OPINIONS on OPINOSIS

OPINOSIS - A Graph-Based Approach to Abstractive Summarization of Highly Redundant Opinions

by Kavita Ganesan , ChengXiang Zhai and Jiawei Han ($\leftarrow$ GZH)

Cosmina CROITORU

Presentation's structure

- Background
- The GZH's paper in a nutshell.
- OPINOSIS
- My Opinions

Text summarization

- Automatic creation of a shortened version of a text maintaining its most important points
- Coherent and correctly-developed summaries
- A possible approach to Information overload
- Useful summary : concise, readable, and fairly well-formed

Text summarization

Types of summaries:

- Purpose (Indicative, informative, and critical)
- Form
  - Extractive (salient paragraphs, sentences, phrases)
  - Abstractive(concise summary of the central subject)
- Dimensions (Single-document vs. multi-document)
- Context (Query-specific vs. query-independent)

Multi-document summarization

Information organized around the key aspects to represent a wider diversity of views on the topic.

- Centroid-based, sentence utility
  MEAD (Radev et al. 00)
- Reformulation
  (McKeown et al. 99, McKeown et al. 02)
- Generation by Selection and Repair
  (DiMarco et al. 97)

MEAD 1

- Implements extractive summarization: selects a subset of highly relevant sentences from the cluster's overall set of sentences.
- Deep NLP and machine learning techniques.
  - Decision-tree, trained on a manually annotated corpus for CST relationships
  - CST (Cross-document Structure Theory) relationships: subsumption, identity, paraphrase, elaboration/refinement, etc.

MEAD 2

- For each sentence computes:
  - centroid score (a measure of the centrality of a sentence to the overall topic of a cluster)
  - position score (decreases linearly as the sentence gets farther from the beginning of a document)
  - overlap-with-first score (the inner product of the weighted vector representation of the sentence and the first sentence (or title, if there is one)
- Produces a cluster centroid, consisting of words which are central to all of the documents in the cluster.
- Ranks sentences on their distance to the centroid.

Natural Language Processing (NLP)

- **Shallow NLP:** mixing simple syntactic feature (word order or location and similarity) with domain-specific interpretation.
- **Deep NLP:** sophisticated *syntactic, semantic and contextual processing*: named-entity recognition, relation detection, coreference resolution, syntactic alternations, word sense disambiguation, logic form transformation, logical inferences (abduction) and commonsense reasoning, temporal or spatial reasoning, etc.

POS Annotation

http://opennlp.sourceforge.net./

POS Tag	Meaning	Example
cc	coordinating conjunction	*and*
dt	determiner	*the*
nn	noun, singular	*table*
vb	verb, base form	*take*
jj	adjective	*red*
rb	adverb	*however, here, good*
in	preposition	*in, of, like*
to	TO	*to go, to him*

