Diverse Paraphrasing and its Effectiveness in Data Augmentation

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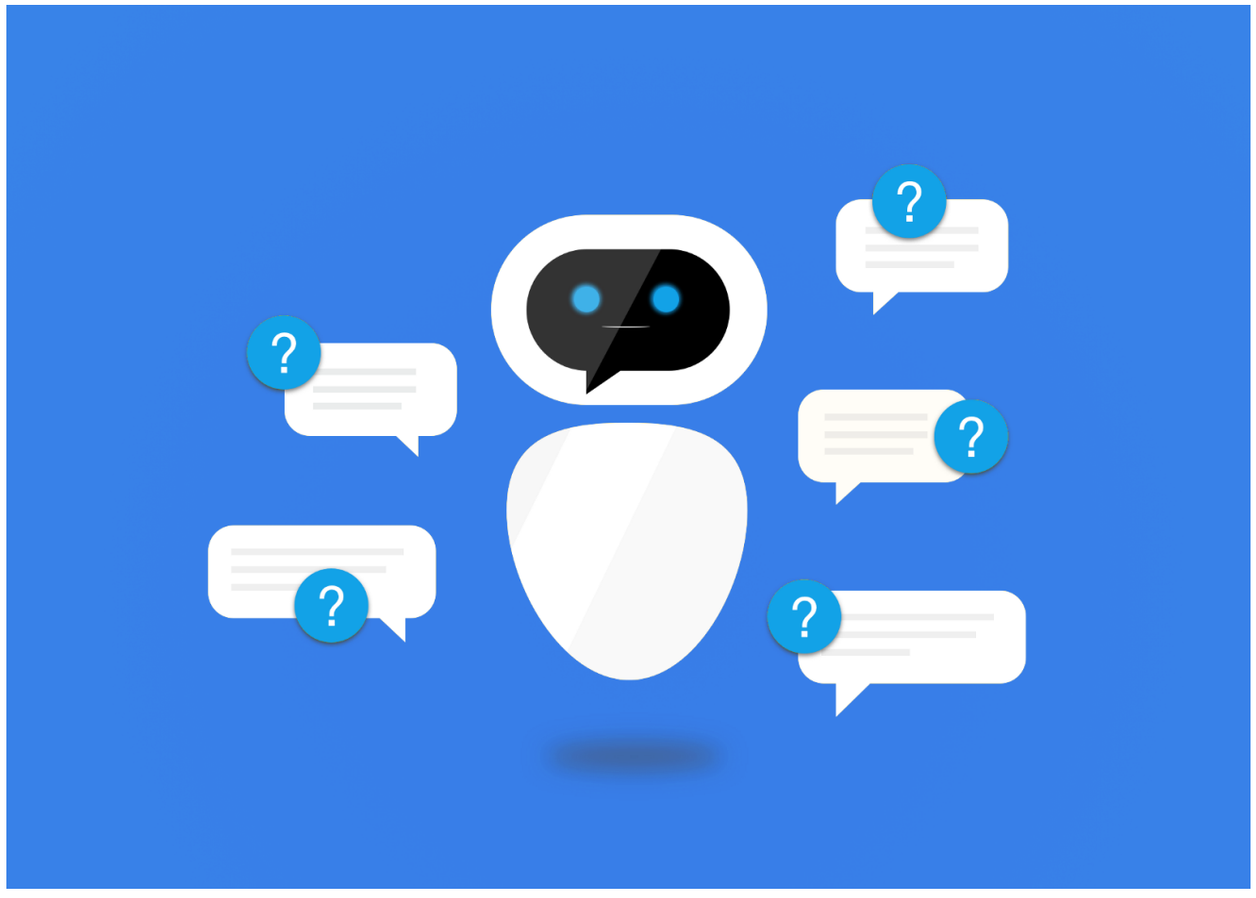
Indian Institute of Science, Bangalore

*Equal Contributions

Conversational Agents

Conversational Agents



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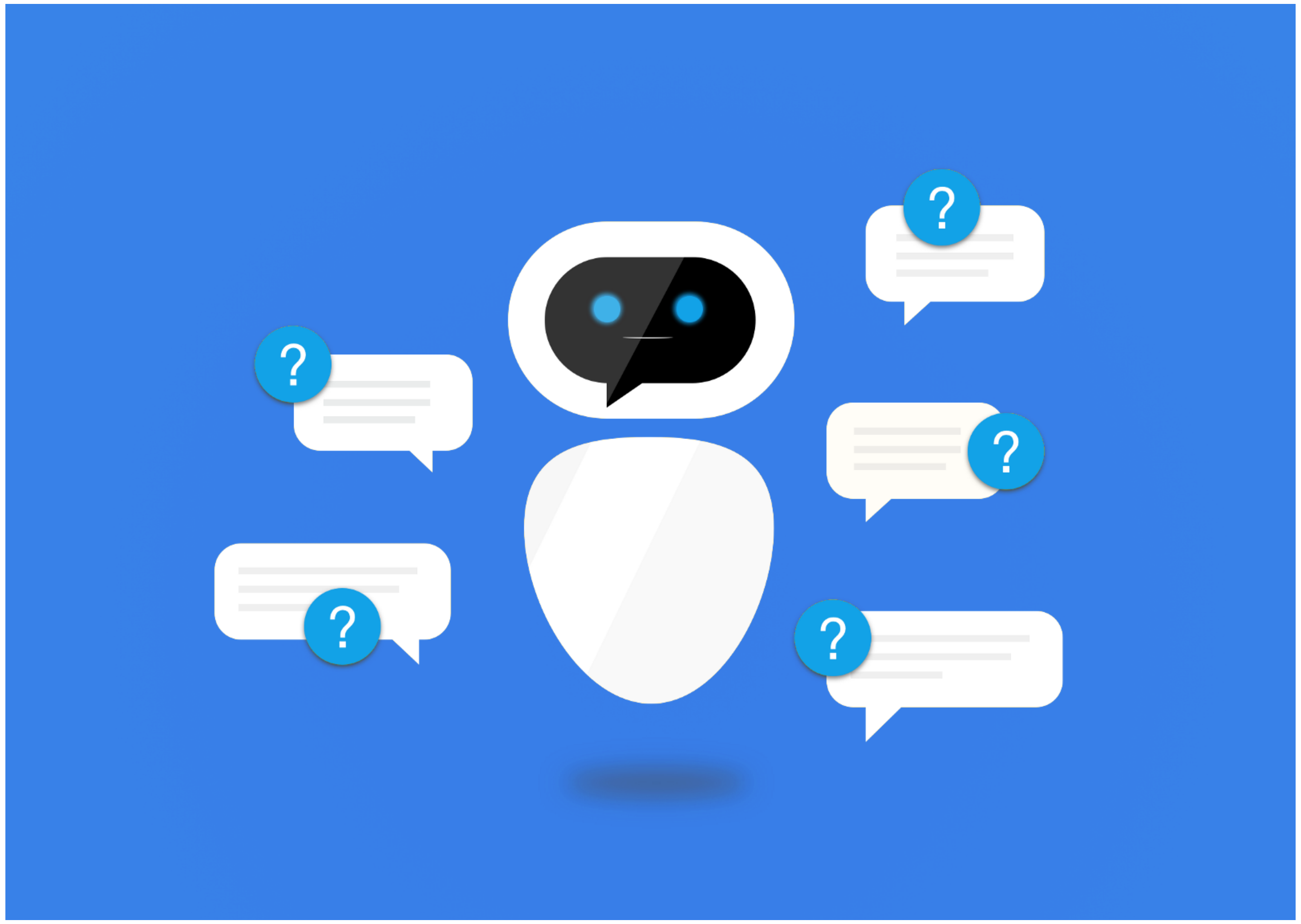
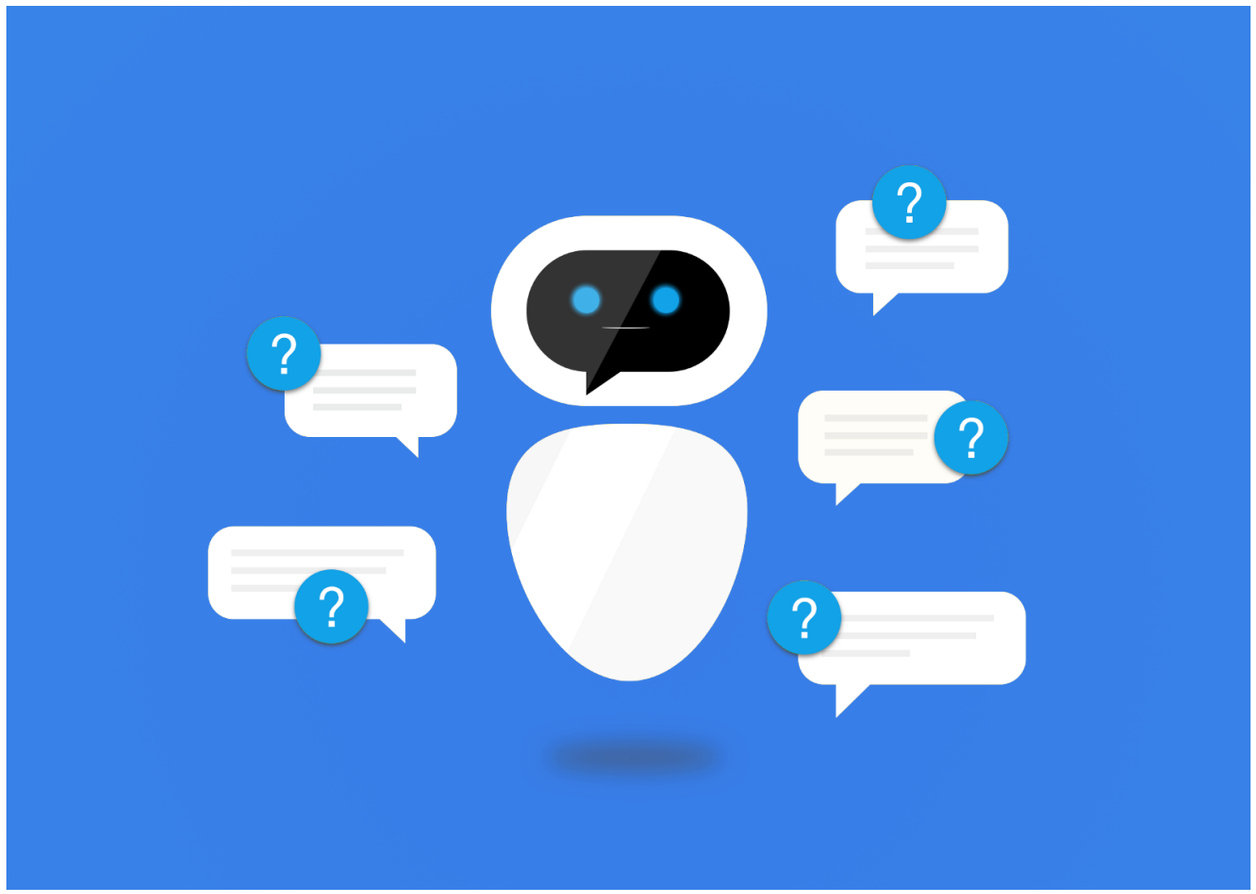
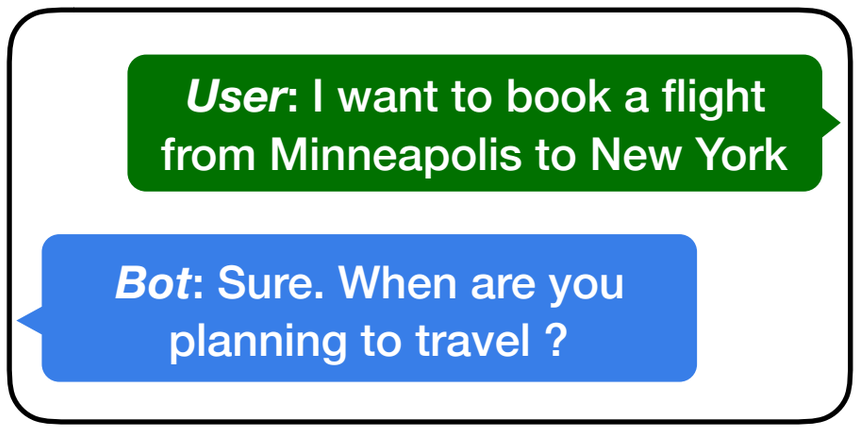


User: I want to book a flight from Minneapolis to New York

Conversational Agents





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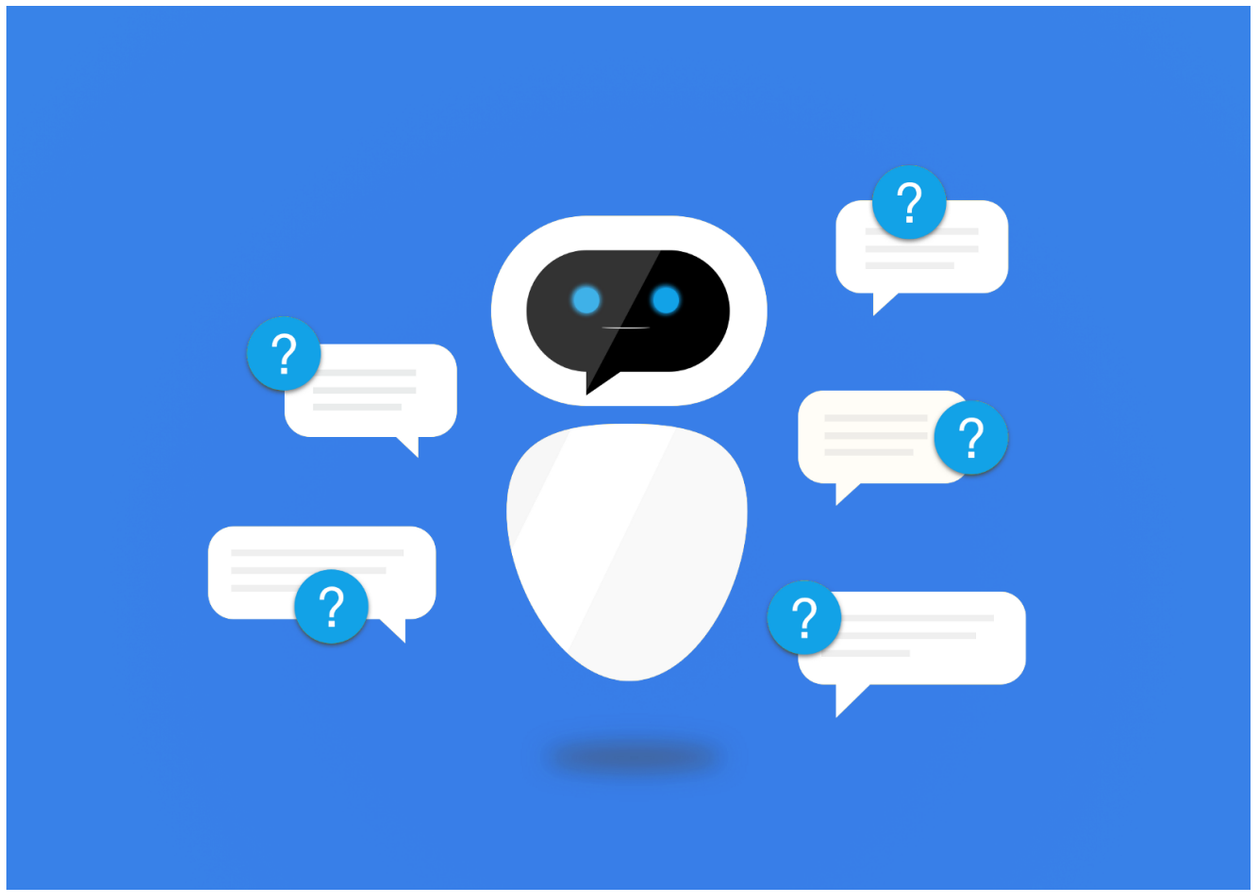


