Text Summarisation for Evidence Based Medicine

Diego Mollá

Centre for Language Technology,
Macquarie University

IIT Patna, 16 December 2012

Contents

About us: Macquarie University




About us: Centre for Language Technology

`http://www.clt.mq.edu.au`

Core Staff (* involved in the AISRF project)

- Prof. Robert Dale
- * Prof. Mark Johnson
- * A. Prof. Mark Dras
- A. Prof. Steve Cassidy
- * Dr. Diego Molla-Aliod
- Dr. Rolf Schwitter

About Us: Research Group on Natural Language Processing of Medical Texts

`http://web.science.mq.edu.au/~diego/medicalnlp/`

Active Members

Diego Mollá Senior lecturer at Macquarie University.

Abeed Sarker PhD student at Macquarie University.

Sara Faisal Shash Masters student.

Past Members

María Elena Santiago-Martínez Research programmer.

Patrick Davis-Desmond Masters student.

Andreea Tutos Masters student.

About Me: Diego Mollá-Aliod

Some Highlights

- MSc (1992), PhD (1996) University of Edinburgh.
- ExtrAns and WebExtrAns projects at University of Zurich.
- AnswerFinder project and Medical NLP research at Macquarie University.

Research interests

- Question Answering.
- Summarisation.
- Information Extraction.

MACQUARIE UNIVERSITY

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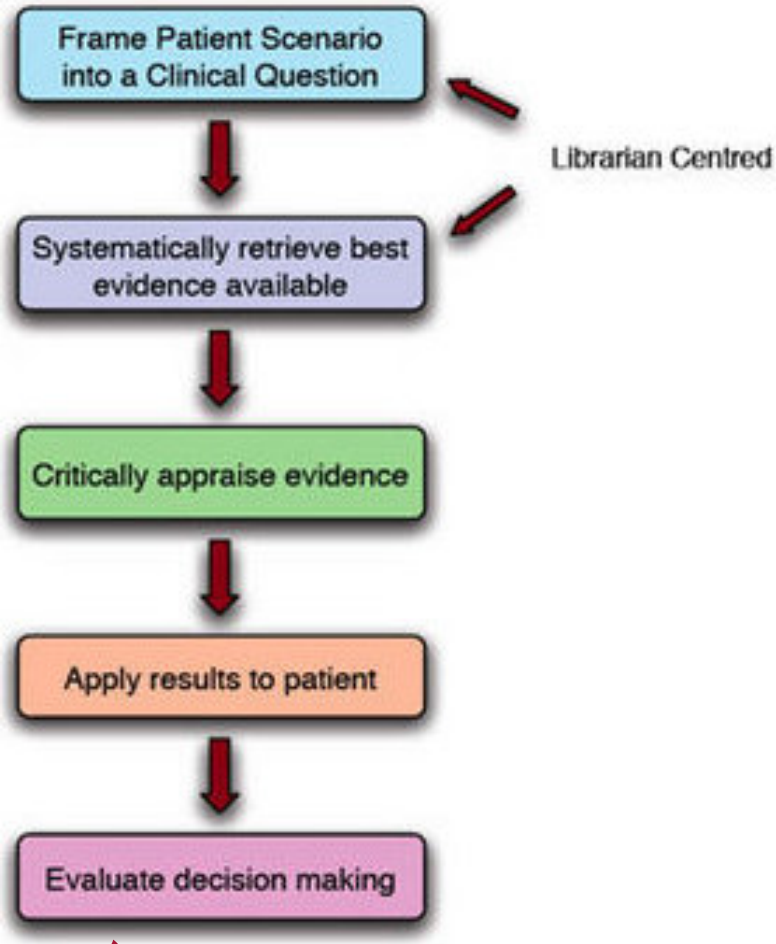
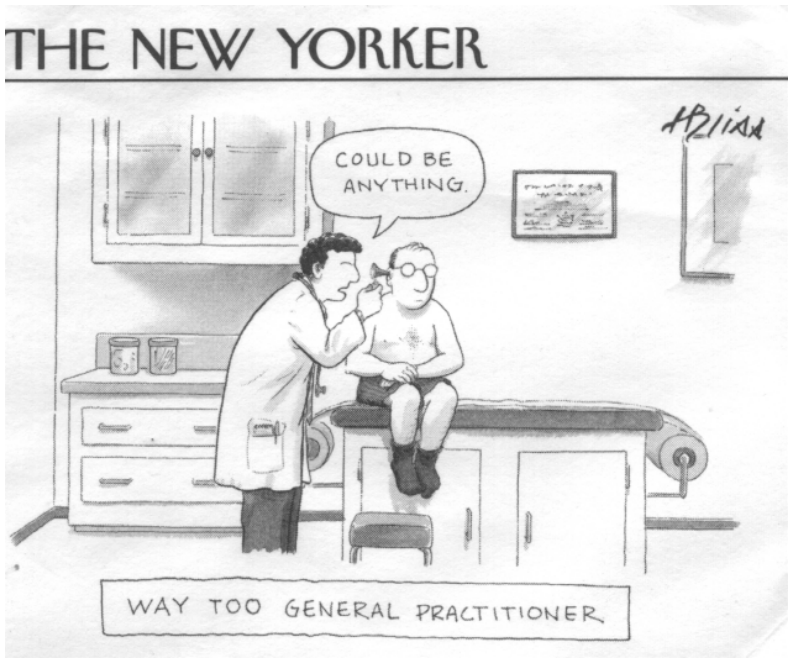
Evidence Based Medicine

http://laikaspoetnik.wordpress.com/2009/04/04/evidence-based-medicine-the-facebook-of-medicine/

Suggested Steps in EBM

http://hlwiki.slais.ubc.ca/index.php?title=Five_steps_of_EBM





PICO for Asking the Right Question

	1	2	3	4
	Patient or Problem	**Intervention** (a cause, prognostic factor, treatment, etc.)	**Comparison Intervention** (if necessary)	**Outcomes**
Tips for Building	Starting with your patient, ask "How would I describe a group of patients similar to mine?" Balance precision with brevity.	Ask "Which main intervention am I considering?"	Ask "What is the main alternative to compare with the intervention?" Again, be specific	Ask "What can I hope to accomplish?", or "What could this exposure really affect?" Again, be specific
Example	"In patients with heart failure from dilated cardiomyopathy who are in sinus rhythm..."	"...would adding anticoagulation with warfarin to standard heart failure therapy..."	"...when compared with standard therapy alone..."	"...lead to lower mortality or morbidity from thromboembolism. Is this enough to be worth the increased risk of bleeding?"

Where to search for external evidence?

1. Evidence-based Summaries (Systematic Reviews):
   - The Cochrane Library (http://www.thecochranelibrary.com/).
   - EBM Online (http://ebm.bmj.com).
   - UptoDate (http://www.uptodate.com).
   - ...

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   - UptoDate (http://www.uptodate.com).
   - ...
2. Search the Medical Literature:
   - E.g. PubMed (http://www.ncbi.nlm.nih.gov/pubmed/).

Searching Cochrane

The Cochrane Collaboration
Working together to provide the best evidence for health care

to The Cochrane Library

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Home › Home

Use the tabs below to filter your search results:

Search

Cochrane Reviews | Colloquia abstracts | Methodology | Newsletters | Policy Manual | Registered titles | Whole site

Enter your keywords:

sleep apnea

Search

Showing results 1 to 10 of 12

Anti-inflammatory drugs for the treatment of obstructive **sleep** ...

Skip to main content Cochrane Summaries **...** Anti-inflammatory drugs for the treatment of obstructive **sleep apnea** in children. **...**

summaries.cochrane.org/CD00707...uctive-sleep-apnea-in-children

Pharmacotherapy for hypertension in adults with obstructive ...

