CS395T: Structured Models for NLP
Lecture 22: Summarization

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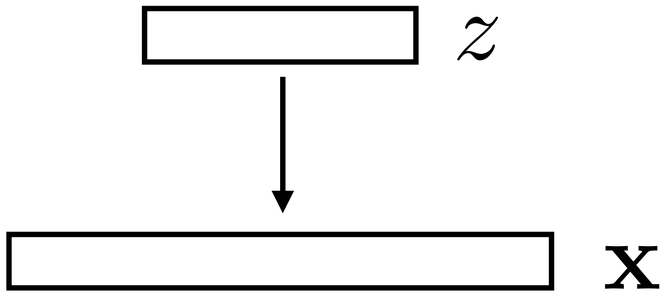
Administrivia

- Proposal feedback posted
- Presentation assignments posted soon

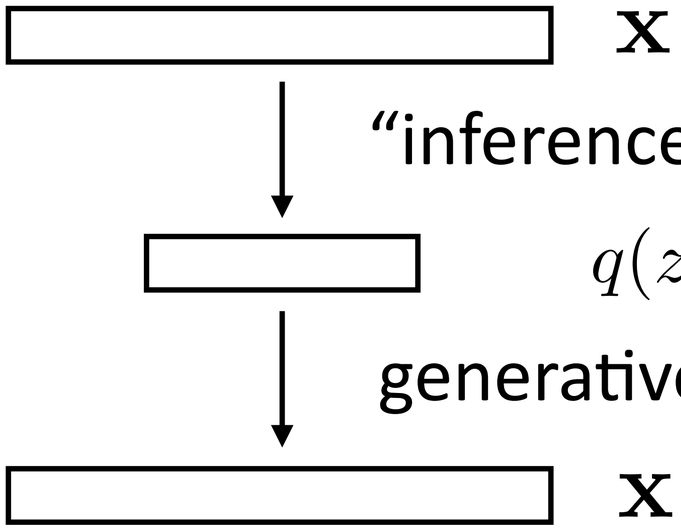
Variational Autoencoders

$$\mathbb{E}_{q(z|\mathbf{x})}[\log P(\mathbf{x}|z,\theta)] - \mathrm{KL}(q(z|\mathbf{x})\|P(z))$$

Generative model (test):



Autoencoder (training):



Input

"inference network"

distribution over z

generative model

Maximize P(**x**|z,θ)

Miao et al. (2015)

Training VAEs

For each example **x**

Compute *q* (run forward pass to compute mu and sigma)

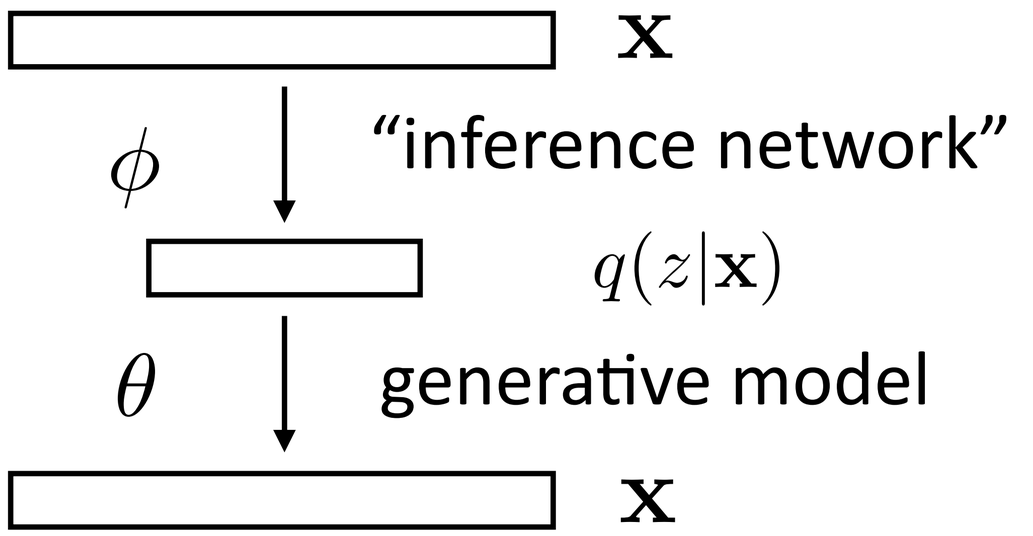
For some number of samples

Sample z ~ *q*

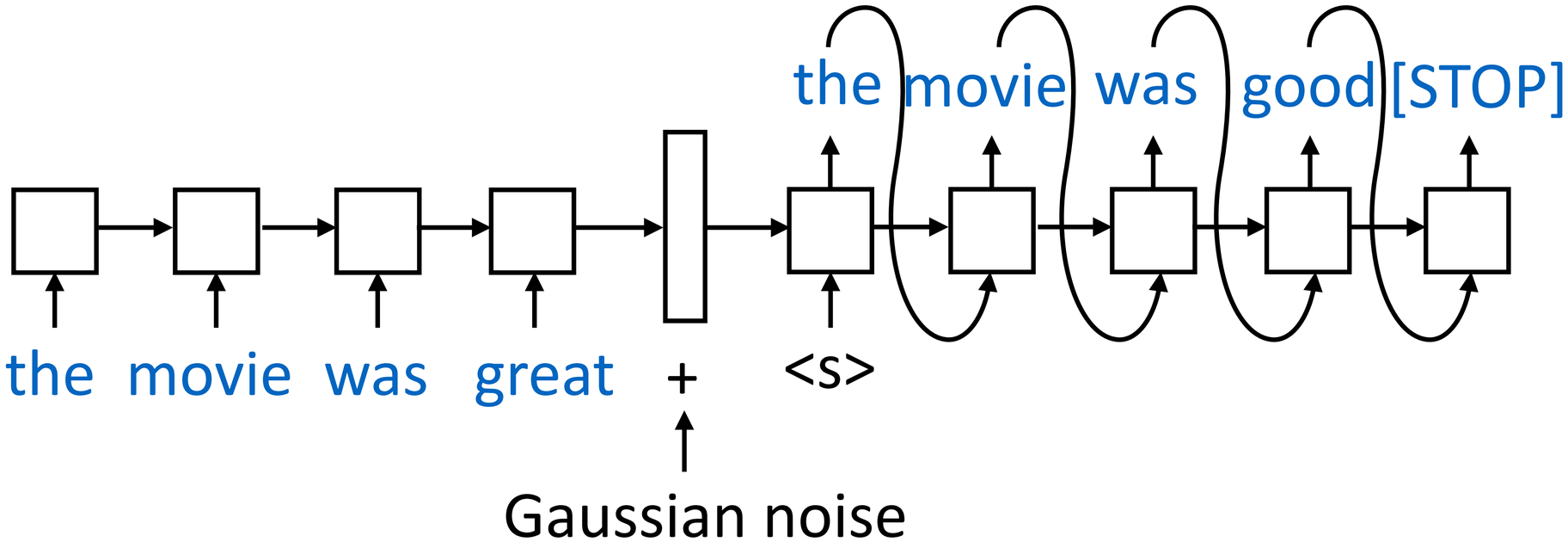
Compute P(**x**|z) and compute loss

Backpropagate to update phi, theta

Autoencoder (training):



