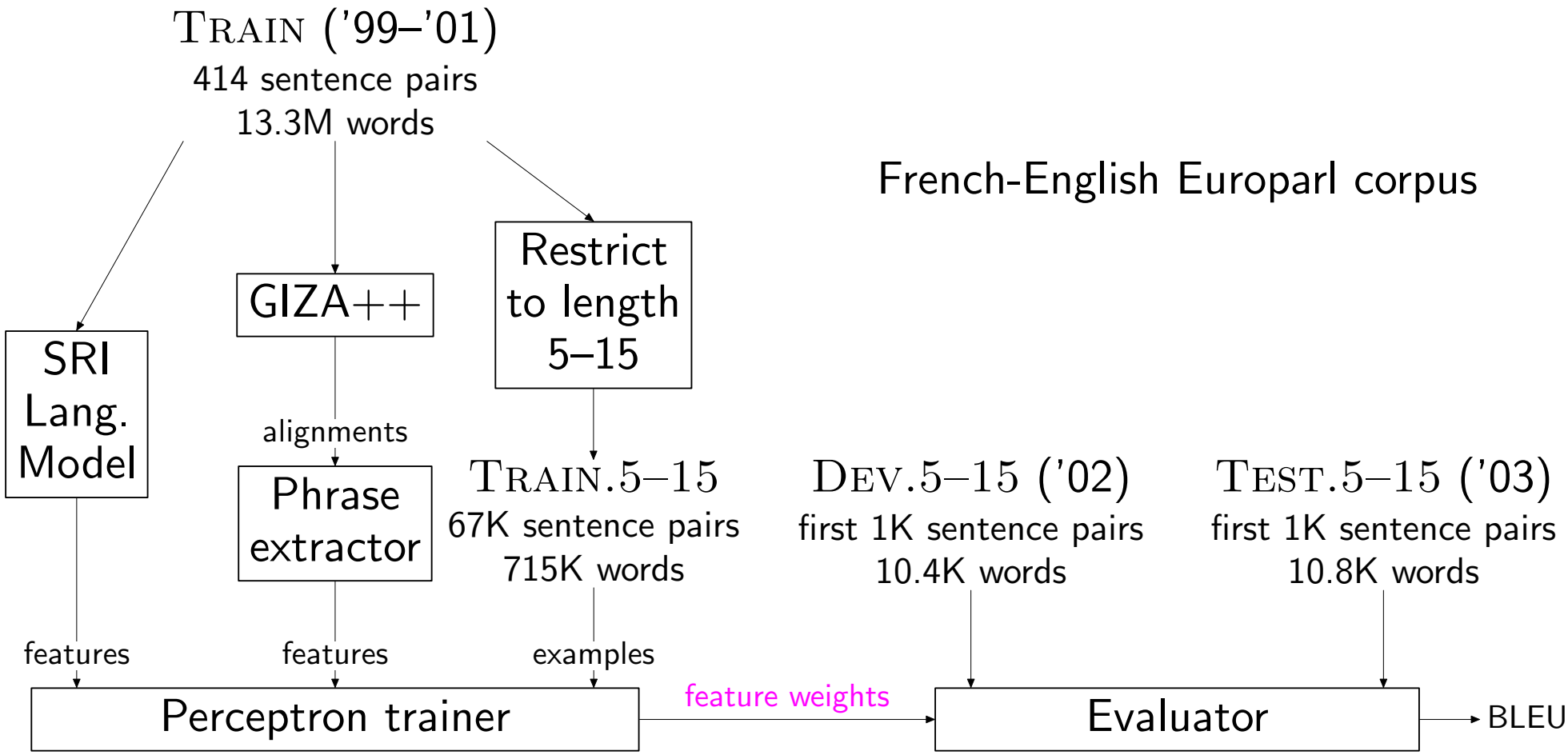

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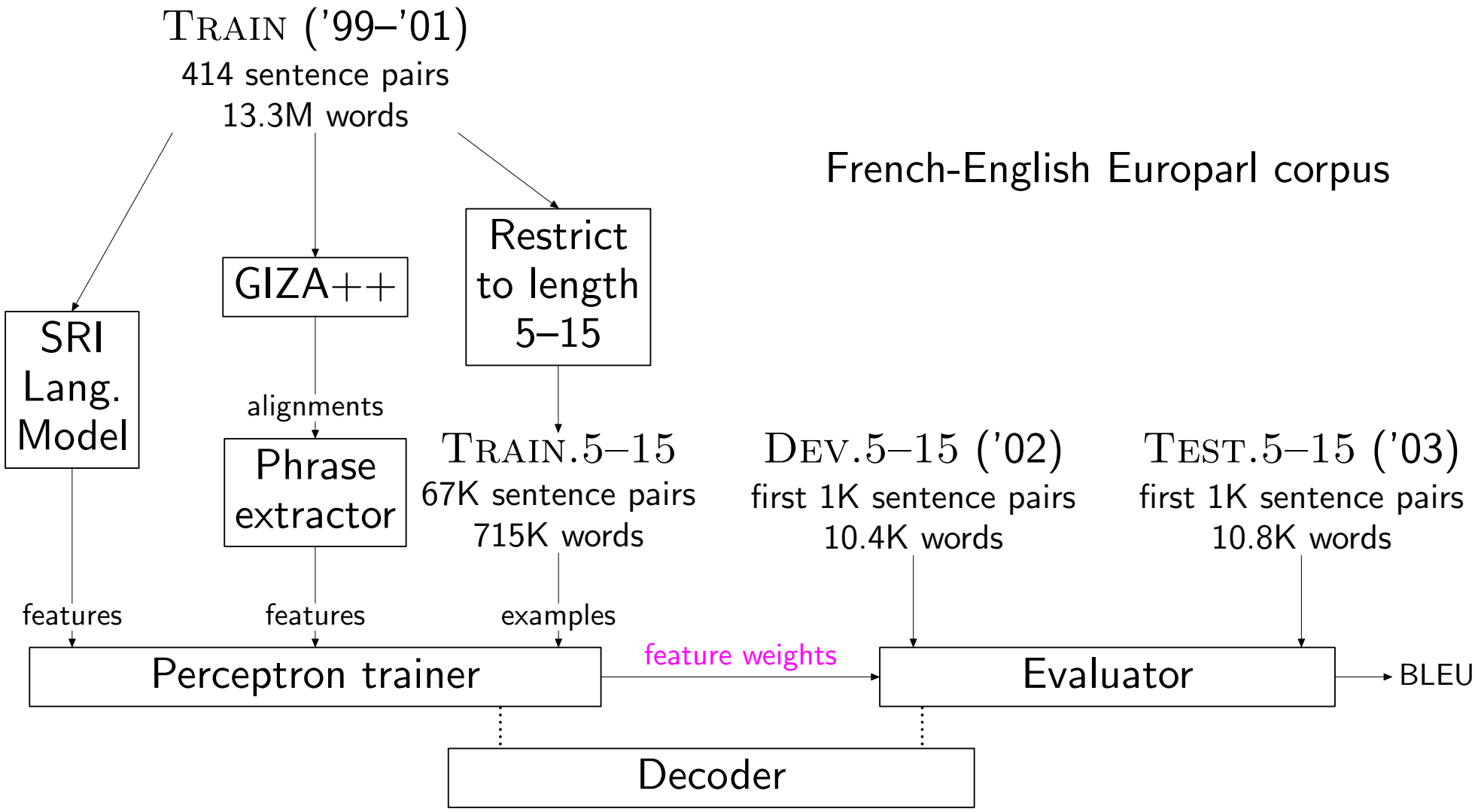

