

Do Context-Aware Translation Models Pay the Right Attention?

Kayo Yin¹, Patrick Fernandes^{1,2}, Danish Pruthi¹, Aditi Chaudhary¹
André F.T. Martins^{2,3}, Graham Neubig¹

¹



Carnegie Mellon University
Language Technologies Institute

²



³



Why is Context Important for Translation?

We'll have to get rid of that mole.

Why is Context Important for Translation?

*Things could start to get dangerous if the ministers find out.
We'll have to get rid of that mole.*

Why is Context Important for Translation?

*Things could start to get dangerous if the ministers find out.
We'll have to get rid of that mole.*

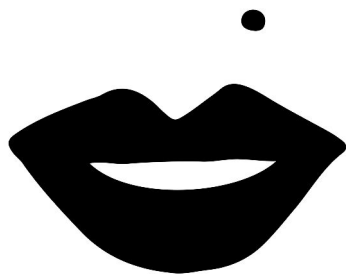


Why is Context Important for Translation?

Could it be anything serious, Doctor?
We'll have to get rid of that mole.

Why is Context Important for Translation?

Could it be anything serious, Doctor?
We'll have to get rid of that mole.



Why is Context Important for Translation?

English:

*Things could start to get dangerous if the ministers find out.
We'll have to get rid of that mole.*



French:

*Les choses pourraient commencer à devenir dangereuses si
les ministres le découvriraient.
Nous devons nous débarrasser de cette taupe.*



Why is Context Important for Translation?

English:

Could it be anything serious, Doctor?

We'll have to get rid of that mole.



French:

Serait-ce quelque chose de grave, docteur ?

Nous devons nous débarrasser de ~~cette~~ taupo.

cet grain de beauté

Why is Context Important for Translation?

English:

*So you see how bad the **implications** are.*

Yes, **they** are quite devastating.



French:

*Vous voyez donc à quel point les **implications** sont mauvaises.*

*Oui, **ils** sont assez dévastateurs.*

Why is Context Important for Translation?

English:

*So you see how bad the **implications** are.*

Yes, **they** are quite devastating.



French:

*Vous voyez donc à quel point les **implications** sont mauvaises.*

Oui, ~~**ils**~~ sont assez ~~dévastateurs~~.

elles

dévastatrices

Context-Aware NMT

Source input Have we got her report?
Yes, it's in the infirmary already.

Context-aware NMT output On dispose de son rapport?
Oui, elle est déjà à l'infirmerie.

Context-Aware NMT

Source input Have we got her report?
Yes, it's in the infirmary already.

Context-aware NMT output On dispose de son rapport?
Oui, elle est déjà à l'infirmerie.

Context-Aware NMT

Source input Have we got her report?
Yes, it's in the infirmary already.

Context-aware NMT output On dispose de son rapport?
Oui, elle est déjà à l'infirmerie.

Context-Aware NMT

Source input

~~Have we got her report?~~
Yes, **it**'s in the **infirmary** already.

Context-aware NMT output

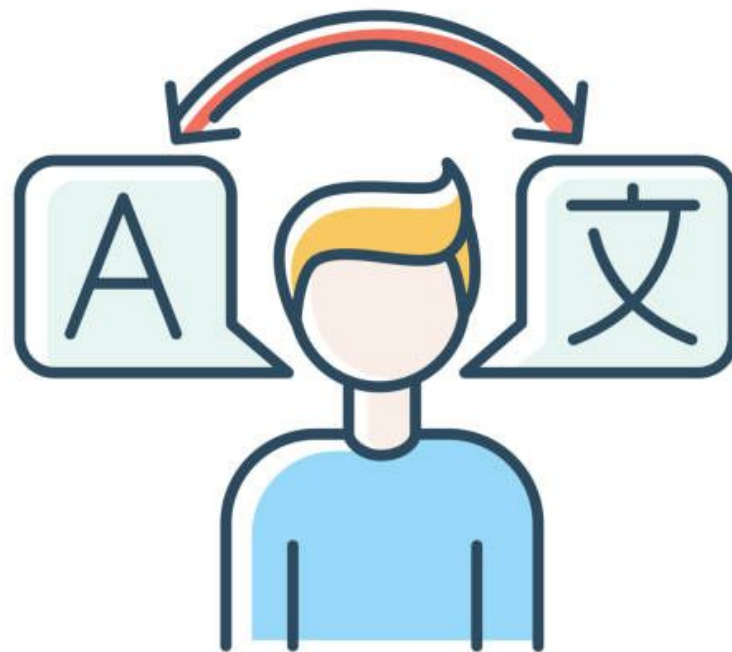
~~On dispose de son rapport?~~
Oui, **elle** est déjà à l'infirmerie.

Outline

1. What context is useful during ambiguous translations?
2. Are models paying attention to this context or not?
3. If not, can we encourage them to do so?

Outline

1. What context is useful during translation?
2. Are models paying attention to this context or not?
3. If not, can we encourage them to do so?



User Study

Task 1 - Example 1

Source context:

Look after her a lot.
Okay.
Any questions?
Have we got her report?

Source sentence:

Yes, it's in the infirmary already.

Source context you highlighted:

[Reset Highlights](#)

Source sentence you highlighted:

[Reset Highlights](#)

Target context:

Dorlotez-la.
D'accord.
Vous avez des questions?
On dispose de son rapport?

Target sentence:

Oui, ____ est à l'infirmerie.

- ☐ **il**
- ☐ **elle**

How confident are you?

Not at all

Somewhat

Very

Target context you highlighted:

[Reset Highlights](#)

Target sentence you highlighted:

[Reset Highlights](#)

Mismatch between source and target side

User Study

Task 1 - Example 1

Source context:

Look after her a lot.
Okay.
Any questions?
Have we got her report?

Source sentence:

Yes, it's in the infirmary already.

Source context you highlighted:

[Reset Highlights](#)

Source sentence you highlighted:

[Reset Highlights](#)

Target context:

Dorlotez-la.
D'accord.
Vous avez des questions?
On dispose de son rapport?

Target sentence:

Oui, ____ est à l'infirmerie.

☒ il

☐ elle



How confident are you?

Not at all

Somewhat

Very

Target context you highlighted:

[Reset Highlights](#)

Target sentence you highlighted:

[Reset Highlights](#)

Mismatch between source and target side

User Study

Task 1 - Example 1

Source context:

Look after her a lot.
Okay.
Any questions?
Have we got her report?

Source sentence:

Yes, it's in the infirmary already.

Source context you highlighted:

[Reset Highlights](#)

Source sentence you highlighted:

[Reset Highlights](#)

Target context:

Dorlotez-la.
D'accord.
Vous avez des questions?
On dispose de son **rapport**?



Target sentence:

Oui, ____ est à l'infirmerie.

☒ **il**

☐ **elle**

How confident are you?

Not at all

Somewhat

Very

Target context you highlighted:

- rapport

[Reset Highlights](#)

Target sentence you highlighted:

[Reset Highlights](#)

Mismatch between source and target side

User Study

Task 1 - Example 33

Source context:

Source sentence:

Ace of diamonds.

Source context you highlighted:

[Reset Highlights](#)

Source sentence you highlighted:

- Ace

[Reset Highlights](#)

Target context:

Target sentence:

As de _____

☒ carreau.

☐ diamant.

How confident are you?

Not at all

Somewhat

Very

Target context you highlighted:

[Reset Highlights](#)

Target sentence you highlighted:

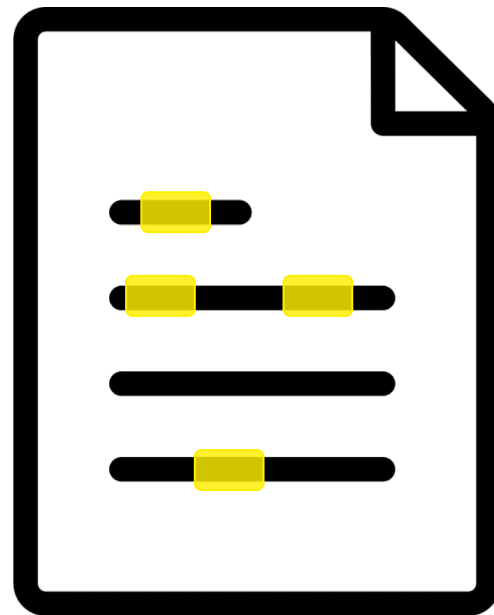
[Reset Highlights](#)

Mismatch between source and target slide

What Context do Human Translators Use?