Autoencoders

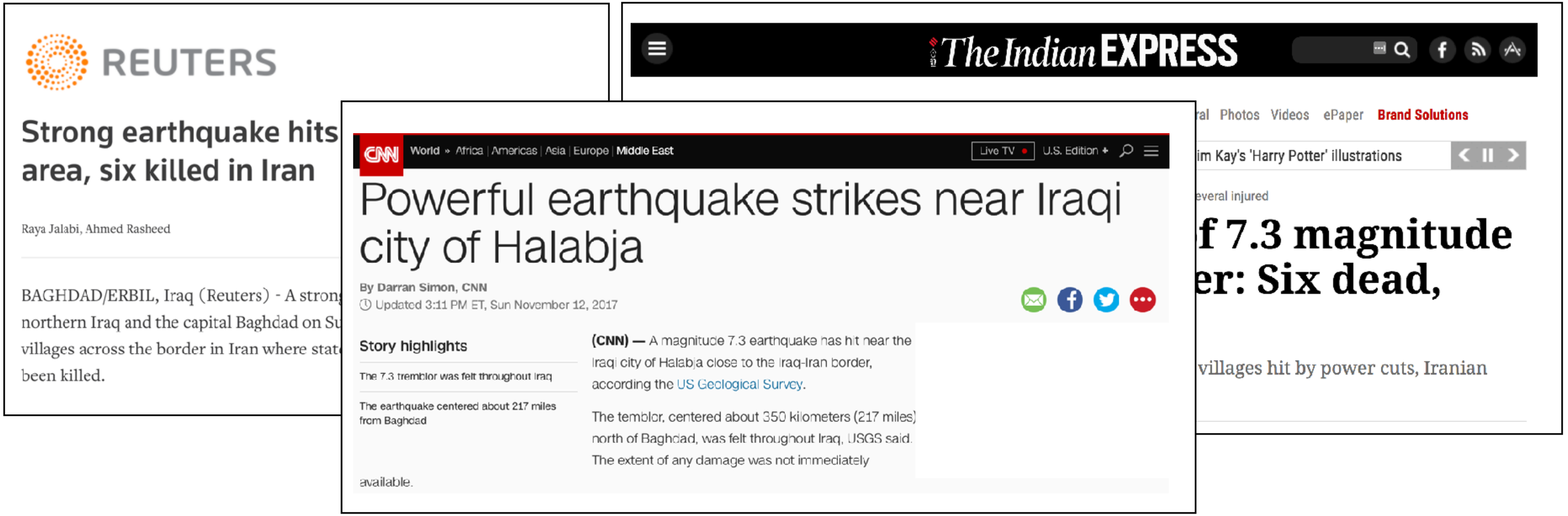


- During training, add Gaussian noise and force the network to predict
- Same computation graph as VAE with reparameterization, add KL term to make the objective the same
- Inference network (q) is the encoder and generator is the decoder

This Lecture

- Extractive systems for multi-document summarization
- Extractive + compressive systems for single-document summarization
- Single-document summarization with neural networks

Summarization



- What makes a good summary?

Summarization

BAGHDAD/ERBIL, Iraq (Reuters) - A strong earthquake hit large parts of northern Iraq and the capital Baghdad on Sunday, and also caused damage in villages across the border in Iran where state TV said at least six people had been killed.

There were no immediate reports of casualties in Iraq after the quake, whose epicenter was in Penjwin, in Sulaimaniyah province which is in the semi-autonomous Kurdistan region very close to the Iranian border, according to an Iraqi meteorology official.

But eight villages were damaged in Iran and at least six people were killed and many others injured in the border town of Qasr-e Shirin in Iran, Iranian state TV said.

The US Geological Survey said the quake measured a magnitude of 7.3, while an Iraqi meteorology official put its magnitude at 6.5 according to preliminary information.

Many residents in the Iraqi capital Baghdad rushed out of houses and tall buildings in panic.

…

Summarization

Indian Express — A massive earthquake of magnitude 7.3 struck Iraq on Sunday, 103 kms (64 miles) southeast of the city of As-Sulaymaniyah, the US Geological Survey said, reports Reuters. US Geological Survey initially said the quake was of a magnitude 7.2, before revising it to 7.3.

The quake has been felt in several Iranian cities and eight villages have been damaged. Electricity has also been disrupted at many places, suggest few TV reports.

Summary

A massive earthquake of magnitude 7.3 struck Iraq on Sunday. The epicenter was close to the Iranian border. Eight villages were damaged and six people were killed in Iran.

What makes a good summary?

Summary

A strong earthquake of magnitude 7.3 struck Iraq and Iran on Sunday. The epicenter was close to the Iranian border. Eight villages were damaged and six people were killed in Iran.

- Content selection: pick the right content
  - Right content was repeated within and across documents
  - Domain-specific (magnitude + epicenter of earthquakes are important)
- Generation: write the summary
  - Extraction: pick whole sentences from the summary
  - Compression: compress those sentences but basically just do deletion
  - Abstraction: rewrite + reexpress content freely

Extractive Summarization

Extractive Summarization: MMR

- Given some articles and a length budget of *k* words, pick some sentences of total length <= *k* and make a summary
- Pick important yet diverse content: maximum marginal relevance (MMR)

While summary is < *k* words

Calculate $$MMR \stackrel{\text{def}}{=} Arg \max_{D_i \in R \setminus S} \left[\lambda (Sim_1(D_i, Q) - (1-\lambda) \max_{D_j \in S} Sim_2(D_i, D_j)) \right]$$

"max over all sentences not yet in the summary"

"make this sentence similar to a query"

"make this sentence maximally different from all others added so far"

Add highest MMR sentence that doesn't overflow length

Carbonell and Goldstein (1998)

Extractive Summarization: Centroid

- Represent the documents and each sentences as bag-of-words with TF-IDF weighting

While summary is < *k* words

Calculate score(sentence) = cosine(sent-vec, doc-vec)

Discard all sentences whose similarity with some sentence already in the summary is too high

Add the best remaining sentence that won't overflow the summary

Radev et al. (2004)