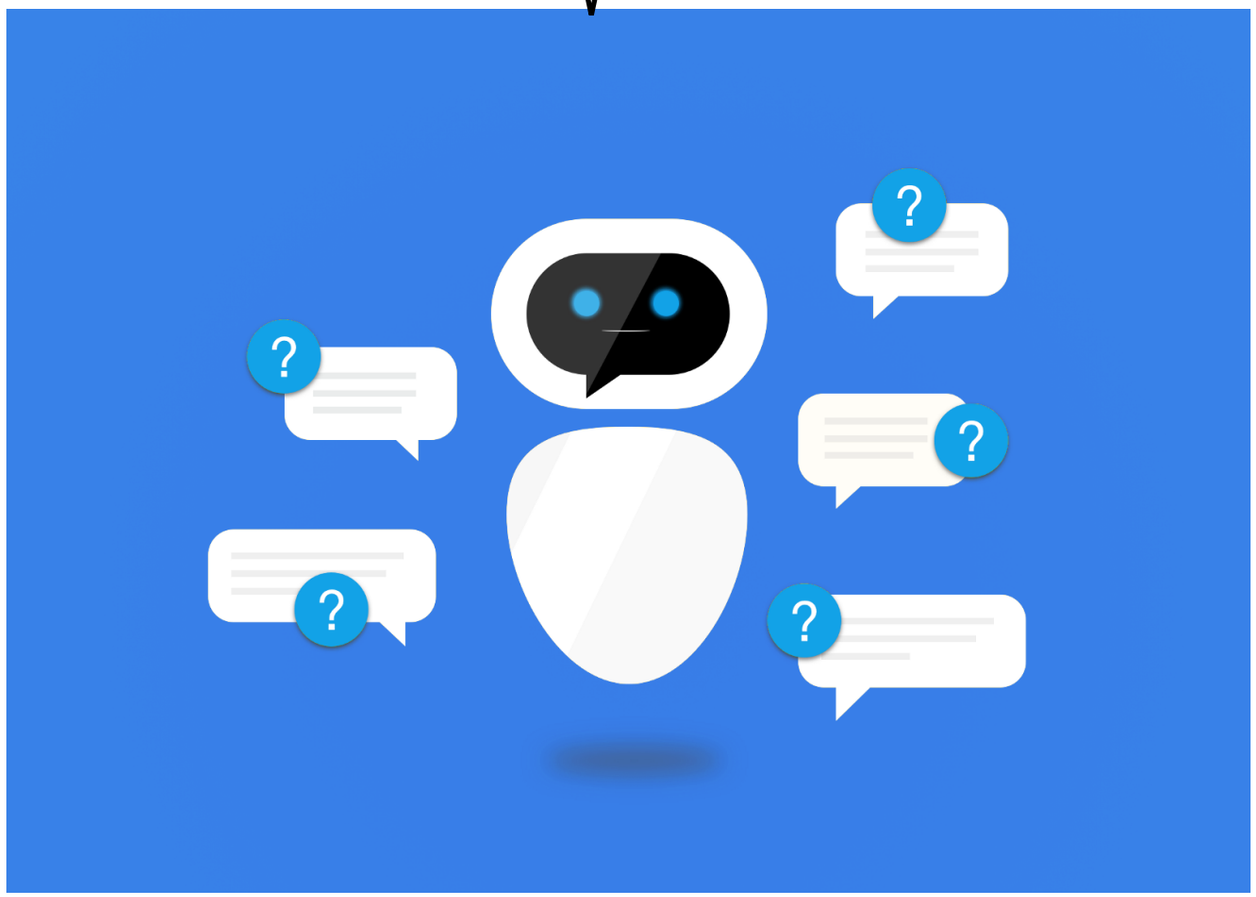
User: I want to book a flight from Minneapolis to New York

Bot: Sure. When are you planning to travel ?

User: Can you book plane to New York from Minneapolis

Conversational Agents

Sorry, I don’t understand what you’re saying



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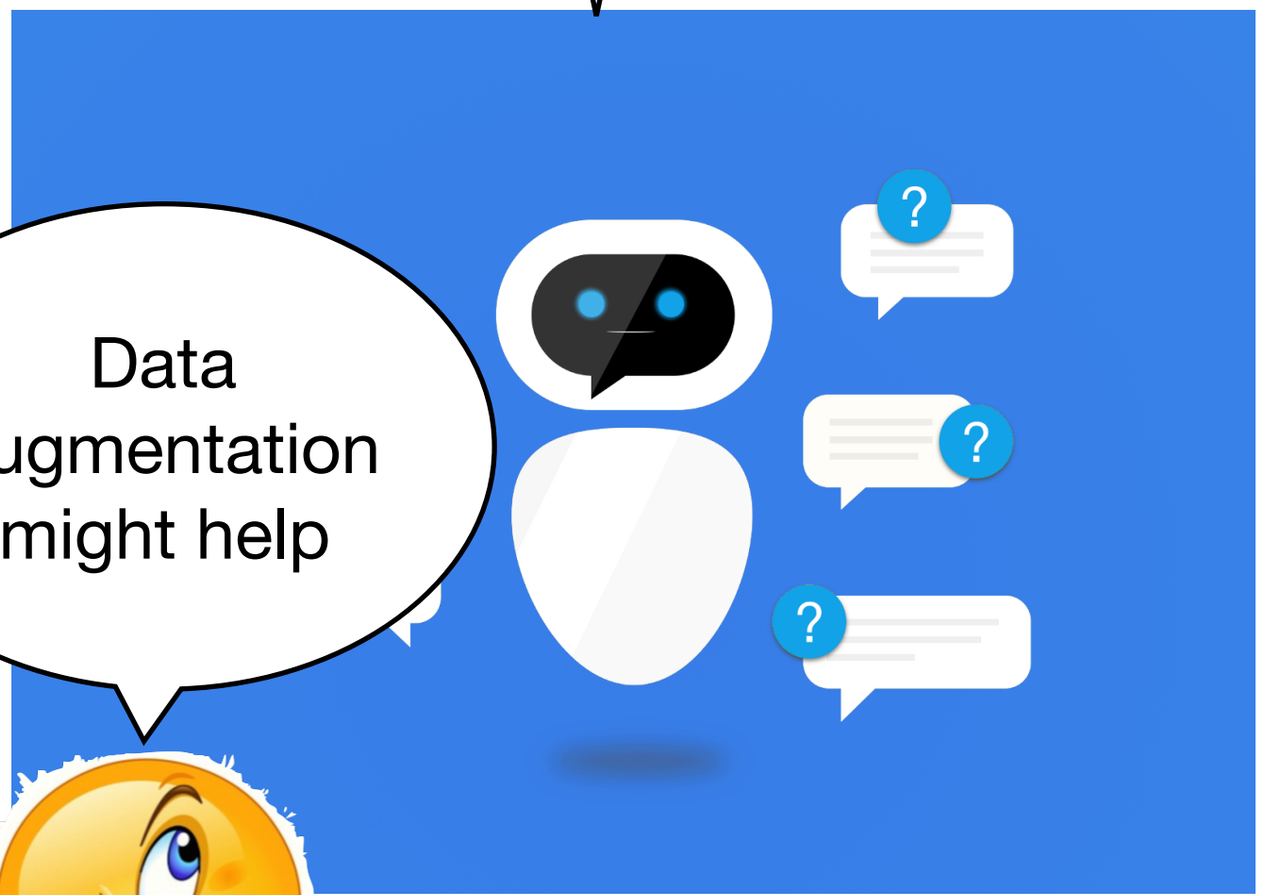
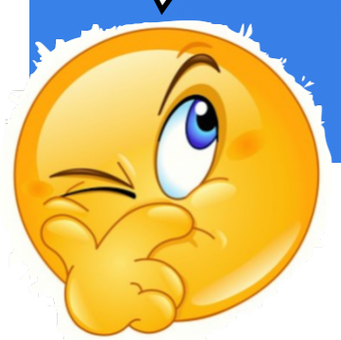


Data augmentation might help



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Paraphrase Generation

Rephrasing a given text in multiple ways

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Source	how do i increase body height ?

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Rephrasing a given text in multiple ways

Source	how do i increase body height ?
Paraphrases	• how could i increase my height ? • what should i do to increase body height ? • what are the ways to increase height ? • are there some ways to increase body height ?

Paraphrase Generation

Rephrasing a given text in multiple ways

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Fidelity
(Meaning preserving)

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Fidelity
(Meaning preserving)

Diversity
(Lexical & syntactical variety)

Current State

Current State

Synonym or phrase replacement

Current State

Synonym or phrase replacement	
Source	how do i increase body height ?

Current State

Synonym or phrase replacement	
Source	how do i increase body height ?
Synonym	how do i grow body height ?

Current State

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Source	how do i increase body height ?
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Phrase	how do i increase the body measurement vertically?

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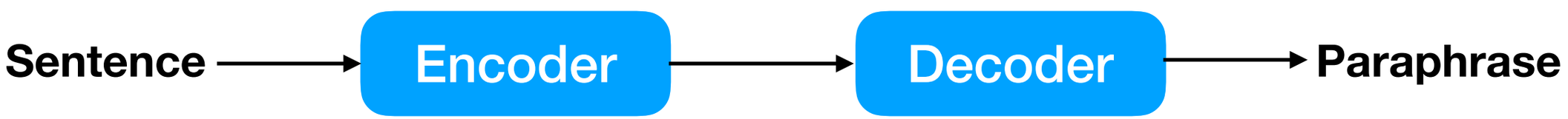

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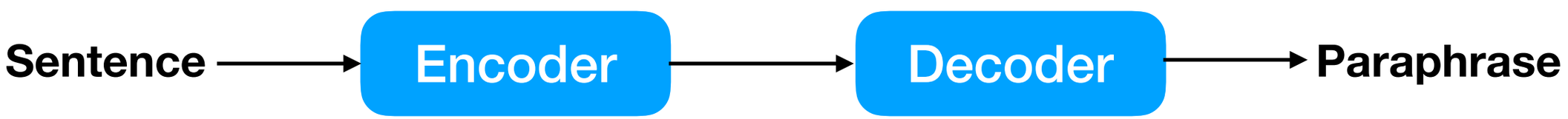

Subsequence Selection - Beam Search (Top-k)

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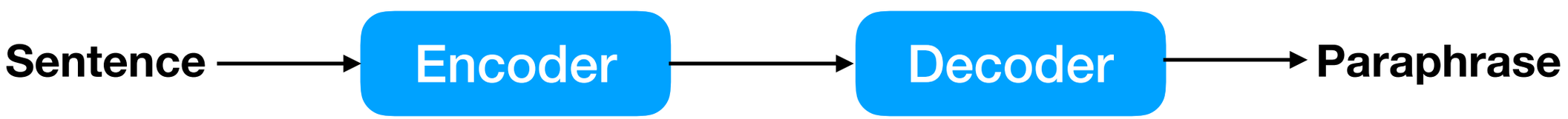

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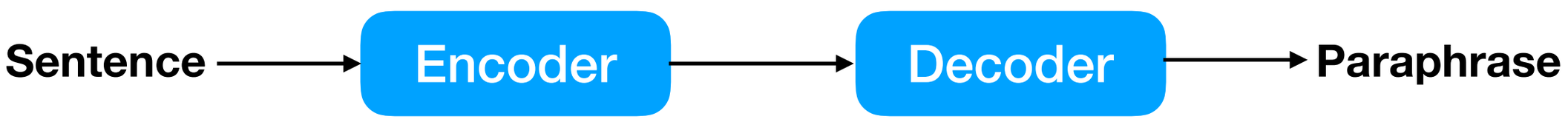

Subsequence Selection - Beam Search (Top-k)	
Source	how do i increase body height ?
Beam	• how do i increase my height ? • how do i increase my body height ? • how do i increase the height ? • how would i increase my body height ?

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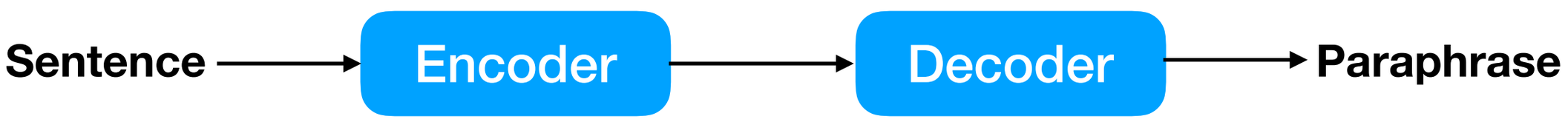

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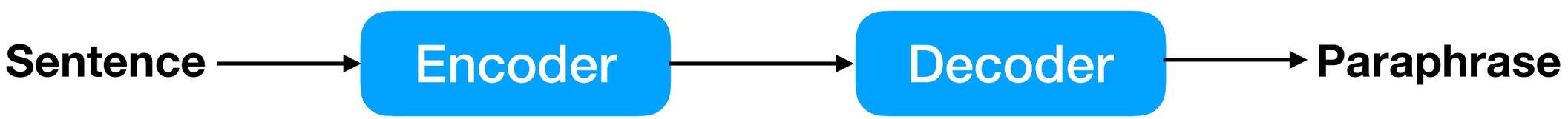

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Fidelity ✓ **Diversity** ✗

What can we do ?

