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Translating Pro-Drop Languages with Reconstruction Models

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Problem Statement

- **Pronouns** are frequently **omitted** in pro-drop languages (e.g., Chinese, Japanese) especially in **informal genres**.

Genres	Sents	ZH-Pro	EN-Pro	DP
Dialogue	2.15M	1.66M	2.26M	26.55%
Newswire	3.29M	2.27M	2.45M	7.35%

- It leads to significant **challenges** with respect to the production of complete **translations**.

Input	(它) 根本 没 那么 严重	Input	这块 面包 很 美味 ! 你 烤 的 (它) 吗 ?
Ref	**It** is not that bad	Ref	The bread is very tasty ! Did you bake **it** ?
SMT	Wasn 't that bad	SMT	This bread , delicious ! Did you bake ?
NMT	**It** 's not that bad	NMT	The bread is delicious ! Are you baked ?

Novelty of Work

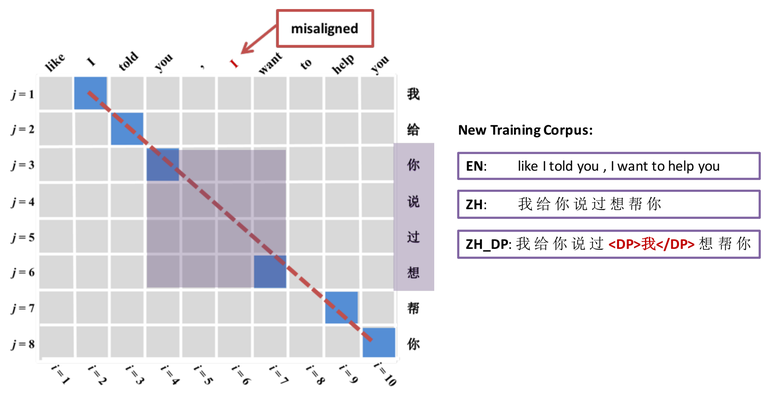
- We show that although NMT models advance SMT models on translating pro-drop languages, there is still **large room for improvement**;

System	Baseline	Oracle	△
SMT	30.16	35.26	+5.10
NMT	31.80	36.73	+4.93

- Little attention has been paid to the problem within NMT. We introduce a **reconstruction-based approach** (+ 3.28 BLEU);
- We release a large-scale **bilingual dialogue corpus** (2.2M Chinese–English sentence pairs).

DP Annotation and Generation

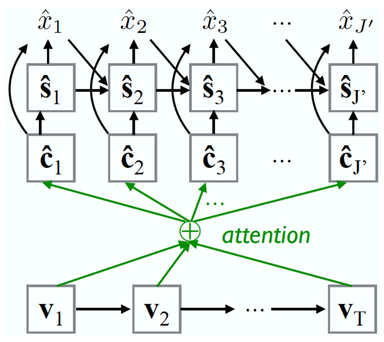
Annotation: as large parallel corpora are usually available, we automatically annotate DP using alignment information.



Generation: we apply RNN for DP position detection and MLP for DP word recovering.

Reconstructor

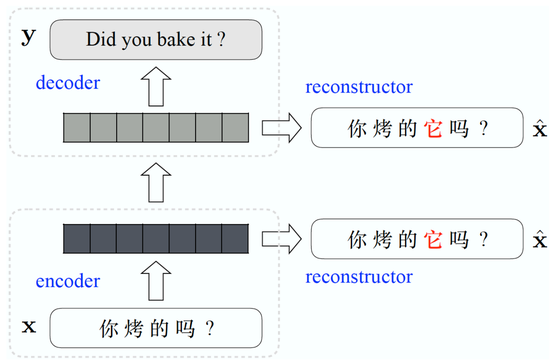
The reconstructor reads a sequence of **hidden states** and the labelled source sentence, and outputs a **reconstruction score**.



$$R(\hat{\mathbf{x}}|\mathbf{v}) = \prod_{j=1}^{J'} R(\hat{x}_j|\hat{x}_{<j}, \mathbf{v}) = \prod_{j=1}^{J'} g_r(\hat{x}_{j-1}, \hat{\mathbf{s}}_j, \hat{\mathbf{c}}_j)$$

Reconstructor-Augmented NMT

Two independent reconstructors with their own parameters, each of which reconstructs the labelled source sentence from the **encoder** and **decoder** hidden states.