Extractive Summarization: Bigram Recall

- Count number of *documents* each bigram occurs in to measure importance

score(*massive earthquake*) = 3

score(*six killed*) = 2

score(*magnitude 7.3*) = 2

score(*Iraqi capital*) = 1

- Find summary that maximizes the score of bigrams it covers

- ILP formulation: c and s are indicator variables indexed over concepts (bigrams) and sentences, respectively

$$\text{Maximize: } \sum_i w_i c_i$$

$$\text{Subject to: } \sum_j l_j s_j \leq L$$

$$s_j Occ_{ij} \leq c_i, \quad \forall i, j$$

$$\sum_j s_j Occ_{ij} \geq c_i \quad \forall i$$

"set c_i to 1 iff some sentence that contains it is included"

sum of included sentences' lengths can't exceed L

Gillick and Favre (2009)

Evaluation: ROUGE

- Rouge-n: n-gram recall of summary w.r.t. gold standard
- Rouge-2 correlates well with human judgments for multi-document summarization tasks

	(C) DUC02 10			(D1) DUC01 50			(D2) DUC02 50			(E1) DUC01 200			(E2) DUC02 200			(F) DUC01 400		
Method	**CASE**	**STEM**	**STOP**	**CASE**	**STEM**	**STOP**	**CASE**	**STEM**	**STOP**	**CASE**	**STEM**	**STOP**	**CASE**	**STEM**	**STOP**	**CASE**	**STEM**	**STOP**
R-1	0.71	0.68	0.49	0.49	0.49	0.73	0.44	0.48	**0.80**	0.81	0.81	**0.90**	0.84	0.84	0.91	0.74	0.73	**0.90**
R-2	0.82	0.85	**0.80**	0.43	0.45	0.59	0.47	0.49	0.62	**0.84**	**0.85**	0.86	**0.93**	**0.93**	**0.94**	**0.88**	**0.88**	0.87
R-3	0.59	0.74	0.75	0.32	0.33	0.39	0.36	0.36	0.45	0.80	0.80	0.81	0.90	0.91	0.91	0.84	0.84	0.82
R-4	0.25	0.36	0.16	0.28	0.26	0.36	0.28	0.28	0.39	0.77	0.78	0.78	0.87	0.88	0.88	0.80	0.80	0.75
R-5	-0.25	-0.25	-0.24	0.30	0.29	0.31	0.28	0.30	0.49	0.77	0.76	0.72	0.82	0.83	0.84	0.77	0.77	0.70
R-6	0.00	0.00	0.00	0.22	0.23	0.41	0.18	0.21	-0.17	0.75	0.75	0.67	0.78	0.79	0.77	0.74	0.74	0.63
R-7	0.00	0.00	0.00	0.26	0.23	0.50	0.11	0.16	0.00	0.72	0.72	0.62	0.72	0.73	0.74	0.70	0.70	0.58
R-8	0.00	0.00	0.00	0.32	0.32	0.34	-0.11	-0.11	0.00	0.68	0.68	0.54	0.71	0.71	0.70	0.66	0.66	0.52
R-9	0.00	0.00	0.00	0.30	0.30	0.34	-0.14	-0.14	0.00	0.64	0.64	0.48	0.70	0.69	0.59	0.63	0.62	0.46
R-L	0.78	0.78	0.78	**0.56**	**0.56**	0.56	0.50	0.50	0.50	0.81	0.81	0.81	0.88	0.88	0.88	0.82	0.82	0.82
R-S*	0.83	0.82	0.69	0.46	0.45	**0.74**	0.46	0.49	**0.80**	0.80	0.80	**0.90**	0.84	0.85	0.93	0.75	0.74	0.89
R-S4	**0.85**	**0.86**	0.76	0.40	0.41	0.69	0.42	0.44	0.73	0.82	0.82	0.87	0.91	0.91	0.93	0.85	0.85	0.85
R-S9	0.82	0.81	0.69	0.42	0.41	0.72	0.40	0.43	0.78	0.81	0.82	0.86	0.90	0.90	0.92	0.83	0.83	0.84
R-SU*	0.75	0.74	0.56	0.46	0.46	**0.74**	0.46	0.49	**0.80**	0.80	0.80	**0.90**	0.84	0.85	0.93	0.75	0.74	0.89

Lin (2004)

Results

Model	R-1	R-2	R-4
Centroid	36.03	7.89	1.20
LexRank	35.49	7.42	0.81
KLSum	37.63	8.50	1.26
CLASSY04	37.23	8.89	1.46
ICSI	38.02	**9.72**	**1.72**
Submodular	38.62	9.19	1.34
DPP	**39.41**	9.57	1.56
RegSum	38.23	9.71	1.59
Better centroid:	38.58	9.73	1.53

Gillick and Favre / bigram recall

- Caveat: these techniques all work better for multi-document than single-document!

Ghalandri (2017)

Multi-Document vs. Single Document

- “a massive earthquake hit Iraq” “a massive earthquake struck Iraq” — lots of redundancy to help select content in multi-document case

- When you have a lot of documents, there are more possible sentences to extract:

But eight villages were damaged in Iran and at least six people were killed and many others injured in the border town of Qasr-e Shirin in Iran, Iranian state TV said.

The quake has been felt in several Iranian cities and eight villages have been damaged.

- Multi-document summarization is easier?