What Context do Human Translators Use?



What Context do Human Translators Use? (Pronoun Anaphora Resolution)



What Context do Human Translators Use? (Pronoun Anaphora Resolution)



What Context do Human Translators Use? (Pronoun Anaphora Resolution)



Have we got her report? Yes, it's in the infirmary already.
On dispose de son rapport? Oui, [il / ~~elle~~] est à l'infirmière.

What Context do Human Translators Use?

(Pronoun Anaphora Resolution)



Have we got her report? Yes, it's in the infirmary already.
On dispose de son rapport? Oui, [il / ~~elle~~] est à l'infirmière.



What Context do Human Translators Use?

(Pronoun Anaphora Resolution)



Have we got her report? It's important. Yes, it's in the infirmary already.
On dispose de son rapport? Il est important. Oui, [il / elle] est à l'infirmière.

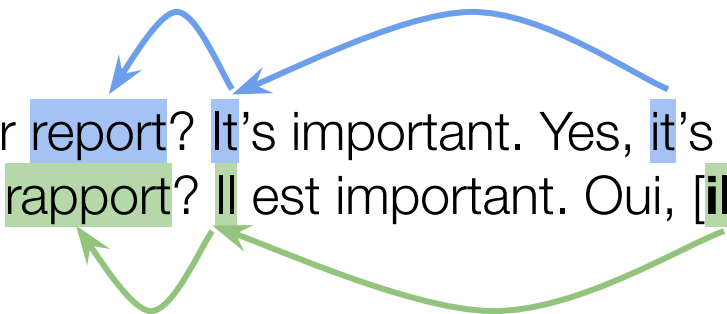


What Context do Human Translators Use?

(Pronoun Anaphora Resolution)



Have we got her report? It's important. Yes, it's in the infirmary already.
On dispose de son rapport? Il est important. Oui, [il / elle] est à l'infirmière.



What Context do Human Translators Use?

(Pronoun Anaphora Resolution)



Have we got her report? It's important. Yes, it's in the infirmary already.
On dispose de son rapport? Il est important. Oui, [il / elle] est à l'infirmerie.



What Context do Human Translators Use?

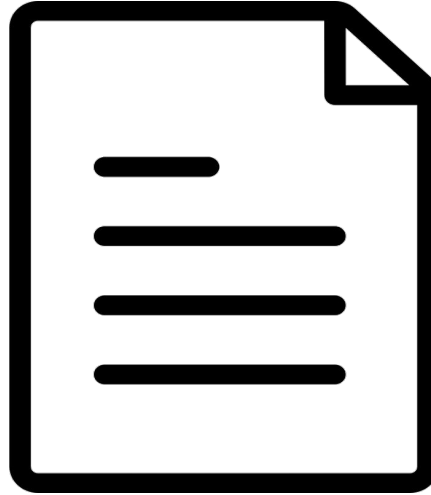
(Pronoun Anaphora Resolution)



Have we got her report? It's important. Yes, it's in the infirmary already.
On dispose de son rapport? Il est important. Oui, [il / elle] est à l'infirmerie.



What Context do Human Translators Use? (Word Sense Disambiguation)



What Context do Human Translators Use? (Word Sense Disambiguation)



What Context do Human Translators Use?

(Word Sense Disambiguation)

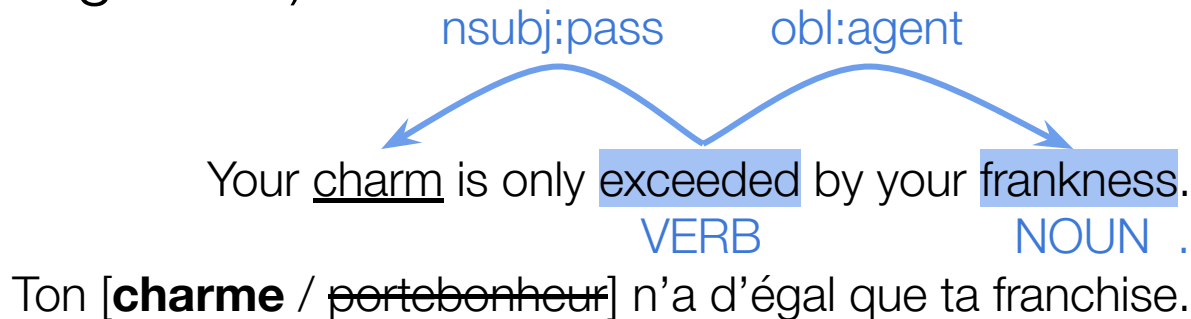


Your charm is only exceeded by your frankness.

Ton [**charme** / ~~portebonheur~~] n'a d'égal que ta franchise.

What Context do Human Translators Use?

(Word Sense Disambiguation)



What Context do Human Translators Use?

(Word Sense Disambiguation)

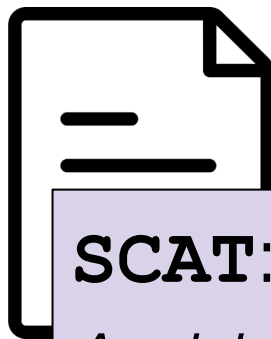


Your charm is only **exceeded** by your **frankness**.
VERB NOUN .

Ton [**charme** / ~~portebonheur~~] n'a **d'égal** que ta **franchise**.



What Context do Human Translators Use? (Word Sense Disambiguation)



SCAT: *Supporting Context for Ambiguous Translations* dataset (14K)

Your charm is only exceeded by your frankness.
NOUN .
a franchise.

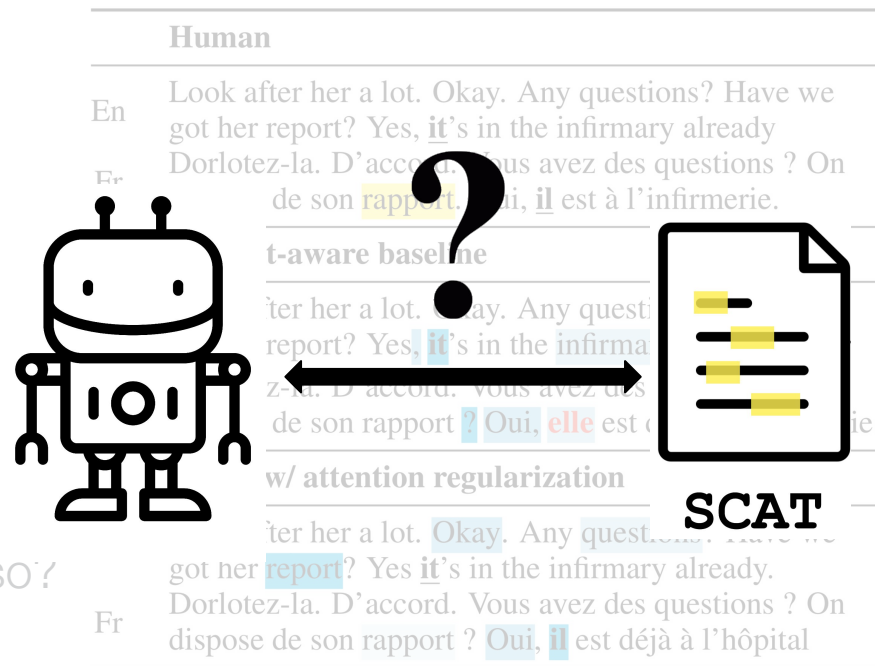
Diagram illustrating word sense disambiguation context:

- Relationship between "charm" and "exceeded": nsubj:pass
- Relationship between "exceeded" and "frankness": obl:agent



Outline

1. What context is useful during translation?
2. Are models paying attention to this context or not?
3. If not, can we encourage them to do so?