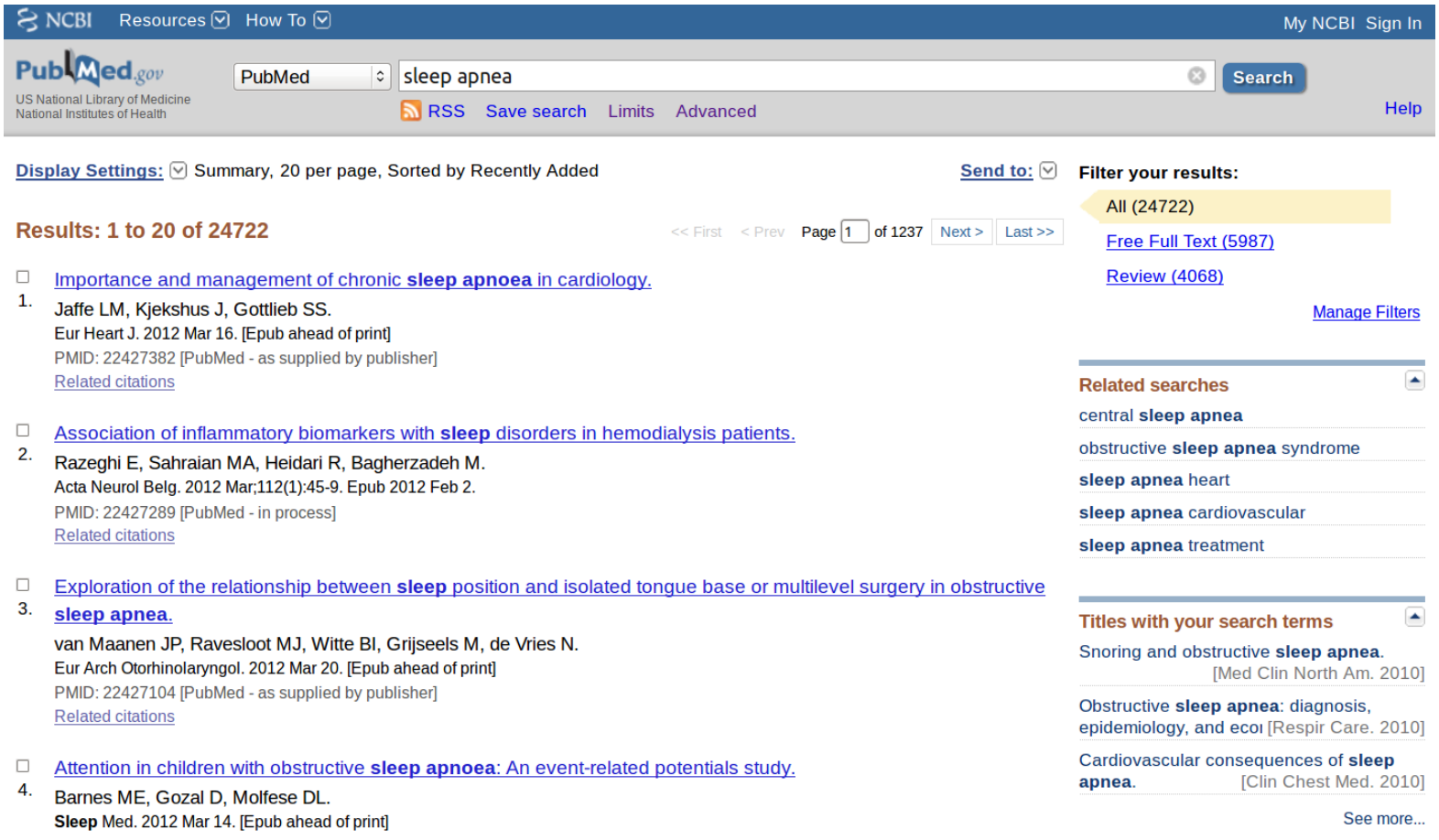
Skip to main content Cochrane Summaries Cochrane Summaries beta. **...** Pharmacotherapy for hypertension in adults with obstructive **sleep apnea**. **...**

summaries.cochrane.org/CD00766...s-with-obstructive-sleep-apnea

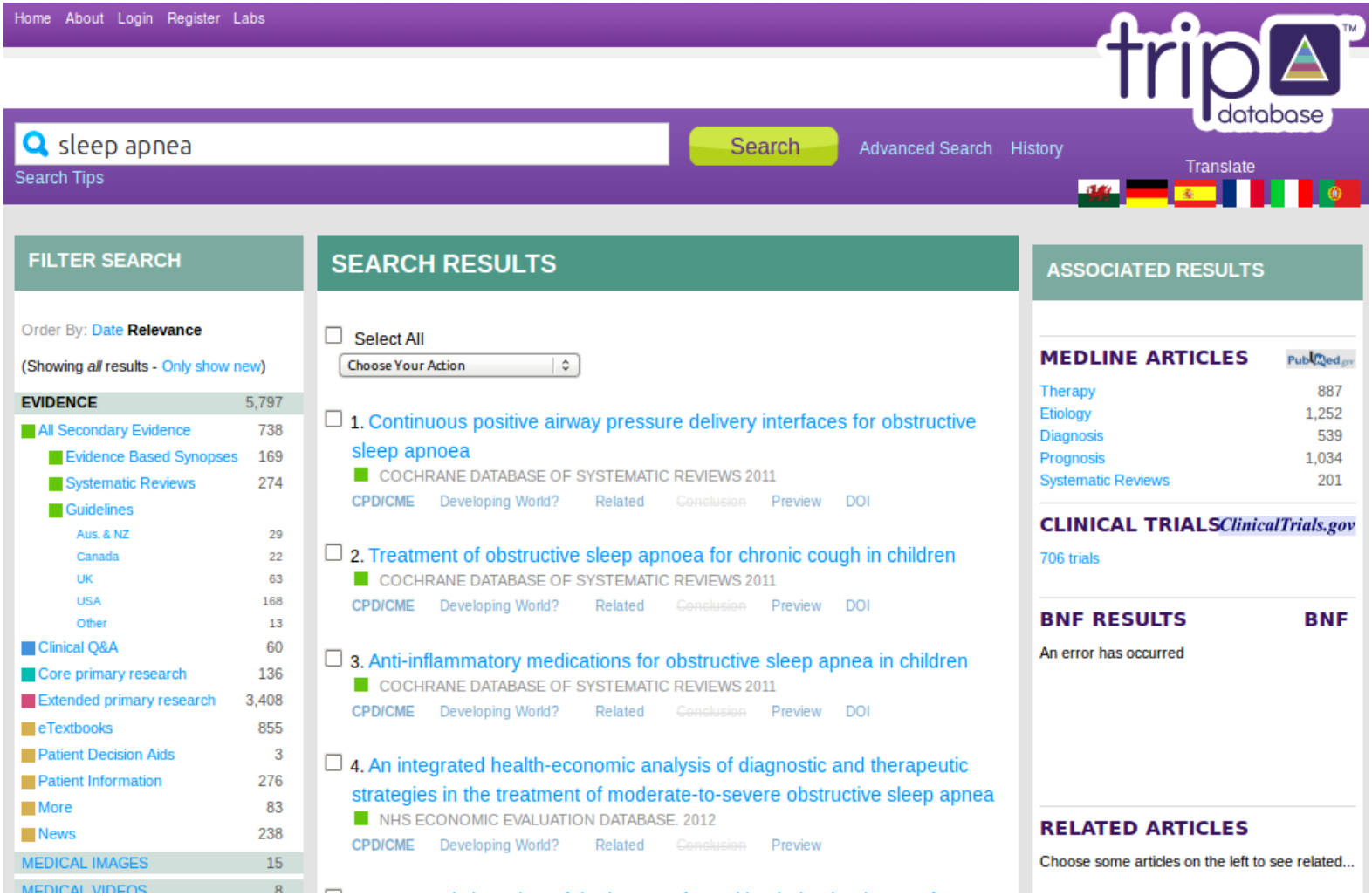
Adenotonsillectomy for obstructive **sleep** apnoea in children | ...

... The Cochrane Library **...** Adenotonsillectomy for obstructive **sleep** apnoea in children. Have your say! 'Your **...**

Searching PubMed



Searching the Trip Database



Appraising the Evidence

The SORT Taxonomy

Level A Consistent and good-quality patient-oriented evidence.

