Constrained Sentence Generation by Metropolis-Hastings Sampling

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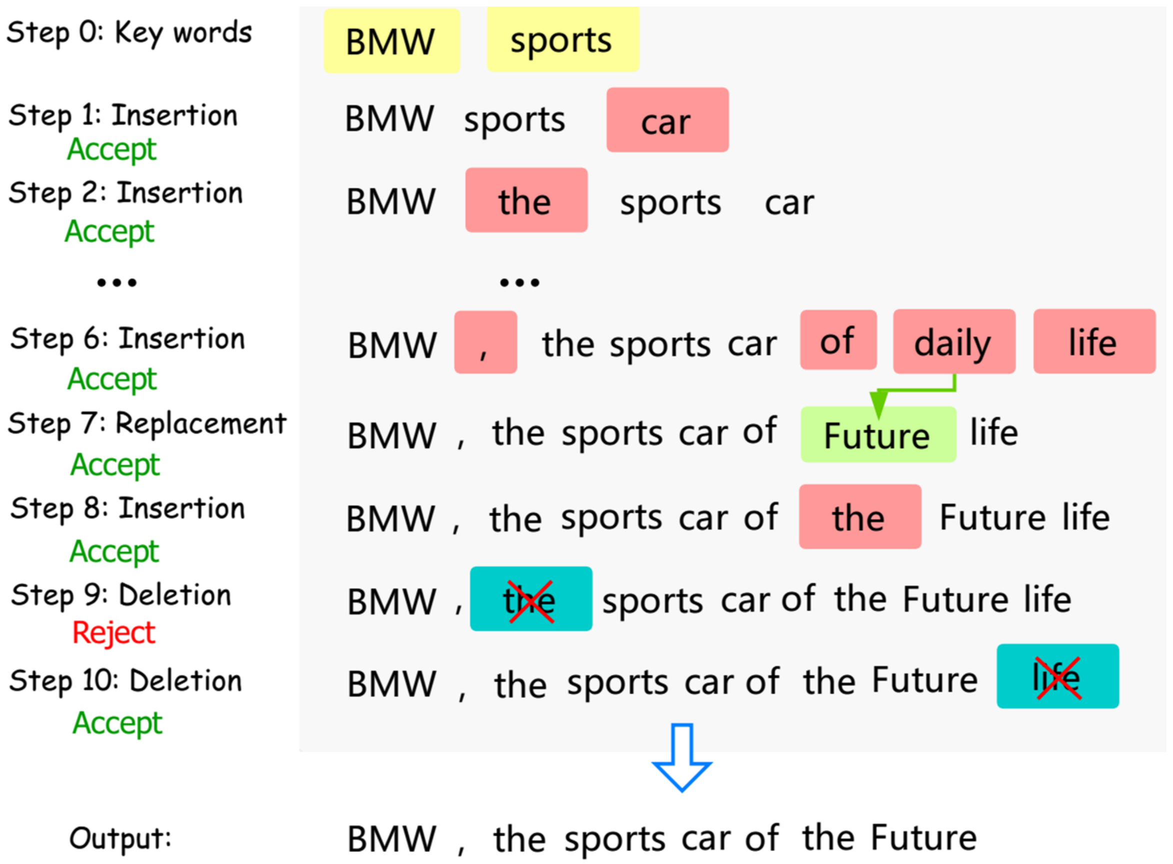
Motivation

- We often need to add constrains to sentence generation
  - Hard constrains (eg. keyword2sentence)
    Juice -> Brand natural juice, specially made for you
  - Soft constrains (eg. paraphrase)
    The movie is a great success -> It is one of my favorite movies

- Current methods don’t work well in constrained sentence generation
  - It’s difficult to add constraints to widely-used sequential sentence generation models, such as seq2seq and VAE.
  - Methods dedicated for constrained sentence generation can only handle a specific problem.
    - GBS and CBS can only generate sentence from certain keywords
    - VAE-SVG can only do paraphrase

Introduction

- We need a practical method for sentence generation under **both** hard and soft constraint! So we propose **Constrained Generation by Metropolis-Hastings sampling (CGMH).**
- **The main idea of CGMH is performing Metropolis-Hastings sampling directly in the space of sentences. The figure on right illustrates CGMH by an example of generating advertisement from keywords.**



