Topic-Aware Response Generation in Task-Oriented Dialogue with Unstructured Knowledge Access

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code: https://github.com/huawei-noah/noah-research/tree/NLP/TARG

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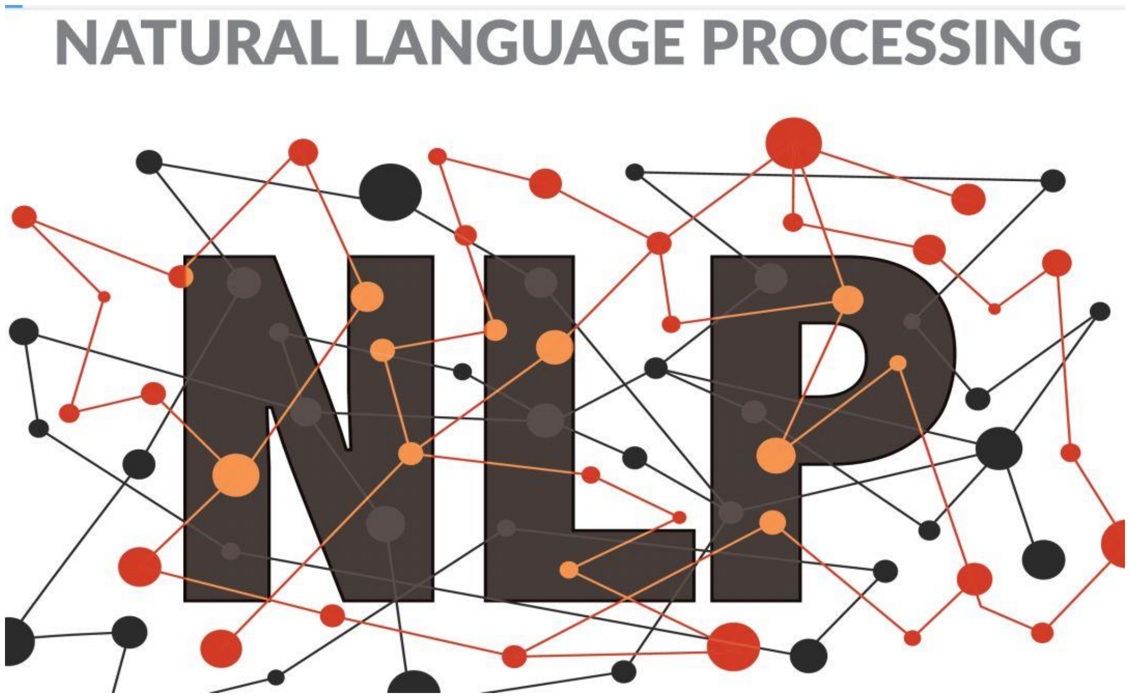
Reported by Junhao Cao