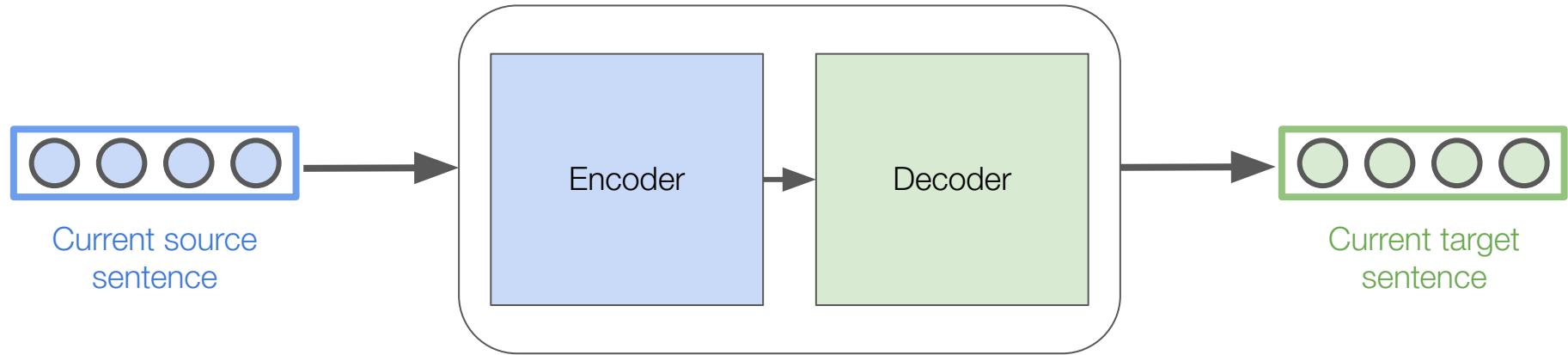
The diagram illustrates the SCAT (Source Context Attention Transfer) model for machine translation. A robot icon represents the model, and a document icon represents the source text. A double-headed arrow connects them, with a large question mark above it, indicating the focus on attention during translation.

The background shows a comparison between a baseline model and the SCAT model using an attention regularization technique.

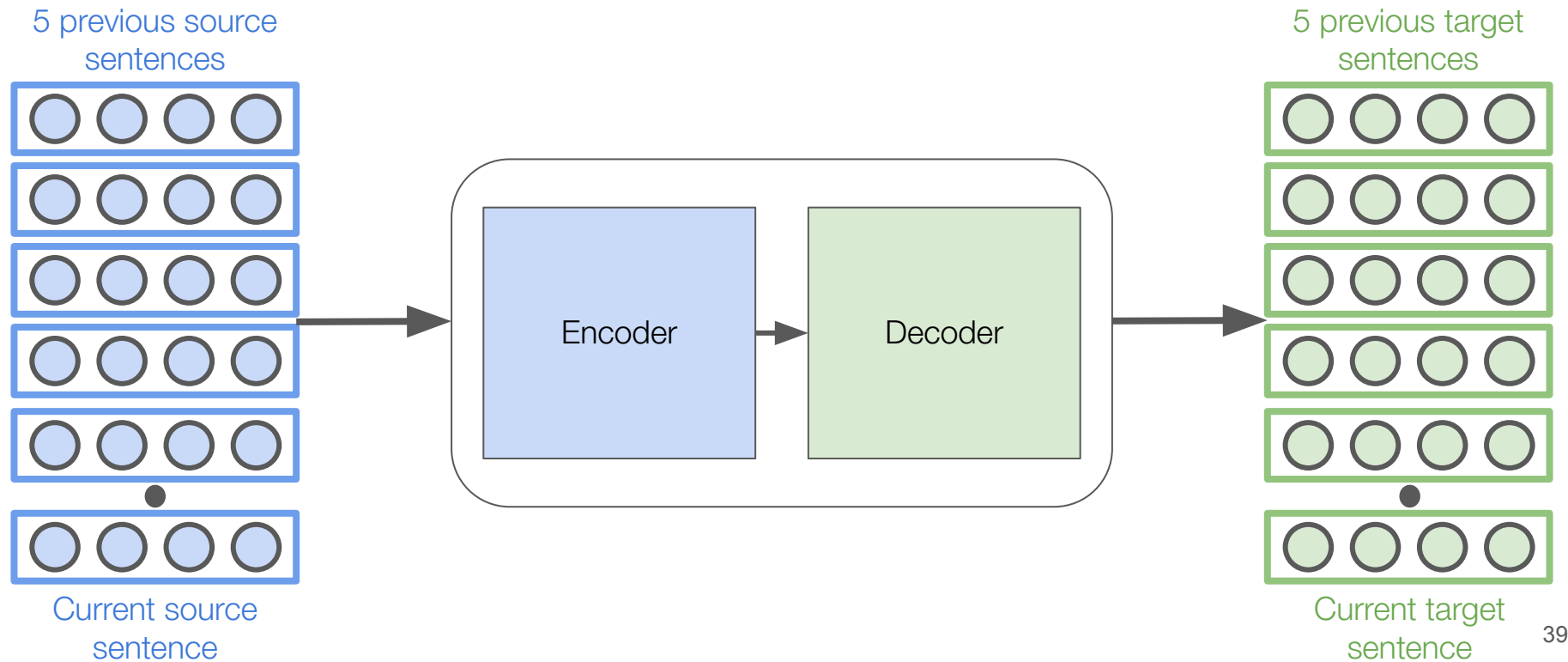
	Human
En	Look after her a lot. Okay. Any questions? Have we got her report? Yes, <u>it's</u> in the infirmary already
Fr	Dorlotez-la. D'accord. Vous avez des questions ? On de son <u>rapport</u> . Oui, <u>il</u> est à l'infirmerie.
t-aware baseline	ter her a lot. Okay. Any questions? Have we got her report? Yes, <u>it's</u> in the infirmary already. D'accord. Vous avez des questions ? On de son rapport ? Oui, <u>elle</u> est à l'infirmerie.
w/ attention regularization	ter her a lot. Okay. Any questions? Have we got her <u>report</u> ? Yes <u>it's</u> in the infirmary already. Dorlotez-la. D'accord. Vous avez des questions ? On dispose de son rapport ? Oui, <u>il</u> est déjà à l'hôpital

SCAT

Model



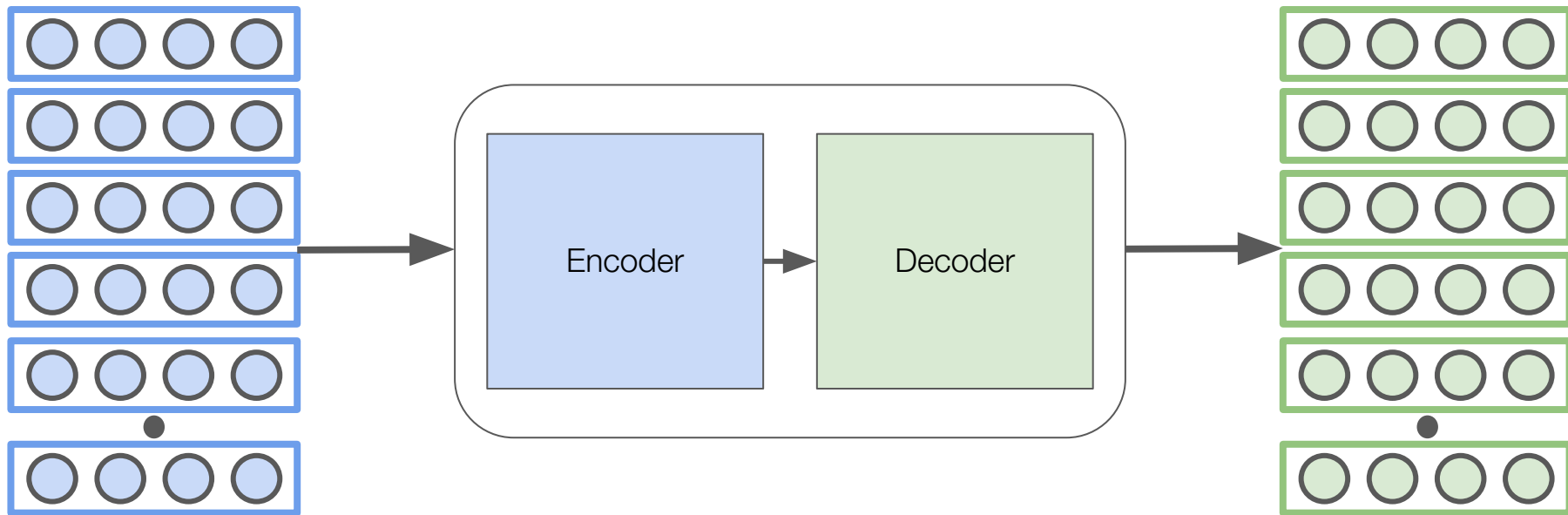
Model



Model



Open Subtitles



Quantifying **Human-Model** Alignment with **SCAT**

En Have we got her report?
Yes, it's in the infirmary
already.