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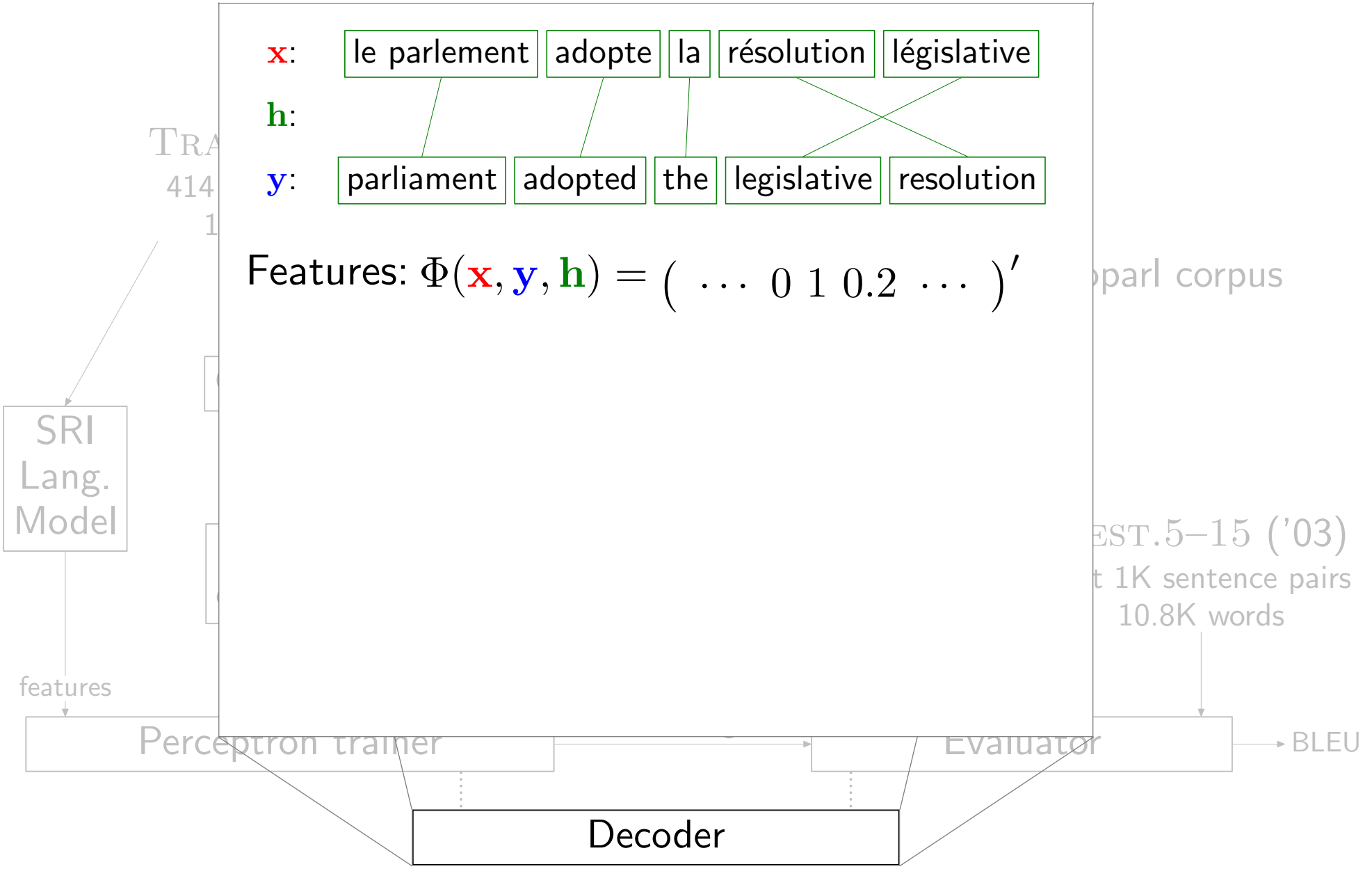

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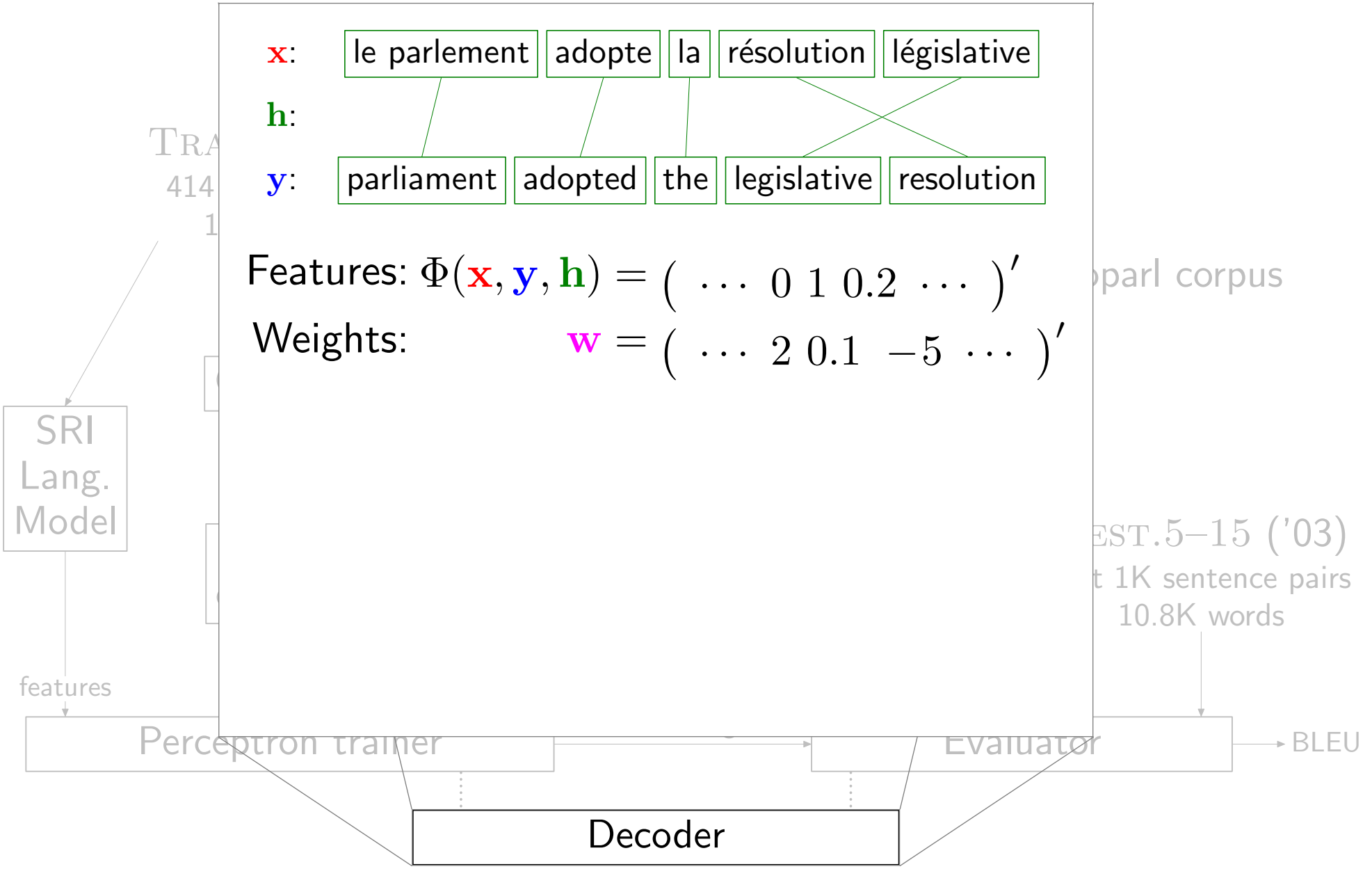

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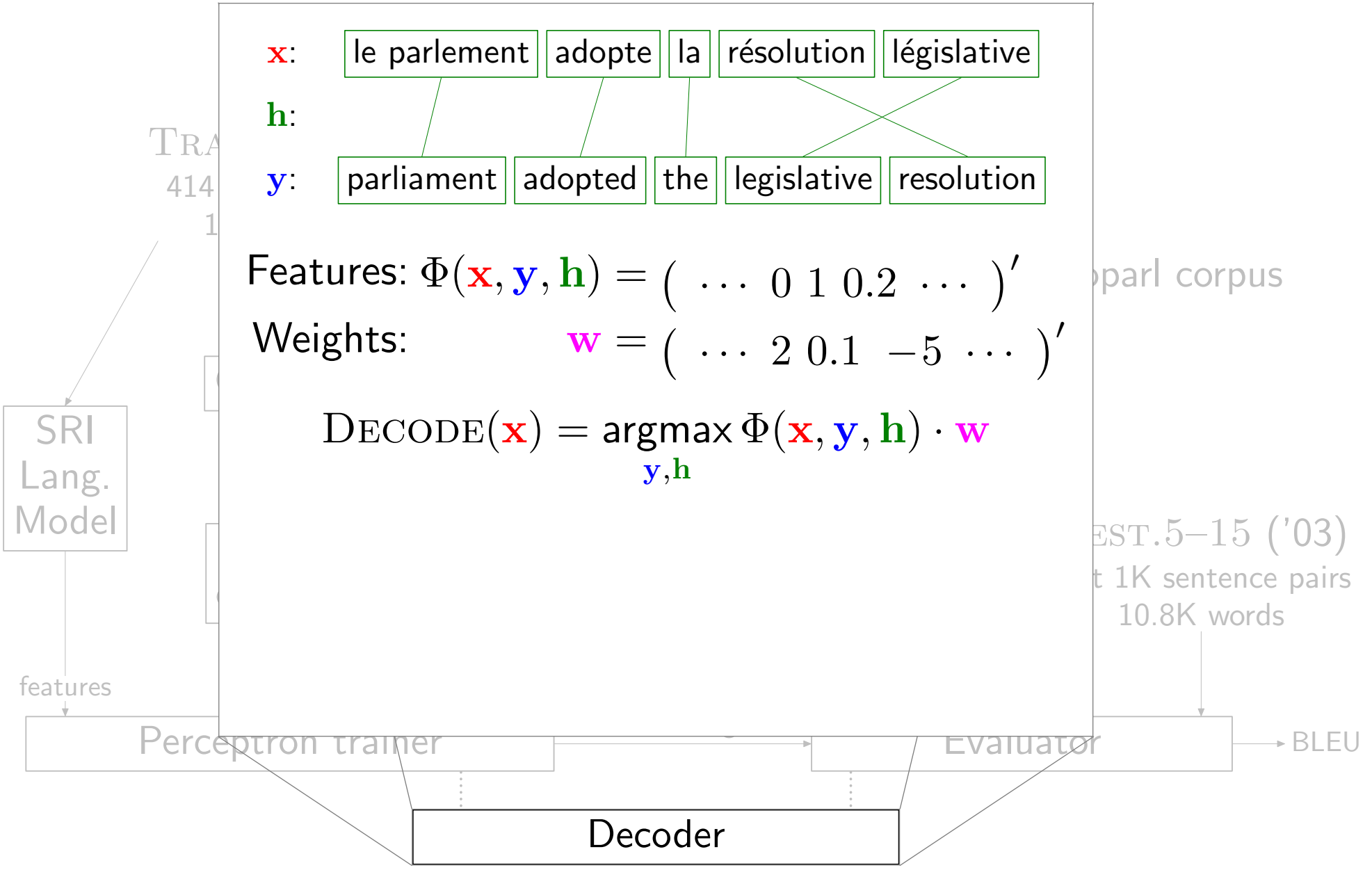