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Subsequence Selection - Beam Search (Diverse selection)

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Subsequence Selection - Beam Search (Diverse selection)	
Source	how do i increase body height ?

What can we do ?

Subsequence Selection - Beam Search (Diverse selection)	
Source	how do i increase body height ?
Beam	• how do i increase my height ? • how can i decrease my body weight ? • what do i do to increase the height ? • i am 17, what steps to take to decrease weight ?

What can we do ?

Subsequence Selection - Beam Search (Diverse selection)	
Source	how do i increase body height ?
Beam	• how do i increase my height ? • how can i decrease my body weight ? • what do i do to increase the height ? • i am 17, what steps to take to decrease weight ?

Diversity ✓

What can we do ?

Subsequence Selection - Beam Search (Diverse selection)	
Source	how do i increase body height ?
Beam	• how do i increase my height ? • how can i decrease my body weight ? • what do i do to increase the height ? • i am 17, what steps to take to decrease weight ?

Fidelity ✗ **Diversity ✓**

What we need

What we need

Fidelity ✓

Diversity ✓

What we need

Fidelity ✓ **Diversity** ✓

DiPS

Find *k* diverse paraphrases with high fidelity

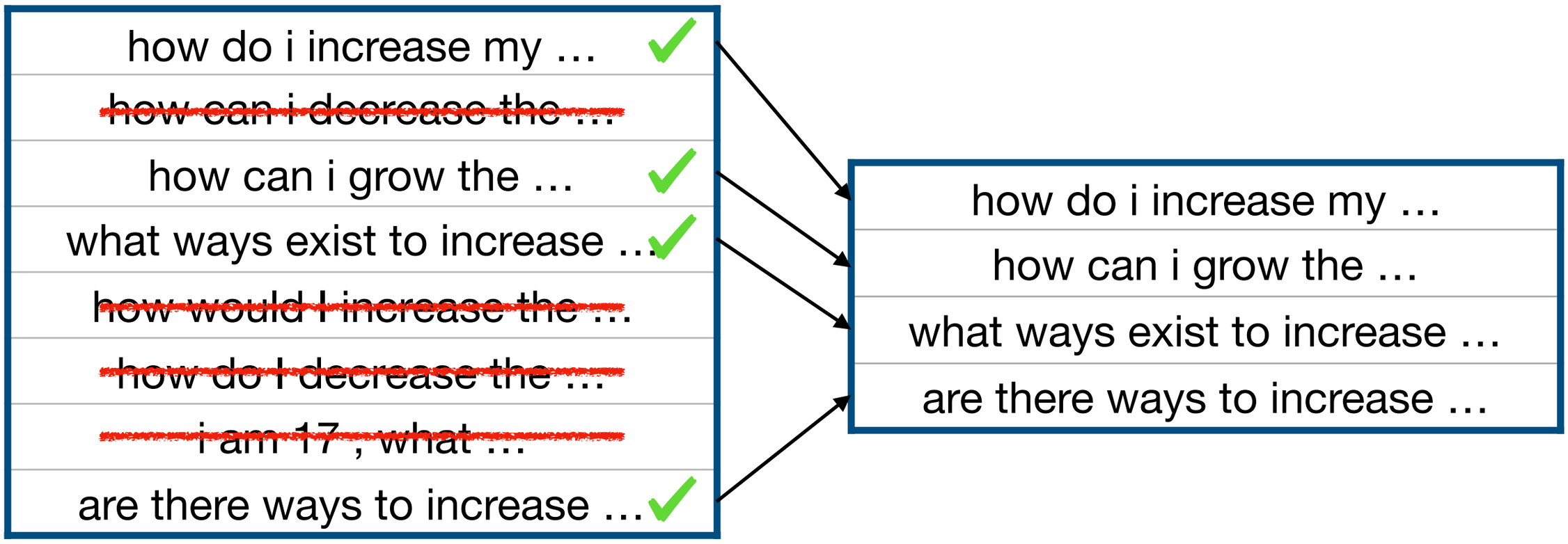
Method based on subset
selection of candidate (sub)sequences

Subset Selection

how do i increase my …
how can i decrease the …
how can i grow the …
what ways exist to increase …
how would I increase the …
how do I decrease the …
i am 17 , what …
are there ways to increase …

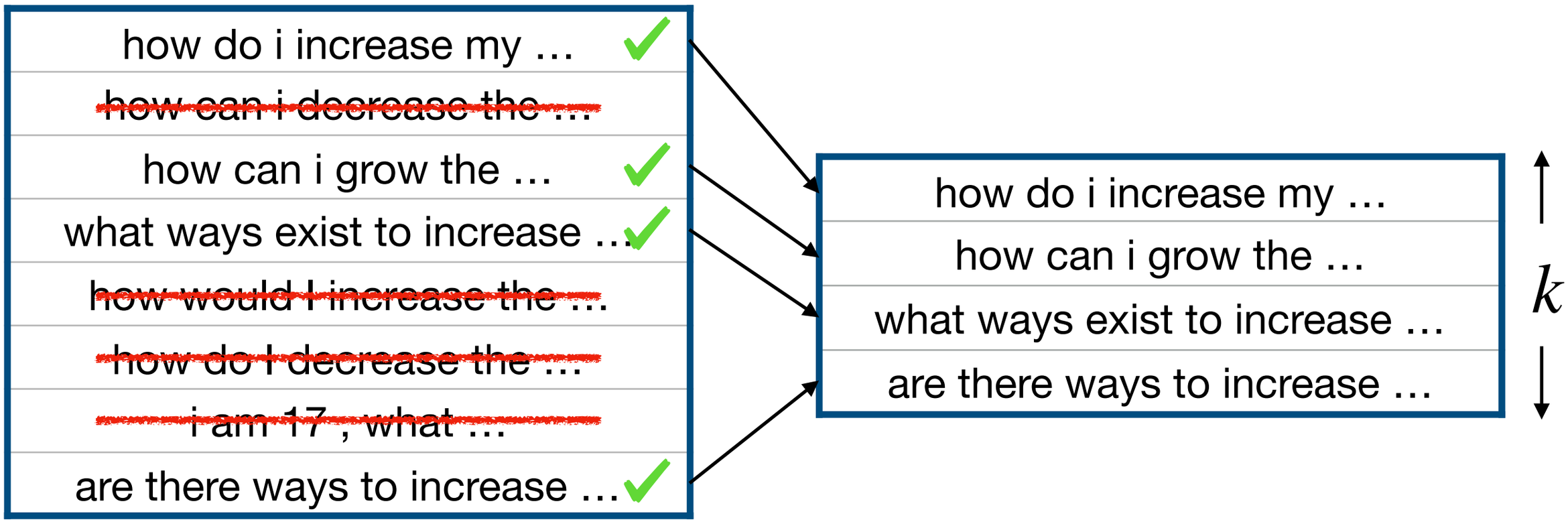
$$V^t$$

Subset Selection



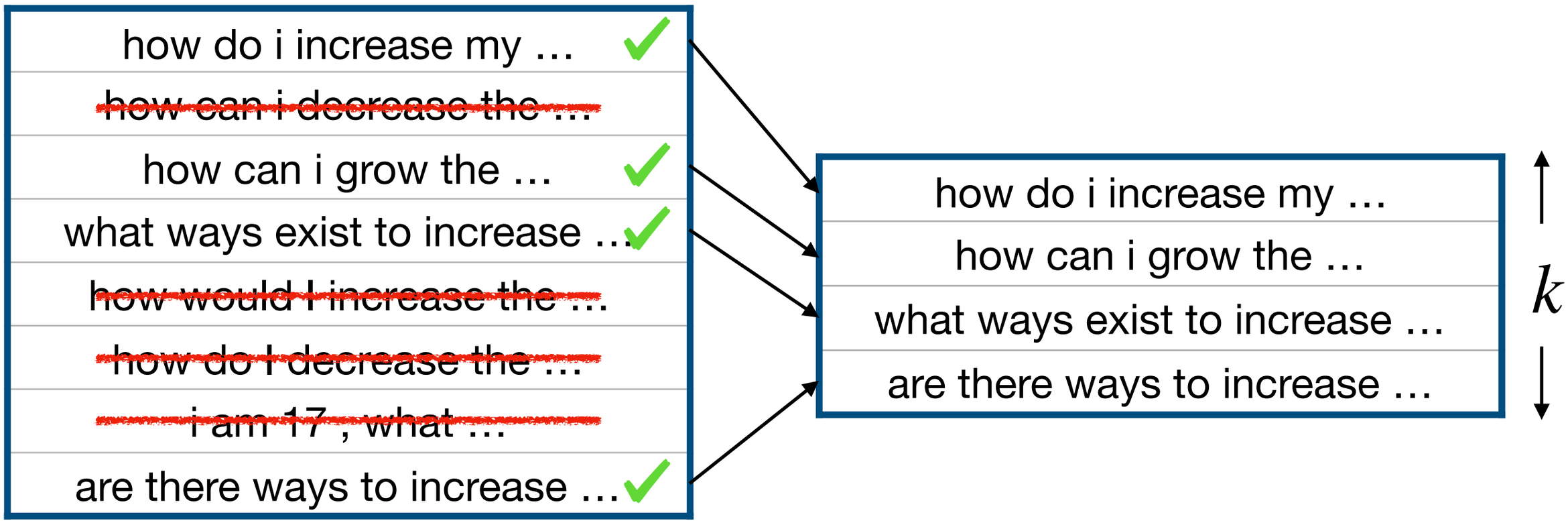
$$V^t \longrightarrow X$$

Subset Selection



$$V^t \xrightarrow{\textbf{argmax}_{X \subseteq V^t,\, |X|=k} F(X)} X$$

Subset Selection



$$V^t \xrightarrow{\textbf{argmax}_{X \subseteq V^t,\, |X|=k} F(X)} X$$

If F is sub modular + monotone = Greedy algo. with good bounds exists

Sub-modularity

F = # Unique Coloured items

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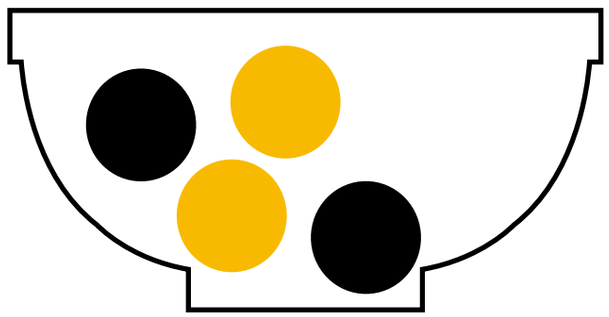
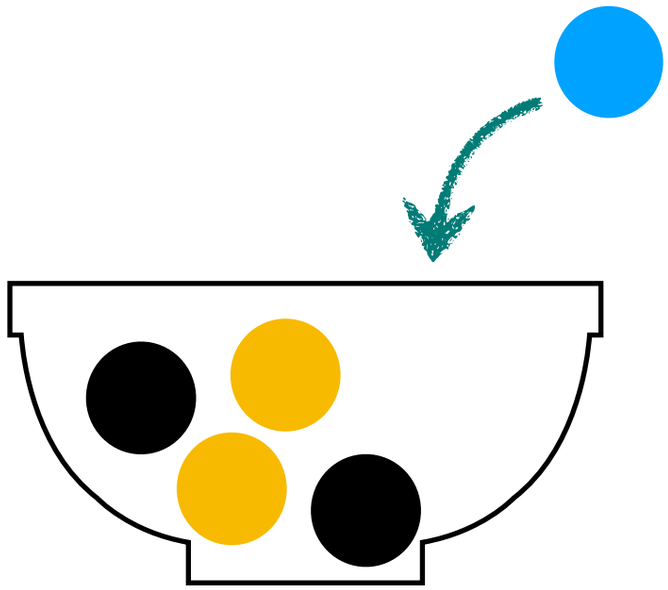


 # Items = 4

F = 2

Sub-modularity

F = # Unique Coloured items



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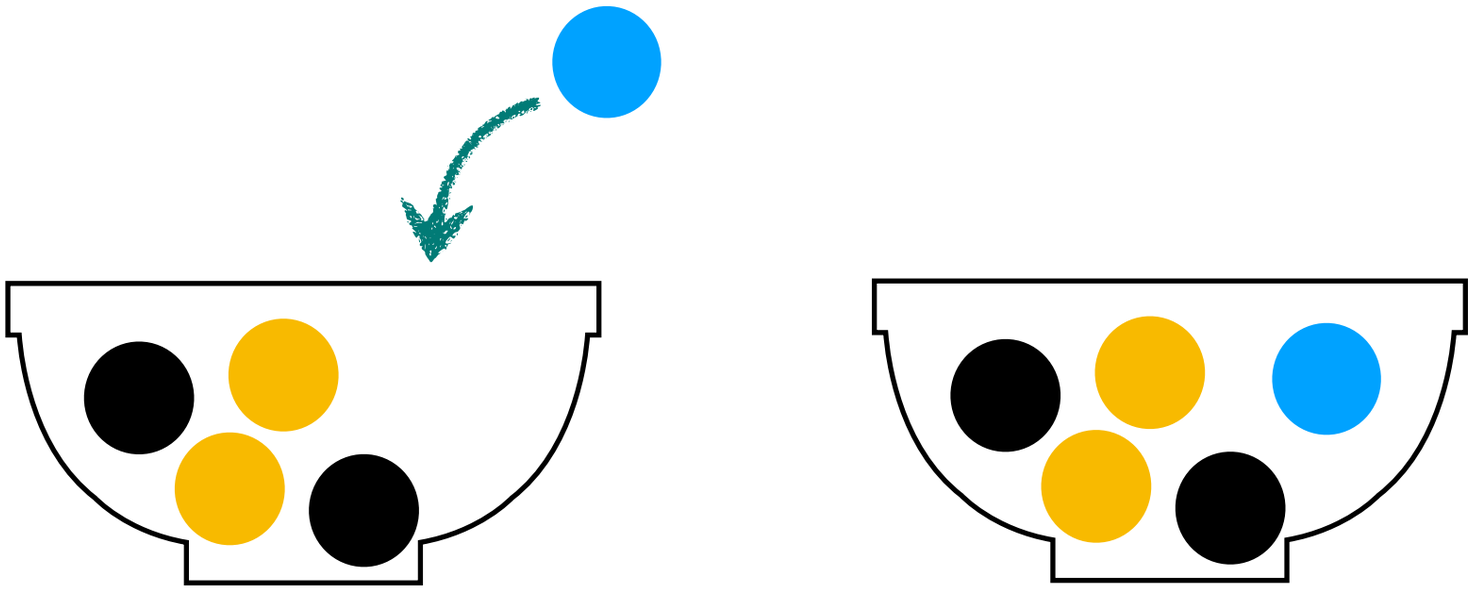