Fr On dispose de son **rapport**?
Oui, il est à l'infirmière.

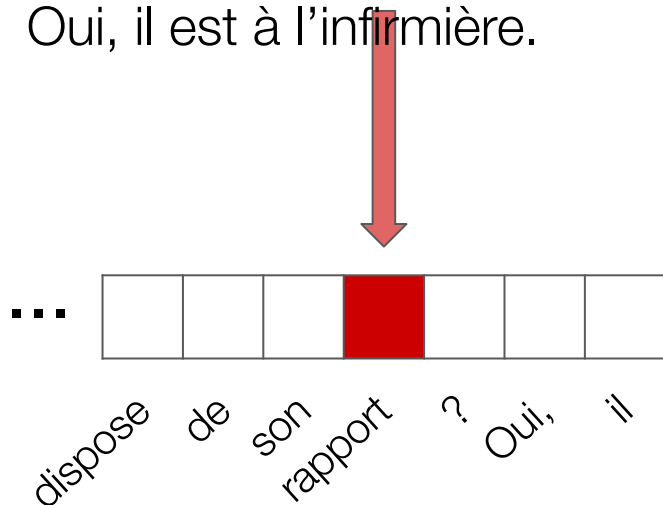
En Have we got her report?
Yes, **it's** in the **infirmary**
already.

Fr On dispose de son rapport? **?**
Oui, il est à l'infirmière.

Quantifying Human-Model Alignment with **SCAT**

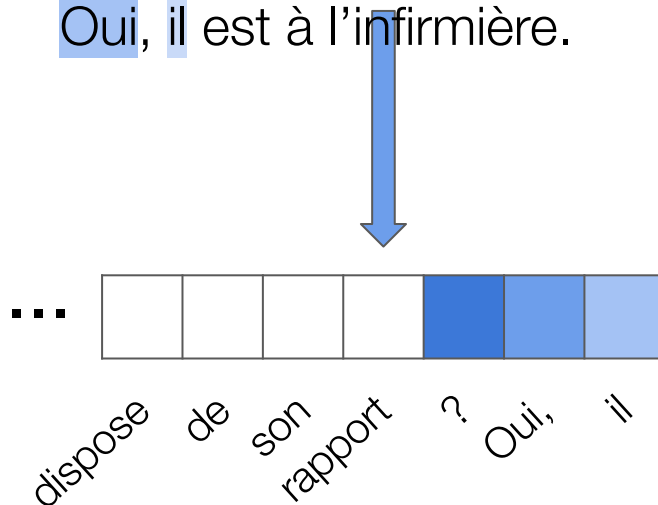
En Have we got her report?
Yes, it's in the infirmary
already.

Fr On dispose de son rapport?
Oui, il est à l'infirmière.



En Have we got her report?
Yes, it's in the infirmary
already.

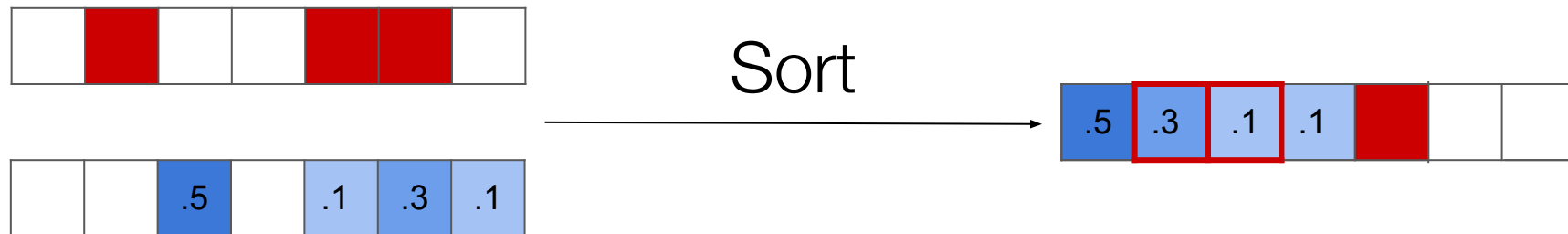
Fr On dispose de son rapport?
Oui, il est à l'infirmière.



Quantifying Human-Model Alignment with **SCAT**



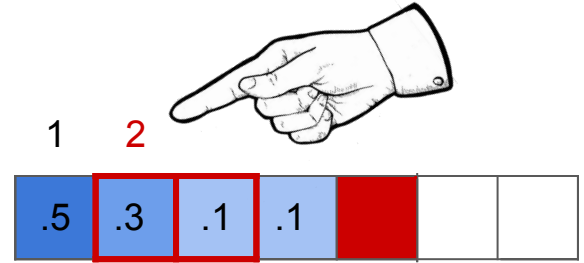
Quantifying Human-Model Alignment with **SCAT**



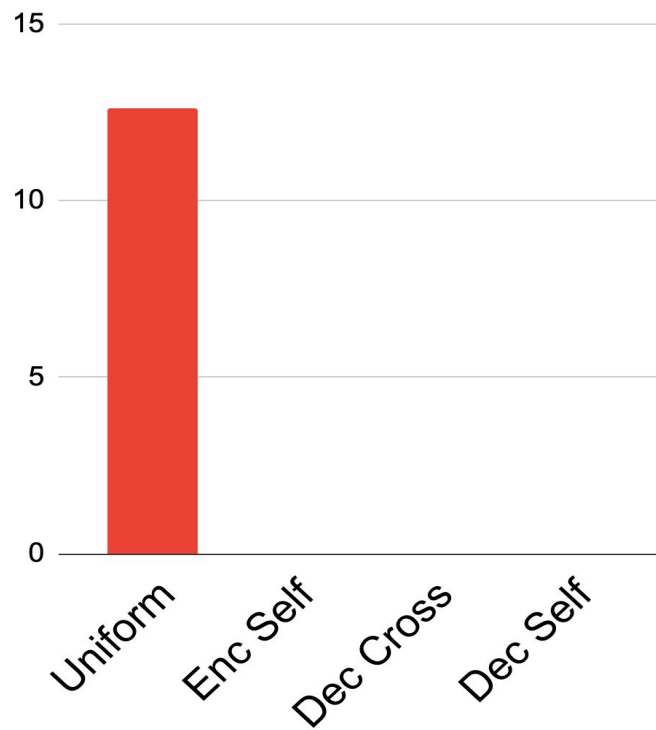
Quantifying Human-Model Alignment with **SCAT**