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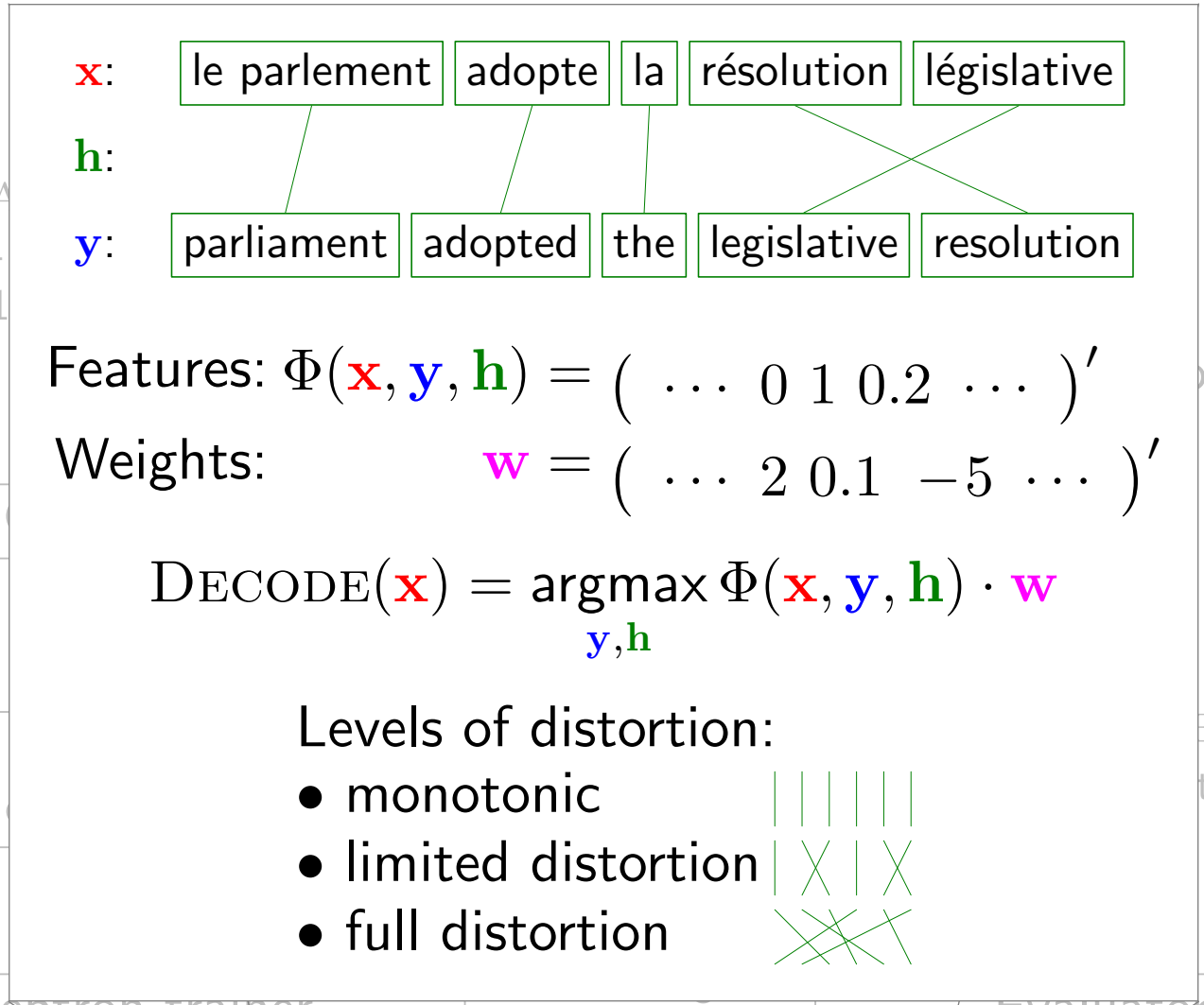

Features: $\Phi(\mathbf{x}, \mathbf{y}, \mathbf{h}) = \begin{pmatrix} \cdots & 0 & 1 & 0.2 & \cdots \end{pmatrix}'$

Weights: $\mathbf{w} = \begin{pmatrix} \cdots & 2 & 0.1 & -5 & \cdots \end{pmatrix}'$

$$\textsc{Decode}(\mathbf{x}) = \underset{\mathbf{y},\mathbf{h}}{\text{argmax}}\, \Phi(\mathbf{x}, \mathbf{y}, \mathbf{h}) \cdot \mathbf{w}$$

Levels of distortion:

- monotonic
- limited distortion
- full distortion

Perceptron training

For each training example $(\mathbf{x}, \mathbf{y})$: [Collins '02]

$$\mathbf{w} \leftarrow \mathbf{w} \begin{array}{ll} +\Phi(\mathbf{x}, \mathbf{y}_\mathsf{t}) & \mid \mathbf{y}_\mathsf{t} = \mathbf{y} \\ -\Phi(\mathbf{x}, \mathbf{y}_\mathsf{p}) & \mid \mathbf{y}_\mathsf{p} = \textsc{Decode}(\mathbf{x}) \end{array}$$

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How to choose $\mathbf{y}_t, \mathbf{h}_t$?

There are several choices and the choice does matter

Update strategies

$$\mathbf{w} \leftarrow \mathbf{w} + \Phi(\mathbf{x}, \boxed{\mathbf{y}_t, \mathbf{h}_t}) - \Phi(\mathbf{x}, \mathbf{y}_p, \mathbf{h}_p)$$

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Training example (reference)

$\mathbf{x}$: voté sur demande d ' urgence

$\mathbf{y}$: vote on a request for urgent procedure

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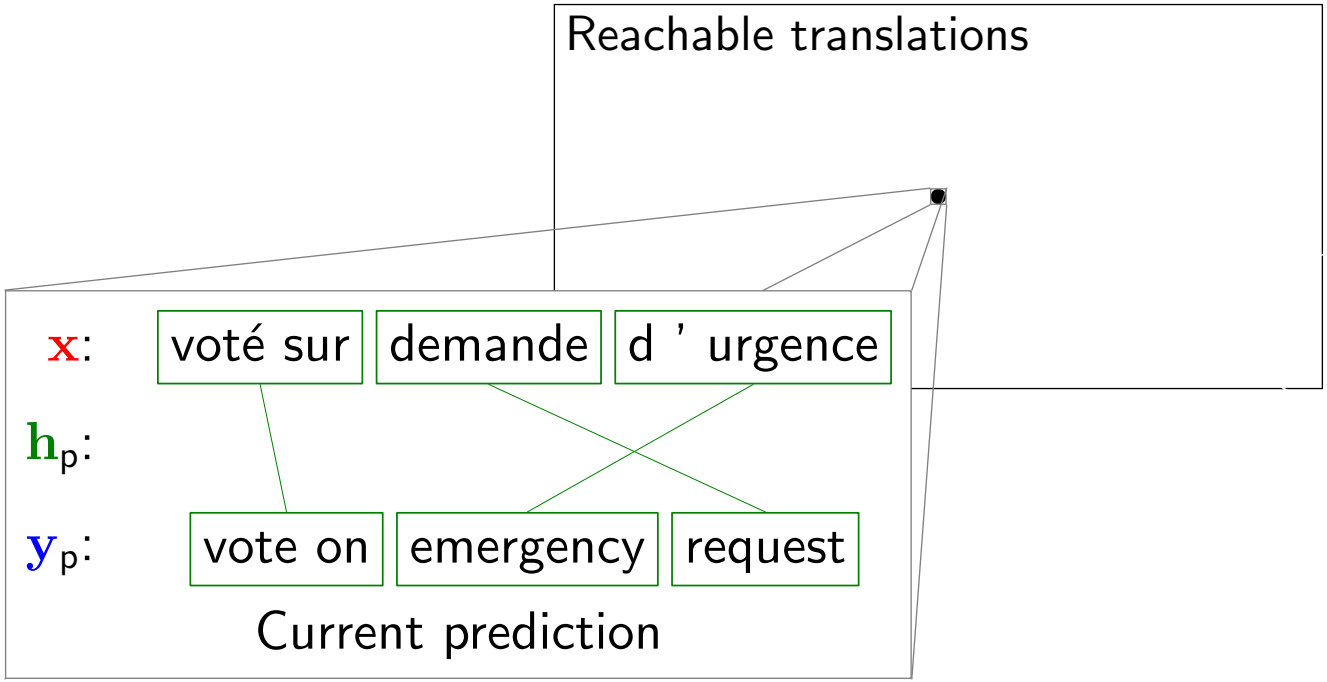