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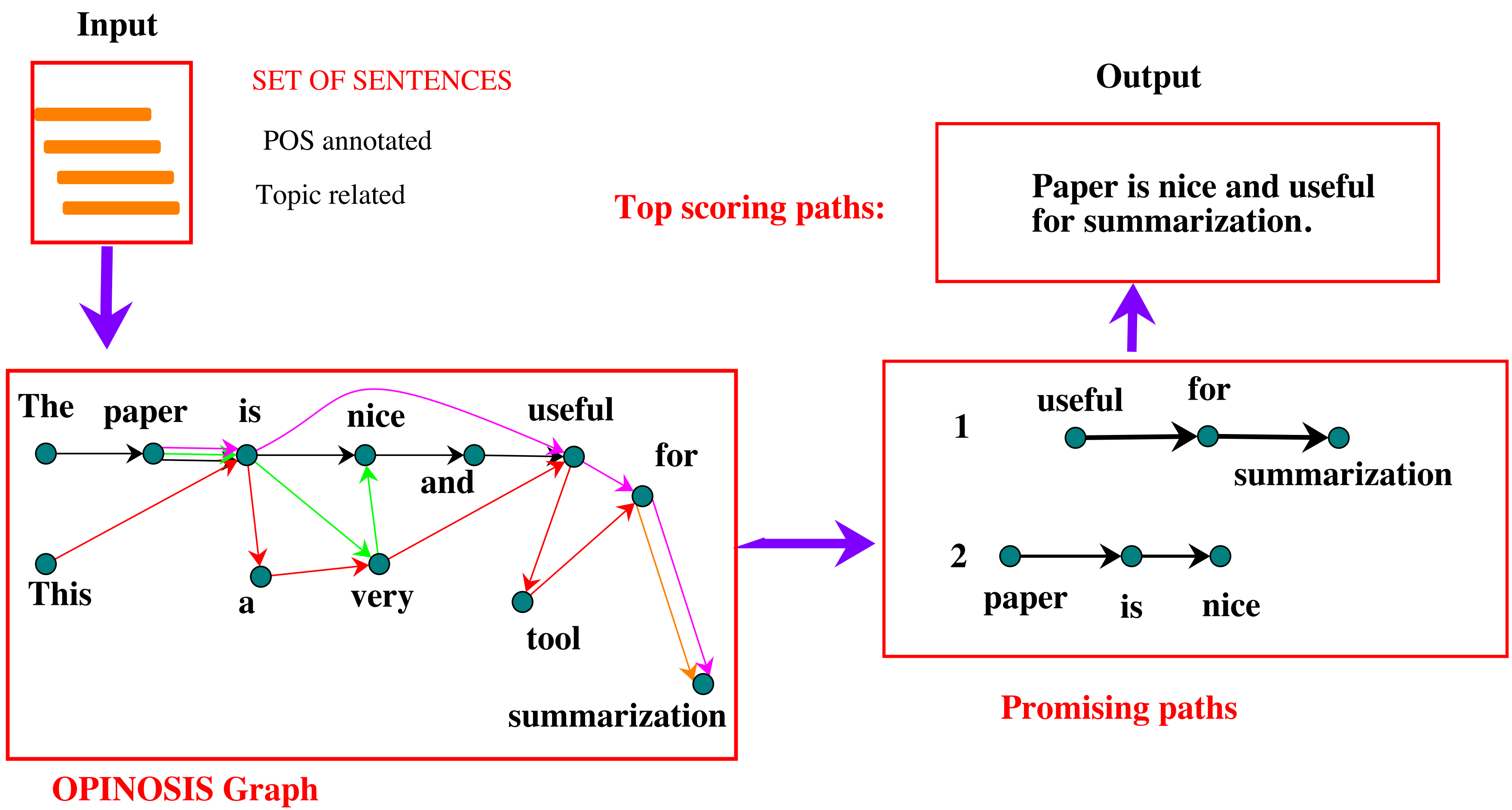
GZH's Paper Summary

- A framework for summarizing highly redundant opinions
- Use graph representation to generate concise abstractive summaries
- Any corpus with high redundancies (Twitter comments, Blog comments, etc)

GZH's Approach Schema



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OPINOSIS-Graph

- Each sentence $\longrightarrow$ sequence of word units
- Word unit : pair $(word, POSannotation)$
- Word units $\longrightarrow$ nodes of OPINOSIS-Graph
- Directed edges: (v, w) iff v and w are successive word units in the same sentence
- v- node $\longleftarrow PRI_v$ Positional Reference Information
- PRI_v list of pairs (SID_v, PID_v)

OPINOSIS-Graph

- $SID_v = i$ iff v is a unit word in sentence i
- PID_v=j iff position of v in sentence SID_v is j
- **Algorithm 1:** $OpinosisGraph(Z)$
- **Input :** *Topic related sentences to be summarized:*

  $$Z = \{z_i\}_{i=1}^{n}$$
- **Output:** $G = (V, E)$

OpinosisGraph(Z)