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Introduction

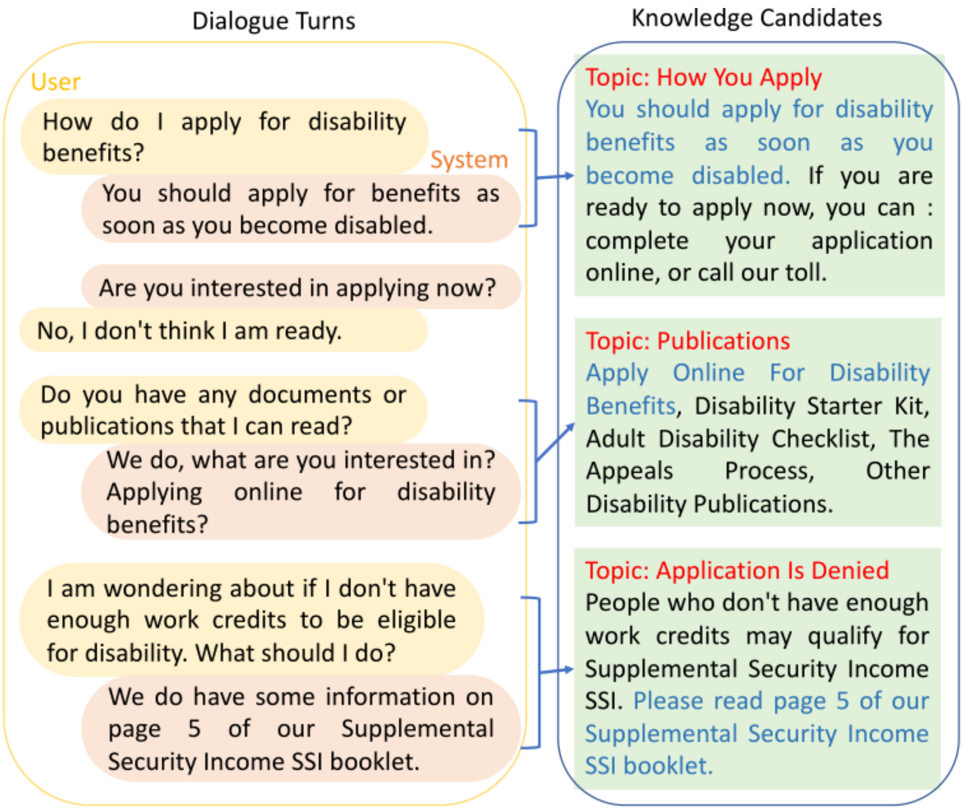


Figure 1: An example of knowledge-grounded dialogue.

we can observe that as the knowledge selection shifts, a corresponding shift occurs between topics. Previous work has not actively exploited this, but we posit that the topic shifts can provide signals that help making knowledge selection。

Method

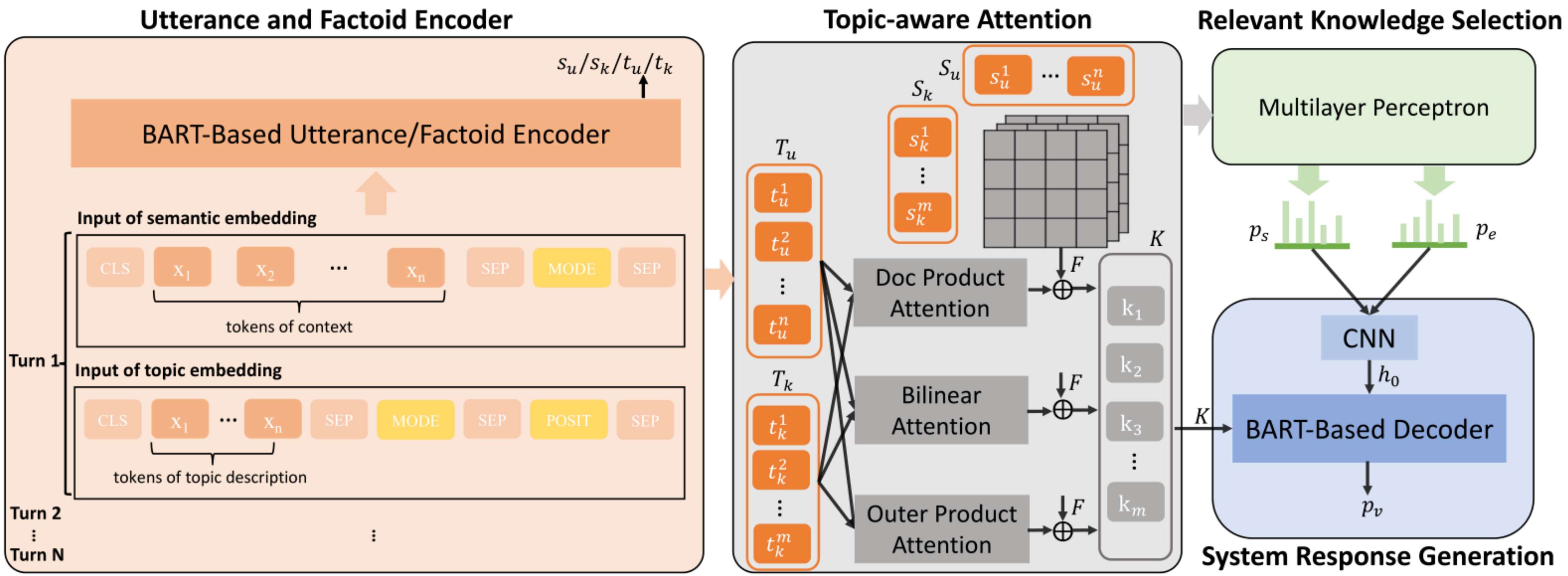


Figure 2: Overview of Topic-Aware Response Generation (TARG).