Compressive Summarization

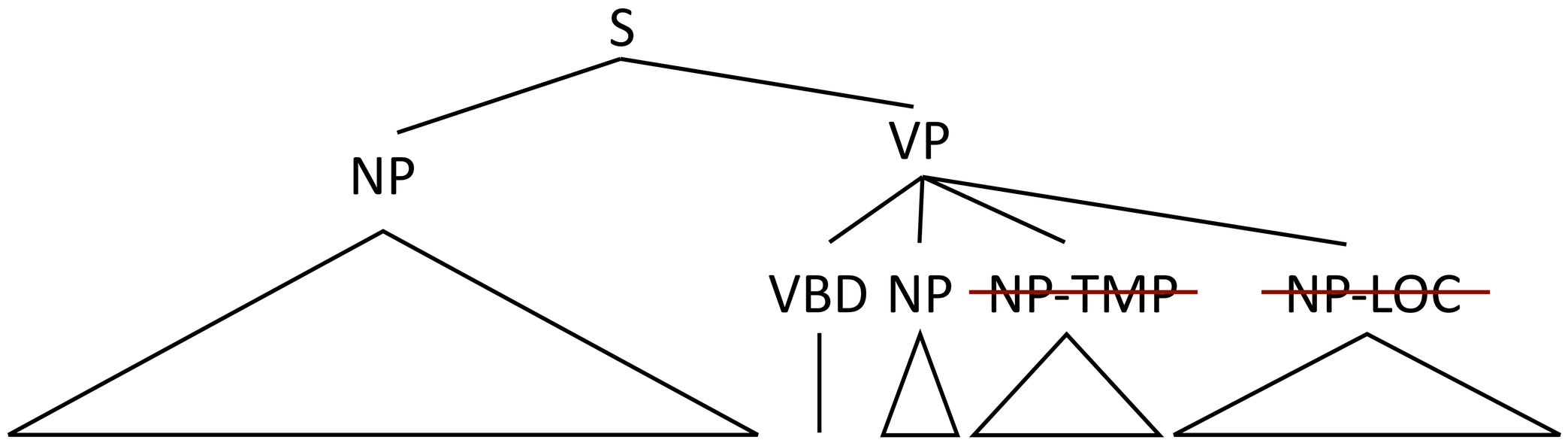
Compressive Summarization

Indian Express — A massive earthquake of magnitude 7.3 struck Iraq on Sunday, 103 kms (64 miles) southeast of the city of As-Sulaymaniyah, the US Geological Survey said, reports Reuters. US Geological Survey initially said the quake was of a magnitude 7.2, before revising it to 7.3.

- Sentence extraction isn't aggressive enough at removing irrelevant content
- Want to extract sentences and also delete content from them

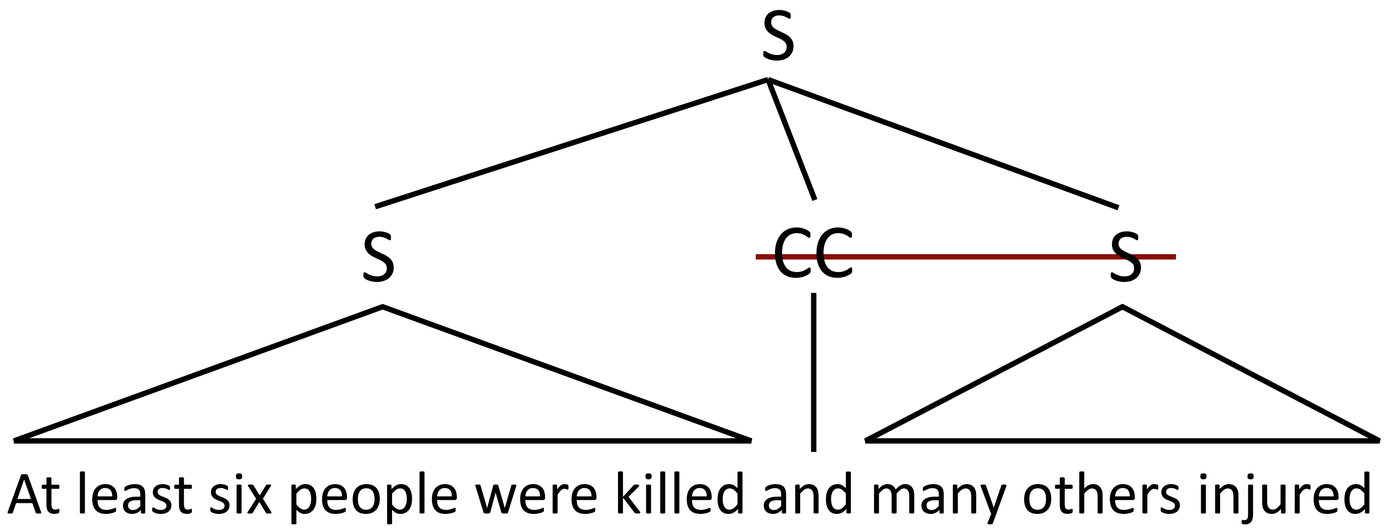
Syntactic Cuts

- Use syntactic rules to make certain deletions
- Delete adjuncts



Syntactic Cuts

- Use syntactic rules to make certain deletions
- Delete second parts of coordination structures



Compressive ILP

- Recall the Gillick+Favre ILP:

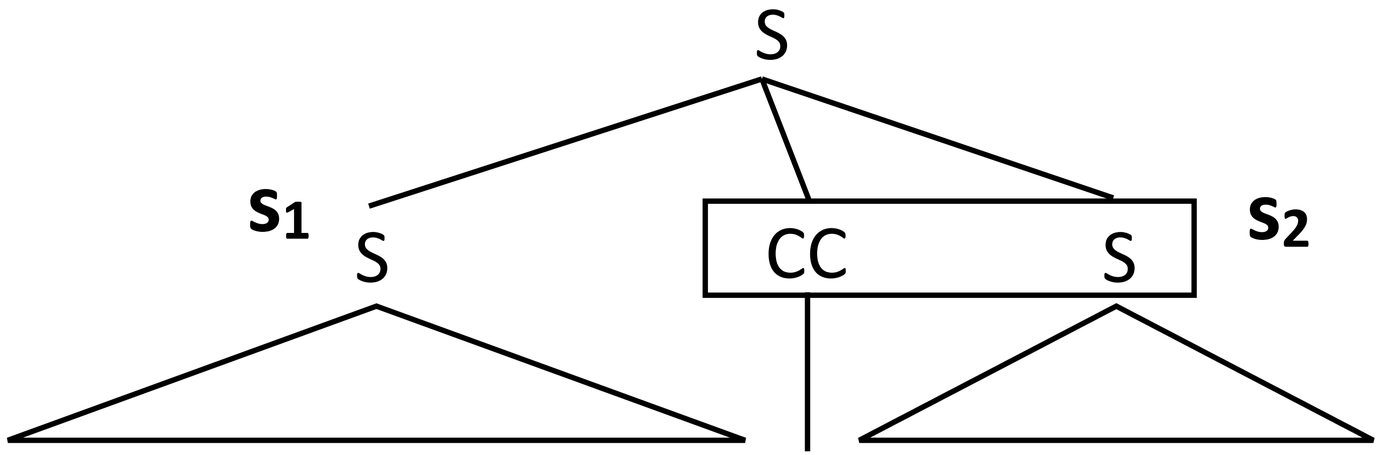
$$\text{Maximize: } \sum_i w_i c_i \qquad s_j Occ_{ij} \leq c_i, \quad \forall i, j$$

$$\text{Subject to: } \sum_j l_j s_j \leq L \qquad \sum_j s_j Occ_{ij} \geq c_i \quad \forall i$$

- Now s_j variables are nodes or sets of nodes in the parse tree

- New constraint: $s_2 \leq s_1$

  "s_1 is a prerequisite for s_2"