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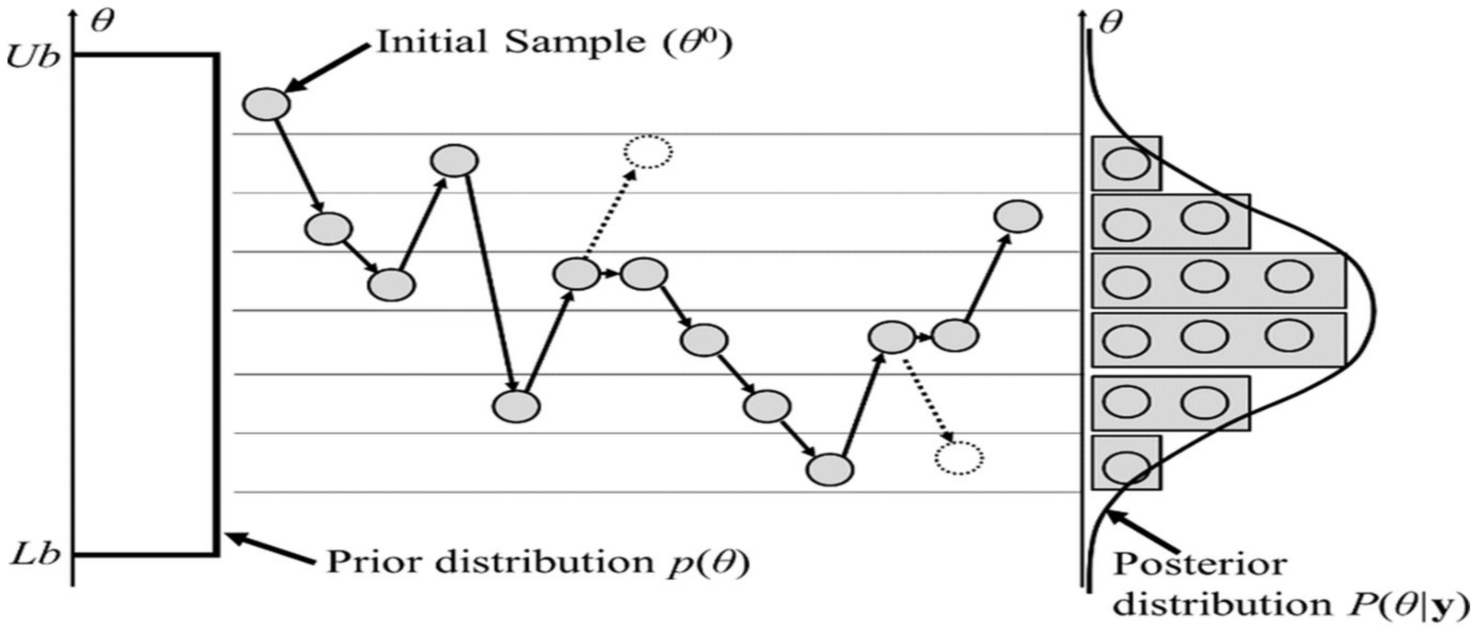
Metropolis-Hastings Sampling

- Metropolis-Hastings(MH) sampling is a 2-step Markov Chain Monte-Carlo (MCMC) algorithm
- MH first proposes a transition and then accepts or rejects the transition. (Gibbs sampling is a special case of MH sampling, which always accepts transitions.)



