Dual Latent Variable Model for Low-Resource Natural Language Generation in Dialogue Systems

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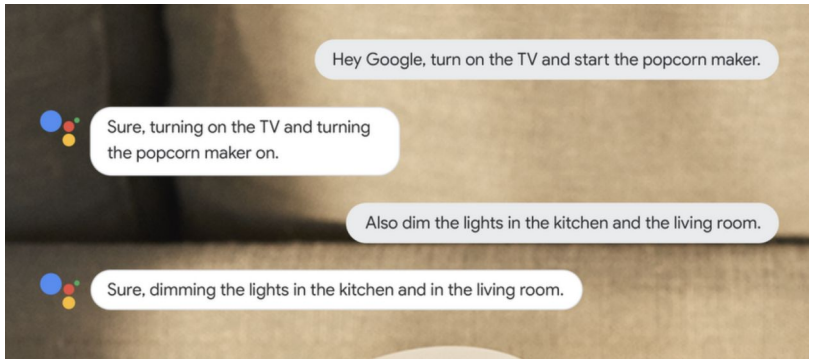
Dialogue system

SHOPPER: Hello

AGENT: Hello, is there anything i can help you with today?

SHOPPER: show me some espadrilles in beige/blue within $200.

AGENT: Sure. let me just quickly browse through my catalogue



Dialogue system

- Input recognizer/decoder
- Natural language understanding
- Dialog manager
- Task managers
- Output generator
- Output renderer

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Natural-language generation

generating **natural language** from a machine-representation system such as a ***knowledge base*** or a ***logical* form**

Natural-language generation

- Weather forecasts
- Automated journalism
- Chatbots
- Summarising medical records
- Product descriptions
- Enhancing accessibility

Dialogue Act and Utterance

Dialogue Act: inform(name=‘ABC’; area=‘XYZ’)

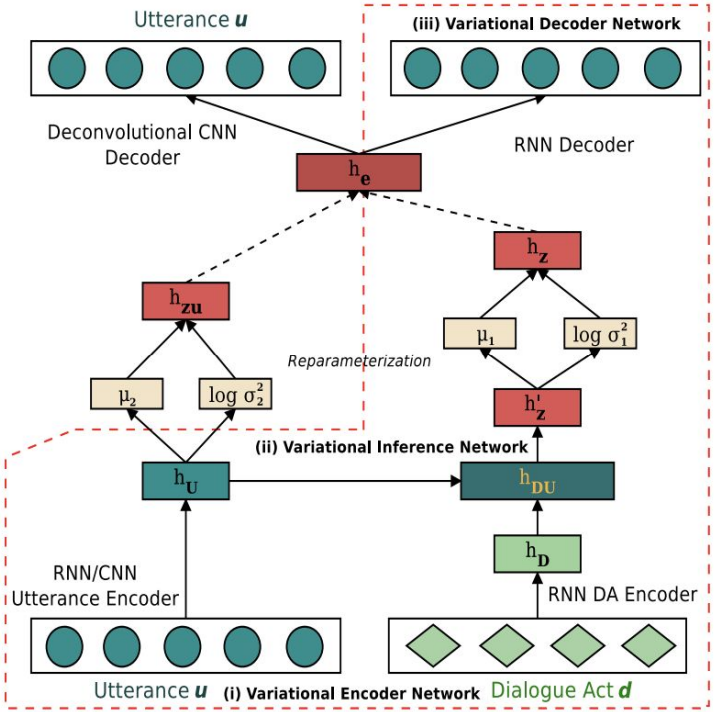
Utterance: The hotel ABC is in XYZ area

Scarce Data

- Domain adaptation
- Model designing for *low-resource* setting

Dual Latent Variable Model

$$p(\mathbf{u}|\mathbf{d}) = \int_z p(\mathbf{u}, z|\mathbf{d})\mathbf{d}_z = \int_z p(\mathbf{u}|z, \mathbf{d})p(z|\mathbf{d})\mathbf{d}_z$$