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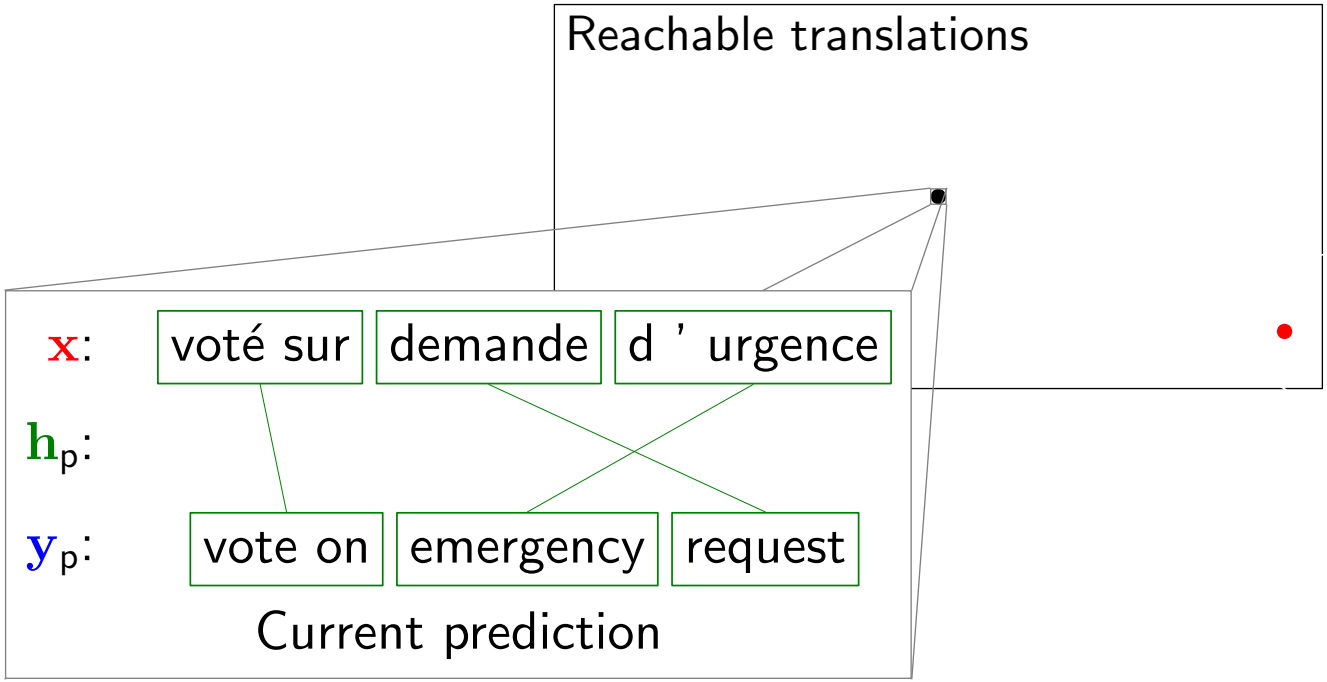

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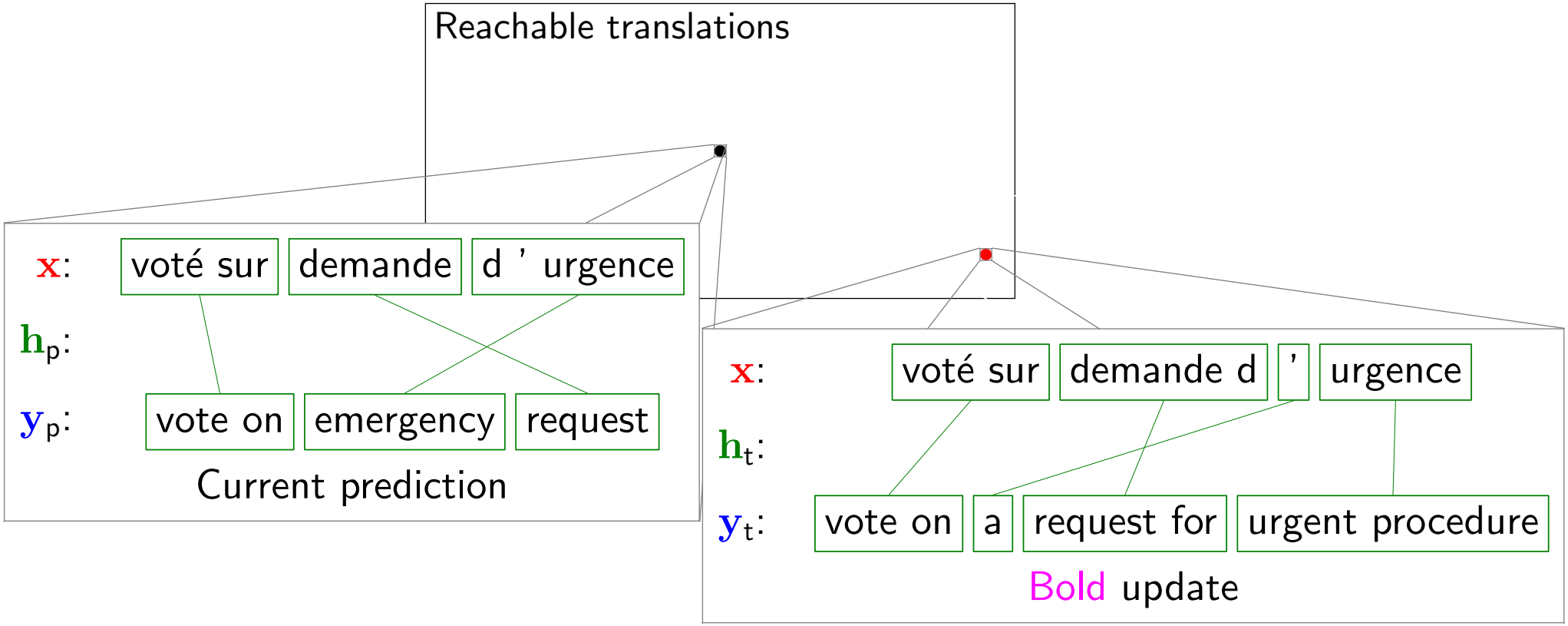

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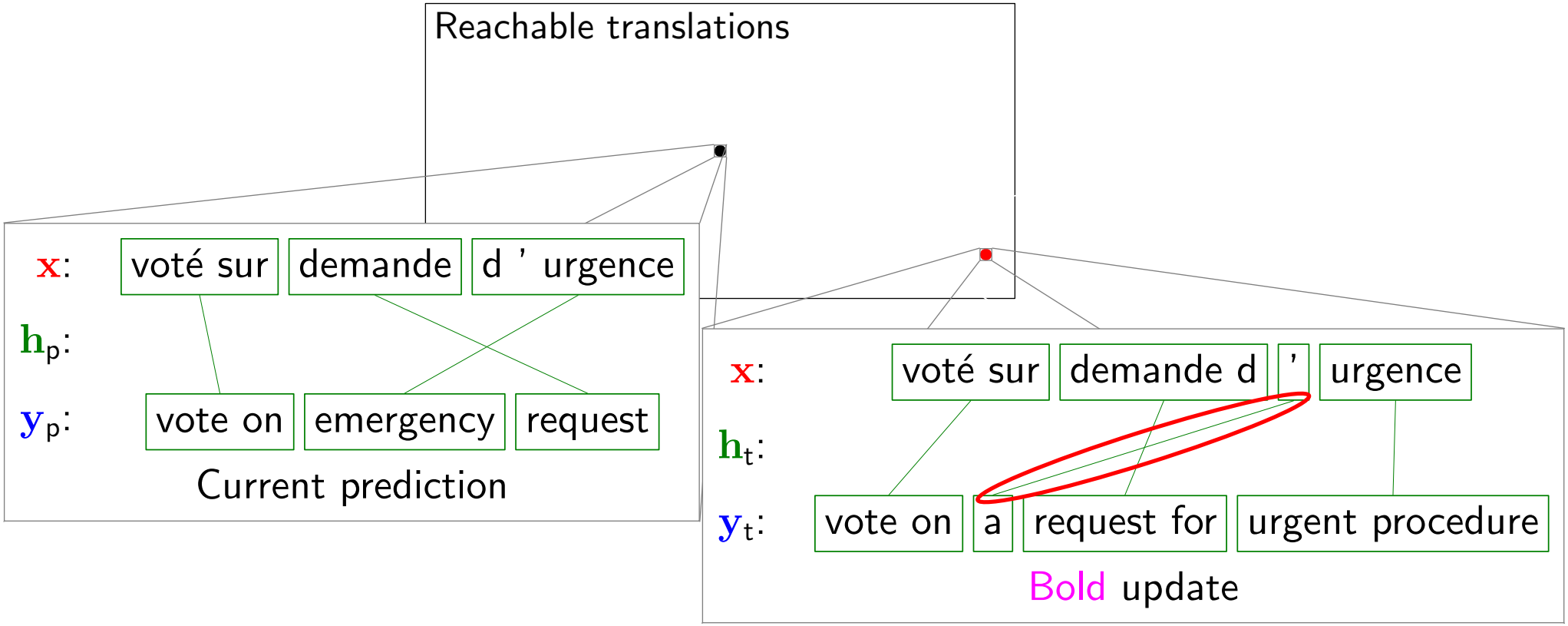