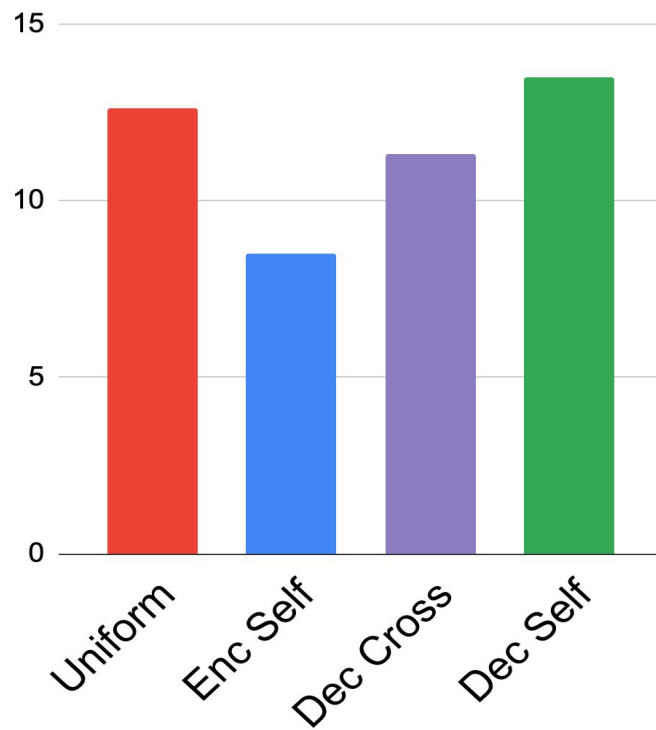
Sort



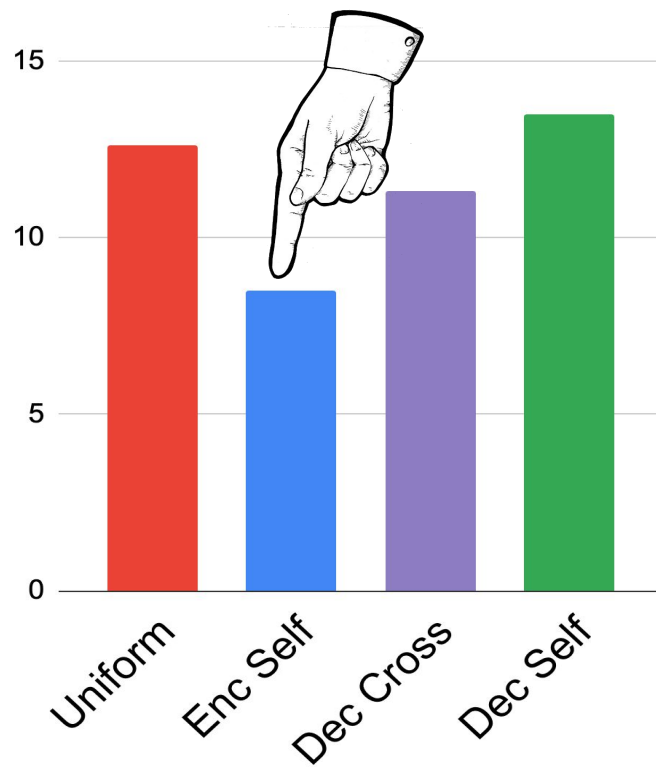
Alignment Results



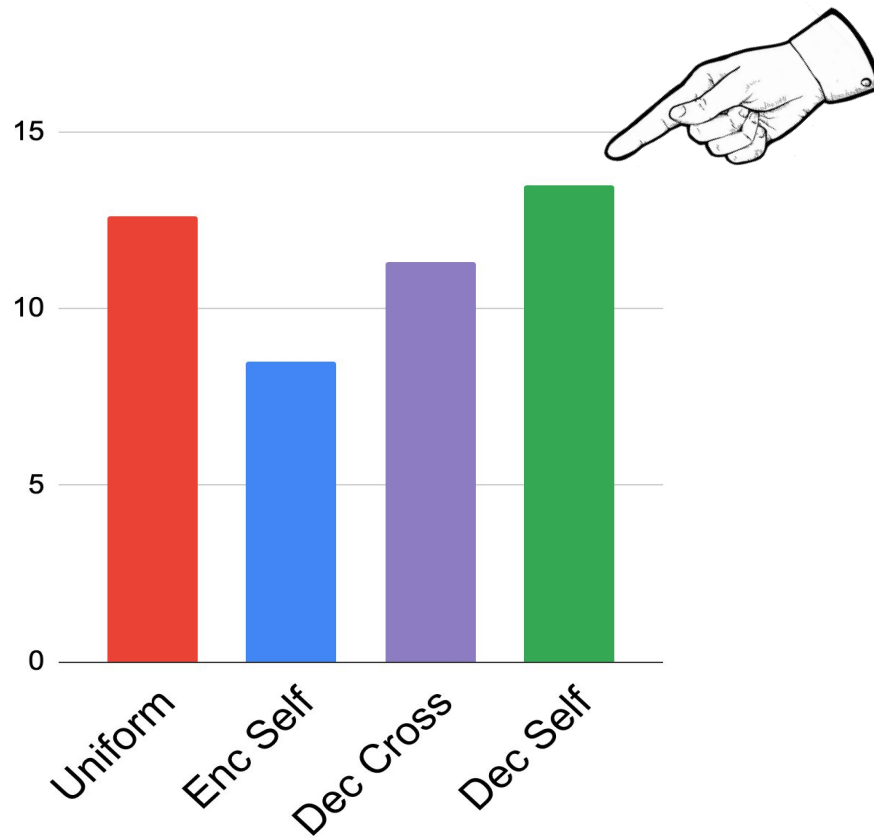
Alignment Results



Alignment Results

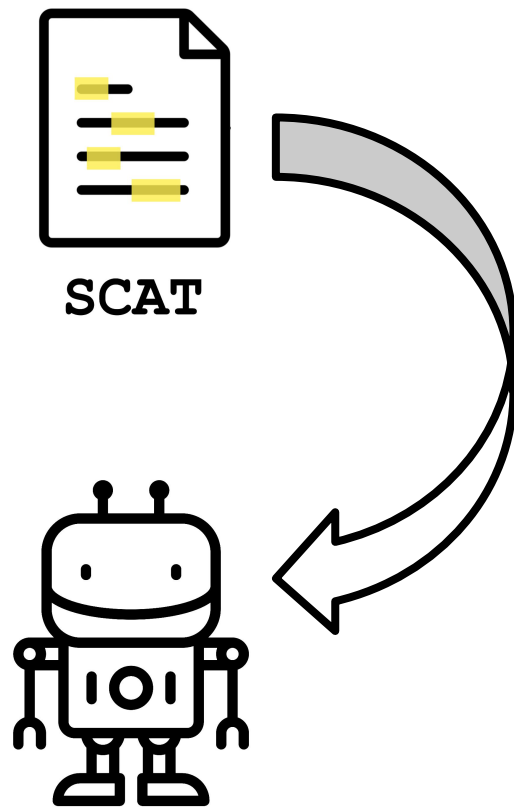


Alignment Results



Outline

1. What context is useful during translation?
2. Are models paying attention to this context or not?
3. If not, can we encourage them to do so?



Attention Regularization

$$\mathcal{L}_{NLL}(\theta) = - \sum_{j=1}^m \log p_{\theta}(y_j | x, y_{i < j})$$



OpenSubtitles18

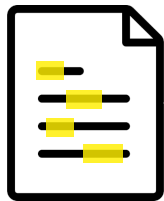
Context-aware
MT Model

Attention Regularization

$$\mathcal{L}_{NLL}(\theta) = - \sum_{j=1}^m \log p_{\theta}(y_j | x, y_{i < j})$$



OpenSubtitles18



SCAT

Context-aware
MT Model

$$\mathcal{R}(\theta) = -\lambda \text{KL}(\alpha_{\text{human-norm}} || \alpha_{\text{model}}(\theta))$$