for $i = 1$ **to** n **do** $\{$

$w \leftarrow Tokenize(z_i)$; $sent\_size \leftarrow SizeOf(w)$

for $j = 1$ **to** $sent\_size$ **do** $\{$

$LABEL \leftarrow w_j$; $SID \leftarrow i$; $PID \leftarrow j$

if $ExistsNode(G, LABEL)$ **then** $\{$

$v_j \leftarrow GetExistingNode(G, LABEL)$

$PRI_{v_j} \leftarrow PRI_{v_j} \cup (SID; PID)\ \}$

else $\{$

$v_j \leftarrow CreateNewNode(G, LABEL)$

$PRI_{v_j} \leftarrow (SID; PID)\ \}$

if $j > 1$ **and not** $ExistsEdge(v_{j-1} \rightarrow v_j, G)$ **then**

$AddEdge(v_{j-1} \rightarrow v_j, G)$

$\}\}$

Remarks on OPINOSIS-Graph

- **Property 1.** (Redundancy Capture) Highly redundant discussions are naturally captured by subgraphs.
- **Property 2.** (Gapped Subsequence Capture) Existing sentence structures introduce lexical links that facilitate the discovery of new sentences or reinforce existing ones.
- **Property 3.** (Collapsible Structures) Nodes that resemble hubs are possibly collapsible.

Valid Paths

- **Valid Start Node - VSN:** v **s.t.** $Average(PID_v) \leq \sigma_{vsn}$
- **Valid End Node - VEN:** v is a punctuation (*period*, *comma*), or any coordinating conjunction (*but*, *yet*).
- **Valid Path :** A path connecting a VSN to a VEN satisfying a set of well-formedness POS constraints.
- Regular-expression POS constraints:
  1. $.\star(/nn) + .\star(/vb) + .\star(/jj) + .\star$
  2. $.\star(/jj) + .\star(/to) + .\star(/vb).\star$
  3. $.\star(/rb)\star.\star(/jj) + .\star(/nn) + .\star$
  4. $.\star(/rb) + .\star(/in) + .\star(/nn) + .\star$