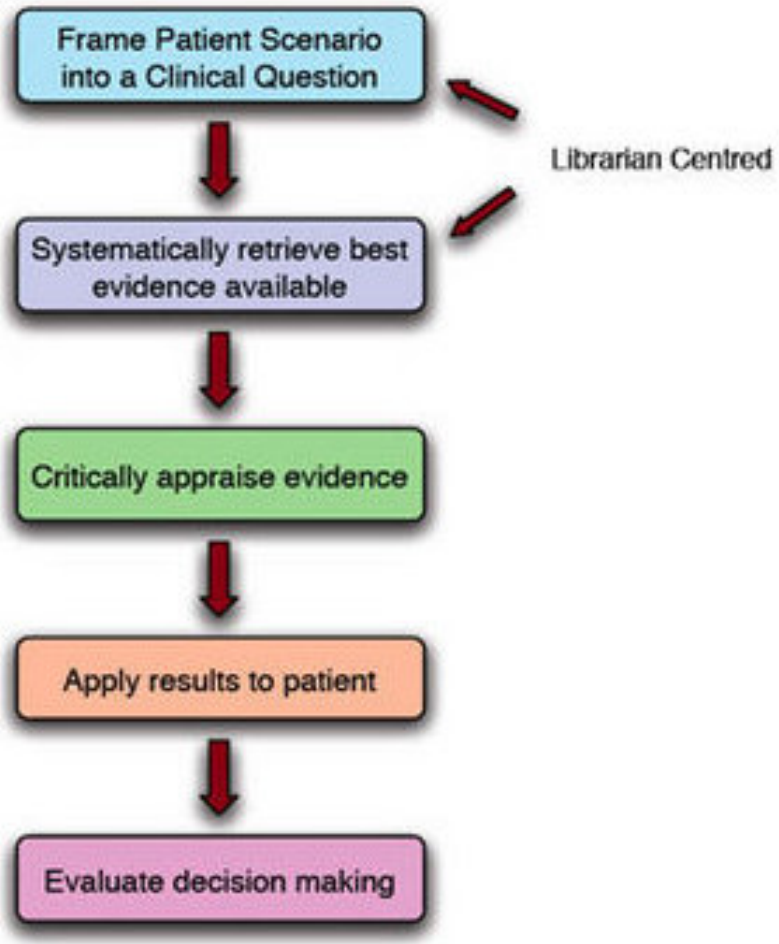
Level B Inconsistent or limited-quality patient-oriented evidence.

Level C Consensus, usual practise, opinion, disease-oriented evidence, or case series for studies of diagnosis, treatment, prevention, or screening.

Contents

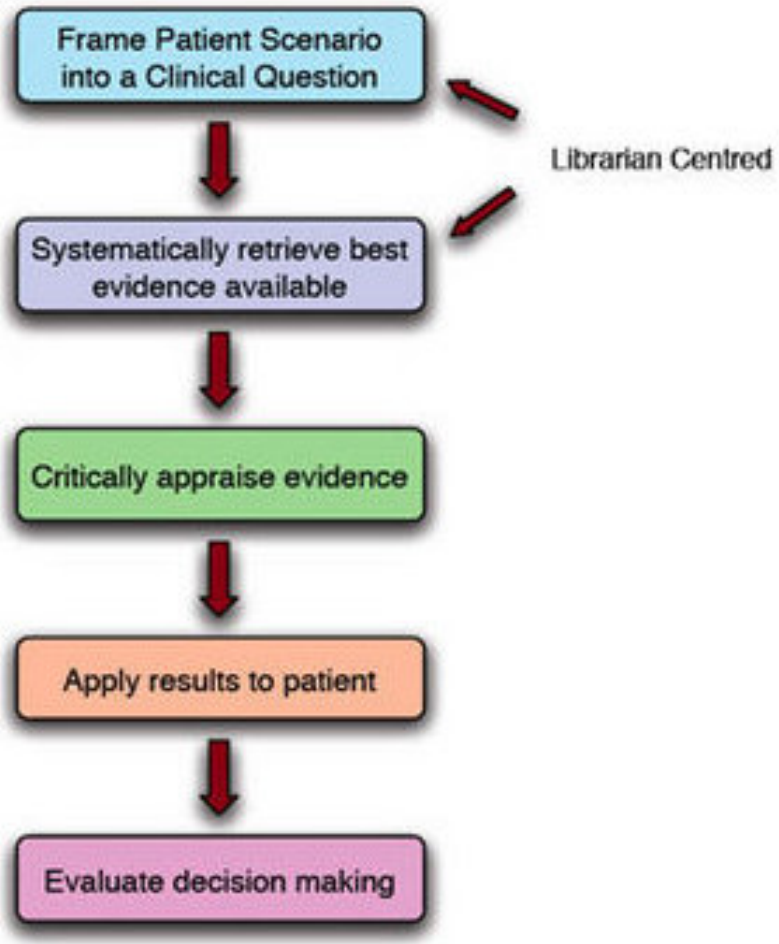
Where can NLP Help?

- Questions:
  - Help formulate answerable questions.
  - From natural question to PICO frames?
  - Question analysis and classification.



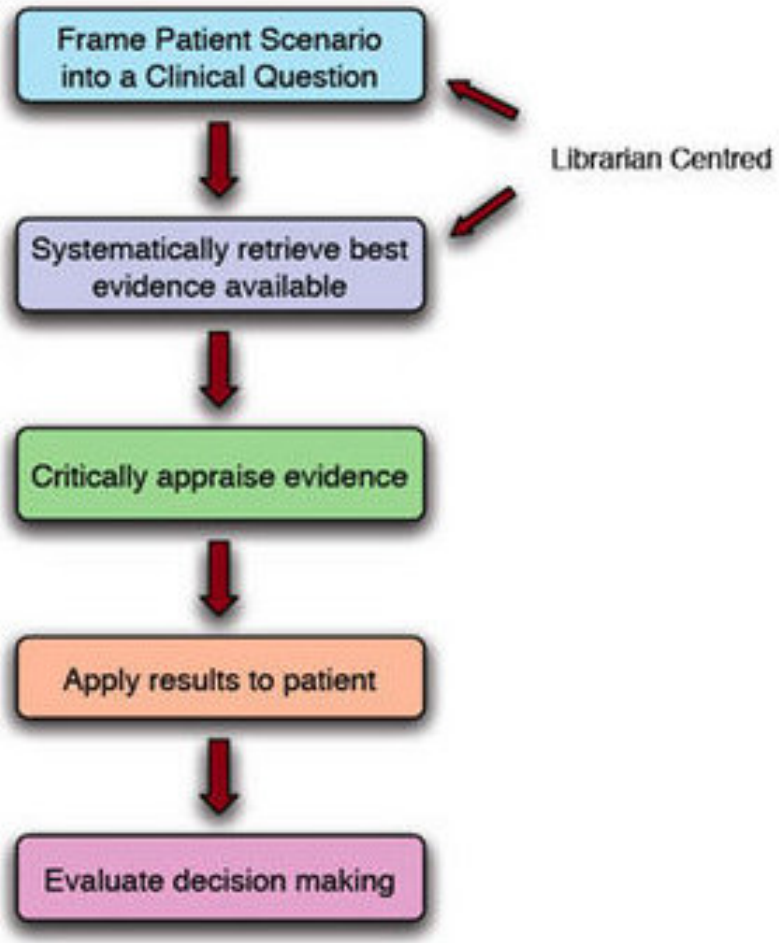
Where can NLP Help?

- Questions:
  - Help formulate answerable questions.
  - From natural question to PICO frames?
  - Question analysis and classification.
- Search:
  - Retrieve and rank relevant literature.
  - Extract the evidence-based information.
  - Summarise the results.



Where can NLP Help? (II)

- Appraisal: Classify the evidence.



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Where's the Corpus for Summarisation?

Summarisation Systems

- CENTRIFUSER/PERSIVAL: Developed and tested using user feedback (iterative design).
- SemRep: Evaluation based on human judgement.
- Demner-Fushman & Lin: ROUGE on original paper abstracts.
- Fiszman: Factoid-based evaluation.

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Corpora

- Several corpora of questions/answers available.
- Answers lack explicit pointers to primary literature.
- Medical doctors want to know the primary sources.

Journal of Family Practice's "Clinical Inquiries"

Which treatments work best for hemorrhoids?

Evidence-based answer

Excision is the most effective treatment for thrombosed external hemorrhoids (strength of recommendation [SOR]: **B**, retrospective studies). For prolapsed internal hemorrhoids, the best definitive treatment is traditional hemorrhoidectomy (SOR: **A**, systematic reviews). Of nonoperative techniques, rubber band ligation produces the lowest rate of recurrence (SOR: **A**, systematic reviews).

Evidence summary

External hemorrhoids originate below the dentate line and become acutely painful with thrombosis. They can cause perianal pruritus and excoriation because of interference with perianal hygiene. Internal hemorrhoids become symptomatic when they bleed or prolapse (TABLE).