Evaluation

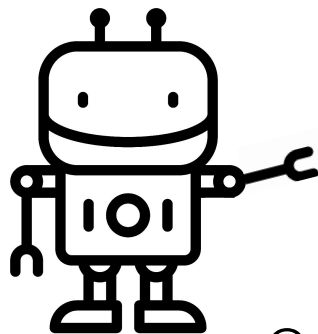
- BLEU
- COMET

Evaluation

- BLEU
- COMET
- Pronouns F-measure

Evaluation

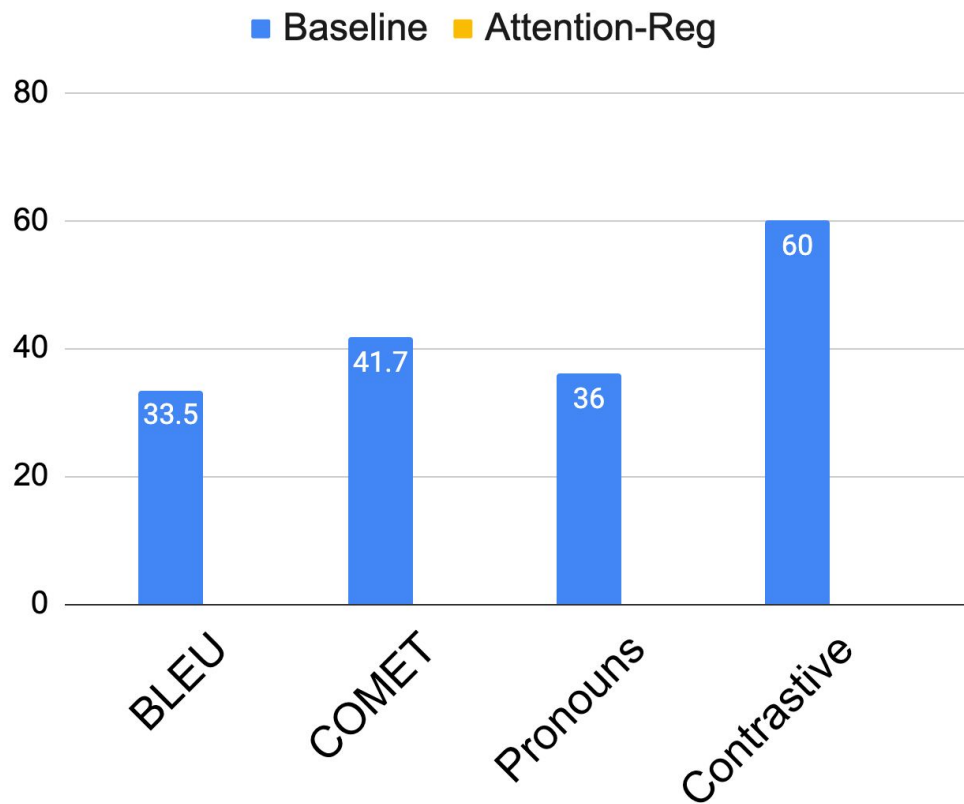
- BLEU
- COMET
- Pronouns F-measure
- Contrastive Evaluation



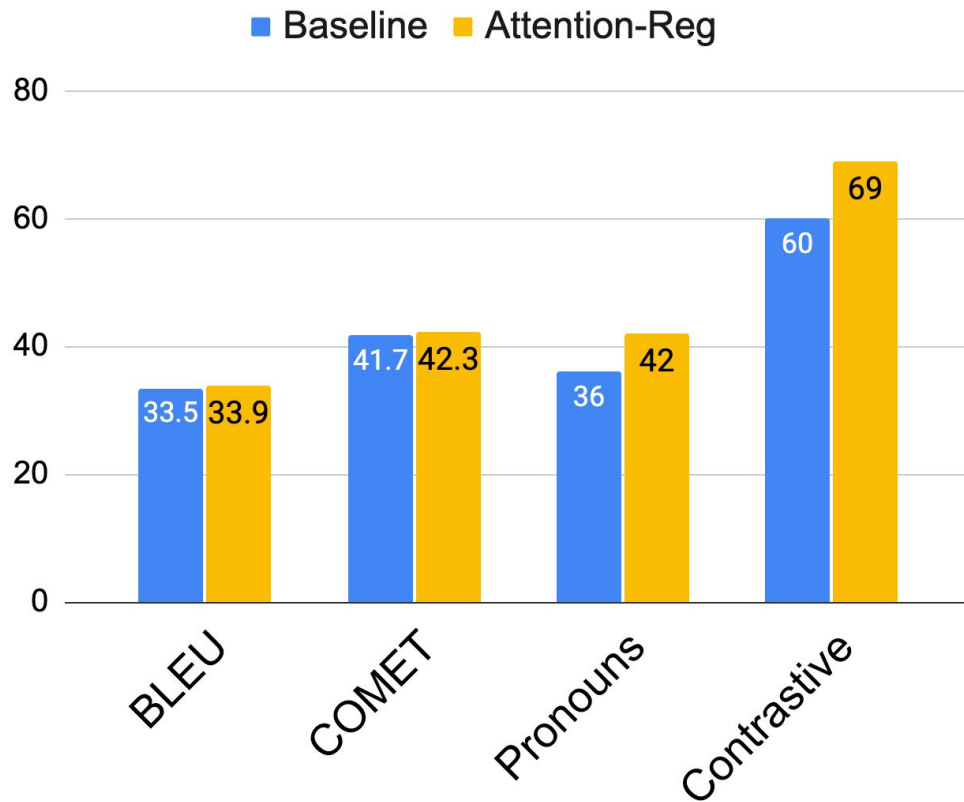
Oui, **il** est déjà à l'infirmierie.

Oui, **elle** est déjà à l'infirmierie.