Variational Inference Network

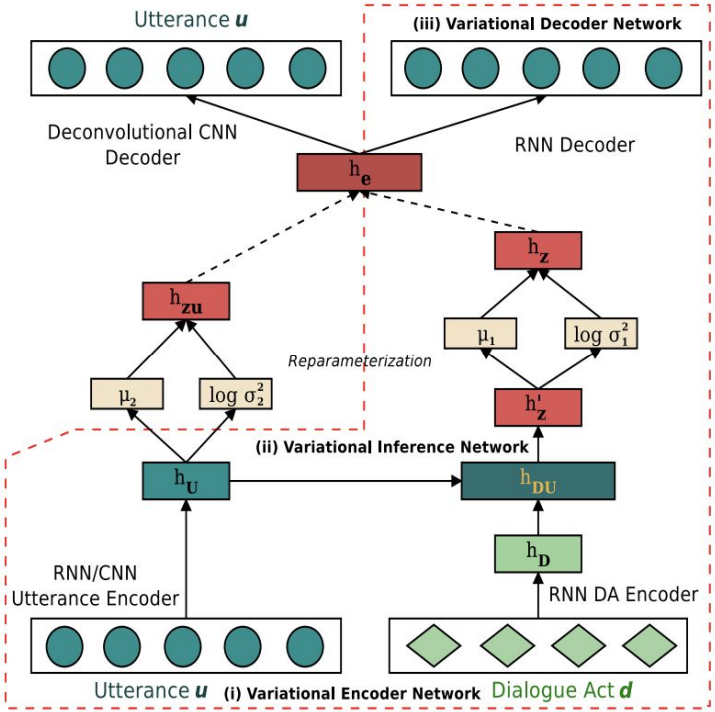
Neural Posterior Approximator

$$\mathbf{h}'_z = g(\mathbf{W}_z[\mathbf{h_D}; \mathbf{h_U}] + b_z)$$

$$q_\phi(z|\mathbf{d}, \mathbf{u}) = \mathcal{N}(z; \mu_1(\mathbf{h}'_z), \sigma_1^2(\mathbf{h}'_z)\boldsymbol{I})$$

$$\mu_1 = \mathbf{W}_{\mu_1}\mathbf{h}'_z + b_{\mu_1}, \log \sigma_1^2 = \mathbf{W}_{\sigma_1}\mathbf{h}'_z + b_{\sigma_1}$$

Dual Latent Variable Model



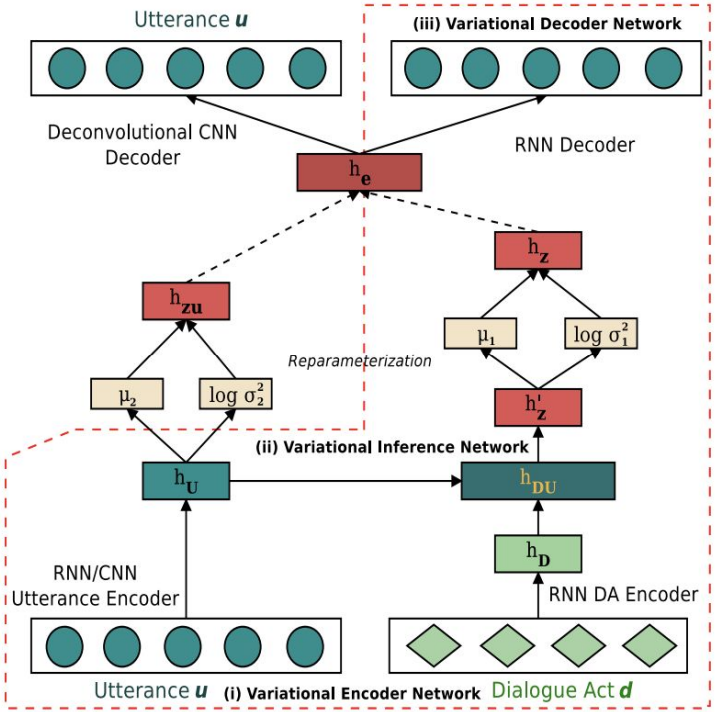
Variational Inference Network

Neural Prior

$$p_\theta(z|\mathbf{d}) = \mathcal{N}(z; \mu_1'(\mathbf{d}), \sigma'^2_1(\mathbf{d})\boldsymbol{I})$$

$$\mathbf{h}_z = \mu_1 + \sigma_1 \odot \epsilon \text{ where } \epsilon \sim \mathcal{N}(0, \boldsymbol{I}).$$