For thrombosed external hemorrhoids, surgery works best

Few studies have evaluated the best treatment for thrombosed external hemorrhoids. A retrospective study of 231 patients treated conservatively or surgically found that the 48.5% of patients treated surgically had a lower recurrence rate than the conservative group (number needed to treat [NNT]=2 for recurrence at mean follow-up of 7.6 months) and earlier resolution of symptoms (average 3.9 days compared with 24 days for conservative treatment).[1]

Another retrospective analysis of 340 patients who underwent outpatient excision of thrombosed external hemorrhoids under local anesthesia reported a low recurrence rate of 6.5% at a mean follow-up of 17.3 months.[2]

A prospective, randomized controlled trial (RCT) of 98 patients treated nonsurgically found improved pain relief with a combination of topical nifedipine 0.3% and lidocaine 1.5% compared with lidocaine alone. The NNT for complete pain relief at 7 days was 3.[3]

Conventional hemorrhoidectomy beats stapling

Many studies have evaluated the best treatment for prolapsed hemorrhoids. A Cochrane systematic review of 12 RCTs that compared conventional hemorrhoidectomy with stapled hemorrhoidectomy in patients with grades I to III hemorrhoids found a lower rate of recurrence (follow-up ranged from 6 to 39 months) in patients who had conventional hemorrhoidectomy (NNT=14).[4] Conventional hemorrhoidectomy showed a nonsignificant trend in decreased bleeding and decreased incontinence.

A second systematic review of 25 studies, including some that were of lower quality, showed a higher recurrence rate at 1 year with stapled hemorrhoidectomy than with conventional surgery.[5]

Nonoperative techniques? Consider rubber band ligation

A systematic review of 3 poor-quality trials comparing rubber band ligation with excisional hemorrhoidectomy in patients with grade III hemorrhoids found that excisional hemorrhoidectomy produced better long-term symptom control but more immediate postoperative complications of anal stenosis and hemorrhage.[6] Rubber band ligation had the lowest recurrence rate at 12 months compared with the other nonoperative techniques of sclerotherapy and infrared coagulation.[7]

Fiber supplements help relieve symptoms

A Cochrane systematic review of 7 RCTs enrolling a total of 378 patients with grade I to III hemorrhoids evaluated the effect of fiber supplements on pain, itching, and bleeding. Persistent hemorrhoid symptoms decreased by 53% in the group receiving fiber.[8]

When surgical hemorrhoidectomy is recommended

The American Society of Colon and Rectal Surgeons recommends adequate fluid and fiber intake for all patients with symptomatic hemorrhoids. For grade I to III hemorrhoids, the society states that banding is usually most effective. When office treatments fail, the society recommends surgical hemorrhoidectomy (SOR: **B**).

The society recommends excision of thrombosed hemorrhoids less than 72 hours old and expectant treatment with hemorrhoids that present early. Surgical hemorrhoidectomy should be reserved for when conservative treatment fails and for patients with symptomatic grade III and IV hemorrhoids.[10] ■

TABLE

Classification of sympto internal hemorrhoid

GRADE	DESCRIPTION
I	Hemorrhoids do not protru
II	Hemorrhoids protrude wit reduce spontaneously
III	Hemorrhoids protrude and by hand
IV	Hemorrhoids are permane

Source: Madoff RD, et al. *Gastroenterology.* 2004.[10]

References

1. Greenspon J, Williams SB, Young HA, et al. Thrombosed external hemorrhoids: outcome after conservative or surgical management. *Dis Colon Rectum.* 2004;47:1493-1498.
2. Jongen J, Bach S, Stubinger SH, et al. Excision of thrombosed external hemorrhoids under local anesthesia: a retrospective evaluation of 340 patients. *Dis Colon Rectum.* 2003;46:1226-1231.
3. Perrotti P, Antropoli C, Molino D, et al. Conservative treatment of acute thrombosed external hemorrhoids with topical nifedipine. *Dis Colon Rectum.* 2001;44:405-409.
4. Jayaraman S, Colquhoun PH, Malthaner RA. Stapled versus conventional surgery for hemorrhoids. *Cochrane Database Syst Rev.* 2006;(4):CD005393.
5. Tjandra JJ, Chan MK. Systematic review on the procedure for prolapse and hemorrhoids (stapled hemorrhoidopexy). *Dis Colon Rectum.* 2007;50:878-892.
6. Shanmugam V, Thaha MA, Rabindranath KS, et al. Systematic review of randomized trials comparing rubber band ligation with excisional haemorrhoidectomy. *Br J Surg.* 2005;92:1481-1487.
7. Johanson JF, Rimm A. Optimal nonsurgical treatment of hemorrhoids: a comparative analysis of infrared coagulation, rubber band ligation, and injection sclerotherapy. *Am J Gastroenterol.* 1992;87:1600-1606.
8. Alonso-Coello P, Guyatt G, Heels-Ansdell D, et al. Laxatives for the treatment of hemorrhoids. *Cochrane Database Syst Rev.* 2005(4):CD004649.

The XML Contents I

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<record id="7843">
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    <sniptext>Excision is the most effective treatment for thrombosed
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    <long id="1_1">
      <longtext>A retrospective study of 231 patients treated
       conservatively or surgically found that the 48.5% of patients
       treated surgically had a lower recurrence rate than the
       conservative group (number needed to treat [NNT]=2 for
       recurrence at mean follow-up of 7.6 months) and earlier
       resolution of symptoms (average 3.9 days compared with 24 days
       for conservative treatment).</longtext>
      <ref id="15486746" abstract="Abstracts/15486746.xml">Greenspon
       J, Williams SB, Young HA ,et al. Thrombosed external
       hemorrhoids: outcome after conservative or surgical
       management. Dis Colon Rectum. 2004; 47: 1493-1498.</ref>
    </long>
    <long id="1_2">
      <longtext>A retrospective analysis of 340 patients who underwent
       outpatient excision of thrombosed external hemorrhoids under
       local anesthesia reported a low recurrence rate of 6.5% at a
```

The XML Contents II