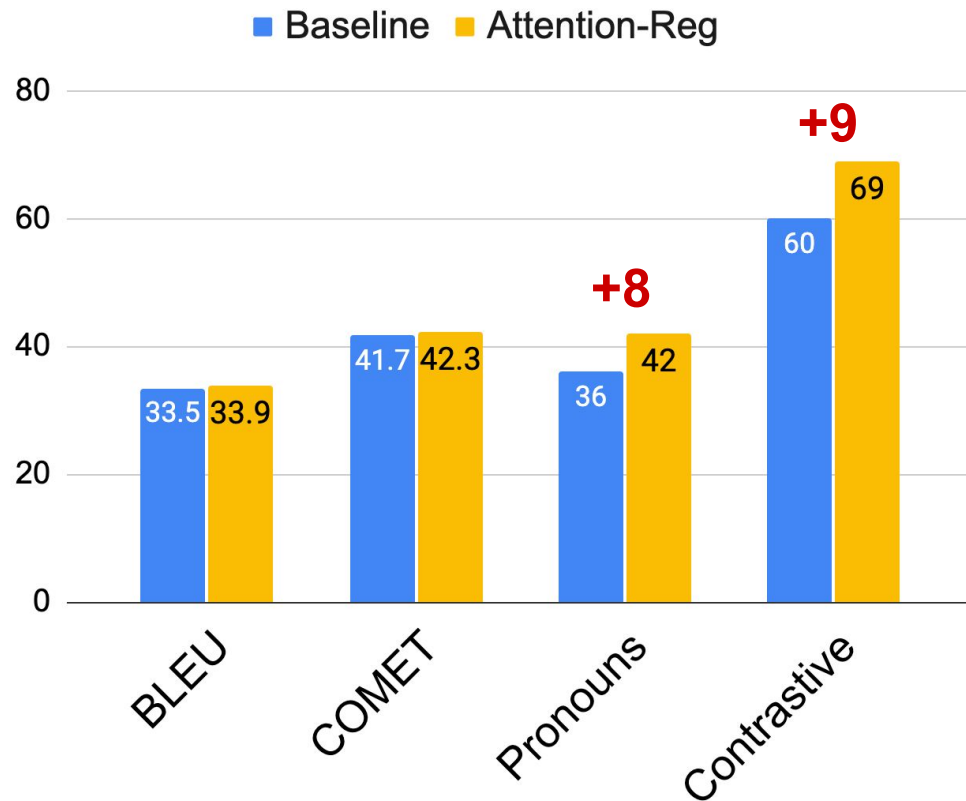
Results



Results

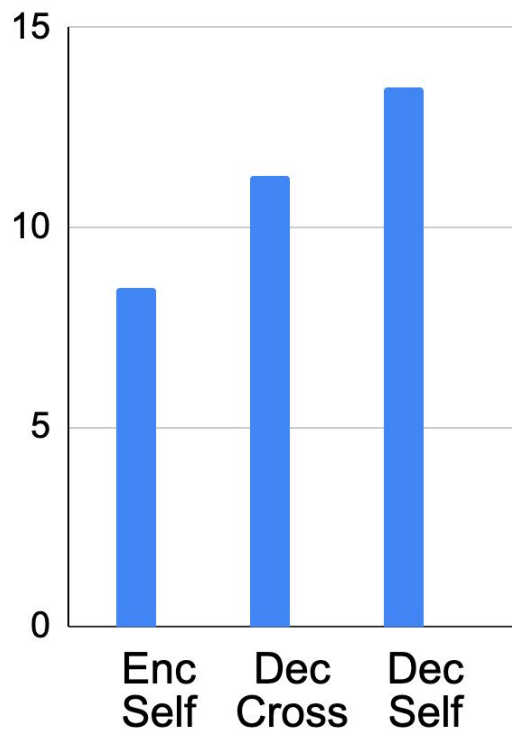


Results



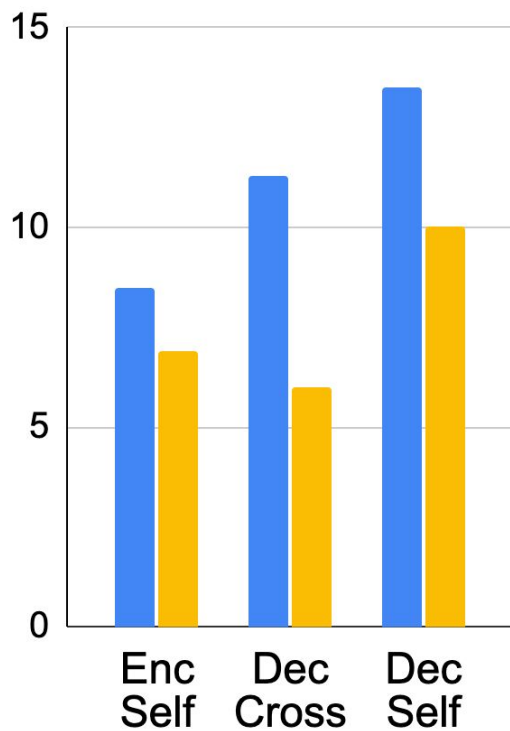
Results

■ Baseline ■ Attention-Reg



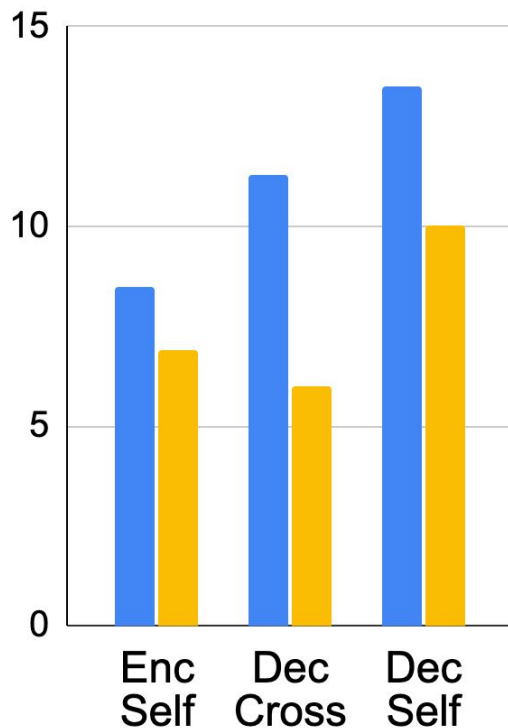
Results

■ Baseline ■ Attention-Reg



Results

■ Baseline ■ Attention-Reg



Baseline

Have we got her report?
Yes, it's in the infirmary already.

On dispose de son rapport?
Oui, elle est déjà à l'infirmerie.

Attention-Reg

Have we got her report?
Yes, it's in the infirmary already.

On dispose de son rapport?
Oui, il est déjà à l'infirmerie.

Results

■ Baseline ■ A

15

10

5

0

Enc
Self

Dec
Cross

Dec
Self

More experiments & results in paper:

→ Increased usage of **supporting context**

Have we got her report?

Yes, it's in the infirmary already.

son rapport?
à l'infirmerie.

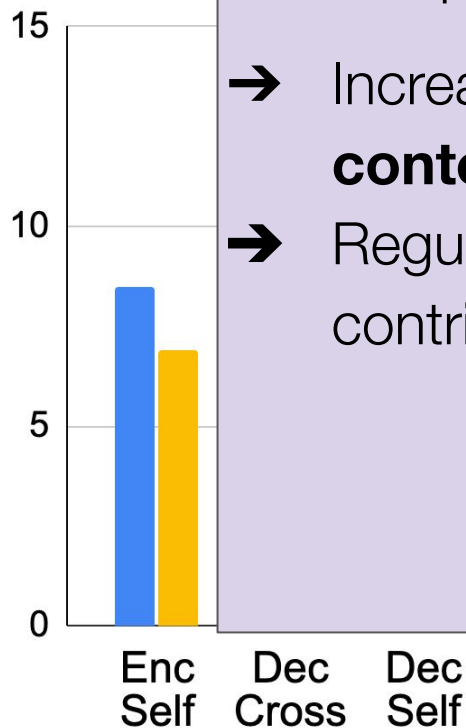
got her report?
rmay already.

e de son rapport?

Oui, il est déjà à l'infirmerie.

Results

■ Baseline ■ A



More experiments & results in paper:

- Increased usage of **supporting context**
- Regularizing **encoder self-attention** contributes the most

Have we got her report?

Yes, **it** is in the **infirmary** already.

son rapport?
à l'infirmerie.

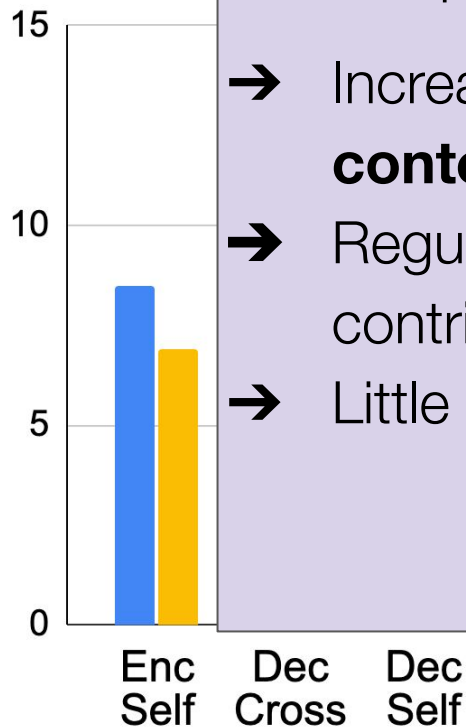
got her **report**?
rmay already.

e de son **rapport**?

Oui, **il** est déjà à l'infirmerie.

Results

■ Baseline ■ A



More experiments & results in paper:

- Increased usage of **supporting context**
- Regularizing **encoder self-attention** contributes the most
- Little difference in **WSD** performance

Have we got her report?

Yes, **it** is the **infirm**ary already.

son rapport?
à l'infirm

ot her **report**?
rmay already.

e de son **rapport**?

Oui, **il** est déjà à l'infirm

Summary

Task 1 - Example 13

Source context:
Their ancestors refused to come on the Mayflower. They didn't want to rub elbows with tourists.

Source sentence:
So they swam over.

Source context you highlighted:
[Reset Highlights](#)

Source sentence you highlighted:
[Reset Highlights](#)

Target context:
Leurs ancêtres n'ont pas pris le Mayflower... pour ne pas se frotter aux touristes.

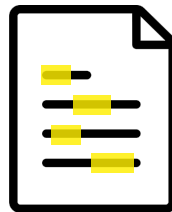
Target sentence:
_____ sort _____ à la nage.
☒ Ils ... venus
☐ Elles ... venues

How confident are you?

Target context you highlighted:
• ancêtres
[Reset Highlights](#)

Target sentence you highlighted:
[Reset Highlights](#)

Mismatch between source and target site



14k SCAT

Summary

Task 1 - Example 13

Source context:
Their ancestors refused to come on the Mayflower. They didn't want to rub elbows with tourists.

Source sentence:
So they swam over.

Source context you highlighted:
[Reset Highlights](#)

Source sentence you highlighted:
[Reset Highlights](#)

Target context:
Leurs ancêtres n'ont pas pris le Mayflower... pour ne pas se frotter aux touristes.

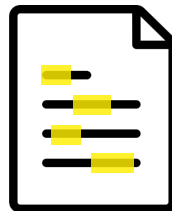
Target sentence:
_____ sort _____ à la nage.
• Ils ... venus
○ Elles ... venues

How confident are you?

Target context you highlighted:
• ancêtres
[Reset Highlights](#)

Target sentence you highlighted:
[Reset Highlights](#)

Mismatch between source and target site



14k SCAT

Baseline
Model

Summary

Task 1 - Example 13

Source context:
Their ancestors refused to come on the Mayflower. They didn't want to rub elbows with tourists.

Source sentence:
So they swam over.