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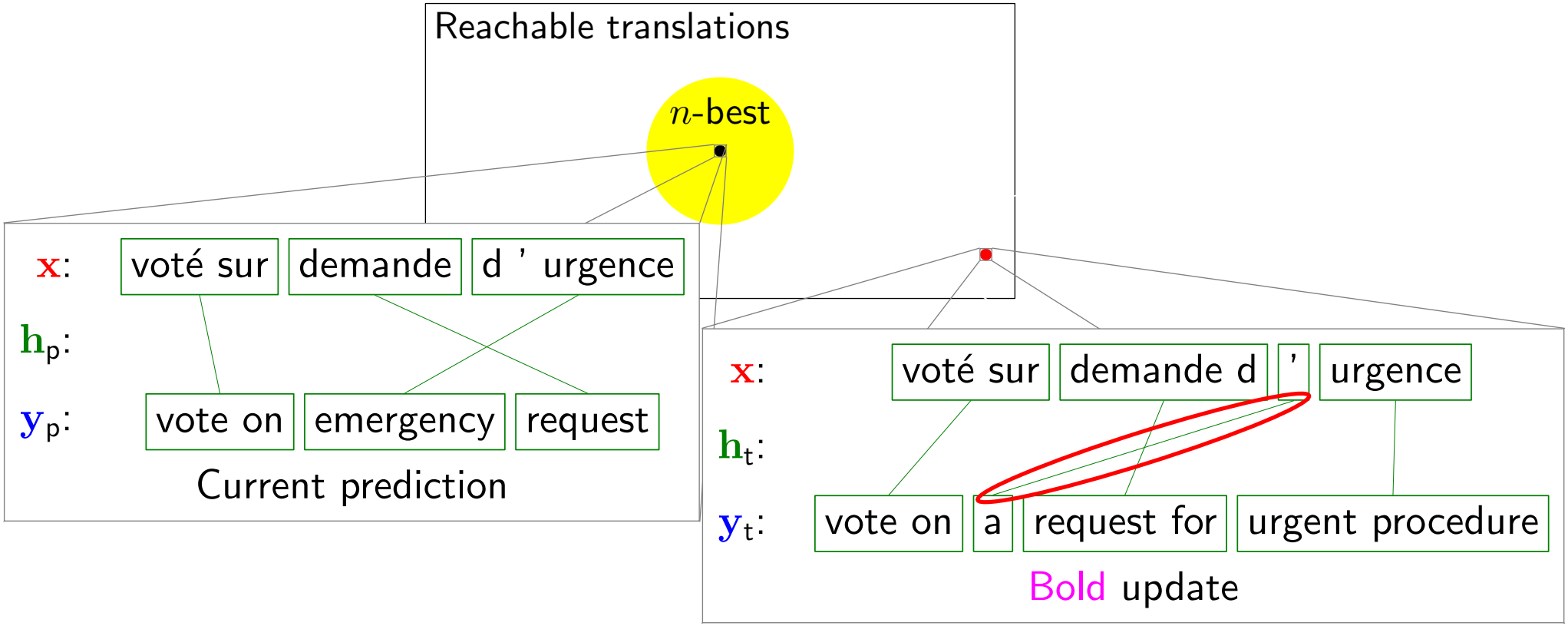

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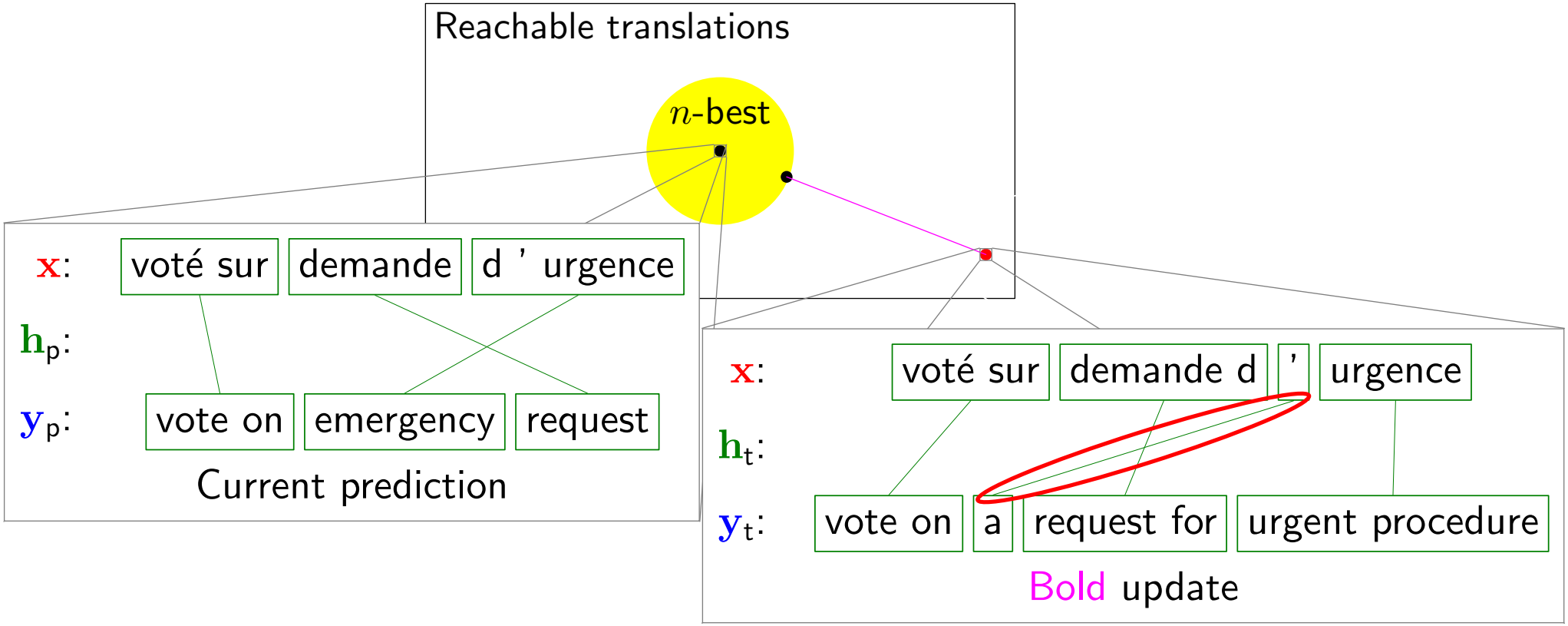


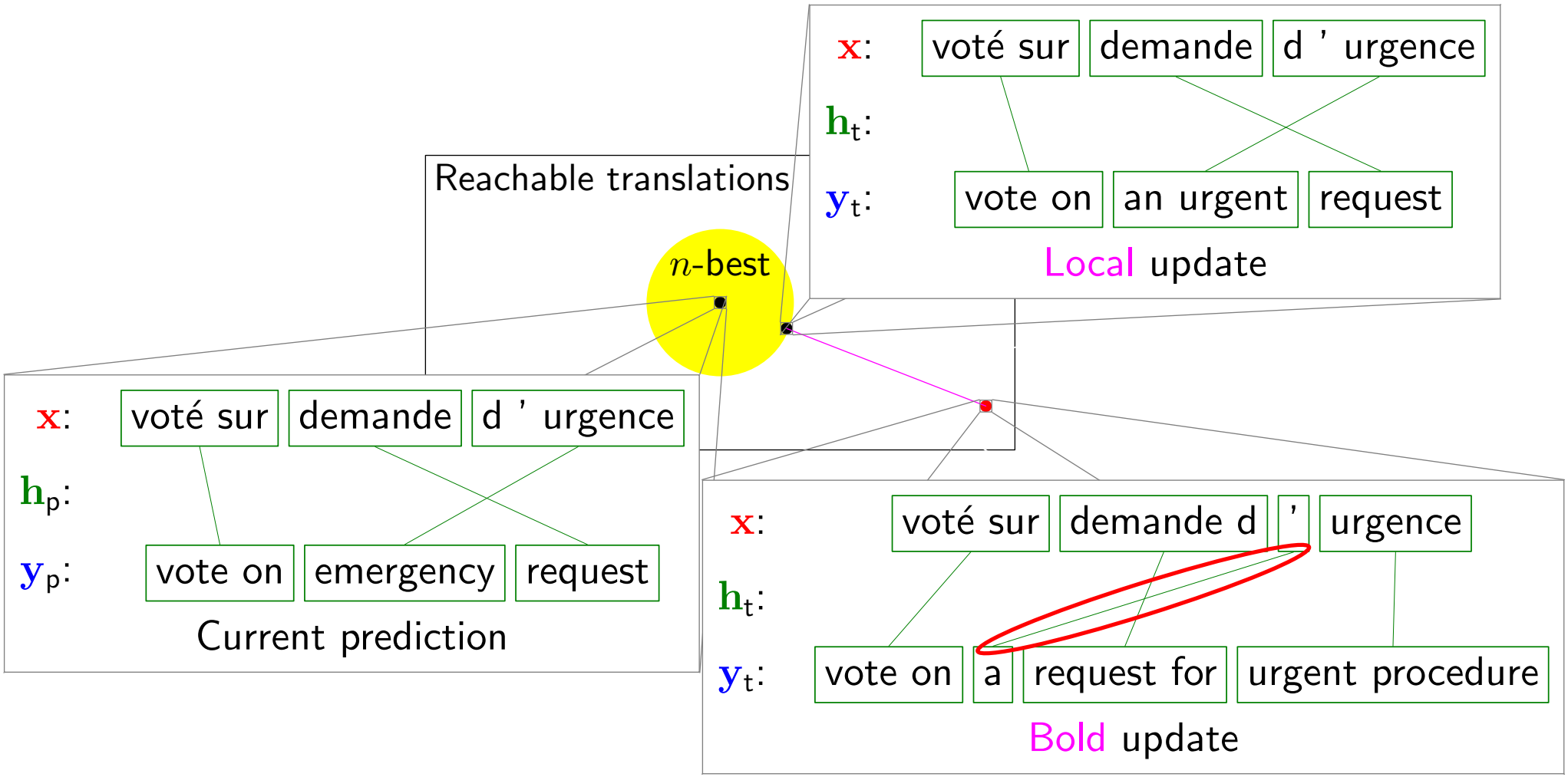
Update strategies

$$\mathbf{w} \leftarrow \mathbf{w} + \Phi(\mathbf{x}, \boxed{\mathbf{y}_t, \mathbf{h}_t}) - \Phi(\mathbf{x}, \mathbf{y}_p, \mathbf{h}_p)$$