Redundancy and Gap

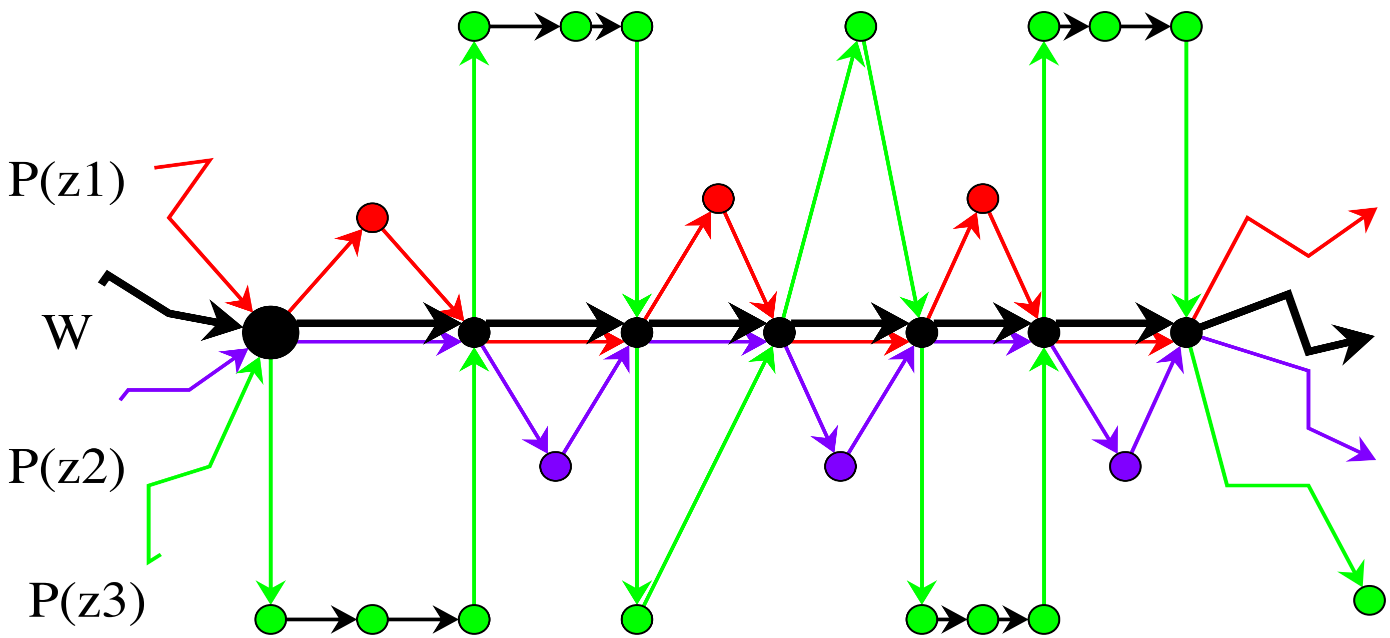
Path Scoring

Favor a valid path with a high redundancy score, to represent well most of the redundant opinions.

- $W = \{v_1, v_2 \ldots, v_s\}$ a "path" in the Opinosis-Graph.
- Sentence z_i cover W if $\forall j \in \{1, \ldots, s-1\}$ $\exists(i, p) \in PRI_{v_j}$ and $\exists(i, p') \in PRI_{v_{j+1}}$ such that $p' - p \leq \sigma_{gap}$.
- Path redundancy of the path W:

  $r(W) = |\{z_i | z_i$ cover $W\}|$.

Redundancy and Gap



$$\sigma_{gap} = 1 \Rightarrow r(W) = 0$$
$$\sigma_{gap} = 2 \Rightarrow r(W) = 2$$
$$\sigma_{gap} = 4 \Rightarrow r(W) = 3$$

Redundancy and Gap

Scores

$W = \{v_1, v_2 \ldots, v_s\}$; $|W|$ = length of W;
$W_{i,j}$ = the subpath $\{v_i, \ldots, v_j\}$ $(1 \leq i < j \leq s)$

- $S_{basic}(W) = \frac{1}{|W|} \sum_{k=1,s} r(W_{1,k})$
- $S_{wt\_len}(W) = \frac{1}{|W|} \sum_{k=1,s} r(W_{1,k}) \cdot |W_{1,k}|$
- $S_{wt\_loglen}(W) =$
  $\frac{1}{|W|} \left[r(W_{1,2}) + \sum_{k=2,s} r(W_{1,k}) \cdot \log |W_{1,k}| \right]$

Path Composition

- **Collapsible Node:** node v_c with $POS = vb$
- **Collapsed candidates:** Remaining path after a candidate node v_c:

$$\overbrace{v_0, \ldots, v_c}^{\text{anchor}}, \quad \underbrace{v_{first}, \quad \ldots \quad, \quad v_{last}}_{\text{collapsed candidate}}$$

$$CC(v_c) = \cup_{P\ \text{anchor}} \{P' | P' \text{ collapsed candidate for } P\}.$$

- **Stitched sentence:** Logical sentence obtained from an anchor and its collapsed candidates.

Stitched sentence

- Collapsible node: v_c anchor of v_c: P
- Collapsed candidates for P: $\{P_1, \ldots, P_{k-1}, P_k\}$
- Stitched sentence ($k \geq 2$):
  $P P_1$commaP_2comma$\ldots$commaP_{k-1}ccP_k.
  Examples:

  The paper is nice, deep and useful for summarization.

  The paper is nice, interesting but not useful.
- coordinating conjunction cc: from all parents u in G of the first node v of P_k, having POS=cc, select argmax$_{u:POS(u)=cc} r(\{u, v\})$.

System's parameters

- σ_{gap} - controls the maximum allowed gaps in discovering redundancies.
- σ_{vsn} - qualify nodes that tend to occur early on in a sentence.
- σ_{ss} - controls the maximum number of paths to be chosen (summary size).
- σ_{r} - a redundancy score threshold, to prune non-promising paths.

Empirically set.