$$J(\theta,\gamma,\psi) = \arg\max_{\theta,\gamma,\psi} \sum_{n=1}^{N} \Big\{ \underbrace{\log P(\mathbf{y}^n|\mathbf{x}^n;\theta)}_{likelihood} + \underbrace{\log R_{enc}(\hat{\mathbf{x}}^n|\mathbf{h}^n;\theta,\gamma)}_{enc\text{-}rec} + \underbrace{\log R_{dec}(\hat{\mathbf{x}}^n|\mathbf{s}^n;\theta,\psi)}_{dec\text{-}rec} \Big\}$$

Experiments

- **Data**

Data	|S|	|W|		|P|		|V|		|L|	
		Zh	En	Zh	En	Zh	En	Zh	En
Train	2.15M	12.1M	16.6M	1.66M	2.26M	151K	90.8K	5.63	7.71
Tune	1.09K	6.67K	9.25K	0.76K	1.03K	1.74K	1.35K	6.14	8.52
Test	1.15K	6.71K	9.49K	0.77K	0.96K	1.79K	1.39K	5.82	8.23

- **Main Results**

Model	#Params	Speed		BLEU	
		Training	Decoding	Test	△
Baseline	86.7M	1.60K	2.61	31.80	– / –
Baseline (+DPs)	86.7M	1.59K	2.63	32.67†	+0.87 / –
+ enc-rec	+39.7M	0.71K	2.63	33.67†‡	+1.87 / +1.00
+ dec-rec	+34.1M	0.84K	2.18	33.48†‡	+1.68 / +0.81
+ enc-rec + dec-rec	+73.8M	0.57K	2.16	**35.08**†‡	**+3.28 / +2.41**
Multi-source (Zoph and Knight 2016)	+20.7M	1.17K	1.27	32.81†	+1.01 / +0.14
Multi-layer (Wu et al. 2016)	+27.0M	0.53K	2.12	33.46†‡	+1.62 / +0.79
Enc-Dec-Rec (Tu et al. 2017)	+34.1M	0.87K	2.26	33.08†	+1.28 / +0.41

- **Effect of DP Generation Performance**

Model	Automatic	Manual	△
Baseline (+DPs)	32.67	36.73	+4.06
+ enc-rec	33.67	37.58	+3.91
+ dec-rec	33.48	37.23	+3.75
+ enc-rec + dec-rec	35.08	38.38	+3.30

- **Contribution Analysis**

Model	Test	△
Baseline	31.80	– / –
Baseline (+DPs)	32.67	+0.87 / –
+ enc-rec	33.67	+1.87 / +1.00
+ dec-rec	33.15	+1.35 / +0.48
+ enc-rec + dec-rec	**34.02**	**+2.22 / +1.35**

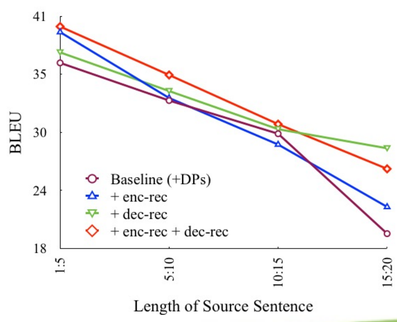
Reconstruction used in training only

- **Effect of Reconstruction**

Model	Test	△
Baseline	31.80	– / –
Baseline (+DPs)	32.67	+0.87 / –
+ enc-rec	33.21	+1.41 / +0.54
+ dec-rec	33.08	+1.28 / +0.41
+ enc-rec + dec-rec	**33.25**	**+1.45 / +0.58**

Replacing DP sentence with original one

- **Length Analysis**



- **Error Analysis**

Model	Error	Sub.	Obj.	Dum.	All
BASE	Total	112	41	45	198
+ ENC	Fixed	51	22	28	101
	New	25	8	4	37
+ DEC	Fixed	57	21	17	95
	New	19	10	6	36
+ ENC + DEC	Fixed	50	34	33	117
	New	11	14	7	32

Fixed Error	
Input	等 我 搬进 来 (**我**) 可以 买 一台 泡泡机 吗 ?
Ref.	When I move in, can I get a bubble machine?
NMT	When I move in *to* buy a bubble machine.
Our	When I move in, can **I** buy a bubble machine?
Non-Fixed Error	
Input	(**他**) 是 个 训练营 ?
Ref.	It is a camp?
NMT	*He* was a camp?
Our	*He*'s a camp?
Newly Introduced Error	
Input	(**我**) 要 把 这 戒指 还给 你
Ref.	I need to give this ring back to you.
NMT	**I**'m gonna give you the ring back.
Our	*To* give it back to you.

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