Training example (reference)

$\mathbf{x}$: voté sur demande d ' urgence

$\mathbf{y}$: vote on a request for urgent procedure



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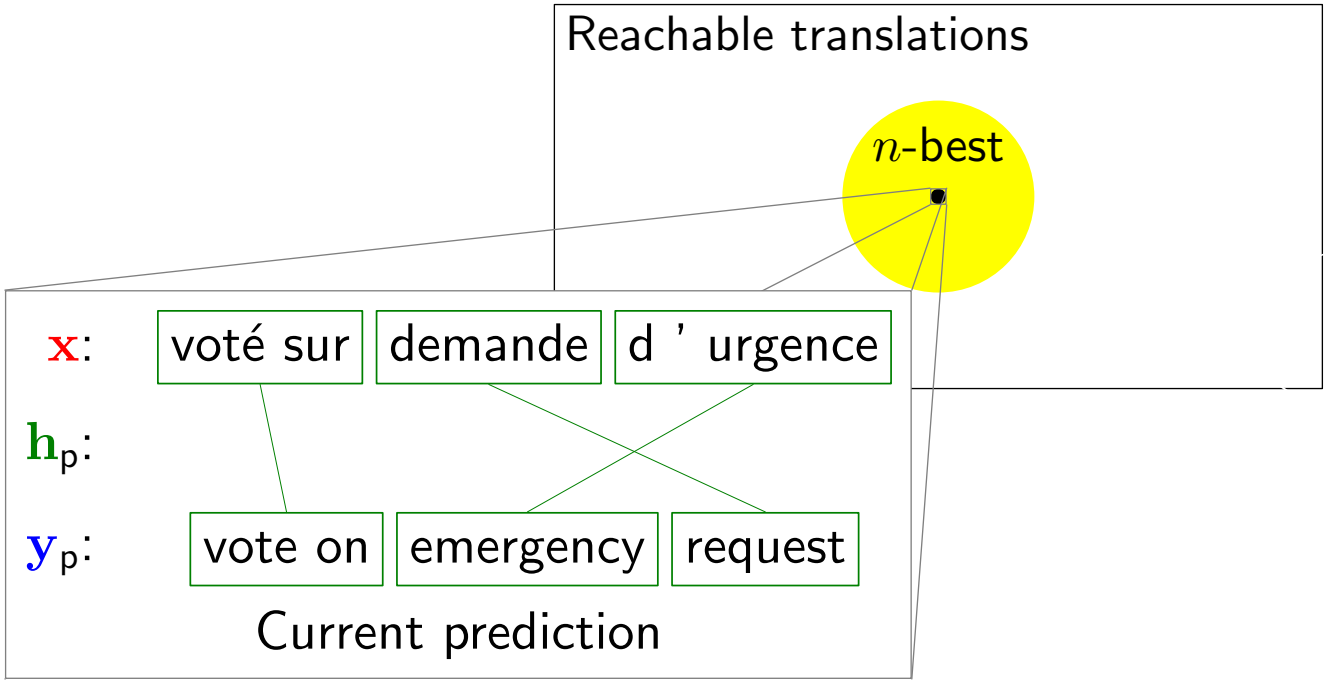

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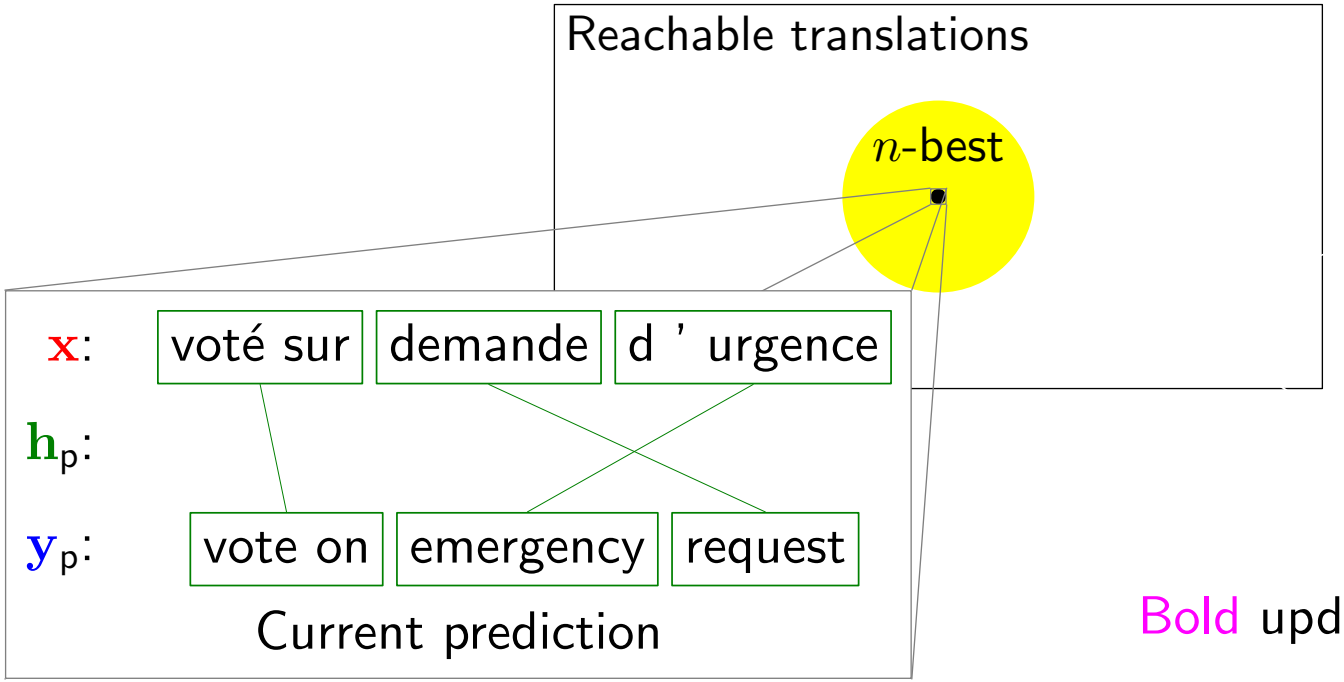

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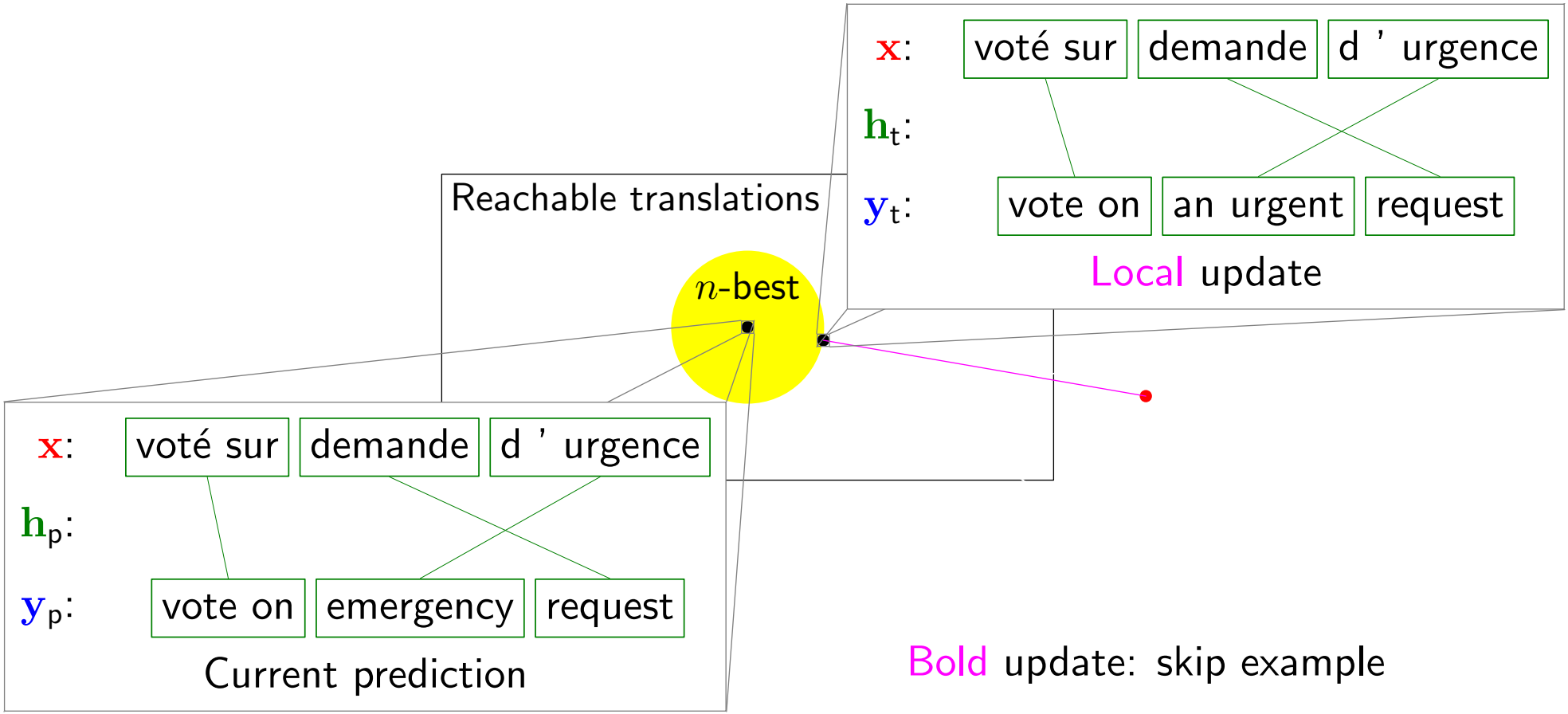