Summarization

- **Algorithm 2:** $OpinosisSummarization(Z)$
- **Input :** *Topic related sentences to be summarized:*

$$Z = \{z_i\}_{i=1}^{n}$$

- **Output:** $\mathcal{O} = \{Opinosis\ Summaries\}$

$\mathbf{OpinosisSummarization(Z)}$

$g \leftarrow OpinosisGraph(Z)$

$node\_size \leftarrow SizeOf(g)$

for $j = 1$ **to** $node\_size$ **do** $\{$

if $VSN(v_j)$ **then** $\{$

$pathLen \leftarrow 1;\ score \leftarrow 0$

$cList \leftarrow CreateNewList()$

$\textbf{Traverse}(cList, v_j, score, PRI_{v_j}, label_{v_j}, pathLen)$

$candidates \leftarrow \{candidates \cup cList\}$

$\}\}$

$\mathcal{C} \leftarrow EliminateDuplicates(candidates)$

$\mathcal{C} \leftarrow SortByPathScore(\mathcal{C})$

for $i = 1$ **to** $\sigma_{s,s}$ **do**

$\mathcal{O} = \mathcal{O} \cup PickNextBestCandidate(\mathcal{C})$

Comments on Traverse

- Traverse is a recursive Depth First Search to find **valid paths** (σ_r used to avoid unuseful paths)
- The PRI overlap information, path length, summary sentence and path score are maintained during recursion
  - when v, the node visited, is collapsible, corresponding collapsed candidates are composed with the current path to v
  - the stitched sentence and its final score are added to the list of candidate summaries

Evaluation techniques

- Strong focus on evaluation : BLEU, ROUGE...
- ROUGE metric (Recall-Oriented Understudy for Gisting Evaluation)
  1. Calculates n-gram overlaps between system generated summaries and model summaries (human made)
  2. A high level of overlap should indicate a high level of shared concepts between the two summaries.
  3. Unable to provide any feedback on a summary's coherence

Evaluation techniques

	Relevant	Non-relevant
System relevant	A	B
System non-relevant	C	D

- **Precision** $P = \frac{A}{A+B}$
- **Recall** $R = \frac{A}{A+C}$
- **F-score** $F = \frac{2PR}{P+R}$

Experimental Setup

- Reviews from Tripadvisor.com, Amazon.com and Edmunds.com
  - 51 review documents each about an entity E and a topic X
  - 100 sentencens per review document
  - best 4 reference (human) summaries for each review document
- Performance comparison between humans, Opinosis and the baseline method Mead

Experimental Setup

- For each reference summary compute ROUGE scores over the remaining 4-1=3 reference summaries
- Method MEAD selects 2 most representative sentences as summaries
- Readability test: are Opinosis summaries are readable ?
  - Mix N sentences from system summary and M sentences from human summary
  - Ask a human assessor to pick at most N sentences that are least readable