Method

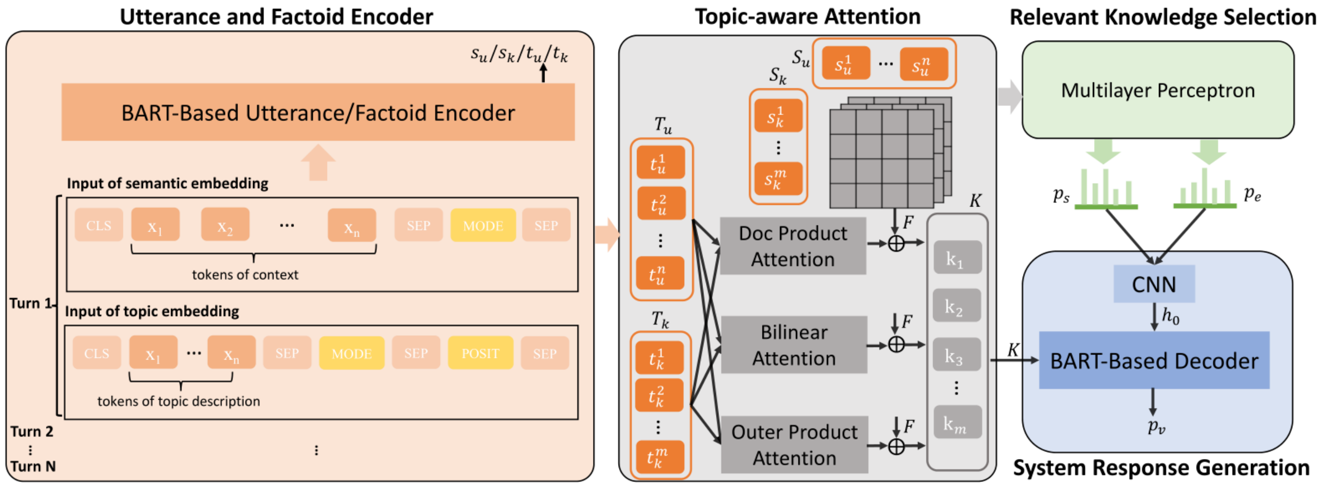


Figure 2: Overview of Topic-Aware Response Generation (TARG).