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$\mathbf{x}$:

$\mathbf{h}_t$:

Decoder	Bold	Local
Monotonic	34.3	**34.6**
Limited distortion	33.5	**34.7**

te

$\mathbf{x}$:

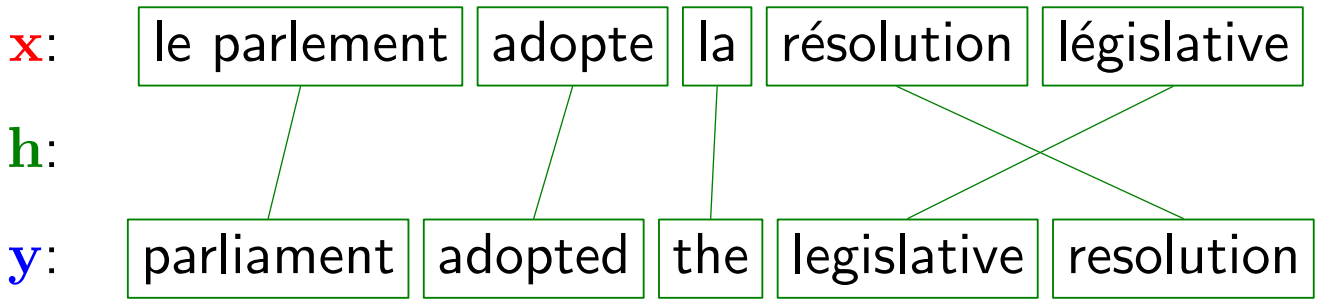
$\mathbf{h}_p$:

$\mathbf{y}_p$:

Current prediction

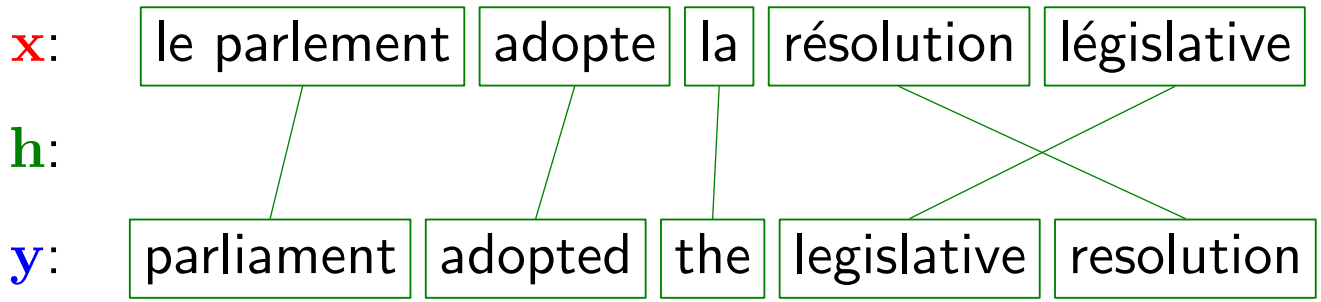
Bold update: skip example

Features



$$\Phi(\mathbf{x}, \mathbf{y}, \mathbf{h}) =$$

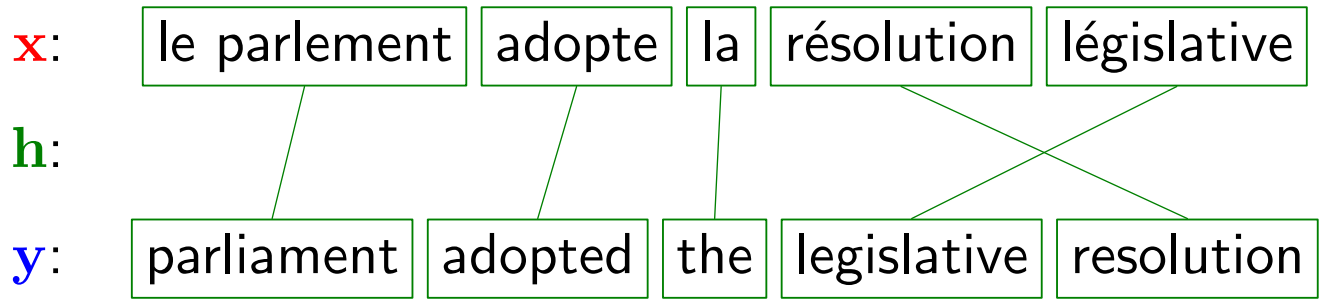
Features



$\Phi(\mathbf{x}, \mathbf{y}, \mathbf{h}) =$

BLANKET	TranslationLogProb	-8.92
	LangModelLogProb	-2.462

Features



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	[parliament adopted the]	1
	...	

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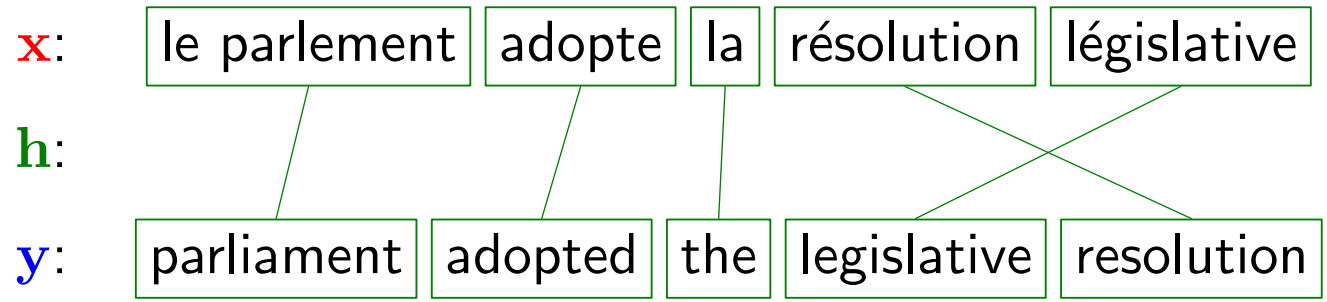

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LEXICAL	le parlement — parliament	1
	[parliament adopted the]	1
	...	
POS	DT NN — NN	1
	[NN VBD DT]	1
	...	
	NN JJ / JJ NN (swap)	1

Effect of features

trente-cinq	langues
five	languages

Features	DEV BLEU
BLANKET (untuned)	33.0

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Tune BLANKET features...

- Resulting relative weights: $\mathbf{w}(\text{TranslationLogProb}) = 2$
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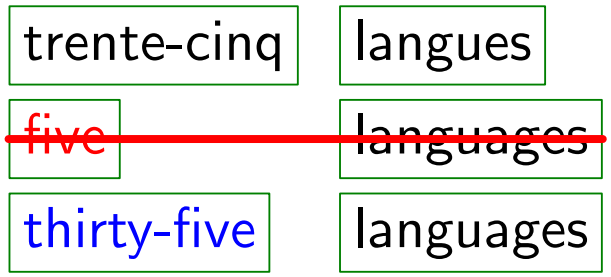

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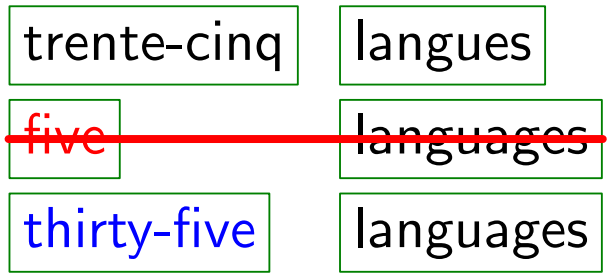