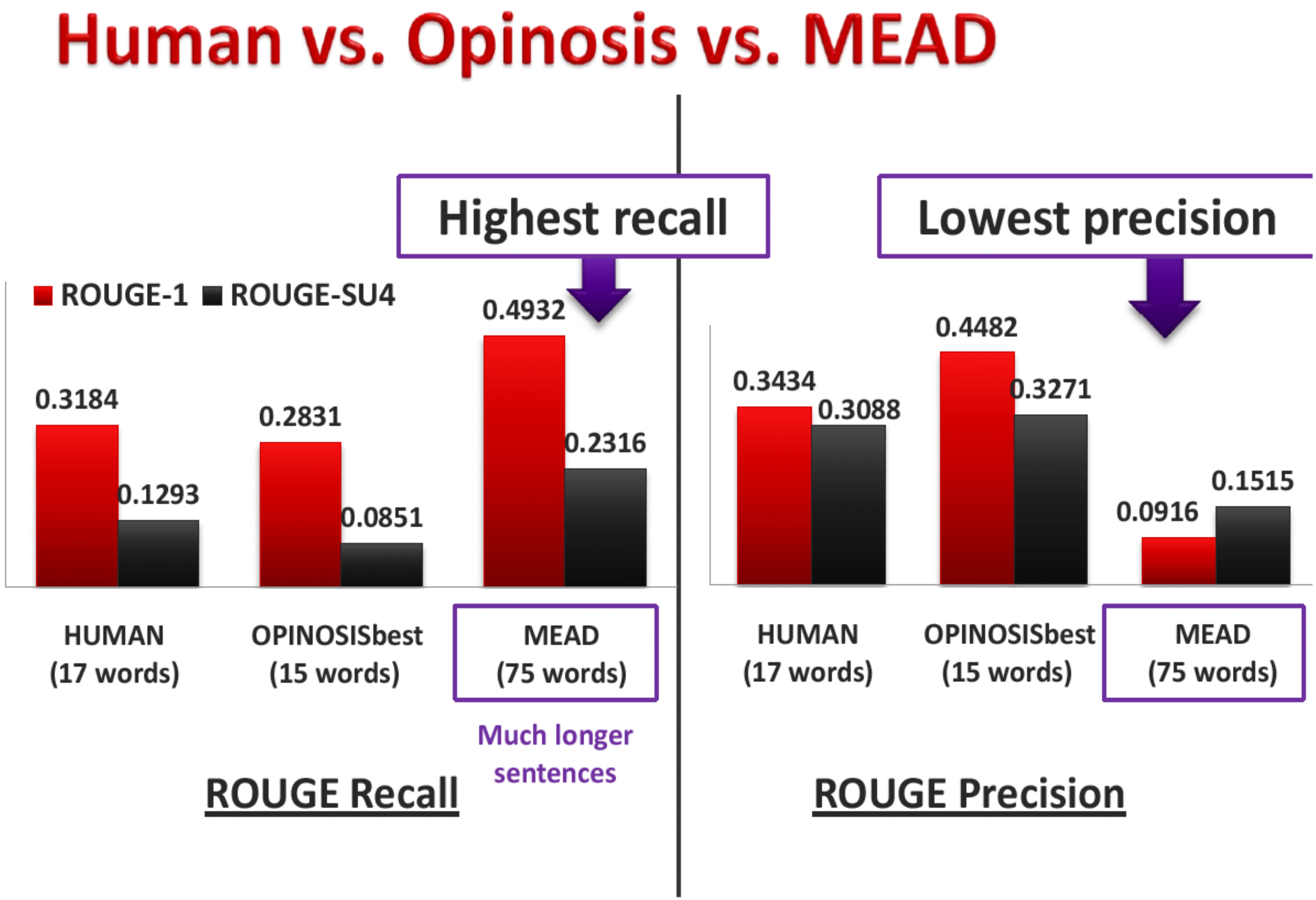
Experimental Setup

- Readability test:

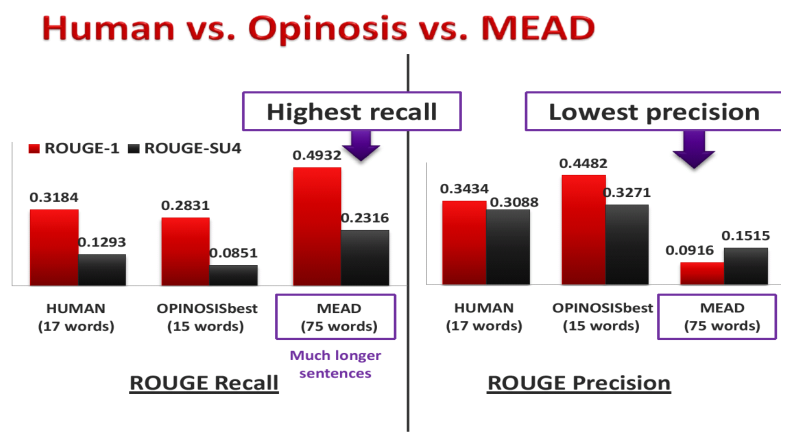
$$readability(\mathcal{O}) = 1 - \frac{\#CorrectPick}{N}$$

- **Opinosis parameters:** $\sigma_{ss} = 2; \sigma_{vsn} = 15$
- $Opinosis_{best}$: $\sigma_{gap} = 4; \sigma_r = 2; S_{wt\_loglen}$
- ROUGE scores reported with the use of stemming and stopword removal