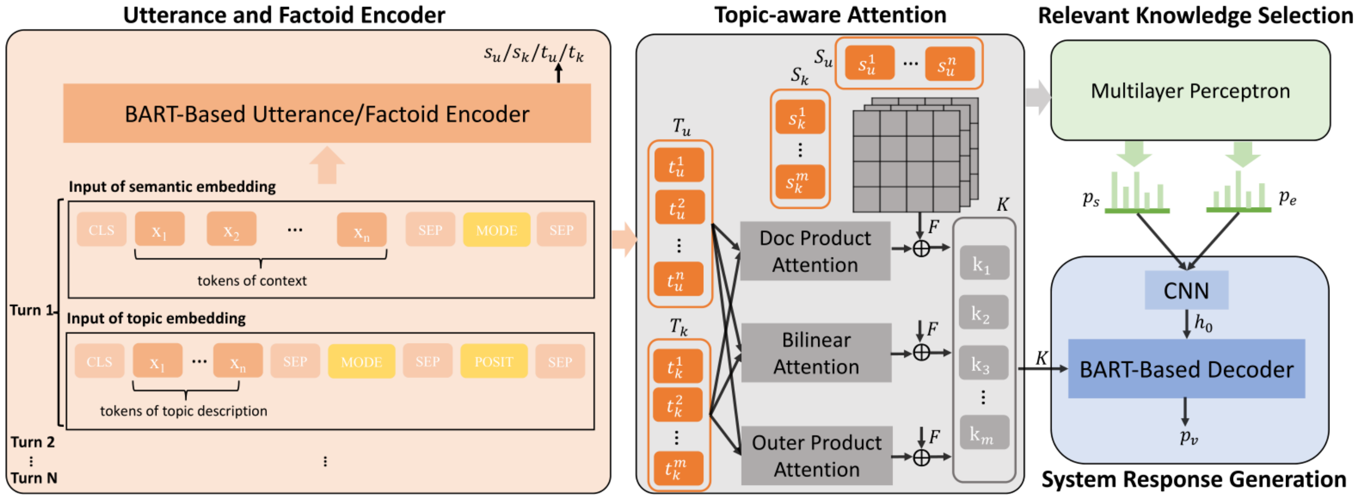
Utterance and Factoid Encoder

$$X = ([\mathrm{CLS}], x_1, ..., x_N, [\mathrm{SEP}], [\mathrm{MODE}], [\mathrm{SEP}])$$

[MODE] is one of [SYS]/[USER]/[KLG]

$$T = ([\mathrm{CLS}], x_1, ..., x_N, [\mathrm{SEP}], [\mathrm{MODE}], [\mathrm{SEP}], [\mathrm{POSIT}], [\mathrm{SEP}])$$

Method



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Topic-aware Attention

Dot Product:

$$A_d^i = \mathrm{softmax}(\exp([t_u^j, t_k^i] w_d), \forall t_u^j \in T_u) \quad (1)$$

Bilinear:

$$A_b^i = \mathrm{softmax}(\exp(t_u^j W_b t_k^{i\top}), \forall t_u^j \in T_u) \quad (2)$$

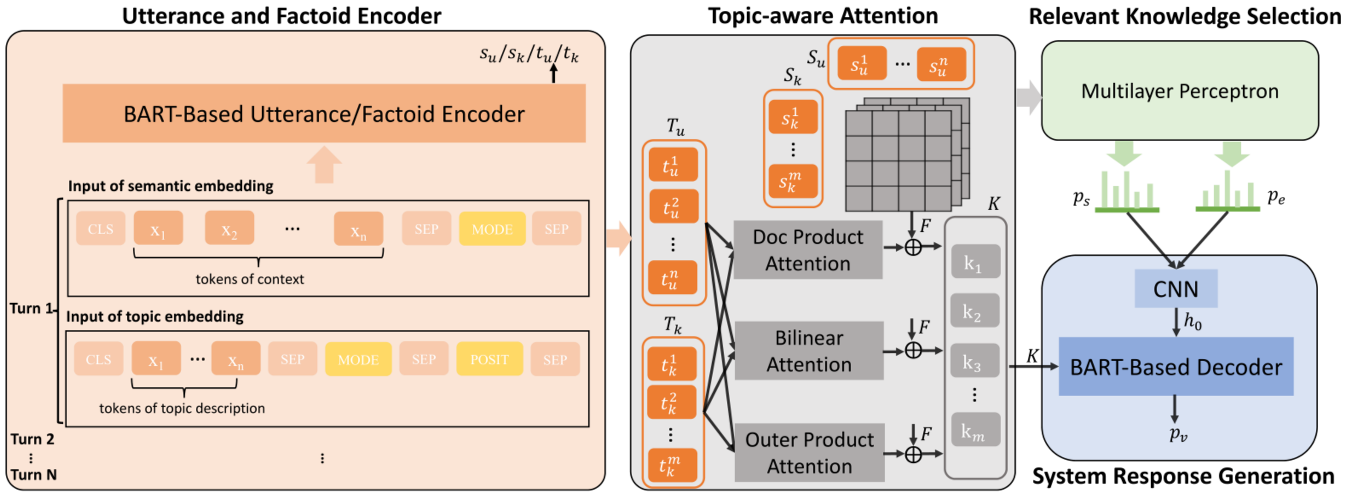
Outer Product:

$$A_o^i = \mathrm{softmax}(\exp((t_u^j \times t_k^i) w_o), \forall t_u^j \in T_u) \quad (3)$$

$$F_{i,j} = v_f^\top \tanh(s_u^j W_f s_k^{i\top} + b_f) \quad (4)$$

$$k_i = [A_d^{i\top} F_i, A_b^{i\top} F_i, A_o^{i\top} F_i] \quad (5)$$

Method



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Relevant Knowledge Selection