Dual Latent Variable Model



Experiments

	Model	Hotel		Restaurant		Tv		Laptop	
		BLEU	ERR	BLEU	ERR	BLEU	ERR	BLEU	ERR
scr100	HLSTM	0.8488	2.79%	0.7436	0.85%	0.5240	2.65%	0.5130	1.15%
	SCLSTM	0.8469	3.12%	0.7543	0.57%	0.5235	2.41%	0.5109	0.89%
	ENCDEC	0.8537	4.78%	0.7358	2.98%	0.5142	3.38%	0.5101	4.24%
	RALSTM	**0.8965**	0.58%	***0.7779***	***0.20%***	***0.5373***	***0.49%***	***0.5231***	**0.50%**
	R-VNLG (Ours)	0.8851	0.57%	0.7709	0.36%	0.5356	0.73%	0.5210	0.59%
	C-VNLG (Ours)	0.8811	***0.49%***	0.7651	**0.06%**	0.5350	0.88%	0.5192	***0.56%***
	DualVAE (Ours)	0.8813	**0.33%**	0.7695	0.29%	0.5359	0.81%	0.5211	0.91%
	CrossVAE (Ours)	***0.8926***	0.72%	**0.7786**	0.54%	**0.5383**	**0.48%**	**0.5240**	**0.50%**
scr10	HLSTM	0.7483	8.69%	0.6586	6.93%	0.4819	9.39%	0.4813	7.37%
	SCLSTM	0.7626	17.42%	0.6446	16.93%	0.4290	31.87%	0.4729	15.89%
	ENCDEC	0.7370	23.19%	0.6174	23.63%	0.4570	21.28%	0.4604	29.86%
	RALSTM	0.6855	22.53%	0.6003	17.65%	0.4009	22.37%	0.4475	24.47%
	R-VNLG (Ours)	0.7378	15.43%	0.6417	15.69%	0.4392	17.45%	0.4851	10.06%
	C-VNLG (Ours)	0.7998	8.67%	0.6838	***6.86%***	0.5040	5.31%	0.4932	3.56%
	DualVAE (Ours)	***0.8022***	***6.61%***	***0.6926***	7.69%	***0.5110***	***3.90%***	***0.5016***	***2.44%***
	CrossVAE (Ours)	**0.8103**	**6.20%**	**0.6969**	**4.06%**	**0.5152**	**2.86%**	**0.5085**	**2.39%**
scr30	HLSTM	0.8104	6.39%	0.7044	2.13%	0.5024	5.82%	0.4859	6.70%
	SCLSTM	0.8271	6.23%	0.6825	4.80%	0.4934	7.97%	0.5001	3.52%
	ENCDEC	0.7865	9.38%	0.7102	13.47%	0.5014	9.19%	0.4907	10.72%
	RALSTM	0.8334	4.23%	0.7145	2.67%	0.5124	3.53%	0.5106	2.22%
	C-VNLG (Ours)	***0.8553***	2.64%	0.7256	***0.96%***	0.5265	**0.66%**	***0.5117***	2.15%
	DualVAE (Ours)	0.8534	***1.54%***	***0.7301***	2.32%	***0.5288***	1.05%	0.5107	***0.93%***
	CrossVAE (Ours)	**0.8585**	**1.37%**	**0.7479**	**0.49%**	**0.5307**	***0.82%***	**0.5154**	**0.81%**

Examples

Model	Generated Responses from TV Domain
DA 1	compare(name='*typhon 45*'; hdmiport='*2*'; family='*l2*'; name='*hades 48*'; hdmiport='*4*'; family='*l7*')
Reference 1	Compared to *typhon 45* which has *2 hdmi port -s* and is in the *L2 product family*, *hades 48* has *4 hdmi port -s* and is in the *L7 product family*. Which one do you prefer ?
ENCDEC-10	the *typhon 45* is in the *l2 product family* and has *2 hdmi port -s* and is in the *l7 product family* with *4 hdmi port -s*, the *hades 48* is in the SLOT_FAMILY product family with a *SLOT_AUDIO*.
HLSTM-10	the *typhon 45* is a great *eco rating*, the *hades 48* is in the *l2 family* with *2 hdmi port -s*. [l7 family] [4 hdmi port -s]
SCLSTM-10	the *typhon 45* is the *hades 48* with *2 hdmi port* in the *l2 family*, the *SLOT_NAME* has *4 hdmi port -s* and *SLOT_HDMIPORT* hdmi port. [l7 family]
C-VNLG-10	the *typhon 45* has *2 hdmi port -s* and the *hades 48* is in the *l2 family* and has *4 hdmi port -s*. [l7 family]
DualVAE-10	the *typhon 45* has *2 hdmi port -s* and is in the *l2 family* while the *hades 48* has *4 hdmi port -s* and is in the *l7 family*. [OK]
CrossVAE-10	the *typhon 45* is in the *l2 family* with *2 hdmi port -s* while the *hades 48* has *4 hdmi port -s* and is in the *l7 family*. [OK]
ENCDEC-30	the *typhon 45* has *2 hdmi port -s*, the *hades 48* has *4 hdmi port -s*, the *SLOT_NAME* has *SLOT_HDMIPORT* hdmi port. [l2 family] [l7 family]
HLSTM-30	the *typhon 45* is in the *l2 product family* with *2 hdmi port -s*, whereas the *hades 48* has *4 hdmi port*. [l7 family]
SCLSTM-30	the *typhon 45* has *2 hdmi port -s*, the *hades 48* is in the *l2 product family*. [l7 family] [4 hdmi port -s]
C-VNLG-30	the *typhon 45* has *2 hdmi port -s*, the *hades 48* is in the *l2 product family* and has *4 hdmi port -s* in *l7 family*.
DualVAE-30	which do you prefer, the *typhon 45* in the *l2 product family* with *2 hdmi port -s* . the *hades 48* is in the *l7 family* with *4 hdmi port -s*. [OK]
CrossVAE-30	the *typhon 45* has *2 hdmi port -s* and in the *l2 family* while the *hades 48* has *4 hdmi port -s* and is in the *l7 family*. which item do you prefer. [OK]

References

https://arxiv.org/pdf/1811.04164.pdf - Dual Latent Variable Model for Low-Resource Natural Language Generation in Dialogue Systems