Performance comparison

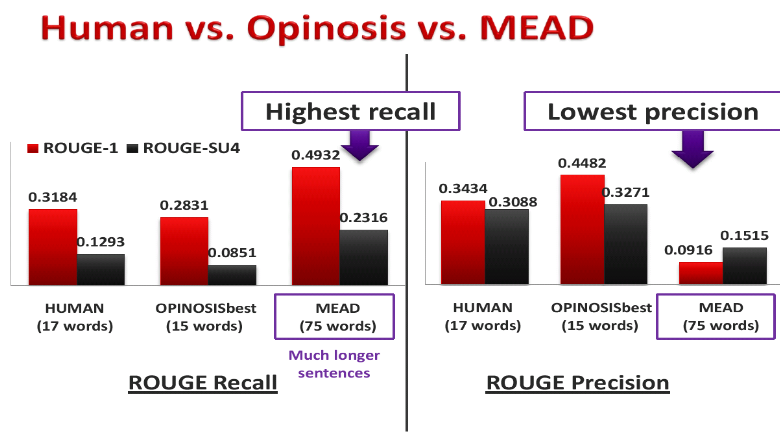


Performance comparison



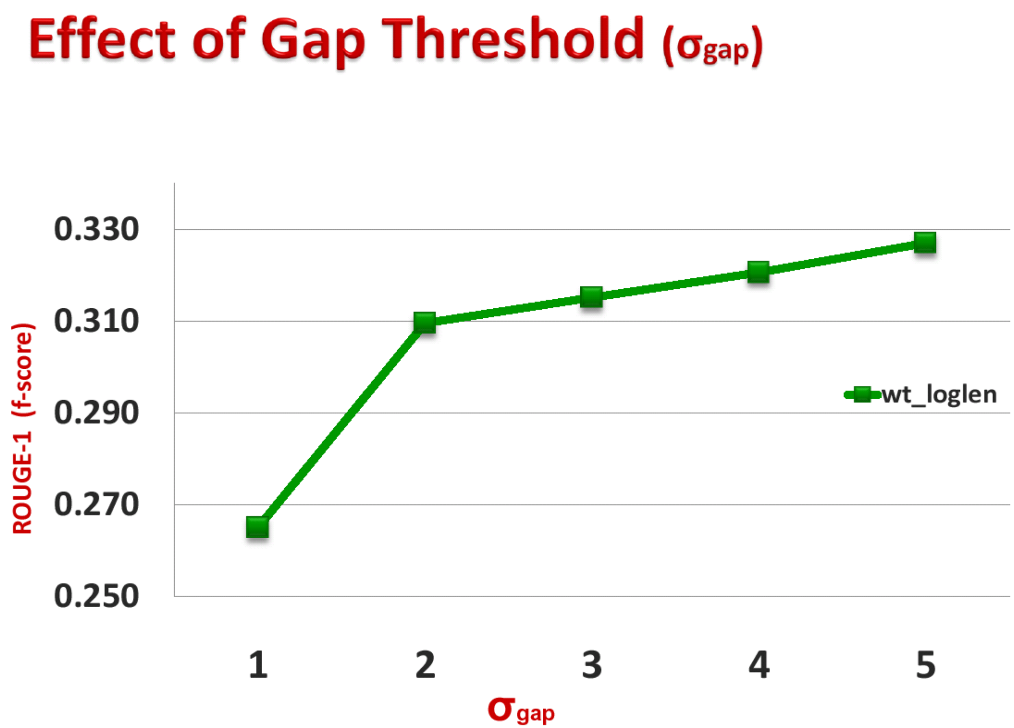
- **Mead :**
  - very high recall scores (explanation: extractive)
  - extremely low precision scores (explanation: sentence extraction)
- **humans**
  - reasonable agreement amongst themselves
  - better than Opinosis
  - comparable to Mead

Performance comparison



- **Opinosis :**
  - closer in performance to humans than to Mead
  - recall scores slightly lower than that achieved by humans
  - improvement of precision by Opinosis over that of humans is more significant than the decrease of recall (Wilcoxon test)