```
        mean follow-up of 17.3 months.</longtext>
        <ref id="12972967" abstract="Abstracts/12972967.xml">Jongen J,
        Bach S, Stubinger SH ,et al. Excision of thrombosed external
        hemorrhoids under local anesthesia: a retrospective evaluation
        of 340 patients. Dis Colon Rectum. 2003; 46: 1226-1231.</ref>
      </long>
      <long id="1_3">
        <longtext>A prospective, randomized controlled trial (RCT) of 98
        patients treated nonsurgically found improved pain relief with a
        combination of topical nifedipine 0.3% and lidocaine 1.5% compared
        with lidocaine alone. The NNT for complete pain relief at 7 days was
        3.</longtext>
        <ref id="11289288" abstract="Abstracts/11289288.xml">Perrotti P,
        Antropoli C, Molino D ,et al. Conservative treatment of acute
        thrombosed external hemorrhoids with topical nifedipine. Dis
        Colon Rectum. 2001; 44: 405-409.</ref>
      </long>
    </snip>
  </answer>
  </record>
```

Components of the Corpus

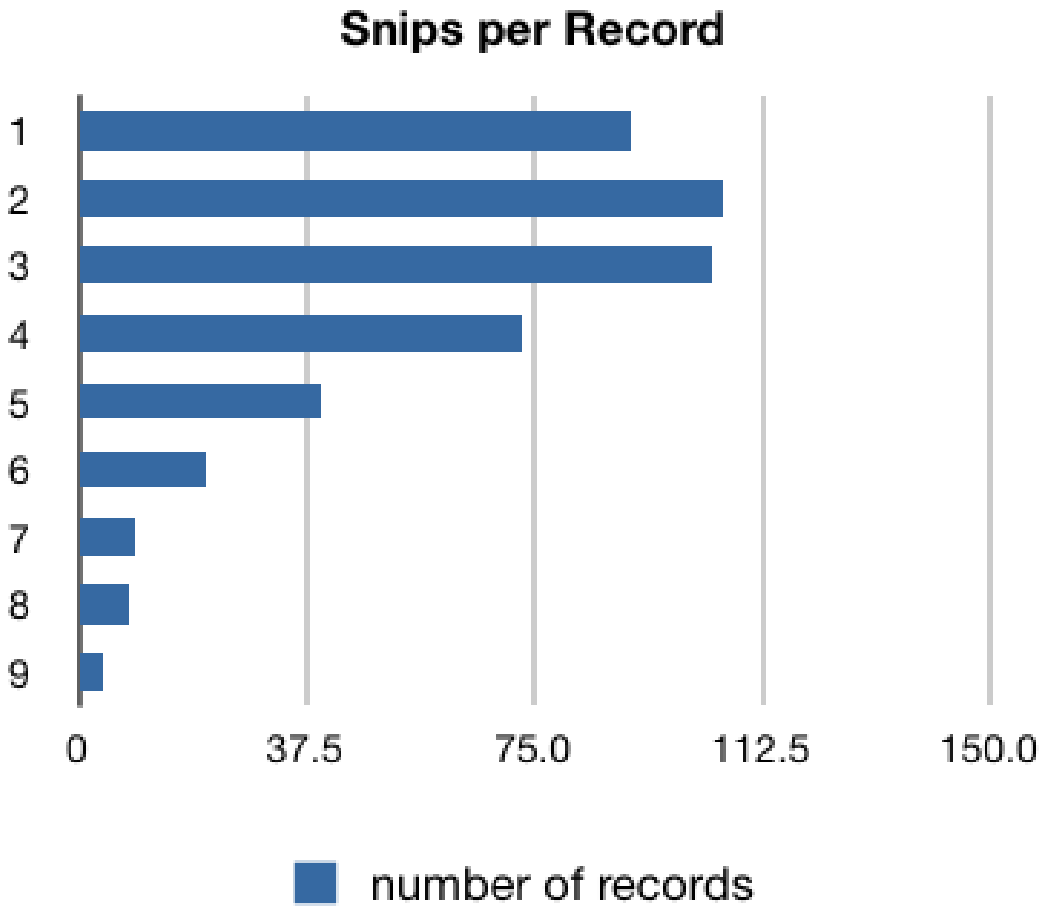
Question	Direct extract from the source.
Answer	Split from the source and manually checked.
Evidence	Extracted from the source.
Additional text	Manually extracted from the source and massaged.
References	PMID looked up in PubMed (automatic and manual procedure).

Corpus Statistics

Size

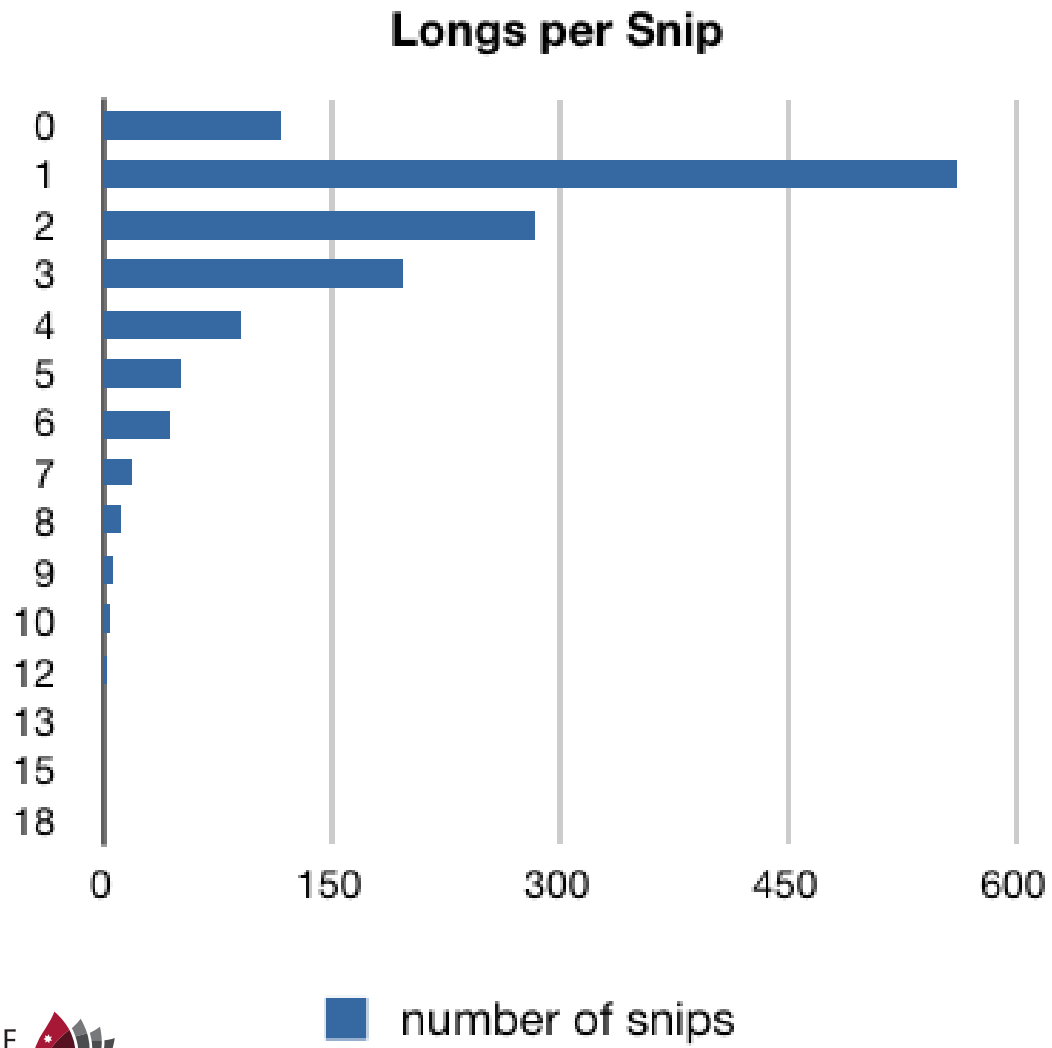
- 456 questions ("records").
- 1,396 answer parts ("snips").
- 3,036 answer justifications ("longs").
- 3,705 references:
  - 2,908 unique references.
  - 2,657 XML abstracts from PubMed.

Answer parts per Question



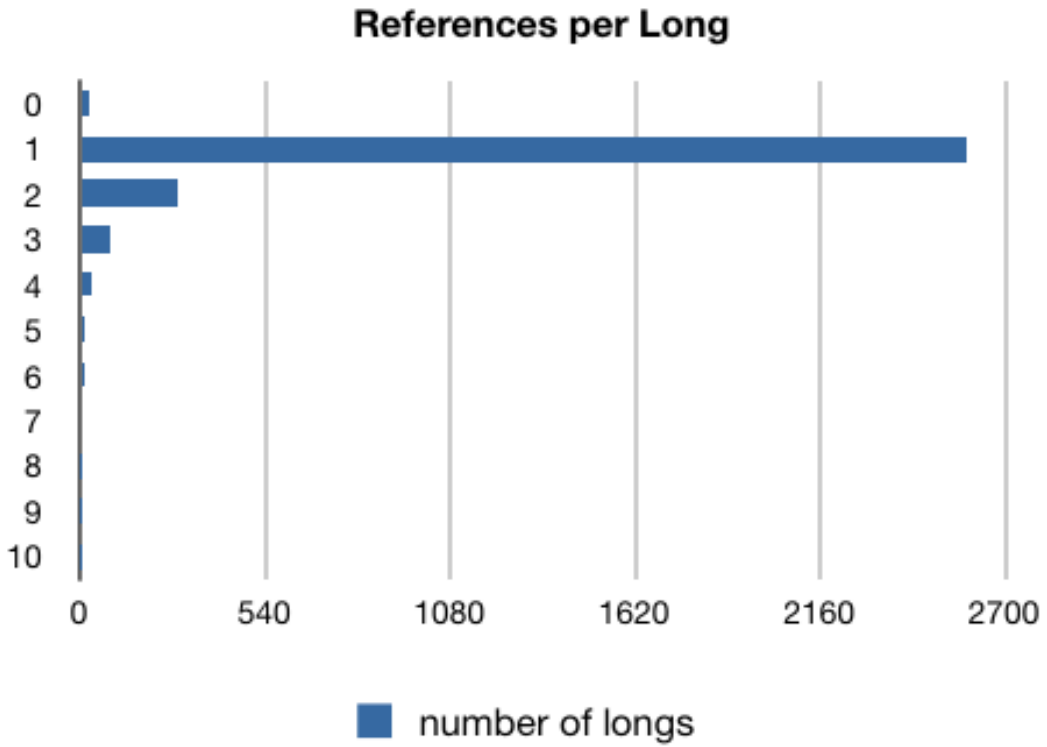
Avg=3.06

Answer justifications per answer part



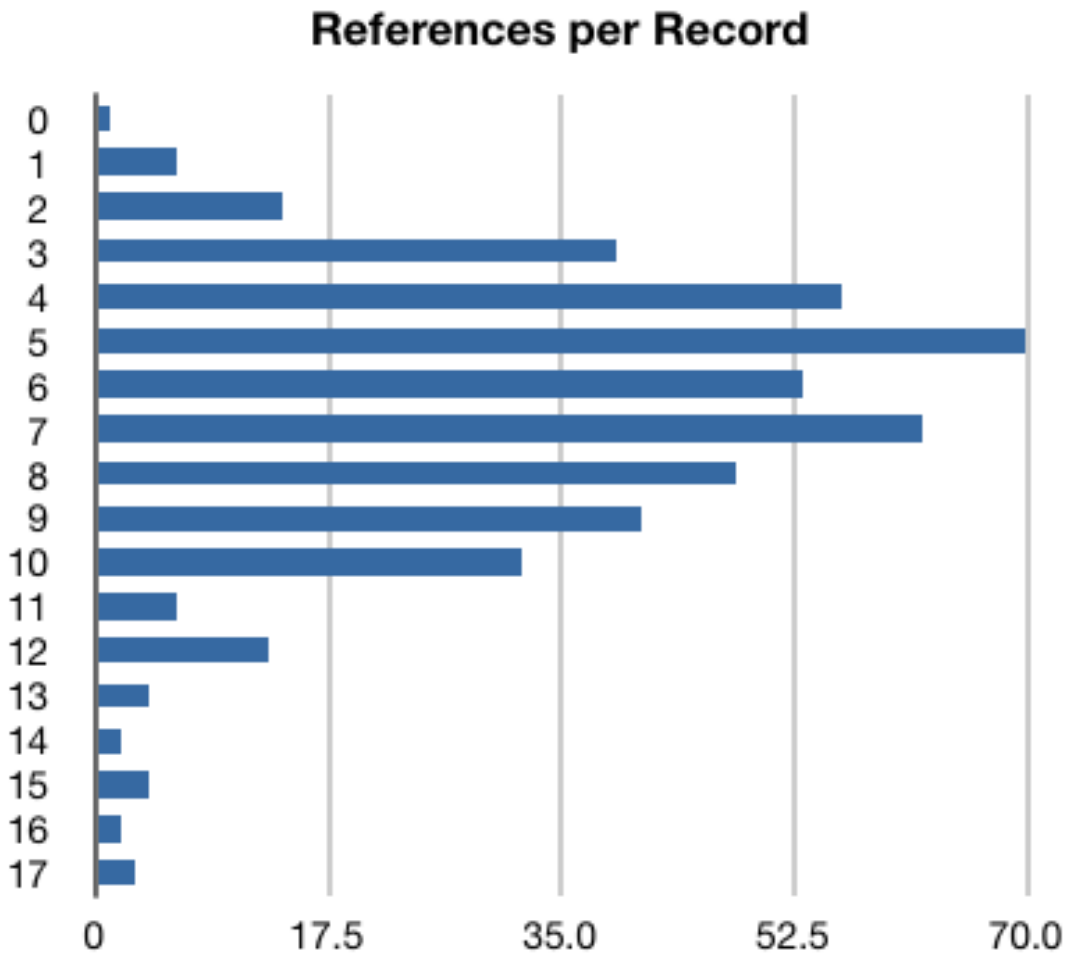
Avg=2.17

References per answer justification



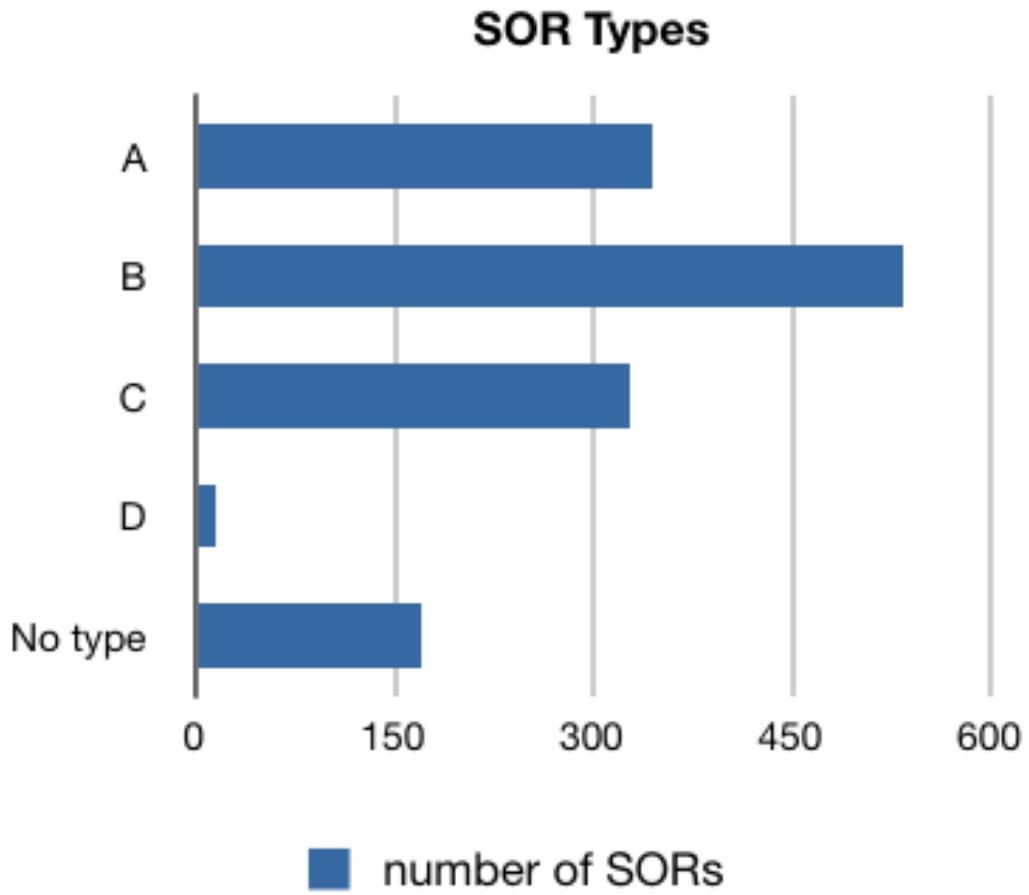
Avg=1.22

References per question



Avg=6.57

Evidence Grade



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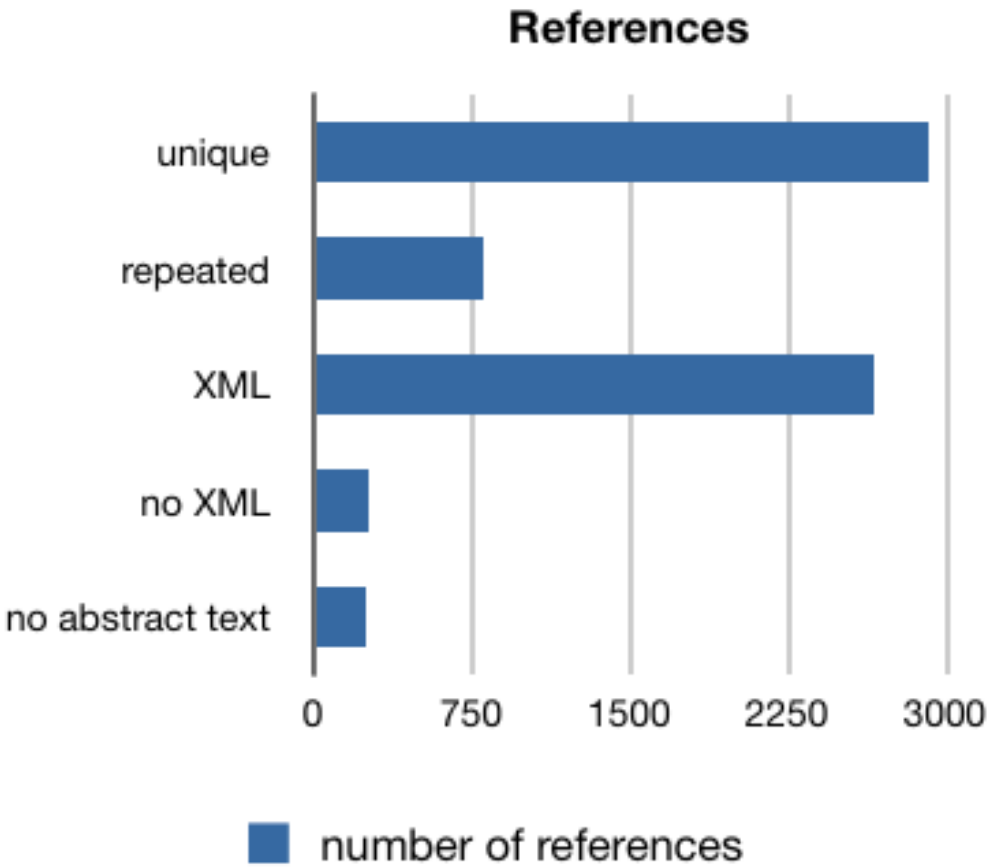
References
unique
repeated
XML
no XML
no abstract text
0
750
1500
2250
3000
number of references

Contents

What is Document Summarisation

Summarisation (or automatic abstracting)

A summary is a text that is produced from one or more texts, that contains a significant portion of the information of the original text(s), and that is no longer than half of the original text(s). (Hovy, 2003)

What is Document Summarisation Good For?

What for?

- For busy people to read the summary instead of the full text.

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- For researchers, web surfers, ... to read the summary to decide if it is worth to read the original text.

What is Document Summarisation Good For?

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- For busy people to read the summary instead of the full text. → informative summary
- For researchers, web surfers, ... to read the summary to decide if it is worth to read the original text. → indicative summary

What is Document Summarisation Good For?

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- For busy people to read the summary instead of the full text. → informative summary
- For researchers, web surfers, ... to read the summary to decide if it is worth to read the original text. → indicative summary
- To avoid having to type out an abstract for a technical report when the publisher requests it.

What is Document Summarisation Good For?

What for?

- For busy people to read the summary instead of the full text. → informative summary