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Method

- We set the stationary distribution as:

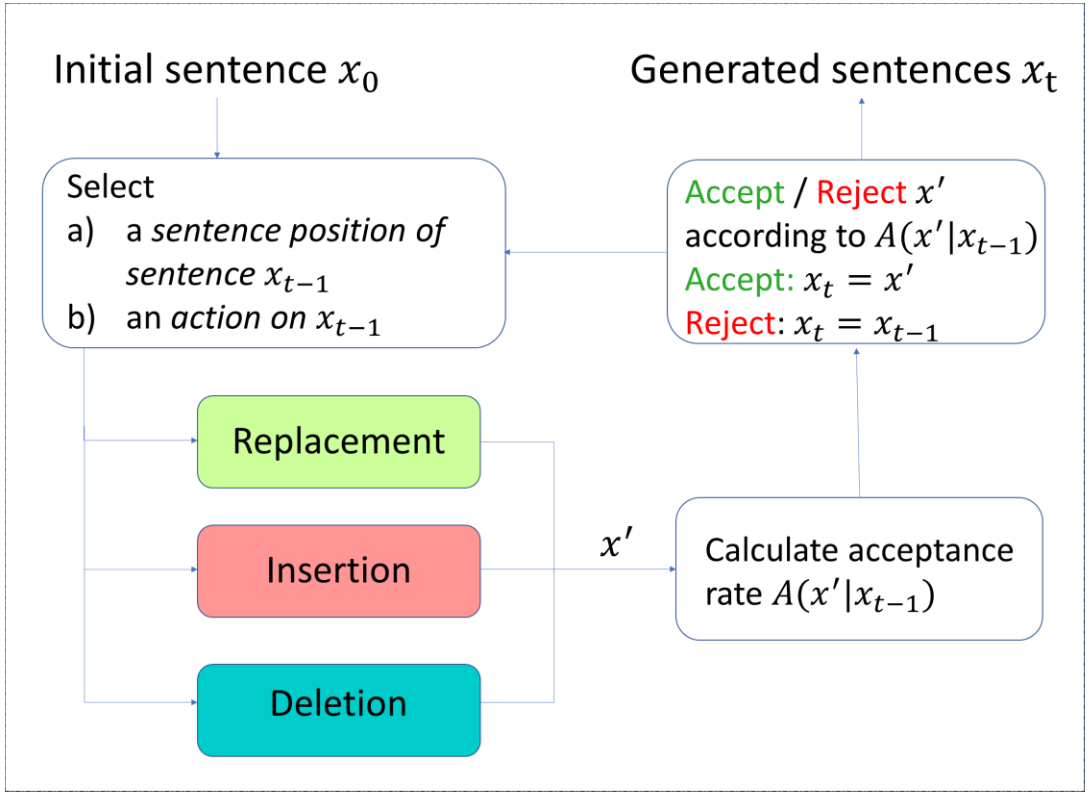
$$\pi(x) = p(x) \cdot \prod_{i} P_C^i(x)$$

  - $p(x)$ is the probability of sentence in a general-purpose language model and $P_C^i(x)$ is the indicator function showing whether constraint i is satisfied.

- We use MH algorithm to sample from $\pi(x)$
  - From a sentence x_{t-1}, we propose a new sentence x' by replacement/insertion/deletion of a position of x_{t-1}
  - Calculate the acceptance rate:

$$A(x'|x_{t-1}) = \min(1, \frac{\pi(x') \cdot g(x_{t-1}|x')}{\pi(x_{t-1}) \cdot g(x'|x_{t-1})})$$

  - Accept x' with probability $A(x'|x_{t-1})$



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Experiment - Keywords2Sentence Generation

- CGMH outperforms previous work in both NLL and human evaluations.

#keyword(s)		CGMH	GBS	sep-B/F	asyn-B/F
1	NLL	**7.04**	7.42	7.80	8.30
	Human	**0.45**	0.32	0.11	0.09
2	NLL	**7.57**	8.72	-	-
	Human	**0.61**	0.55	-	-
3	NLL	**8.26**	8.59	-	-
	Human	**0.56**	0.49	-	-
4	NLL	**7.92**	9.63	-	-
	Human	**0.65**	0.55	-	-

Keyword(s)	Generated Sentences
friends	My good **friends** were in danger .
project	The first **project** of the scheme .
have, trip	But many people **have** never made the **trip** .
lottery, scholarships	But the **lottery** has provided **scholarships** .
decision, build, home	The **decision** is to **build** a new **home** .
attempt, copy, painting, denounced	The first **attempt** to **copy** the **painting** was **denounced** .

Experiment - Unsupervised Paraphrase Generation

- CGMH is the first unsupervised model to achieve comparable results with supervised models.