Gap setting

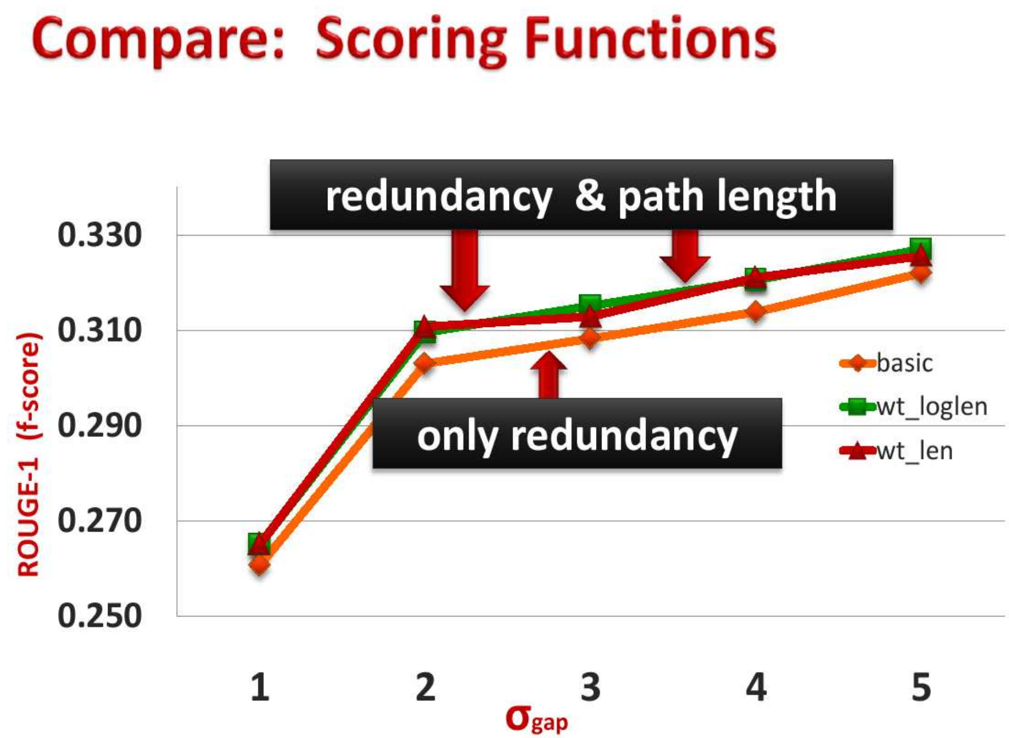


$\sigma_{\mathbf{gap}} = 1$: low performance; redundancies veiled.

$\sigma_{\mathbf{gap}} = 2$: big jump in performance

$\sigma_{\mathbf{gap}} > 2$: slow improving peformance

Comparison of scoring functions



S_{wt_loglen} is the winner !

The effect of heavily favoring redundant subgraphs (S_{basic}) over longer but reasonably redundant ones (S_{wt_loglen}, S_{wt_len}) is not sound.

Readability test

- Human assessor picked the least 2 readable from 565 sentences (102 were Opinosis generated).
- Out of these 102 , the human assessor picked only 34, resulting in an average readability score of 0.67.
- 34 sentences with problems:
  - 11 contained no information, incomprehensible
  - 12 were incomplete (false positives of validity check)
  - 8 had conflicting information (e.g. "the hotel room is clean and dirty").
  - 3 considered "poor grammar"

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My Opinions

Positive Opinions

- **Nice, interesting and simple** approach.
- **Carrying ideas** from sequential data mining.
- Professional evaluation
- Path-aggregation building of a network !
- Adding OPINOSIS to *conference management software systems* (e.g. EasyChair)?

My Opinions

Not quite positive Opinions:

- Gap could change an opinion (Not not).
- Emphasizes too much on the surface order of words (not quite abstractive).
- Shallow NLP must be reward by learning.
- Mathematical inaccuracies in the text.
- Algorithms not optimized for huge corpus.

Opinions ?

Thanks !