 # Items = 4

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 # Items = 4 + 1

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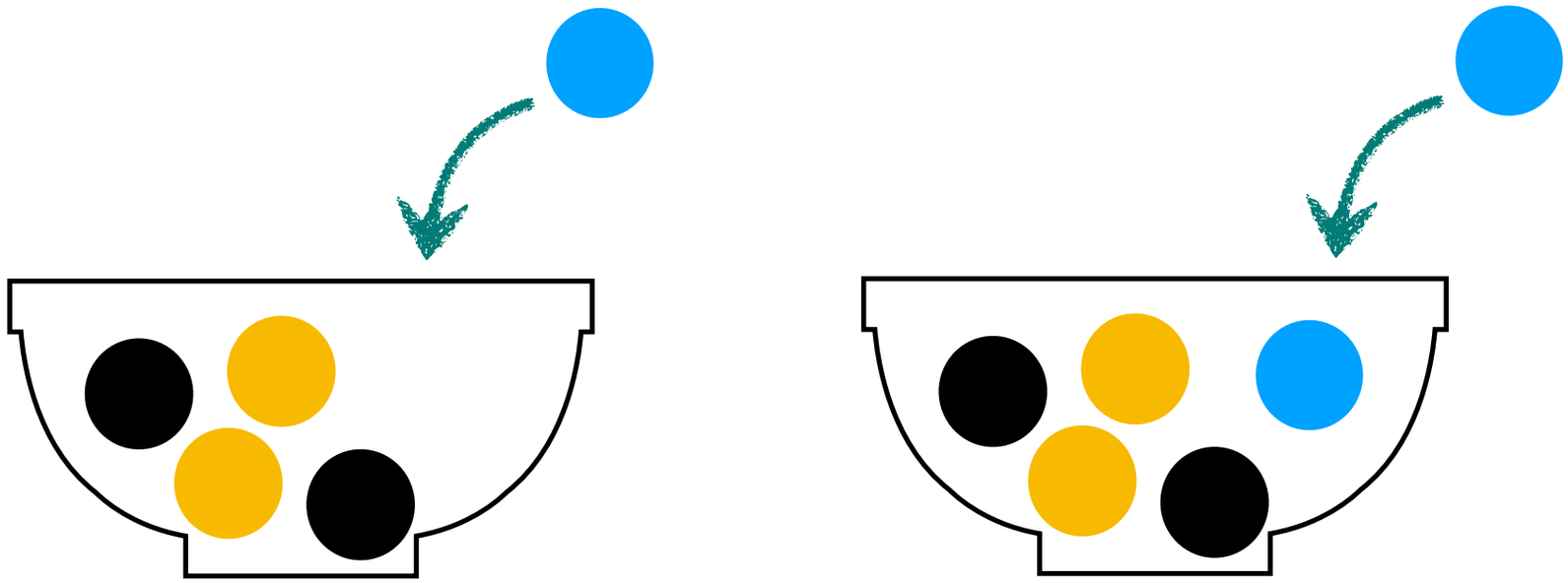

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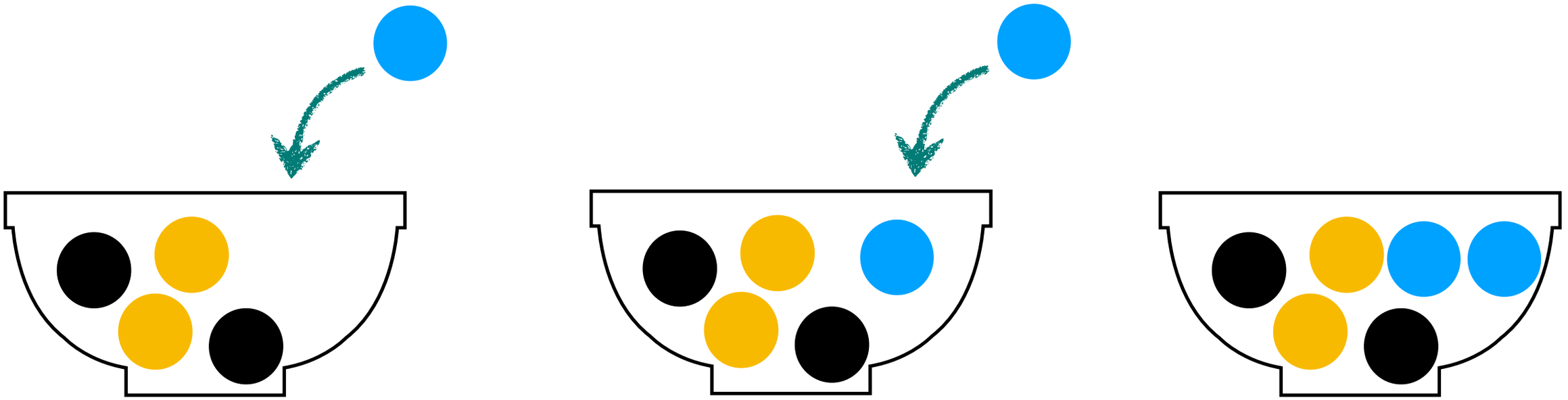

 # Items = 4

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 # Items = 5 + 1

F = 3 + 0

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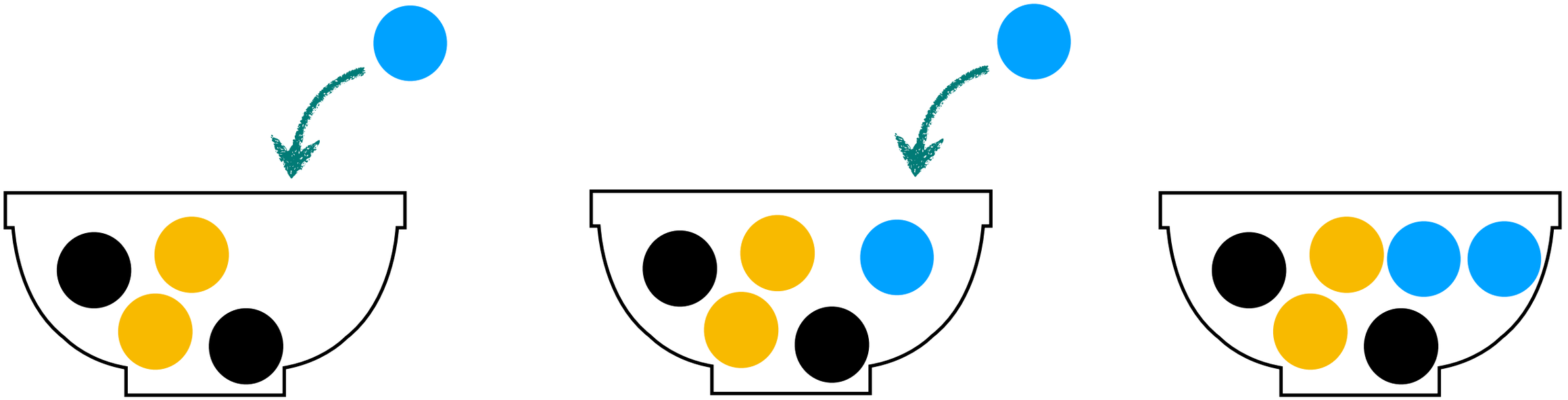

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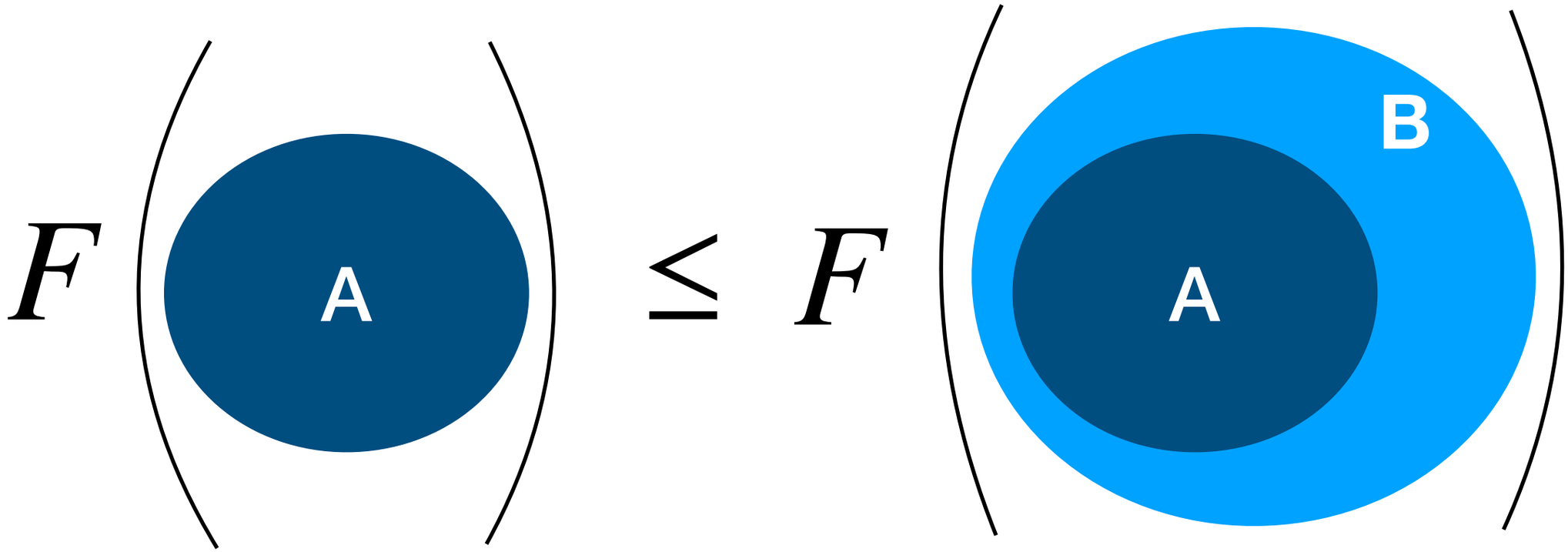
Diminishing Returns

Monotonicity



DiPS

Induce Diversity while not compromising on Fidelity

Diversity Components

'where' , 'can' , 'film', 'I' , 'How',
'find that' , 'that picture',
.....
'I get' , 'can I' , 'Where can I'

$\mathcal{D}_1(X) \equiv$ Rewards unique n-grams

Where ----- can I find --- that picture
------- How can I ---- get that picture

$\mathcal{D}_2(X) \equiv$ Rewards Structural Coverage

Fidelity Components

$V^{(t)}$: 3k Candidate Subsequences

Where can I find that film?

How can I get that picture?

Where can I get that film?

$\mathcal{L}_1(X, s)$

Source Sentence

Where can I get that movie?

Synonym (similar embeddings)

$\mathcal{L}_2(X, s)$

$argmax_{X \subset V^{(t)}} \mathcal{F}(X)$

$V^{(t)}$ X^*

"Where can I get that movie?"

'Where' 'can' 'I' <eos>

ENCODER

<sos>

DECODER

k- sequences

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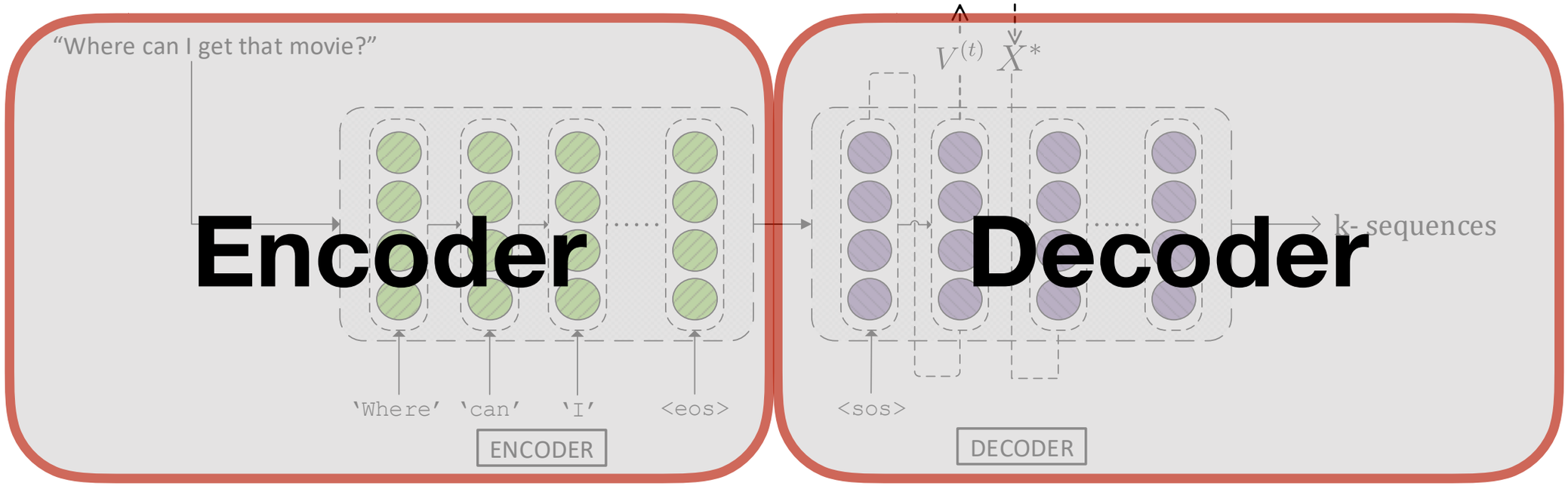

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Synonym (similar embeddings)

$\mathcal{L}_2(X, s)$

$argmax_{X \subset V^{(t)}} \mathcal{F}(X)$

$V^{(t)}$ X^*

"Where can I get that movie?"