- For researchers, web surfers, . . . to read the summary to decide if it is worth to read the original text. → indicative summary
- To avoid having to type out an abstract for a technical report when the publisher requests it. → not realistic

Examples I

Original Text

Abraham Lincoln was born in Kentucky on February 12th, 1809. His family moved to Indiana when he was eight years old. His mother died when he was ten. Abraham Lincoln loved to read. He only went to school for a few months. He had to study and learn on his own. From his childhood, Abraham Lincoln was known as a hard worker. He worked on a farm and in a store and on a boat. He studied law and practiced for many years in Illinois. He married Mary Todd Lincoln. Together they had four sons. Abraham Lincoln was elected as the 16th President of the United States in 1860. He did many things as President. Many people think he was the best American President of all time. He is most remembered for freeing the slaves. He was President of the United States during the time the Civil War was fought. The Civil War was fought between the Northern and Southern states. He was known as a great speaker. Some of his most famous speeches include the Emancipation Proclamation - in which he freed the slaves - and the Gettysburg Address, which starts "Four score and seven years ago ..." While attending a play on April 14th, 1865, Abraham Lincoln was shot by John Wilkes Booth. Lincoln died the next morning. Lincoln's birthday is celebrated in February of each year.

Examples II

Word's Autosummarize

Abraham Lincoln was born in Kentucky on February 12th, 1809.

Abraham Lincoln loved to read.

Abraham Lincoln was elected as the 16th President of the United States in 1860.

The Civil War was fought between the Northern and Southern states.

While attending a play on April 14th, 1865, Abraham Lincoln was shot by John Wilkes Booth.

Lincoln died the next morning.

MEAD

Abraham Lincoln was born in Kentucky on February 12th 1809.

His family moved to Indiana when he was eight years old.

From his childhood Abraham Lincoln was known as a hard worker.

Abraham Lincoln was elected as the 16th President of the United States in 1860.

While attending a play on April 14th 1865 Abraham Lincoln was shot by John Wilkes Booth.

An Ideal Document Summarisation System

Understanding Stage

Document(s) $\rightarrow$ Knowledge base

An Ideal Document Summarisation System

Understanding Stage

Document(s) $\rightarrow$ Knowledge base

Generation Stage

Knowledge base $\rightarrow$ Summary

A Compromise Solution

Sentence Extraction

Document $\rightarrow$ Sentence candidates

A Compromise Solution

Sentence Extraction

Document → Sentence candidates

Cohesion Check

Sentence candidates → Coherent text

A Compromise Solution

Sentence Extraction

Document → Sentence candidates

Cohesion Check

Sentence candidates → Coherent text

Balance and Coverage

Coherent text → Summary

A Compromise Solution

Sentence Extraction

Document → Sentence candidates

This is what most commercial and free summarisers do

Cohesion Check

Sentence candidates → Coherent text

Balance and Coverage

Coherent text → Summary

Contents

General Approach

For each sentence ...

1. Look for clues to its importance.
2. Compute a score for the sentence based on the clues found.
3. Select all sentences whose scores exceed some threshold.
   - Or select the highest scoring sentences up to a certain total.

The Frequency-keyword Approach