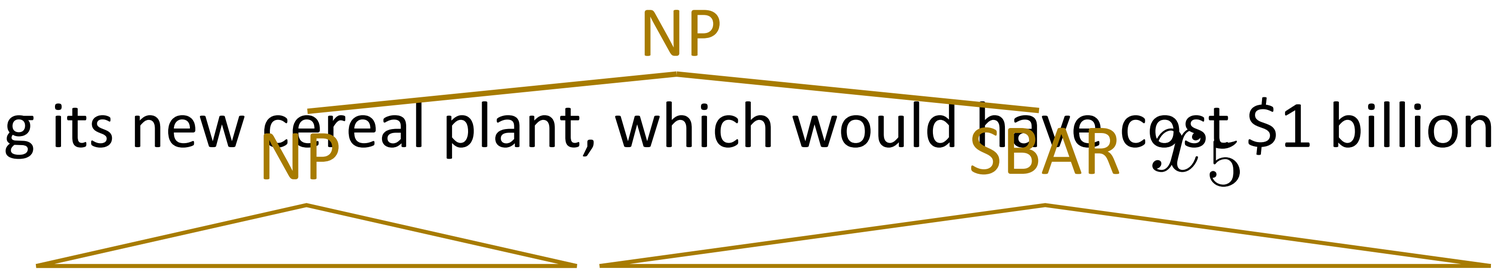
Compressive Summarization

x_1 This hasn't been Kellogg's year.

x_2 The oat-bran craze has cost Kellogg its market share.

x_3 Its president quit suddenly.

x_4 And now Kellogg is canceling its new cereal plant, which would have cost $1 billion.



ILP: $\max_{\mathbf{x}} \left(w^\top f(\mathbf{x}) \right)$

$s.t.$ summary($\mathbf{x}$) obeys length limit

summary($\mathbf{x}$) is grammatical

summary($\mathbf{x}$) is coherent

Constraints

$$\max_{\mathbf{x}} \left(w^\top f(\mathbf{x}) \right) \quad s.t. \ \text{summary}(\mathbf{x}) \text{ obeys length limit}$$

$$\text{summary}(\mathbf{x}) \text{ is grammatical}$$

$$\text{summary}(\mathbf{x}) \text{ is coherent}$$

Grammaticality constraints: allow cuts within sentences

Coreference constraints: do not allow pronouns that would refer to nothing

- If we're confident about coreference, rewrite the pronoun (it→Kellogg)
- Otherwise, force its antecedent to be included in the summary

Durrett et al. (2016)

Features

$$\max_{\mathbf{x}} \left(w^\top f(\mathbf{x}) \right) \quad s.t. \ \text{summary}(\mathbf{x}) \text{ obeys length limit}$$
$$\text{summary}(\mathbf{x}) \text{ is grammatical}$$
$$\text{summary}(\mathbf{x}) \text{ is coherent}$$

- Now uses a feature-based model, where features identify good content

f(And now Kellogg is canceling its new cereal plant) =

Centrality:
$\mathbb{I}$(NumContentWords=4)

Document position:
$\mathbb{I}$(SentenceIndex=4)

Lexical features:
$\mathbb{I}$(FirstWord=*And*)

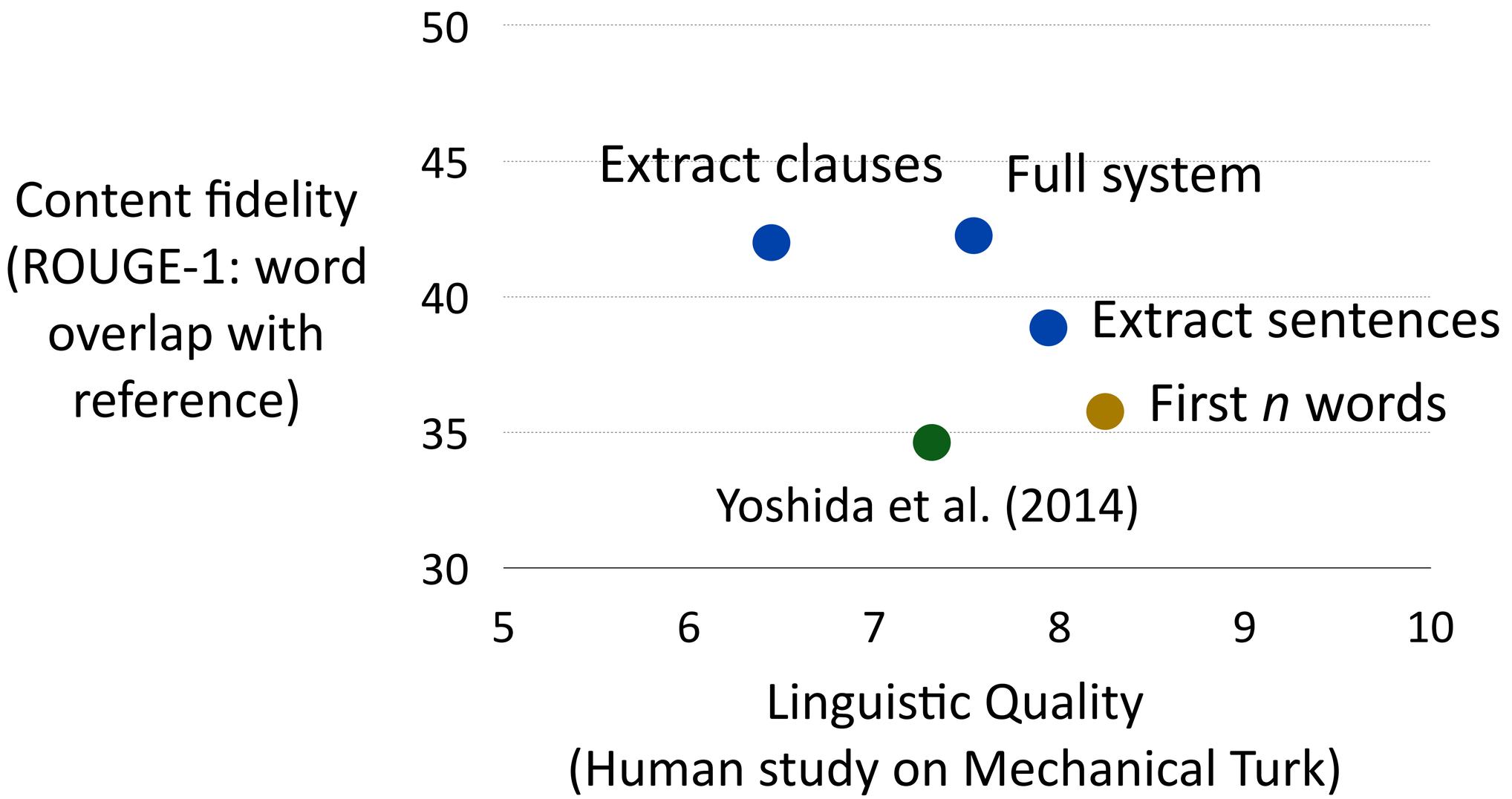
Learning

$$\max_{\mathbf{x}} \left(w^\top f(\mathbf{x}) \right) \quad s.t. \ \text{summary}(\mathbf{x}) \text{ obeys length limit}$$
$$\text{summary}(\mathbf{x}) \text{ is grammatical}$$
$$\text{summary}(\mathbf{x}) \text{ is coherent}$$