'Where' 'can' 'I' <eos>

ENCODER

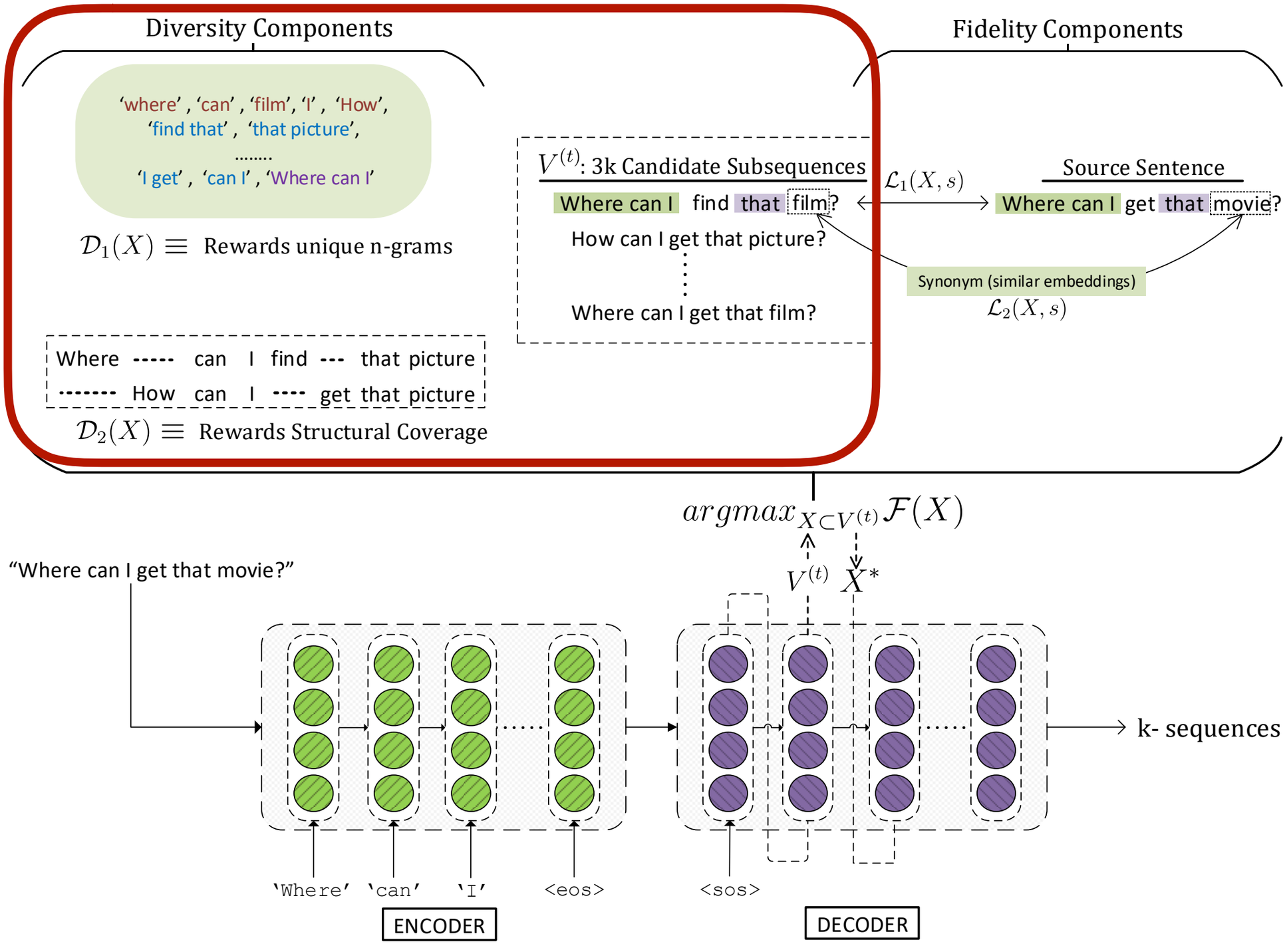
<sos>

DECODER

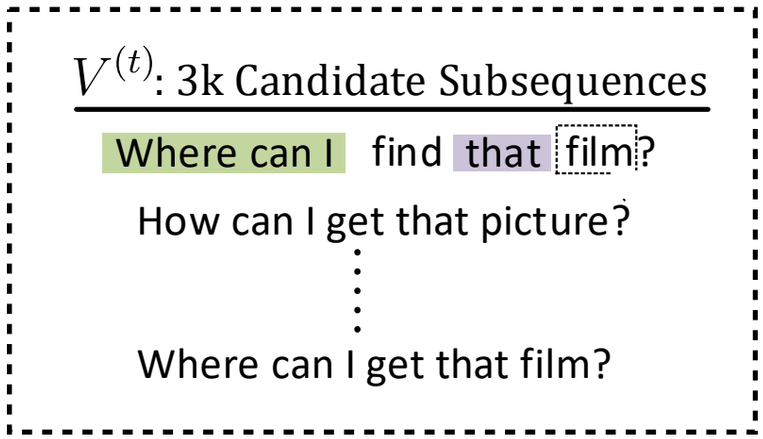
k- sequences

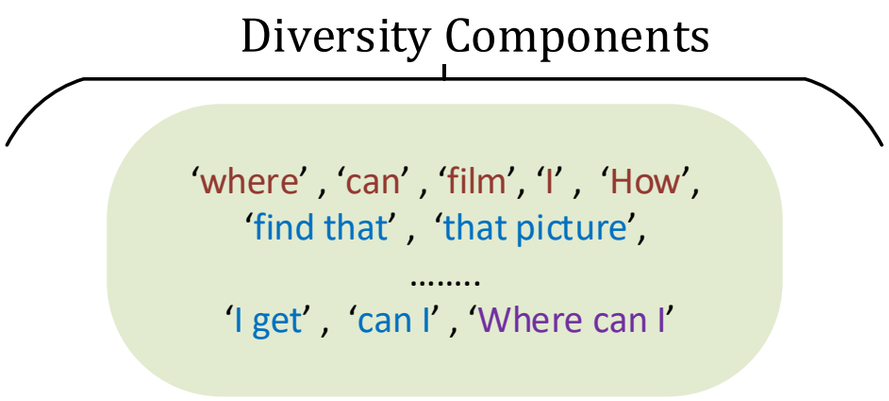
DiPS

Induce Diversity while not compromising on Fidelity

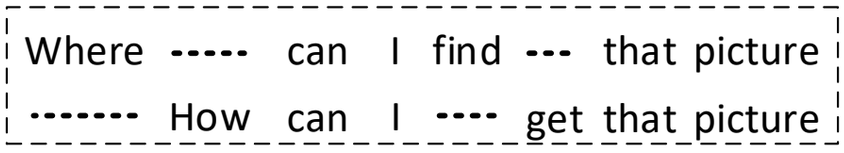


Diversity Components





$\mathcal{D}_1(X) \equiv$ Rewards unique n-grams



$\mathcal{D}_2(X) \equiv$ Rewards Structural Coverage

Diversity Components

$V^{(t)}$: 3k Candidate Subsequences

Where can I find that film?

How can I get that picture?

⋮

Where can I get that film?

Diversity Components

'where' , 'can' , 'film', 'I' , 'How',
'find that' , 'that picture',
.....
'I get' , 'can I' , 'Where can I'

$\mathcal{D}_1(X) \equiv$ Rewards unique n-grams

N-gram uniqueness

$$\sum_{n=1}^{N} \beta^n \left| \bigcup_{x \in X} x_{n-gram} \right|$$

Where ----- can I find --- that picture

------- How can I ---- get that picture

$\mathcal{D}_2(X) \equiv$ Rewards Structural Coverage

Diversity Components

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$\mathcal{D}_2(X) \equiv$ Rewards Structural Coverage

Structural Coverage

$$\sum_{x_i \in V^{(t)}} \sum_{x_j \in X} \mathscr{R}(x_i, x_j)$$

$$\mathscr{R}(x_i, x_j) = 1 - \frac{\textbf{EditDistance}(x_i, x_j)}{|x_i| + |x_j|}$$

DiPS

Induce Diversity while not compromising on Fidelity

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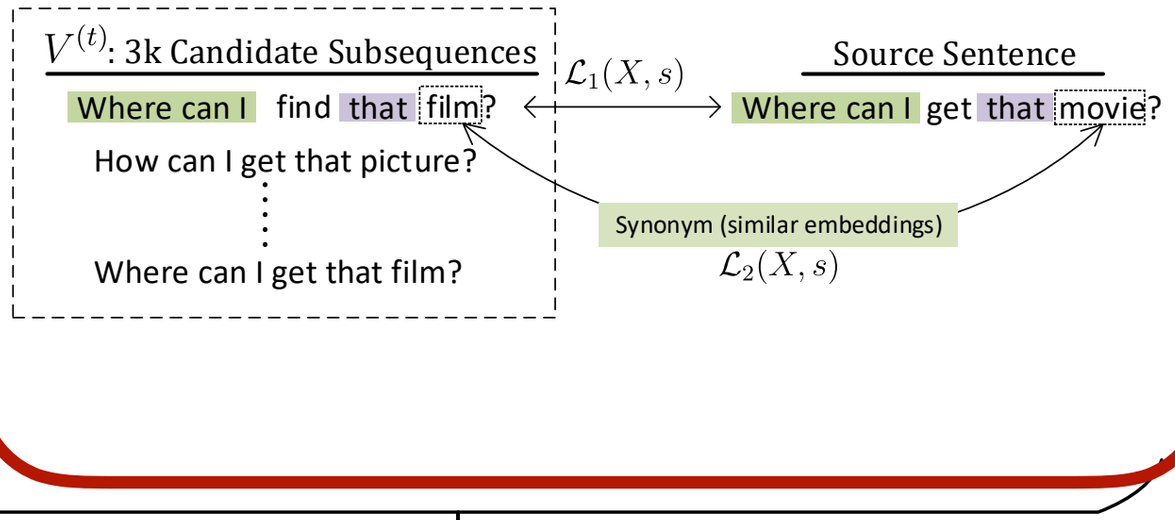

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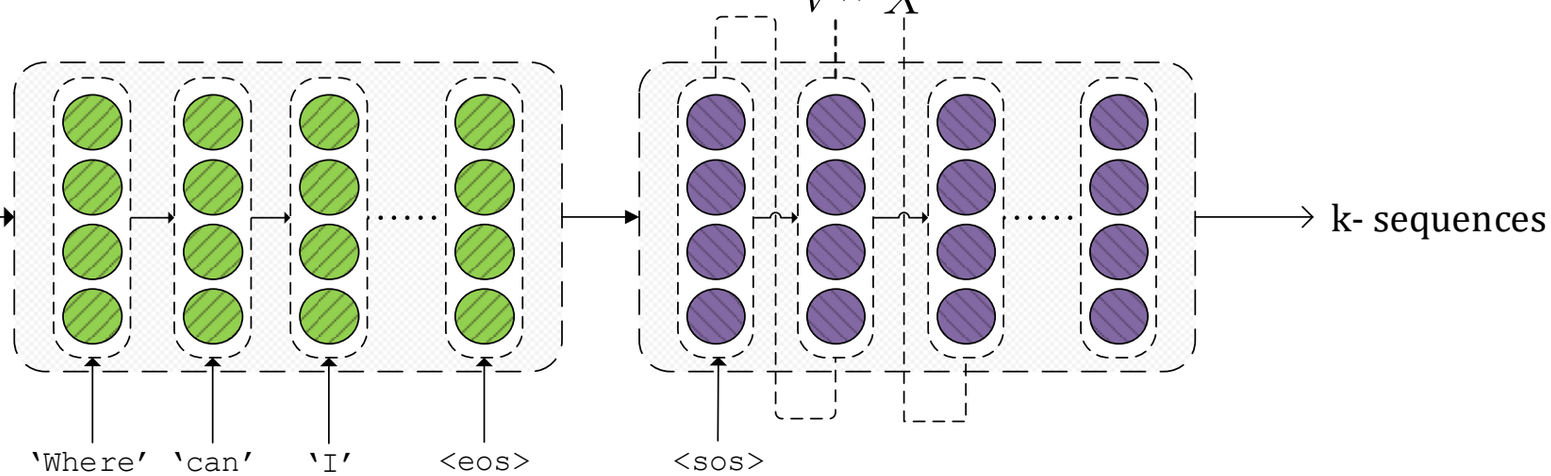
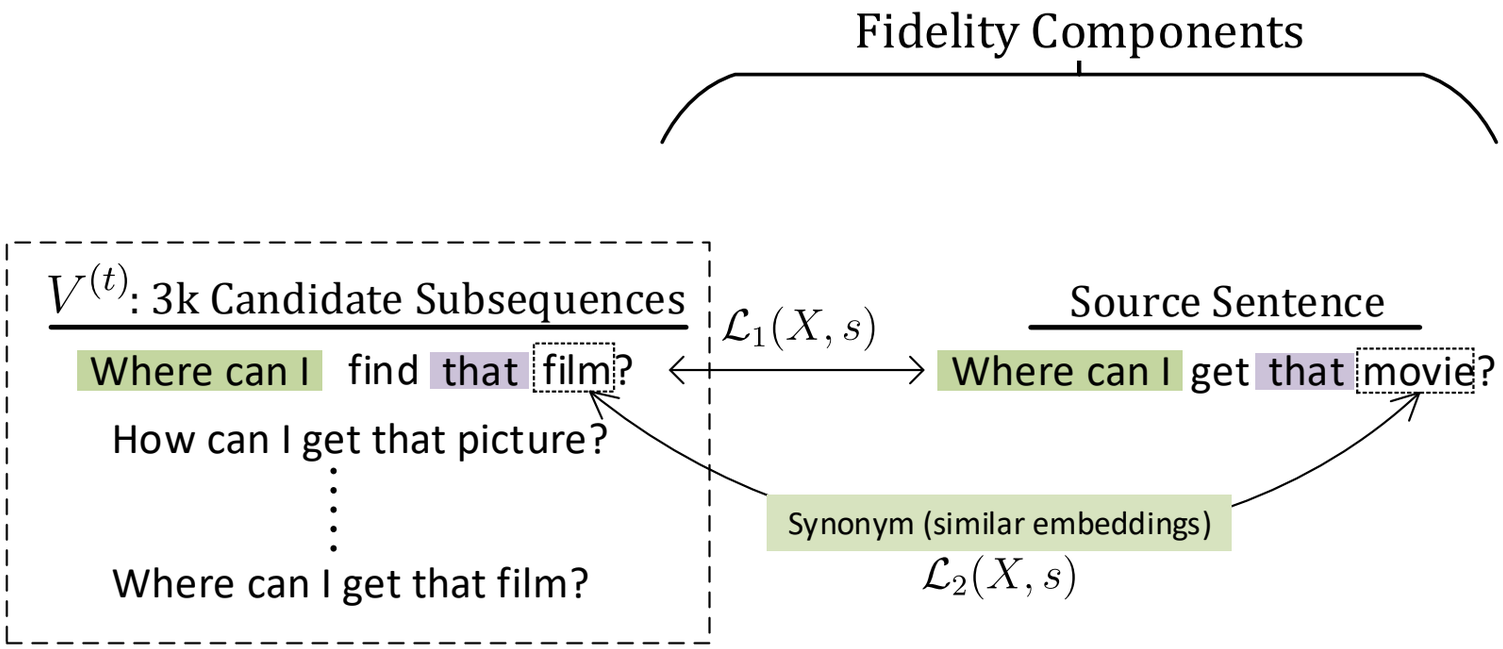
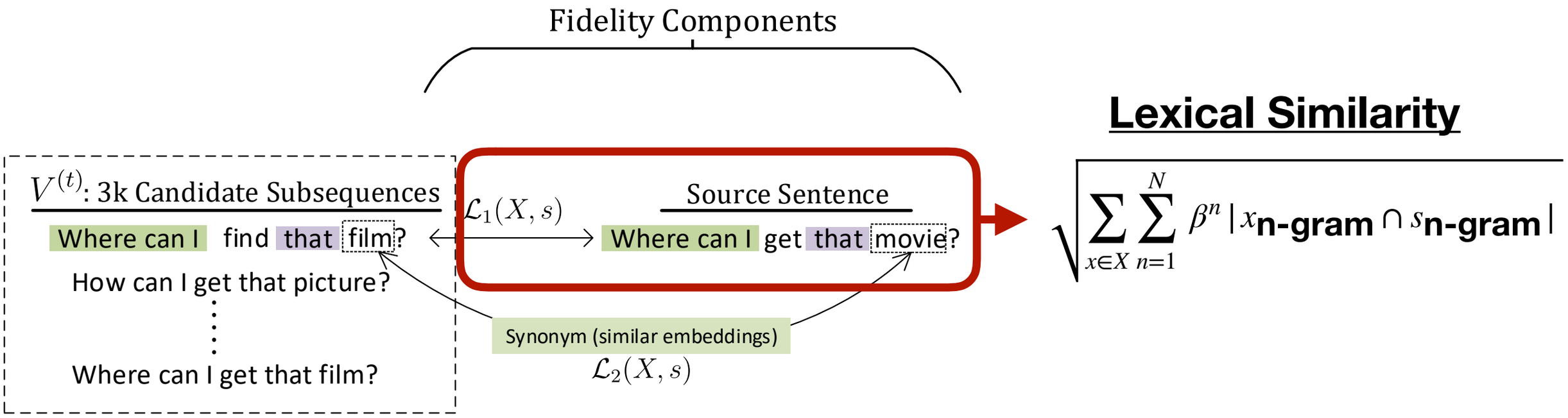