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- j ' ai — i have gets very negative weight
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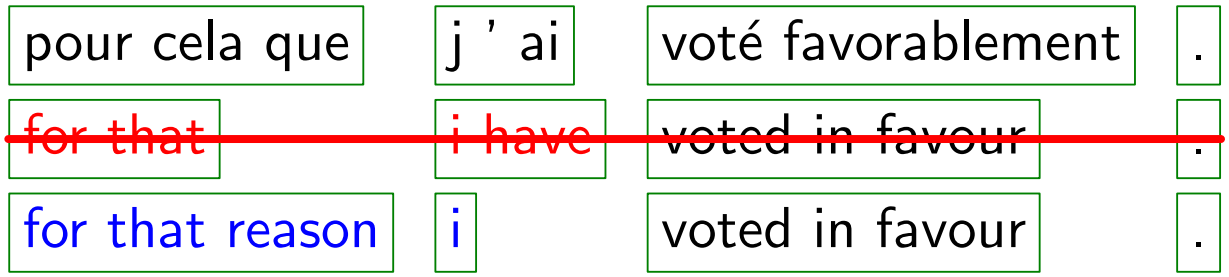

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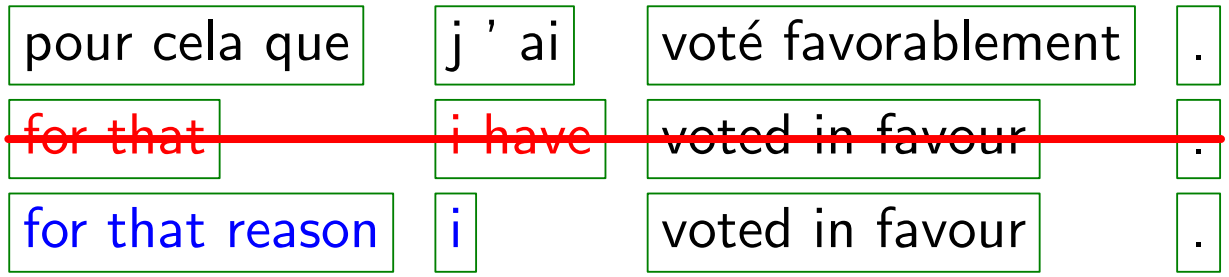

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BLANKET+LEXICAL	35.0

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How can we generalize beyond lexical features?

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- la réalisation du droit — the right has negative weight

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Features	Dev BLEU
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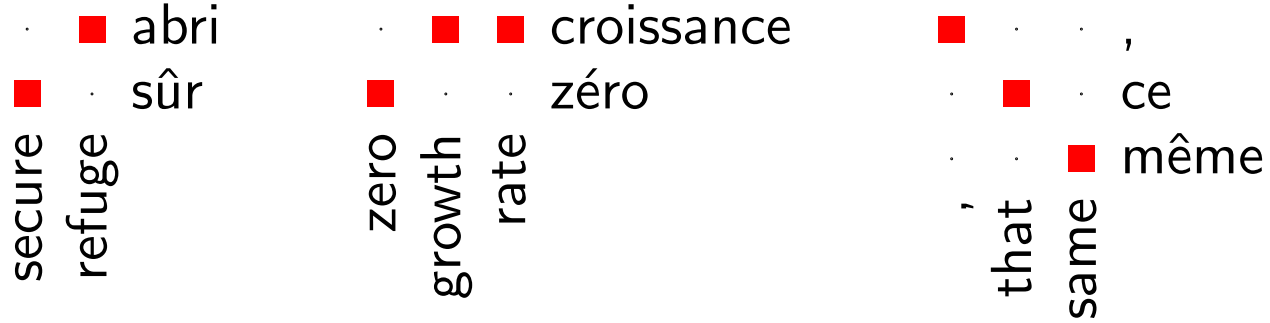
Blanket+Lexical	35.0
Blanket+Lexical+POS	35.3

Alignment constellation features

Phrase-extraction heuristic is important [Koehn '03]



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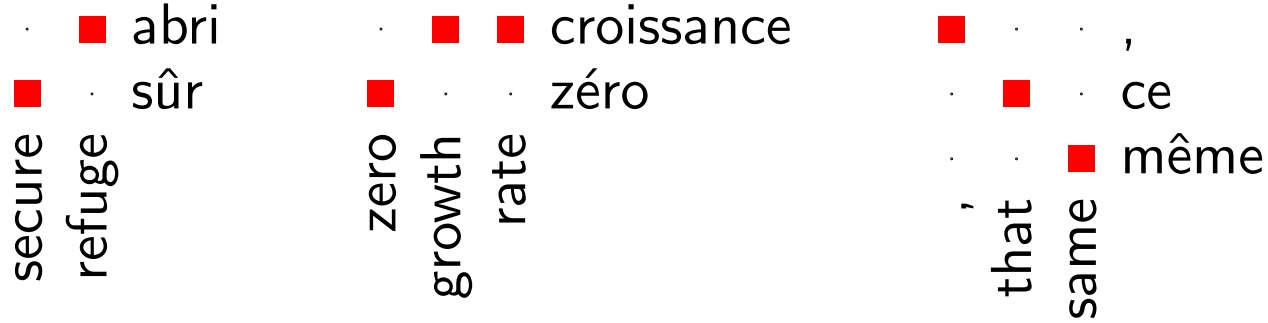

Put features on the phrase-extraction process itself

$$\Phi(\mathbf{x}, \mathbf{y}, \mathbf{h}) = \begin{cases} \boxed{\blacksquare \cdot \\ \cdot \blacksquare} & 1 \\ \ldots & \end{cases}$$

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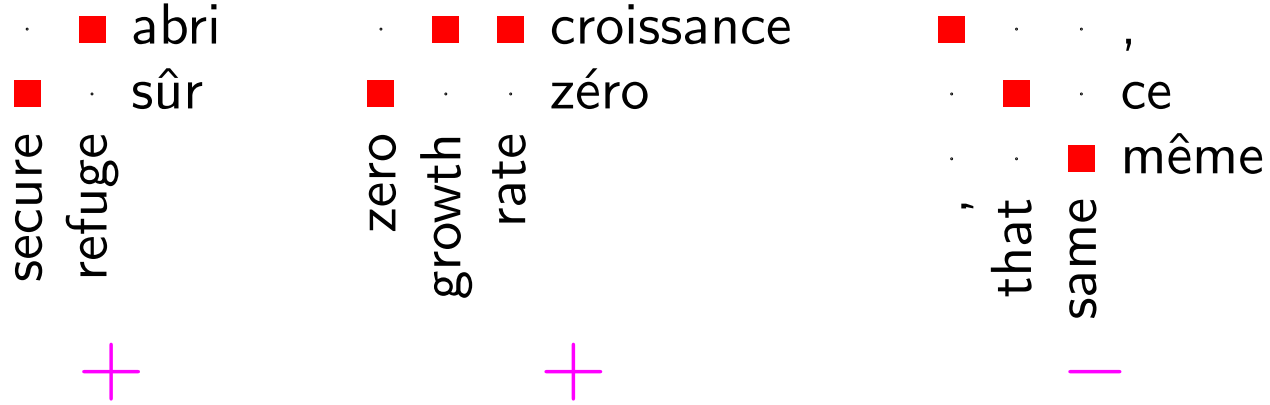

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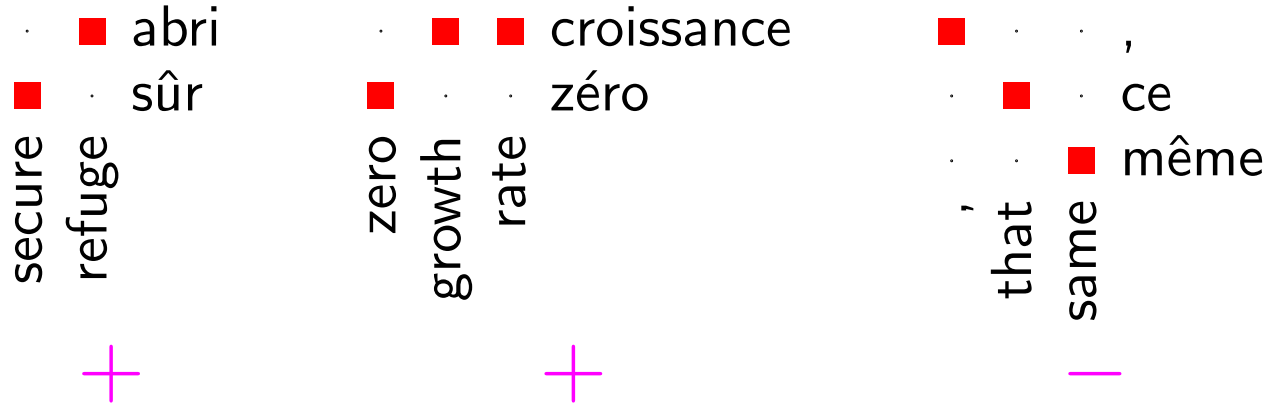

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Features	-Const	+Const
Blanket	31.8	32.2
Blanket+Lexical	32.2	32.5
Blanket+Lexical+POS	32.3	32.5

Summary of results

Monotonic systems	Test BLEU
Pharaoh (MERT)	28.8
Blanket	28.4
Blanket+Lexical+POS	**29.6**

Summary of results

Monotonic systems	Test BLEU
Pharaoh (MERT)	28.8
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Blanket+Lexical+POS	**29.6**

Distortion systems	Test BLEU
Pharaoh (MERT) [Full]	29.5
Blanket [Limited]	30.0
Blanket+Lexical+POS [Limited]	**30.9**

Conclusions

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That's it.