Model	BLEU-ref	BLEU-ori	NLL
Origin Sentence	30.49	100.00	7.73
VAE-SVG (100k)	22.50	-	-
VAE-SVG-eq (100k)	**22.90**	-	-
VAE-SVG (50k)	17.10	-	-
VAE-SVG-eq (50k)	17.40	-	-
Seq2seq (100k)	22.79	33.83	6.37
Seq2seq (50k)	20.18	27.59	**6.71**
Seq2seq (20k)	16.77	22.44	6.67
VAE (unsupervised)	9.25	27.23	7.74
CGMH *w/o matching*	18.85	50.28	7.52
w/ KW	20.17	53.15	7.57
w/ KW + WVA	20.41	53.64	7.57
w/ KW + WVM	20.89	54.96	7.46
w/ KW + ST	20.70	54.50	7.78

Type	Examples
Ori	what 's the best plan to lose weight
Ref	what is a good diet to lose weight
Gen	what 's the best way to slim down quickly
Ori	how should i control my emotion
Ref	how do i control anger and impulsive emotions
Gen	how do i control my anger
Ori	why do my dogs love to eat tuna fish
Ref	why do my dogs love eating tuna fish
Gen	why do some dogs like to eat raw tuna and raw fish

Experiment - Unsupervised Error Correction

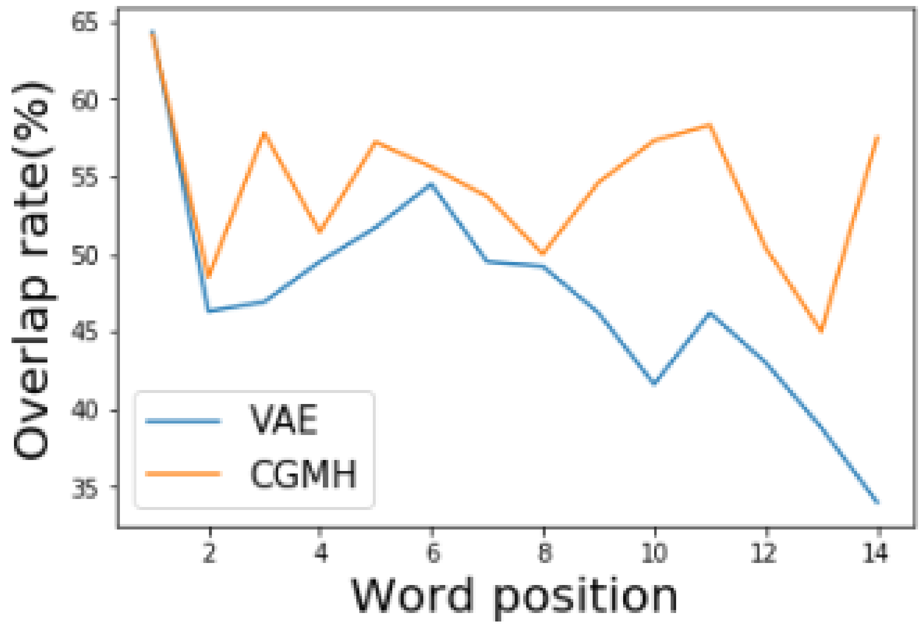
- CGMH outperforms some of the supervised models trained on large parallel corpus.

Model	#parallel data	GLEU
AMU	2.3M	44.85
CAMB-14	155k	46.04
MLE	720k	52.75
NRL	720k	**53.98**
CGMH	0	45.5

Ori	Even if **we are failed** , We have to try to get **a new things** .
Ref	Even if we all failed , we have to try to get new things .
Gen	Even if we are failing , We have to try to get some new things .
Ori	In the world **oil price very high** right now .
Ref	In today 's world , oil prices are very high right now .
Gen	In the world , oil prices are very high right now .

Analysis

- Why CGMH performs better than sequential models?
  - RNN can be thought of as an autoregressive Bayesian network generating words conditioned on previous ones. Hence error will accumulate during generation.
  - CGMH doesn't generate sequentially, so error won't accumulate.
  - At the same time, CGMH has the ability of self-correction. Please refer to the part of sentence correction.



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THANKS.

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