Source context you highlighted:
[Reset Highlights](#)

Source sentence you highlighted:
[Reset Highlights](#)

Mismatch between source and target site

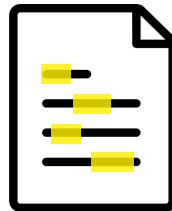
Target context:
Leurs ancêtres n'ont pas pris le Mayflower... pour ne pas se frotter aux touristes.

Target sentence:
_____ sort _____ à la nage.
• ☒ Ils ... venus
○ Elles ... venues

How confident are you?

Target context you highlighted:
• ancêtres
[Reset Highlights](#)

Target sentence you highlighted:
[Reset Highlights](#)

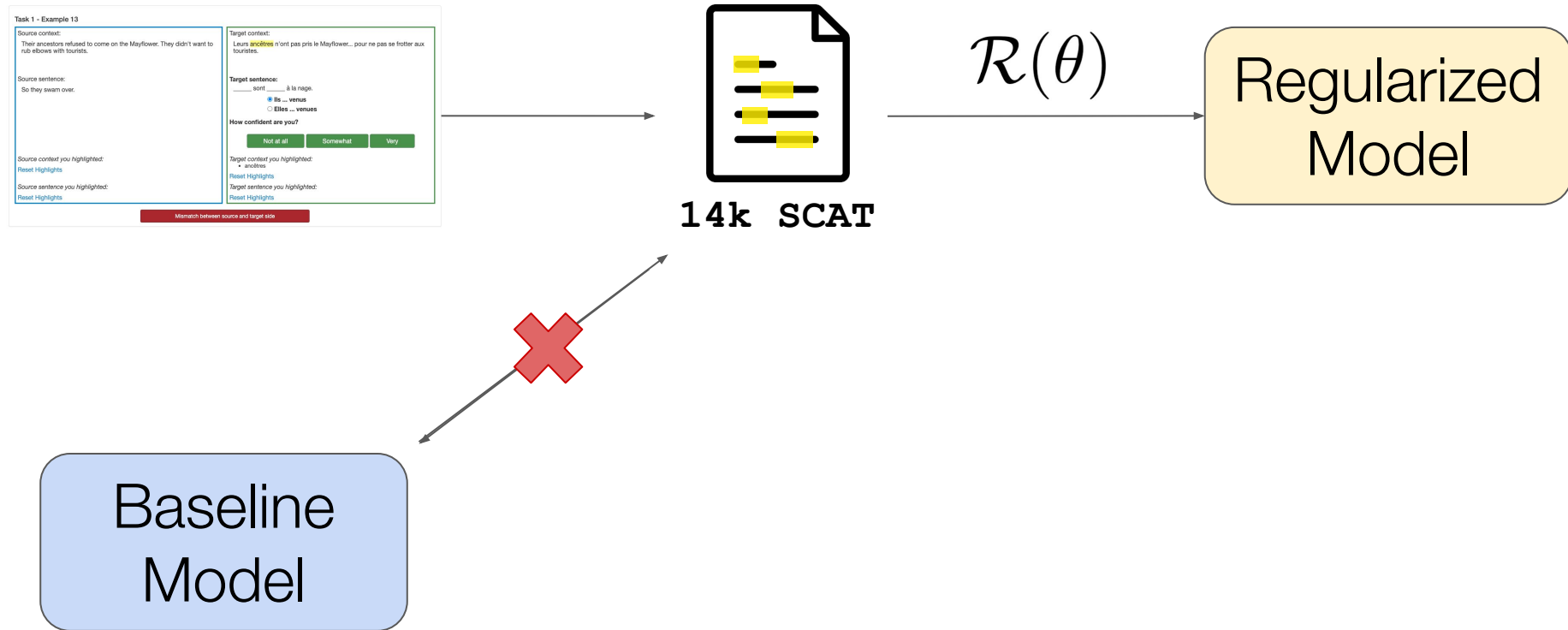


14k SCAT

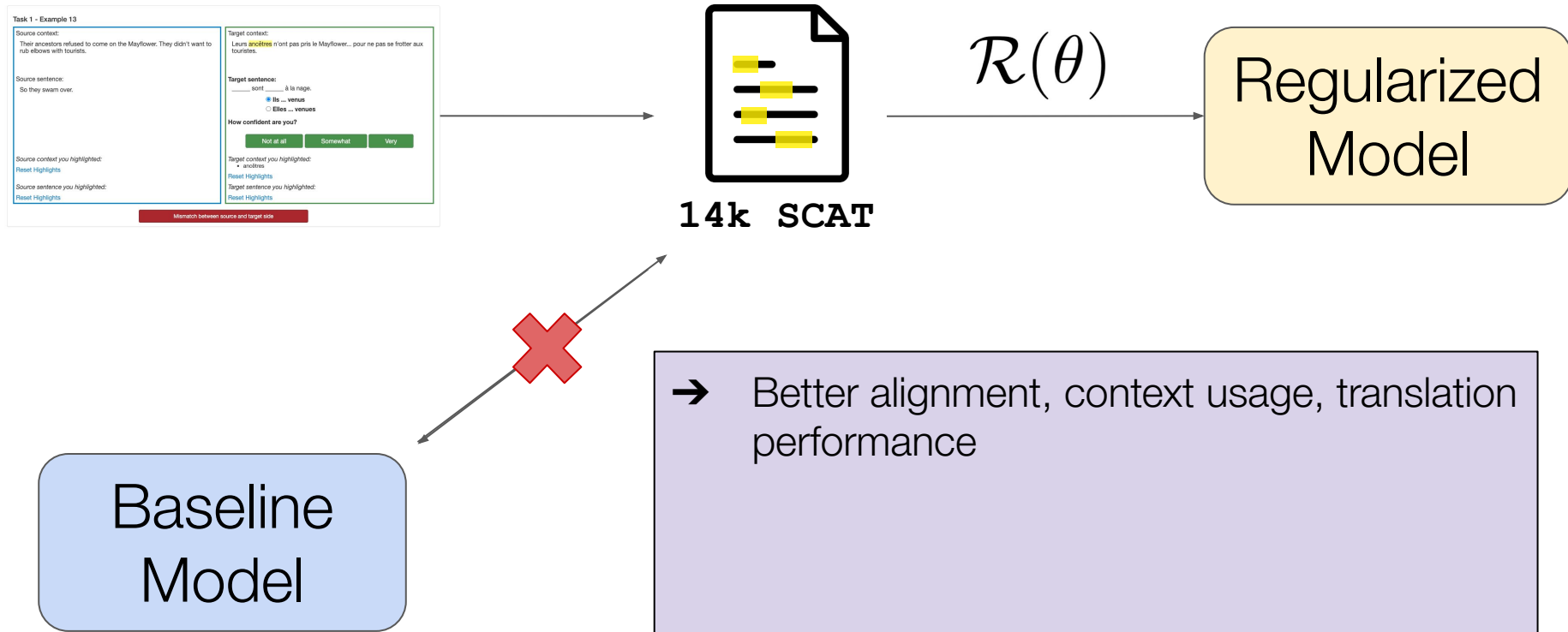


Baseline
Model

Summary



Summary

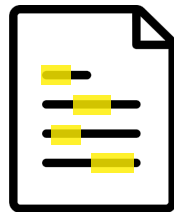


Summary

Task 1 - Example 13

<p>Source context: Their ancestors refused to come on the Mayflower. They didn't want to rub elbows with tourists.</p> <p>Source sentence: So they swam over.</p> <p>Source context you highlighted: Reset Highlights</p> <p>Source sentence you highlighted: Reset Highlights</p>	<p>Target context: Leurs ancêtres n'ont pas pris le Mayflower... pour ne pas se frotter aux touristes.</p> <p>Target sentence: _____ sort _____ à la nage. • <input checked="" type="radio"/> Ils ... venus • <input type="radio"/> Elles ... venues</p> <p>How confident are you? <input type="button" value="Not at all"/> <input type="button" value="Somewhat"/> <input type="button" value="Very"/></p> <p>Target context you highlighted: • Reset Highlights</p> <p>Target sentence you highlighted: Reset Highlights</p>
--	---

Minimatch between source and target site



14k SCAT

$\mathcal{R}(\theta)$

Regularized
Model

Baseline
Model

- Better alignment, context usage, translation performance
- Code & Data:
github.com/neulab/contextual-mt