$$p^s = \mathrm{softmax}(W_s^\top K + b_s^\top), \quad (6)$$

$$p^e = \mathrm{softmax}(W_e^\top K + b_e^\top), \quad (7)$$

System Response Generation

$$f = \mathrm{CNN}(K_{:,s:e}), \quad (8)$$

$$h_t = \mathrm{BART}(w_{t-1}, h_{t-1}, K_{:,s:e}). \quad (9)$$

$$p_v = \mathrm{softmax}(VW_v h_t + b_v), \quad (10)$$

Method

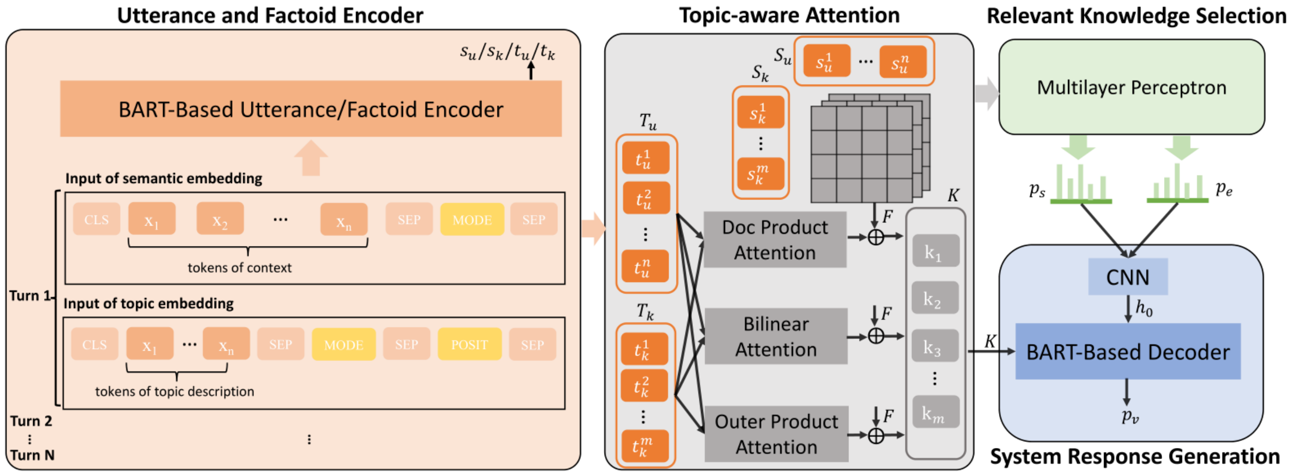

Figure 2: Overview of Topic-Aware Response Generation (TARG).

$$\mathcal{L}_s = -\frac{1}{NM}\sum_{n=0}^{N}\sum_{m=0}^{M}[\log(p^s_{y^s_{nm}}) + \log(p^e_{y^e_{nm}})], \quad (11)$$

$$\mathcal{L}_g = -\frac{1}{NM}\sum_{n=0}^{N}\sum_{m=0}^{M}\log P(Y_{nm}|D_{nm}, K_{nm}), \quad (12)$$

$$\mathcal{L} = \lambda \cdot \mathcal{L}_s + (1-\lambda)\cdot\mathcal{L}_g, \quad (13)$$

Experiment

Model	Knowledge Selection		Response Generation
	EM	F1	BLEU-4
Base-D2D	37.2	52.9	17.7
Base-D2D-ST	27.6	35.2	12.1
JARS	42.1	57.8	-
CAiRE	45.7	60.1	22.3
RWTH	46.6	62.8	24.4
TARG	**49.8**	**66.4**	**28.6**

Table 3: Performance of TARG and related work on Doc2Dial. **Bold** denotes best results in that metric.

Experiment

Model	Knowledge Selection		Response Generation						
	MRR@5	Recall@5	BLEU-1	BLEU-2	BLEU-3	BLEU-4	ROUGE-1	ROUGE-2	ROUGE-L
Base-DSTC	0.726	0.877	0.303	0.173	0.100	0.065	0.338	0.136	0.303
Base-DSTC-ST	0.612	0.743	0.251	0.132	0.083	0.047	0.262	0.104	0.244
KDEAK	0.853	0.896	0.355	**0.230**	0.153	0.104	0.397	**0.190**	0.357
RADGE	**0.937**	0.966	0.350	0.217	0.135	0.089	0.393	0.175	0.355
EGR	0.894	0.934	0.361	0.226	0.140	0.096	0.397	0.179	0.353
TARG	0.935	**0.972**	**0.366**	0.224	**0.156**	**0.111**	**0.408**	0.183	**0.360**

Table 4: Performance of TARG and related work on the DSTC9 dataset. **Bold** denotes best results in that metric.