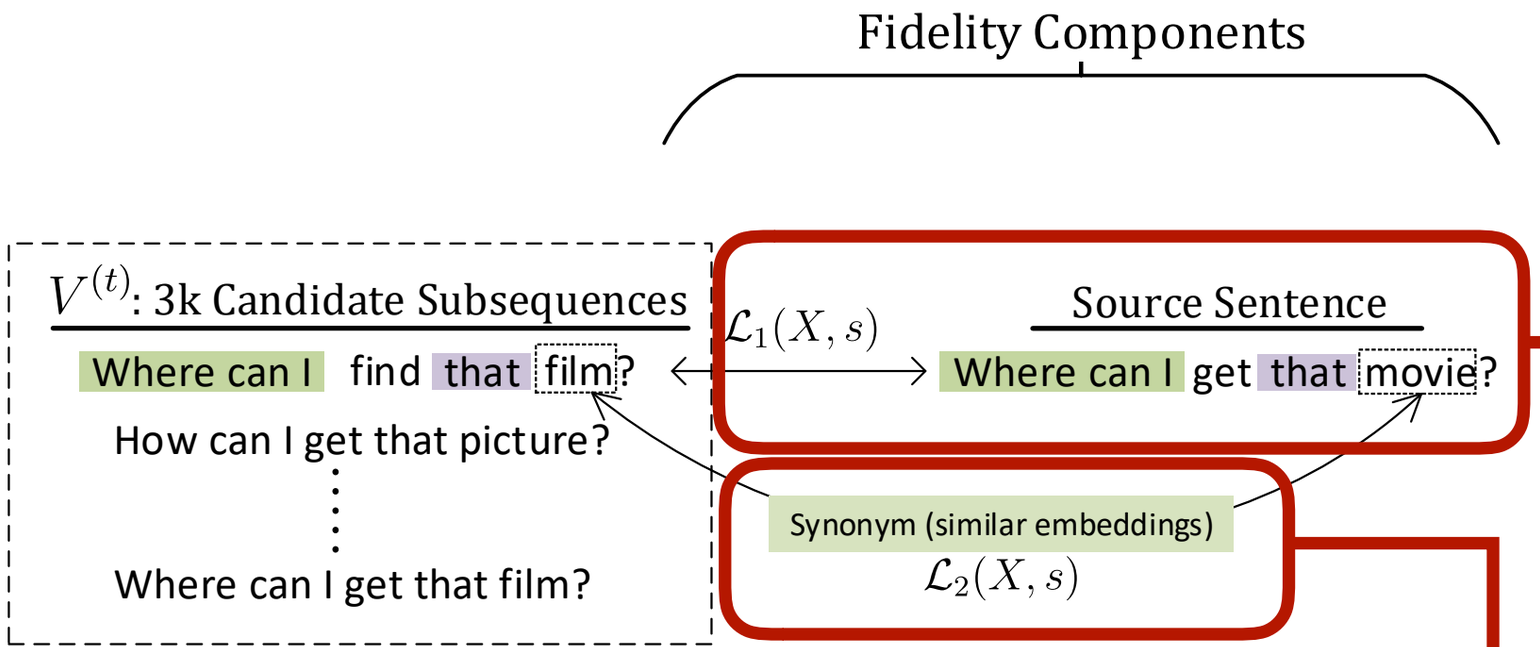
Fidelity Components



Fidelity Components



Fidelity Components



Lexical Similarity

$$\sqrt{\sum_{x \in X} \sum_{n=1}^{N} \beta^n \, |\, x_{\textbf{n-gram}} \cap s_{\textbf{n-gram}} \,|}$$

Embedding based Similarity

$$\sqrt{\sum_{x \in X} \mathcal{S}(x, s)}$$

$$\mathcal{S}(x, s) = \frac{1}{|x|} \sum_{w_i \in x} \textbf{max}_{w_j \in s} \, \psi(\mathbf{v}_{w_i}, \mathbf{v}_{w_j})$$

DiPS Objective

Diversity Components

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Fidelity Components

DiPS Objective

$$\textbf{argmax}_{X \subseteq V,\, X = |k|} F(X)$$

$$F(X) = \lambda(\mu_1 D_1(X) + \mu_2 D_2(X)) + (1 - \lambda)(\nu_1 L_1(X, s) + \nu_2 L_2(X, s))$$

Diversity Components

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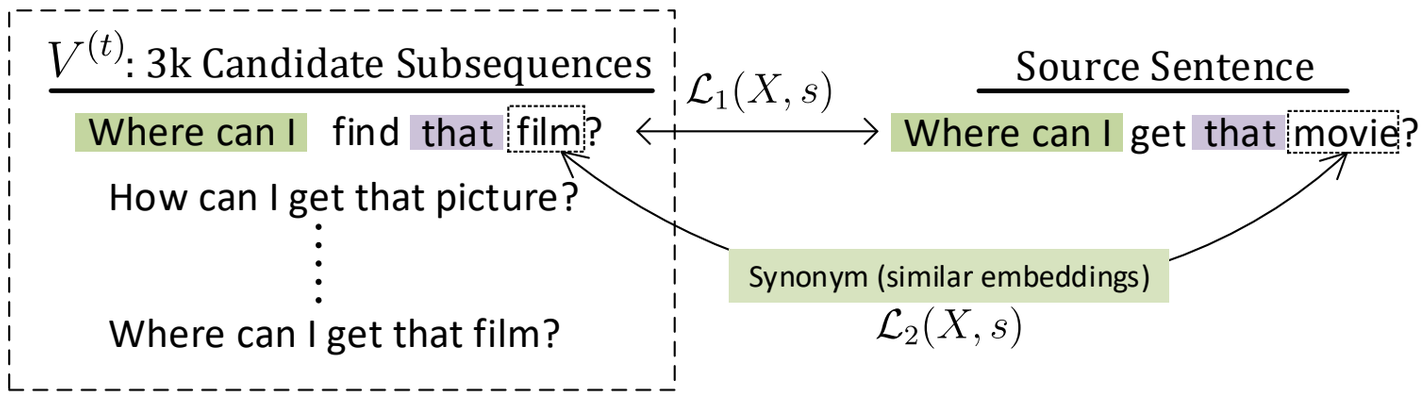

Fidelity & Diversity

(Quora Dataset)

Fidelity & Diversity

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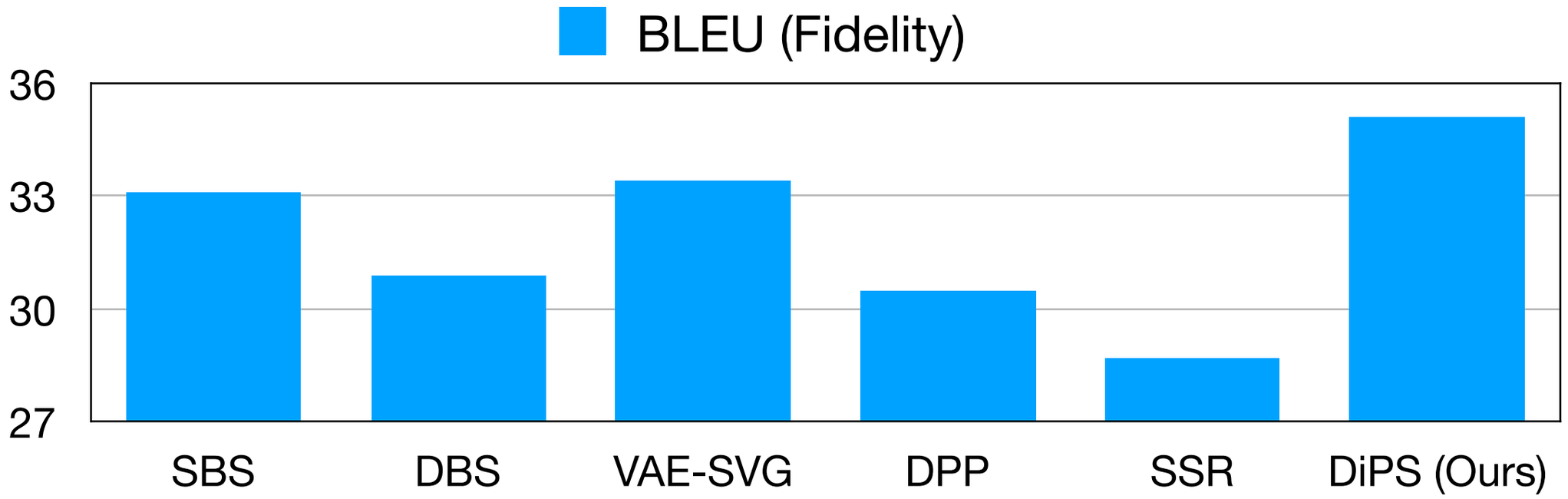

Fidelity & Diversity

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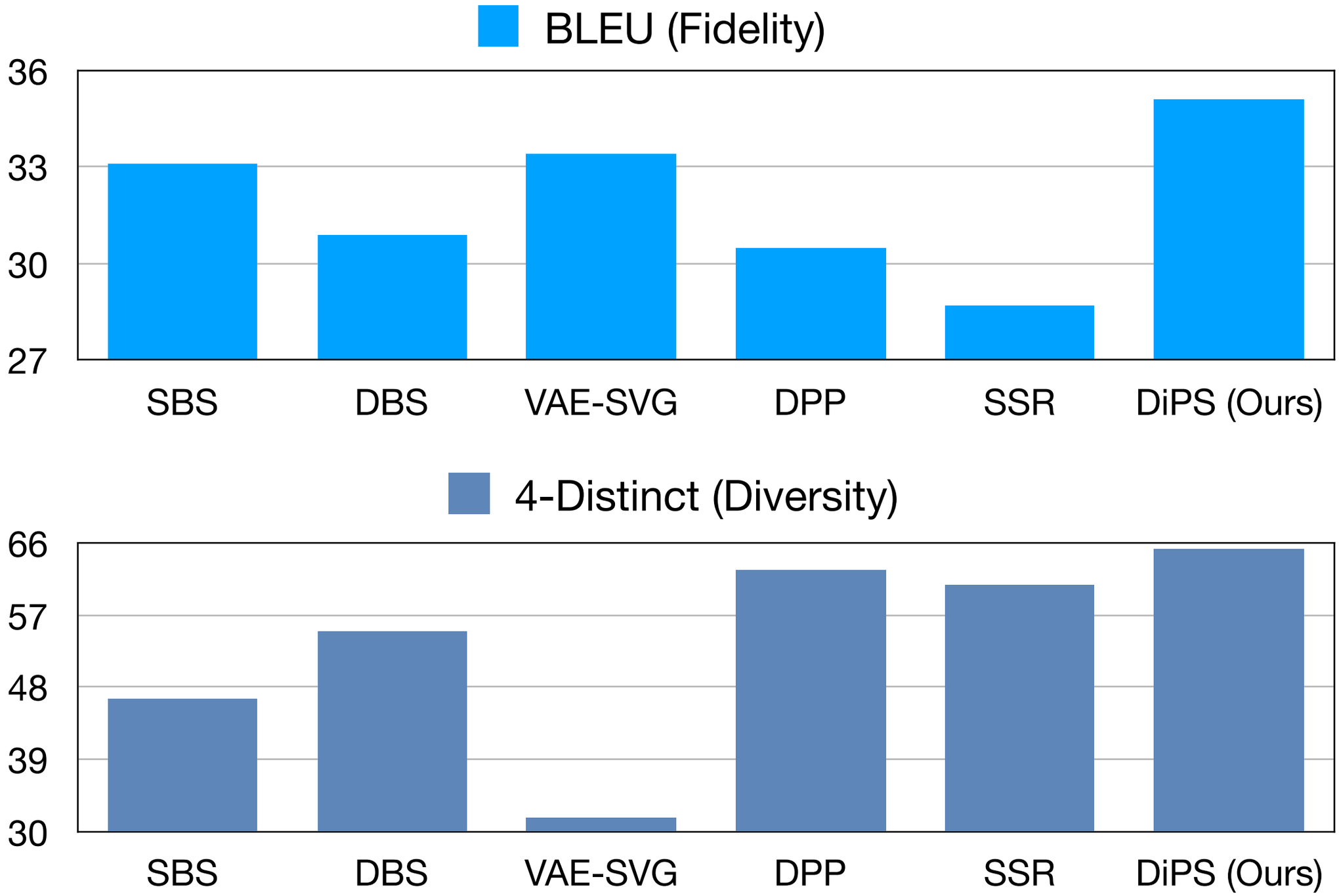