- Train on a large corpus of New York Times documents with summaries (100,000 documents)
- Structured SVM with ROUGE as loss function
  - Augment the ILP to keep track of which bigrams are included or not, use these for loss-augmented decode

Berg-Kirkpatrick et al. (2011), Durrett et al. (2016)

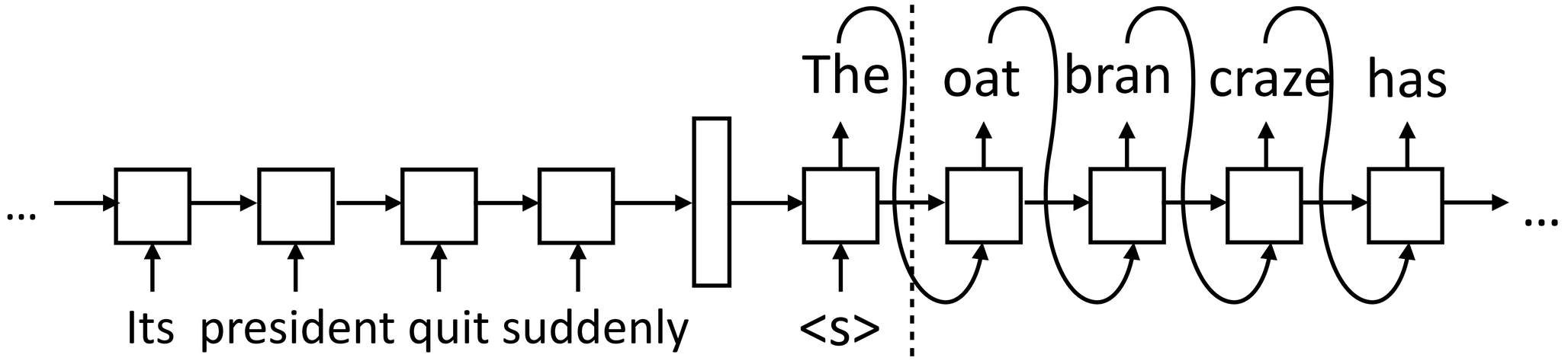
Results: New York Times Corpus



Neural Summarization

Seq2seq Summarization

- Extractive paradigm isn't all that flexible, even with compression
- Training is hard! ILPs are hard! Maybe just use seq2seq?
- Train to produce summary based on document



Chopra et al. (2016)

Seq2seq Summarization

- Task: generate headline from first sentence of article (can get lots of data!)

I(1): brazilian defender pepe is out for the rest of the season with a knee injury , his porto coach jesualdo ferreira said saturday . — sentence
G: football : pepe out for season — reference
A+: ferreira out for rest of season with knee injury — no attention
R: brazilian defender pepe out for rest of season with knee injury — with attention

- Works pretty well, though these models can generate incorrect summaries…
- What happens if we try this on a longer article?

Chopra et al. (2016)

Seq2seq Summarization

Original Text (truncated): lagos, nigeria (cnn) a day after winning nigeria's presidency, ***muhammadu buhari*** told cnn's christiane amanpour that **he plans to aggressively fight corruption that has long plagued nigeria** and go after the root of the nation's unrest. *buhari* said he'll "rapidly give attention" to curbing violence in the northeast part of nigeria, where the terrorist group boko haram operates. by cooperating with neighboring nations chad, cameroon and niger, **he said his administration is confident it will be able to thwart criminals** and others contributing to nigeria's instability. for the first time in nigeria's history, the opposition defeated the ruling party in democratic elections. *buhari* defeated incumbent goodluck jonathan by about 2 million votes, according to nigeria's independent national electoral commission. **the win comes after a long history of military rule, coups and botched attempts at democracy in africa's most populous nation.**

Baseline Seq2Seq + Attention: **UNK UNK** says his administration is confident it will be able to **destabilize nigeria's economy**. **UNK** says his administration is confident it will be able to thwart criminals and other **nigerians**. **he says the country has long nigeria and nigeria's economy.**

- What's wrong with this summary?

See et al. (2017)

Seq2seq Summarization

- Solutions: copy mechanism, coverage, just like in MT…

Baseline Seq2Seq + Attention: **UNK UNK** says his administration is confident it will be able to **destabilize nigeria's economy**. **UNK** says his administration is confident it will be able to thwart criminals and other **nigerians**. **he says the country has long nigeria and nigeria's economy.**