Experiment

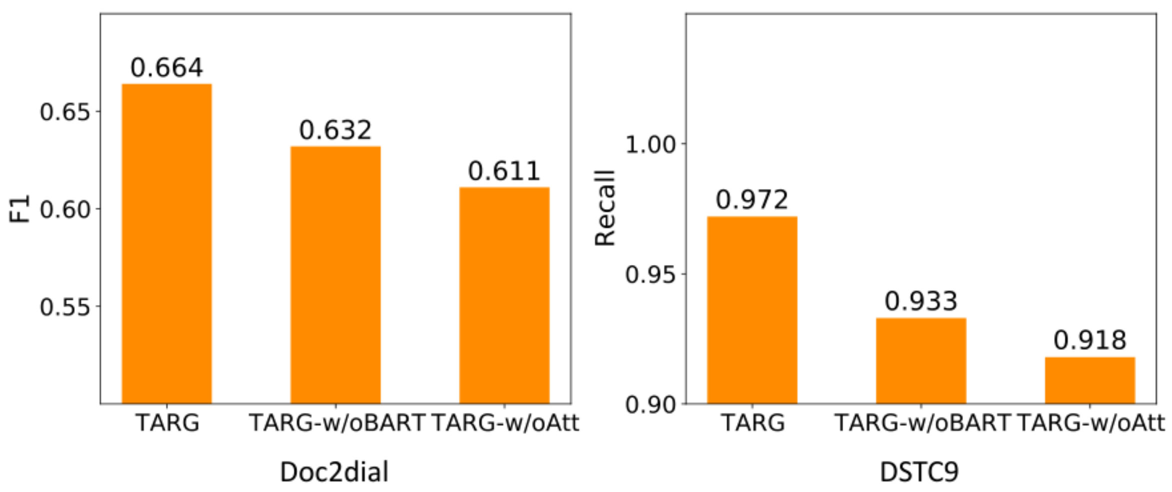

Figure 3: Ablation study for knowledge selection.

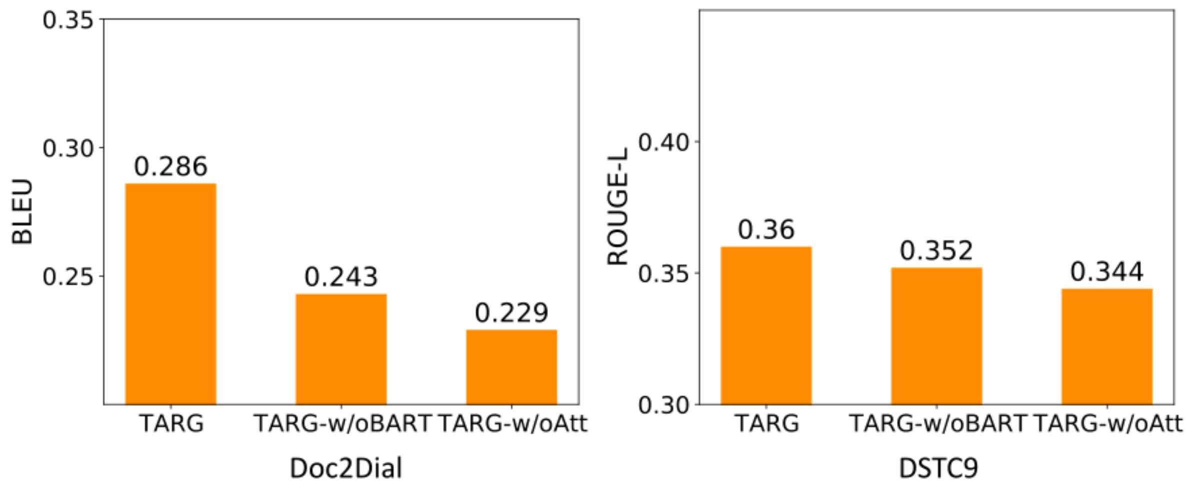

Figure 4: Ablation study for response generation.