Fidelity & Diversity

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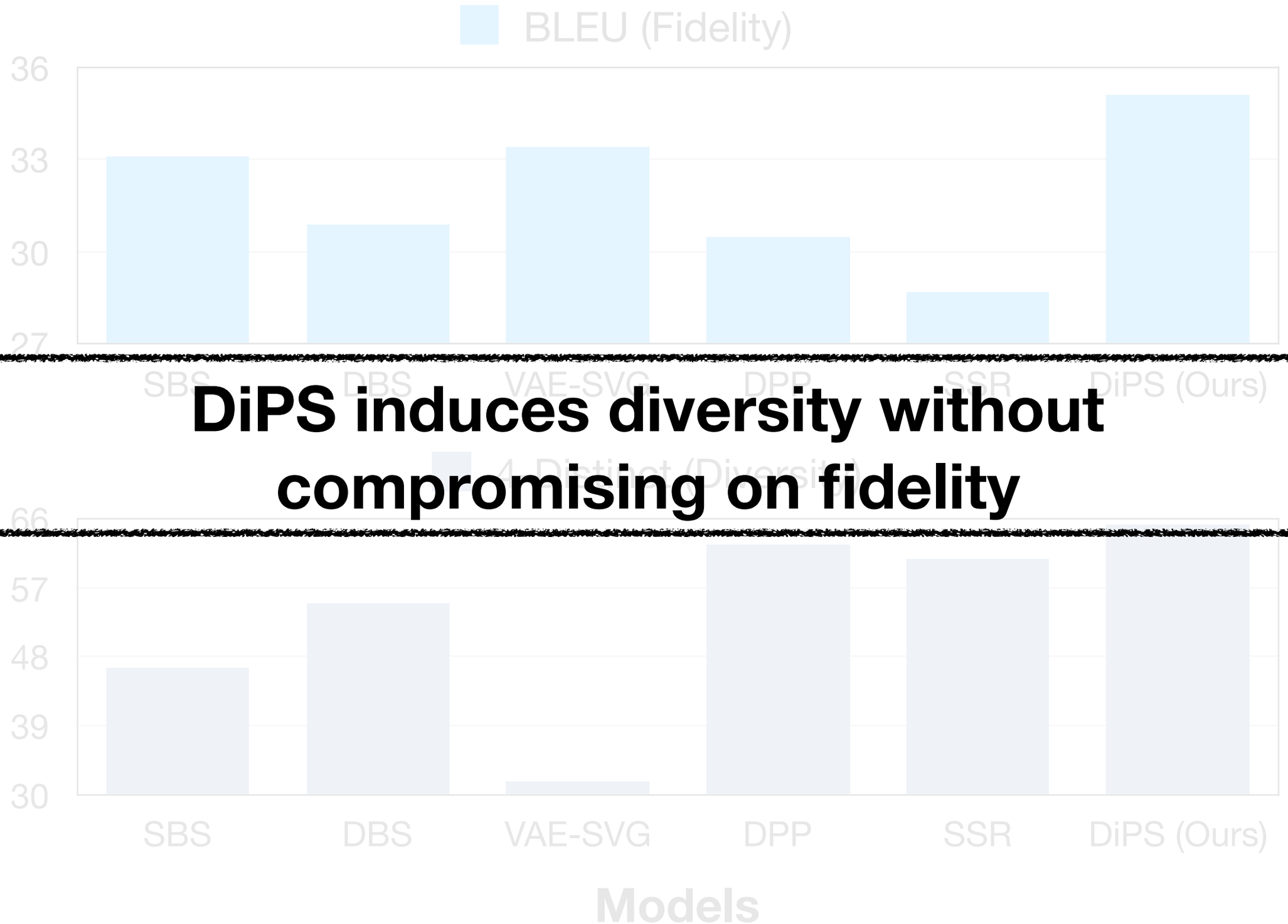
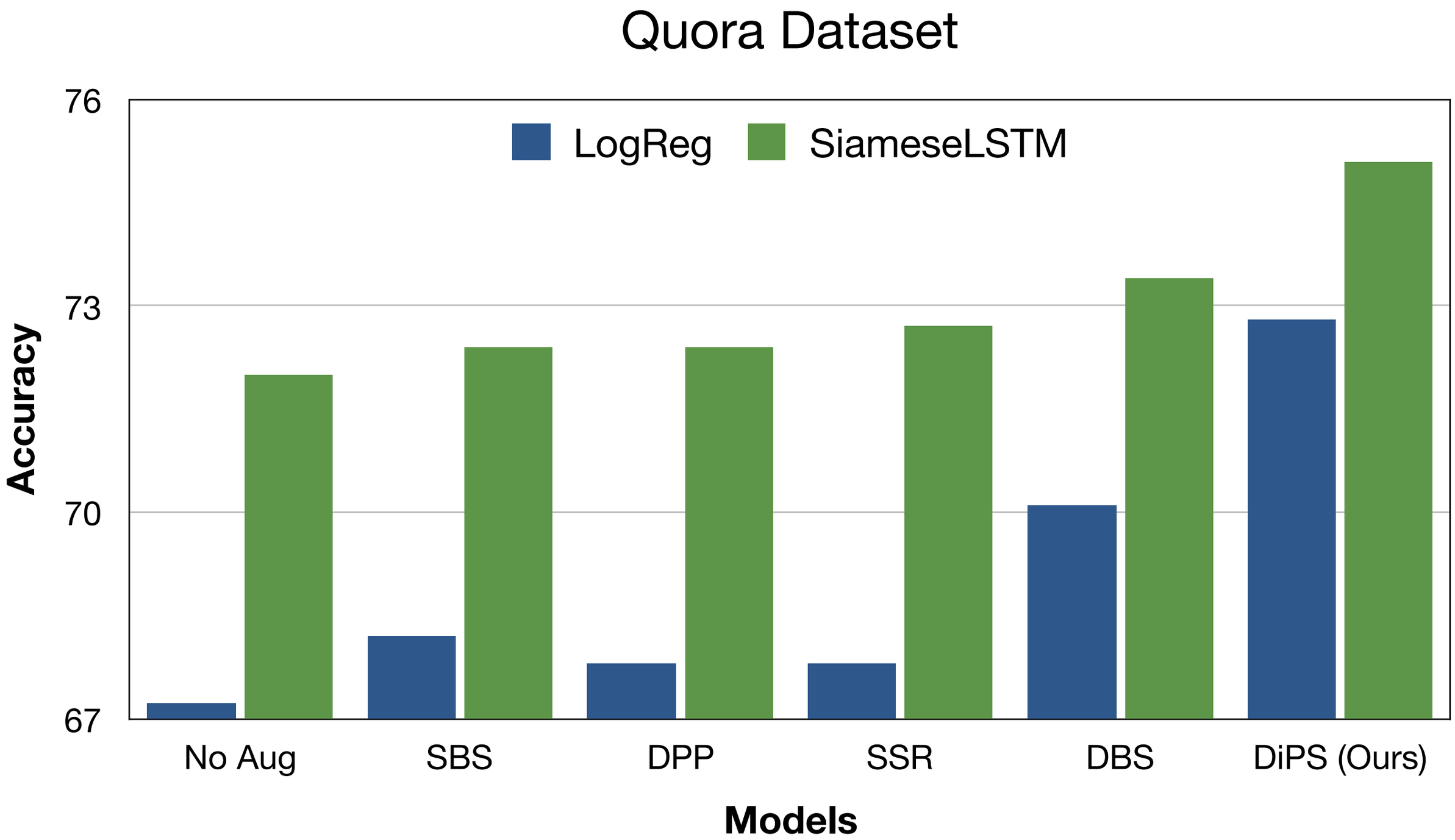
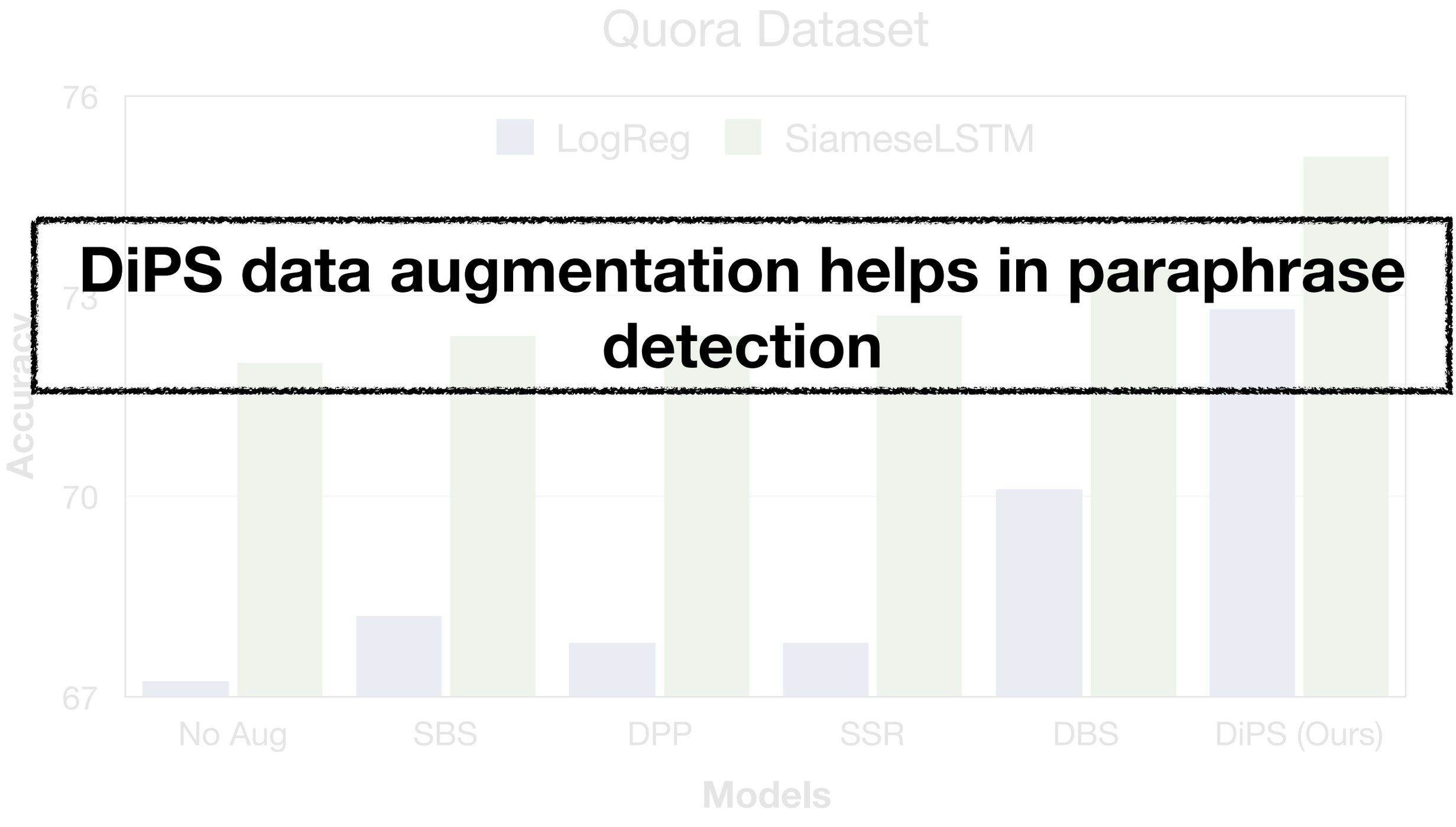