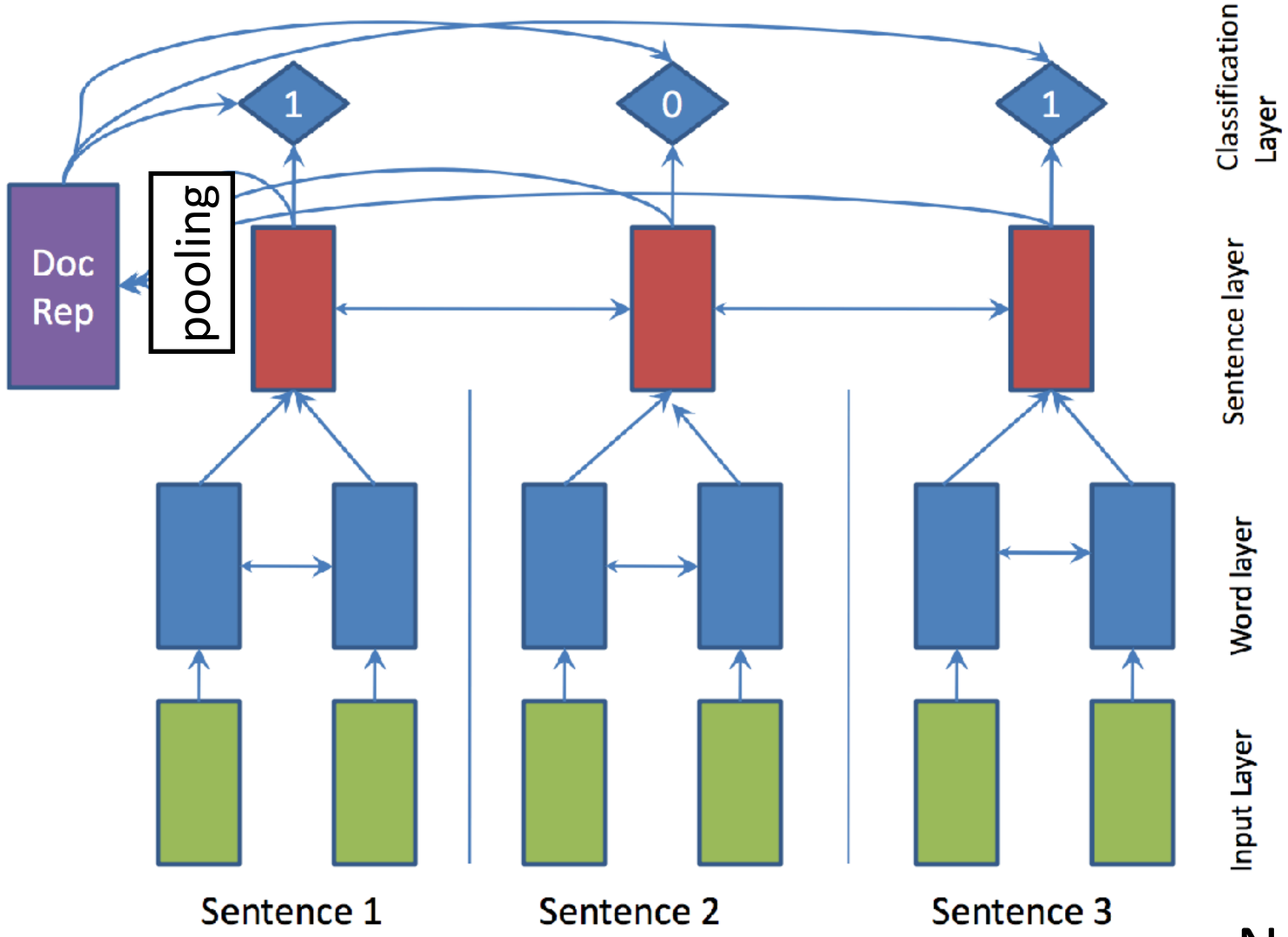
Pointer-Gen: *muhammadu buhari* says he plans to aggressively fight corruption **in the northeast part of nigeria**. he says he'll "rapidly give attention" to curbing violence **in the northeast part of nigeria**. he says his administration is confident it will be able to thwart criminals.

Pointer-Gen + Coverage: *muhammadu buhari* says he plans to aggressively fight corruption that has long plagued nigeria. he says his administration is confident it will be able to thwart criminals. the win comes after a long history of military rule, coups and botched attempts at democracy in africa's most populous nation.

- Things might still go wrong, no way of preventing this…

See et al. (2017)

Neural Extractive Systems



Nallapati et al. (2017)

Neural Systems: Results

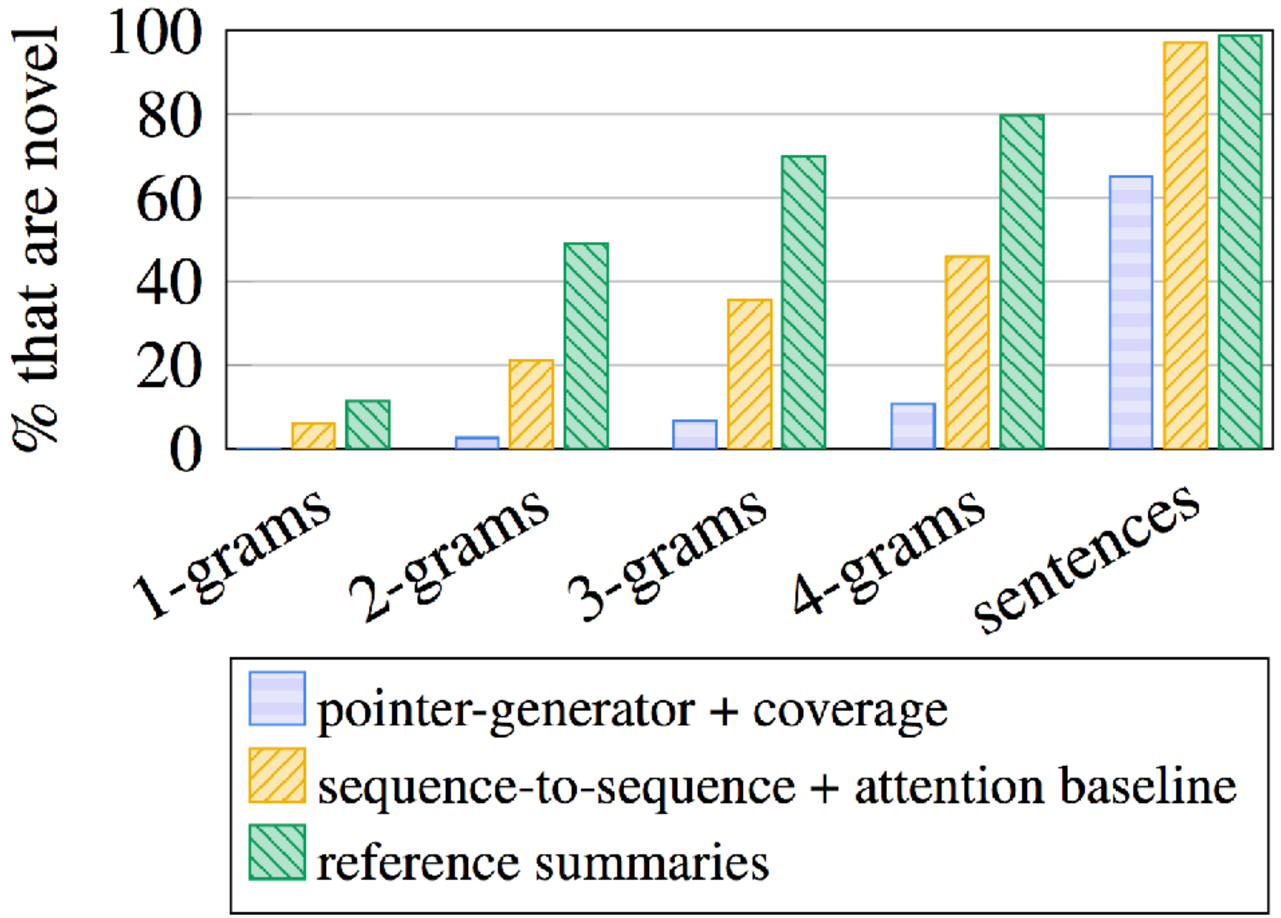
	ROUGE		
	1	2	L
abstractive model (Nallapati et al., 2016)*	35.46	13.30	32.65
seq-to-seq + attn baseline (150k vocab)	30.49	11.17	28.08
seq-to-seq + attn baseline (50k vocab)	31.33	11.81	28.83
pointer-generator	36.44	15.66	33.42
pointer-generator + coverage	**39.53**	**17.28**	**36.38**
lead-3 baseline (ours)	40.34	17.70	36.57
lead-3 baseline (Nallapati et al., 2017)*	39.2	15.7	35.5
extractive model (Nallapati et al., 2017)*	39.6	16.2	35.3