Experiment

Dialogue History Turns	
U1	U: I wanted to know about career options.
S1	S: Do you love working with animals?
U2	U: No, what else you got?
S2	S: Do you like working with computers?
U3	U: I use them but wouldn't care to work on computer related things. Do you have any info for the parents to look at?
S3	S: Is this information for a parent that is planning ahead for a child's higher education?
U4	U: yes it is.
S4	S: We have resources for parents to learn more about saving early, and finding tax breaks.
U5	U: Do you have any info on how college can help me?

Generated Response	
Ground Truth	Yes, you can look at our Reasons to Attend a College or Career School section.
TARG	Please look at Reasons to Attend a College or Career School.
RWTH	Yes, Budgeting Resources for Parents of Students.
Doc2Dial-baseline	Review our resources for parents.

Knowledge Candidates (Factoids)		
	Topic	Context
T1	Exploring Your Career Options	Love working with animals? How about computers? Find possible careers to match your interests.
T2	Resources for Parents of Students	Are you a parent planning ahead for your child s higher education? Review our resources for parents to learn more about saving early, and finding tax breaks.
T3	Preparing for College	Check out Reasons to Attend a College or Career School. Learning About Budgeting Resources for Parents of Students.

Figure 5: Case study on Doc2Dial. Dialogue history turns are grounded to knowledge candidates of the same color.

Experiment

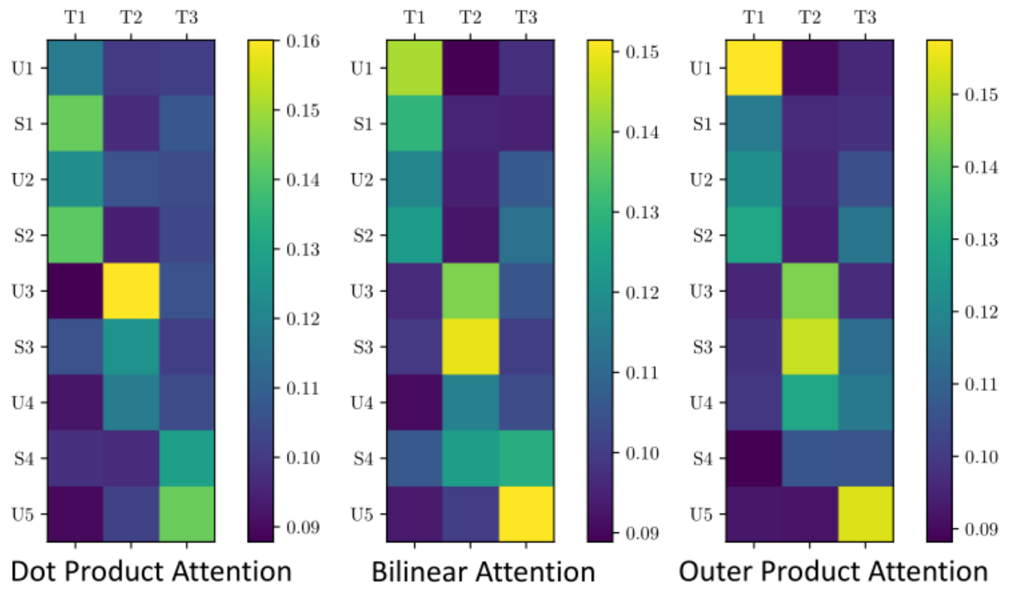

Figure 6: Visualization of learned topic-aware attention of dialogue history utterances U-X and S-X (for user and system utterance) for each topic T-X in the example in Figure 5. Lighter spots mean higher attention scores.

Model	Knowledge Selection		Response Generation
	EM	F1	BLEU
TARG-dot	0.468	0.642	0.261
TARG-bilinear	0.481	0.652	0.268
TARG-outer	0.489	0.655	0.275
TARG	**0.498**	**0.664**	**0.286**

Table 5: Ablation over different attention mechanisms.

Thank you!

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