DiPS induces diversity without compromising on fidelity

Data Augmentation Paraphrase Detection

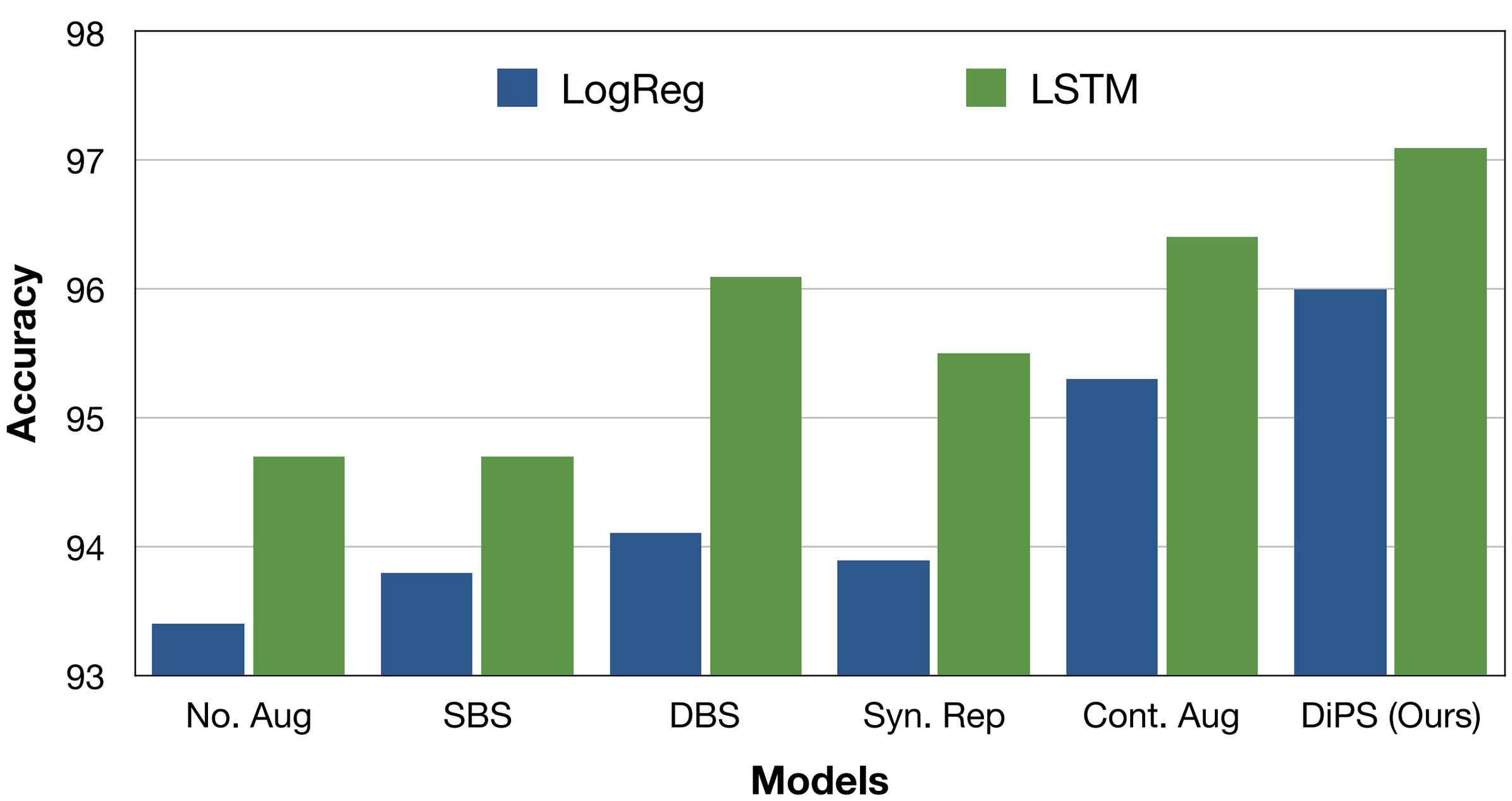


Data Augmentation Paraphrase Detection

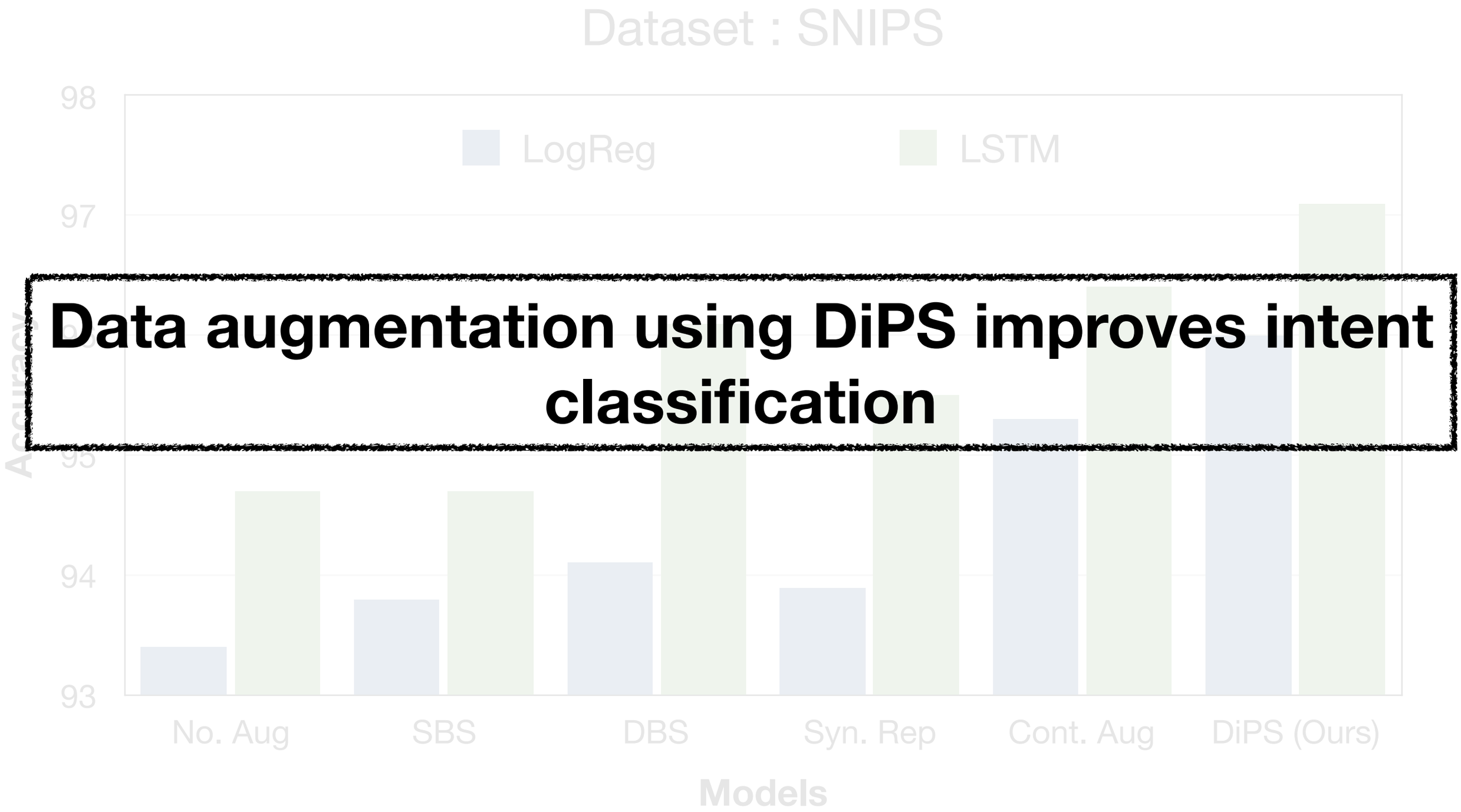


DiPS data augmentation helps in paraphrase detection

Data Augmentation for Intent Classification

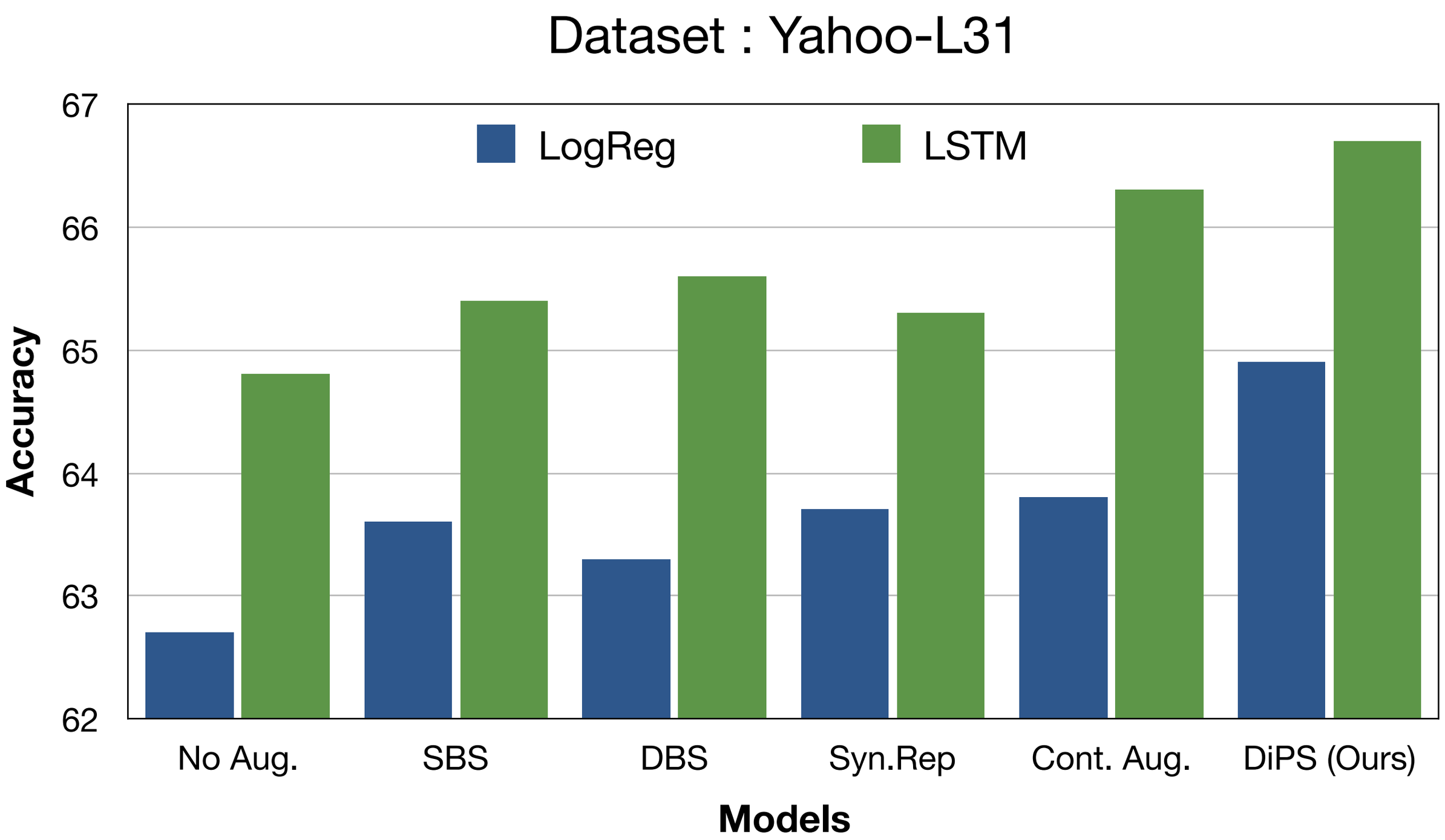


Data Augmentation for Intent Classification

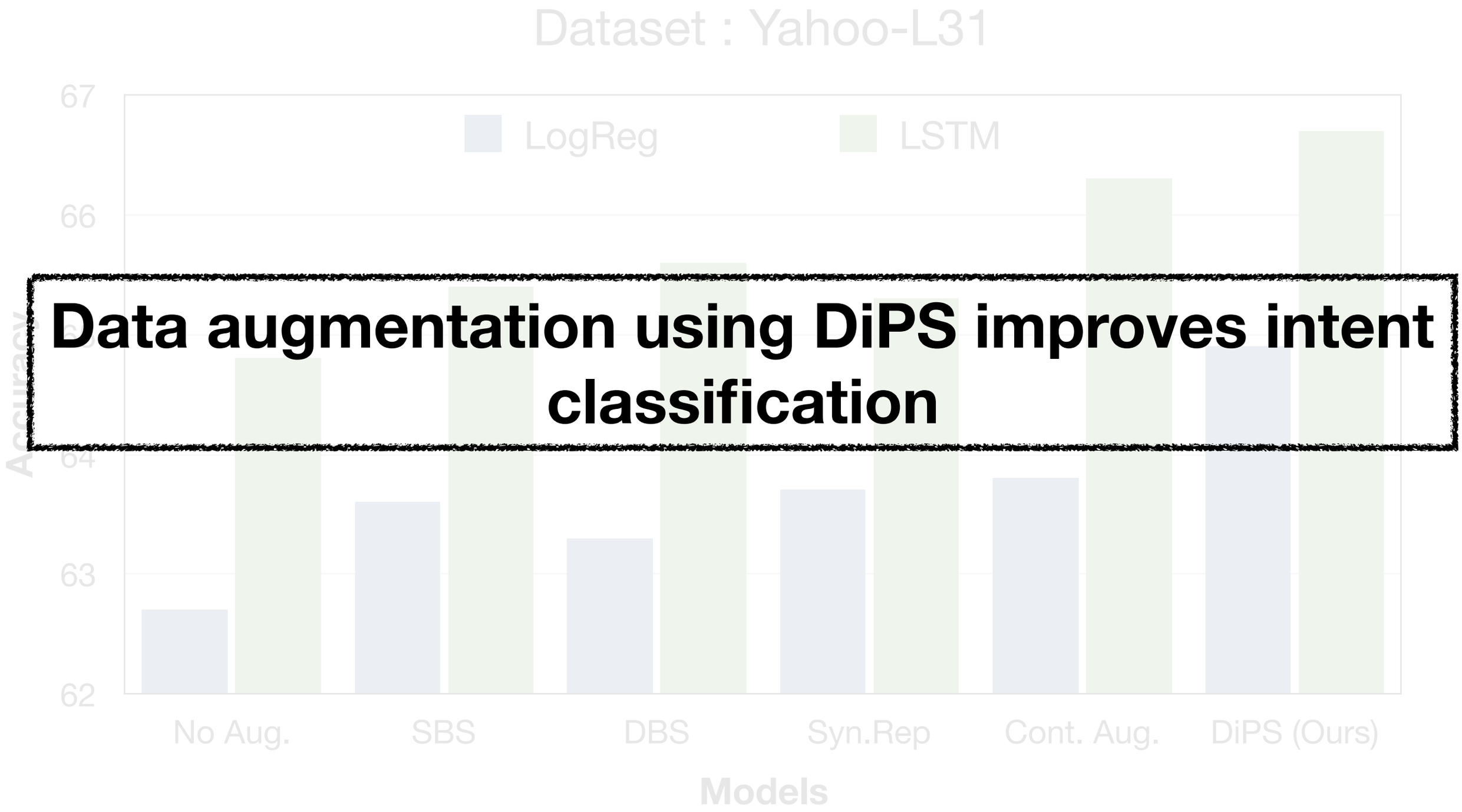


Data augmentation using DiPS improves intent classification

Data Augmentation for Intent Classification



Data Augmentation for Intent Classification



Data augmentation using DiPS improves intent classification

Conclusion

Conclusion

Problem

Diversity in Paraphrases

Without compromising on fidelity

Conclusion

Problem

Diversity in Paraphrases

Without compromising on fidelity

Method

DiPS

Sub-modular optimisation

Conclusion

Problem

Diversity in Paraphrases

Without compromising on fidelity

Method

DiPS

Sub-modular optimisation

Take-Aways

Seq2Seq + Diversity

Data Augmentation Using Paraphrasing

Code

https://github.com/malllabiisc/DiPS

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Acknowledgement

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Government of India
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Thank you