- Copy mechanism and coverage help substantially
- Abstractive systems don't beat a "lead" baseline on ROUGE (less n-gram overlap)

See et al. (2017)

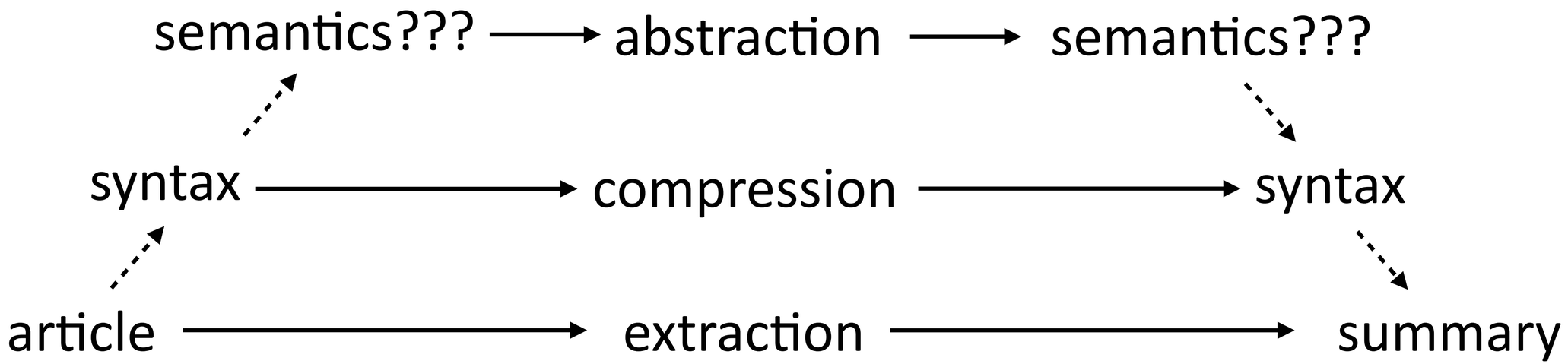
Neural Extractive Systems

- How abstractive is this, anyway?



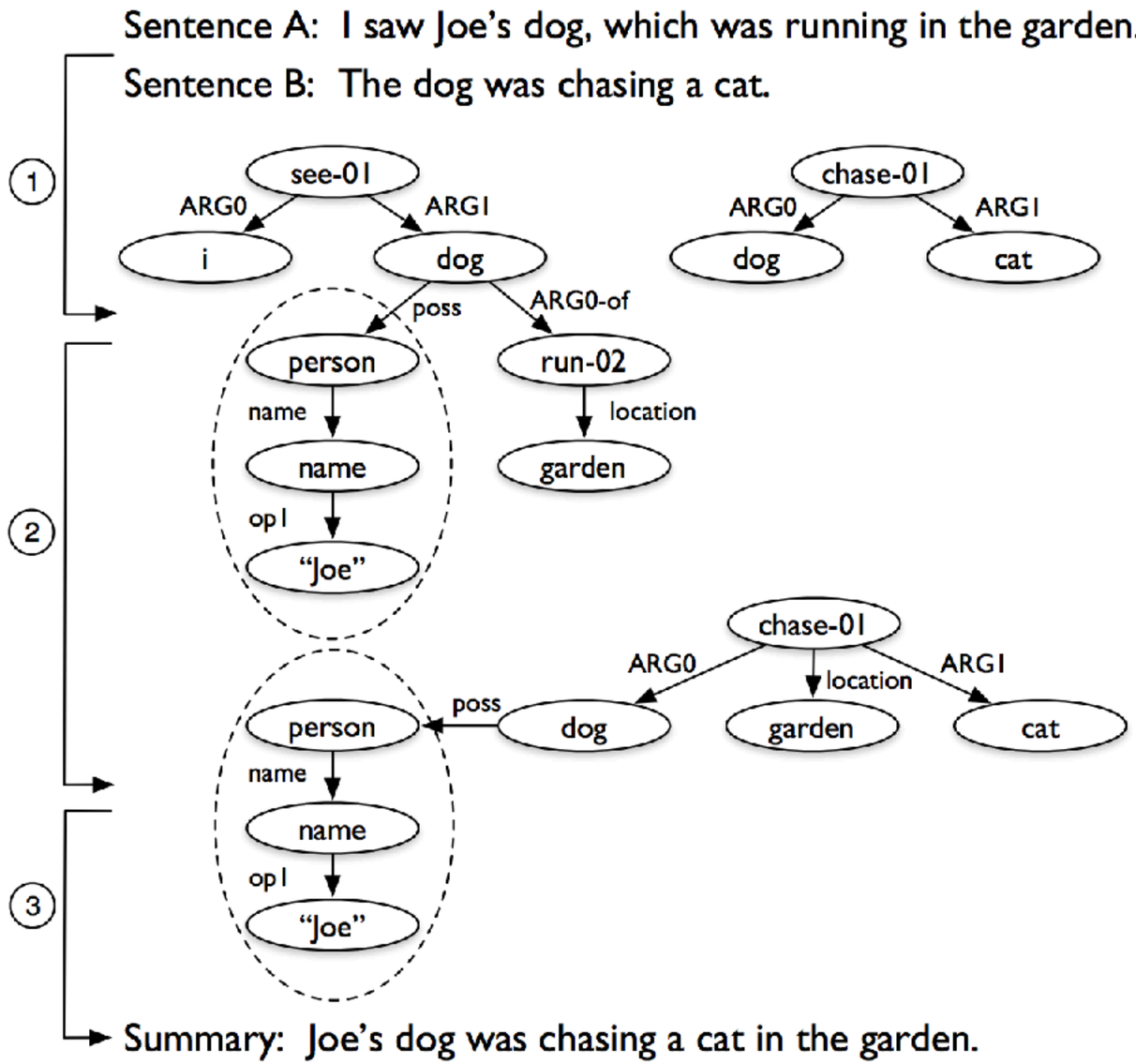
See et al. (2017)

Challenges of Summarization



- True abstraction?
  - Not really necessary for articles
  - Generating from structured information can usually be done with templates…

Challenges of Summarization



Liu et al. (2015)

Takeaways

- Extractive systems built on heuristics / ILPs work pretty well
- Compression can make things better, especially in the single-document setting
- Neural systems (like MT models) can do abstractive summarization