1. Compute the keywords of the document:
   - Ignore the function words by using a stop word list.
   - Sort all remaining words according to frequency or measures such as *tf*.*idf* (next slide).
   - Select the top words (say, the top 5%).

The Frequency-keyword Approach

1. Compute the keywords of the document:
   - Ignore the function words by using a stop word list.
   - Sort all remaining words according to frequency or measures such as $tf.idf$ (next slide).
   - Select the top words (say, the top 5%).
2. Score the document sentences according to the presence of keywords:
   - Simple keyword count.
   - Weighted keyword count (keyword weights for each sentence).
   - Looking for keyword clusters in the sentence.

Finding Most Informative Sentences

tf .idf to find keywords

- Term Frequency (*tf*): Words that are very frequent in a document are more "important".

$$tf(w) = \#\text{ times word } w \text{ is in document}$$

- Inverse Document Frequency (*idf*): Words that appear in many documents are less "important".

$$idf(w) = \log \frac{\#\text{ documents}}{\#\text{ documens that contain word } w}$$

The Biased Keyword Approach

Title and headings biased

Compute a list of keywords on the basis of document structure:

- select candidates from titles and headings only, or
- candidates from titles and headings have more importance:
  - e.g. they are counted as being more frequent.

The Biased Keyword Approach

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- candidates from titles and headings have more importance:
  - e.g. they are counted as being more frequent.

Query biased (customised summaries)

Use the user's query to determine the keyword's weights:

- the user's query determines all the keywords, or
- the user's query introduces additional keywords or updates the weights of existing keywords.

The Location Method

Observation

First and last sentence of a paragraph are usually most central to the theme of a text.

Increase the score of a sentence according to its position in the paragraph:

- Beginning of paragraph.
- End of paragraph.

Cues, Indicator Phrases I

Cues

- Certain words (not necessarily keywords) provide an indication of the importance of the sentence.
- Use these words to determine the sentence score:
  - bonus words increase the sentence score:
    - "greatest", "significant"
  - stigma words decrease the sentence score:
    - "hardly", "impossible", "now"

Cues, Indicator Phrases II

Indicator Phrases

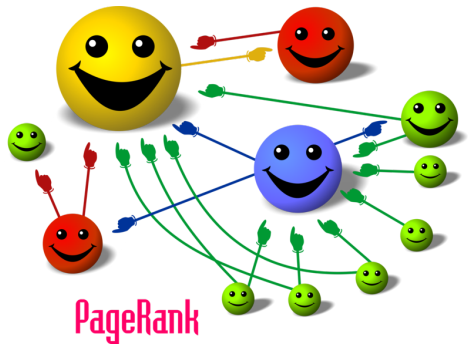
Indicator phrases are specific phrases or patterns of phrases that can be used to determine the sentence importance:

- "The main aim of the present paper is ..."
- "The purpose of this article is ..."
- "In this report, we outline ..."
- "Our investigation has shown that ..."

Relational Criteria

1. Build a semantic structure for the document:
   - sentences are vertices
   - inter-sentence links are edges
     - Rhetorical links (ellaboration, sequence, etc)
     - Cooccurrence of keywords
     - ...
2. Use the link structure to determine the most important sentences

- Degree of the vertex
- Eigenvalues (PageRank style)



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Textual Cohesion

- Lack of cohesion results in "odd" extracts.
- Sentences include references to other sentences:
  - Anaphoric reference:
  - "John saw Mary. *She* was talking over the phone"
  - Rhetorical connectives:
  - " *So*, the following example . . ."
  - Lexical or definite reference:
  - "I saw a man with a book. *The book* was . . ."
- Possible solutions:

Aggregation Add preceding sentences until there are no external references.

Deletion Remove the difficult sentences.

Modification Alter the sentences to eliminate or disguise the problem.

Contents

Balance and Coverage

- We need to process the selected sentences in order to produce a real abstract:
  - Delete redundant sentences.
  - Harmonise tense and voice of verbs.
  - Ensure balance and proper coverage.
- Combination of information extraction and text generation.
- Need to consider text structure:
  - Each sentence plays a role in the text and in relation with the other sentences.
- Problem to address:
  - Lack of balance and coverage:
    - Missing important information.
    - Too much emphasis on less important information.

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Single-document Summarisation

Input

- Question.
- Document Abstract.

Output

- Extractive summary that answers the question.
- Target summary is the annotated answer justification ("long").
- Evaluated using ROUGE-L with Stemming.

General Approach (Sarker et al., CBMS 2012)

In a Nutshell

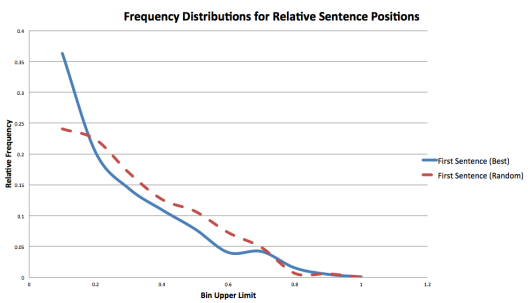
1. Gather statistics from the best 3-sentence extracts.
   - Exhaustive search to find these best extracts.
2. Build three classifiers, one per sentence in the final extract.
   - Classifier 1 based on statistics from best 1st sentence.
   - Classifier 2 based on statistics from best 2nd sentence.
   - Classifier 3 based on statistics from best 3rd sentence.

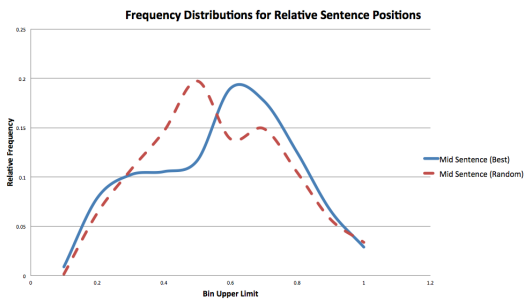
The Statistics Gathered

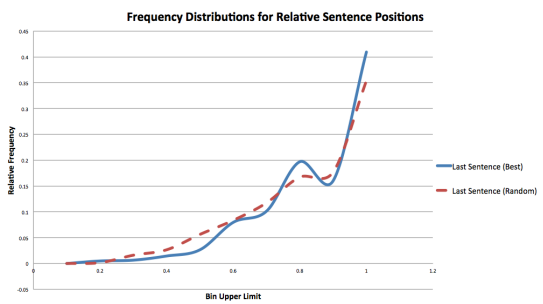
1. Source sentence position.
2. Sentence length.
3. Sentence similarity.
4. Sentence type.

1. Source Sentence Position

- Compute relative positions $(0 \ldots 1)$.
- Create normalised frequency histograms $f_1, f_2, \ldots, f_{10}$.
- Score every relative position in bin i with its bin frequency: $S_{pos}(i) = f_{bin(i)}$.







2. Sentence Length

Reward larger sentences and penalise shorter sentences:

Normalised sentence length

$$S_{len}(i) = \frac{l_s - l_{avg}}{l_d}$$

l_s: sentence length

l_{avg}: average sentence length in the corpus

l_d: document length

3. Sentence Similarity

Sentence Similarity

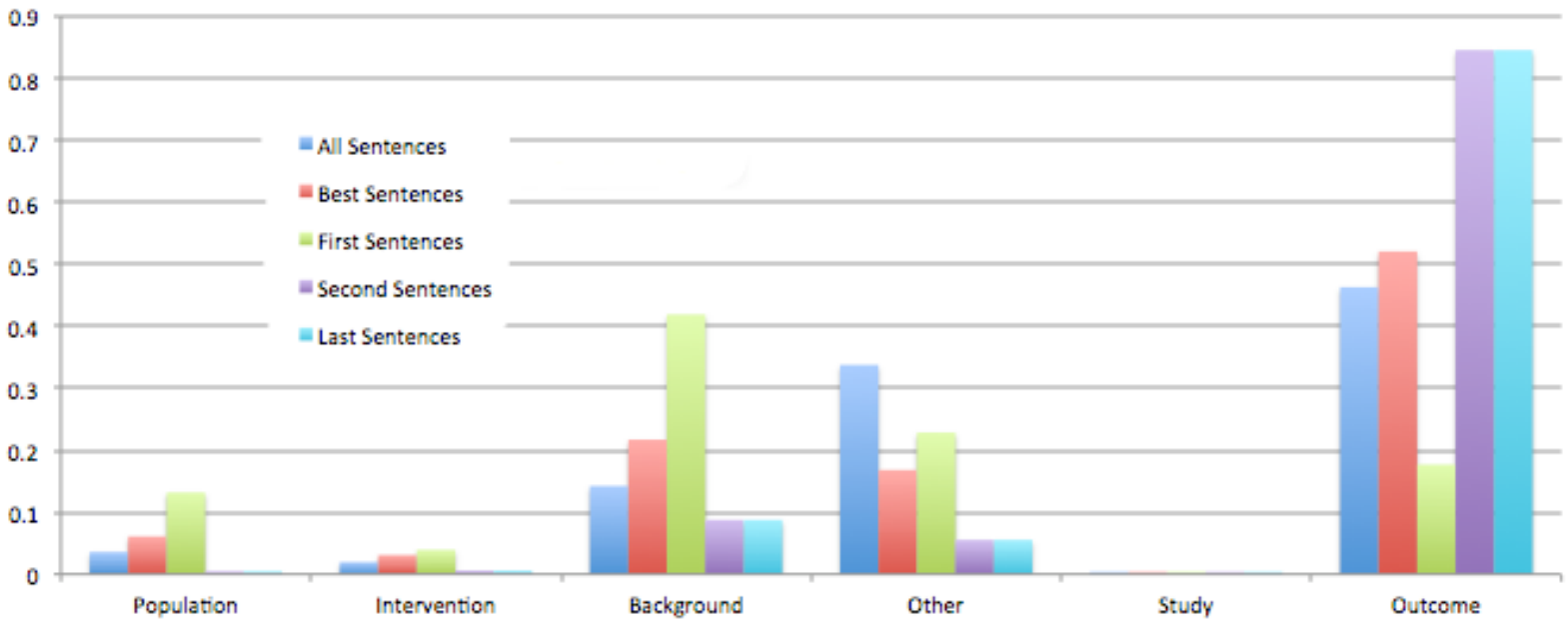
- Lowercase, stem, remove stop words.
- Build vector of $tf.idf$ with remaining words and UMLS semantic types.
- $CosSim(X, Y) = \frac{X.Y}{|X||Y|}$

Maximal Marginal Relevance (Carbonell & Goldstein, 1998)

Reward sentences similar to the query and penalise those similar to other summary sentences.

$$MMR = \lambda(CosSim(S_i, Q)) - (1-\lambda) max_{S_j \epsilon S}(CosSim(S_i, S_j))$$

4. PIBOSO (Kim et al. 2011) I



1. Classify all sentences into PIBOSO types (a variant of PICO).
2. Generate normalised frequency histograms of resulting PIBOSO types.

4. PIBOSO (Kim et al. 2011) II

Position independent

$$S_{PIPS}(i) = \frac{P_{best}}{P_{all}}$$

Position dependent

$$S_{PDPS}(i) = \frac{P_{pos}}{P_{best}}$$

P_{best}: proportion of this PIBOSO type among all best summary sentences.

P_{all}: proportion of this PIBOSO type among all sentences.

P_{pos}: proportion of this PIBOSO type among all best summary sentences at this position.

Classification

Edmunsonian Formula

$$S_{S_i} = \alpha S_{rpos_i} + \beta S_{len_i} + \gamma S_{PIPS_i} + \delta S_{PDPS_i} + \epsilon S_{MMR_i}$$

- MMR is replaced with cosine similarity for first sentence.
- In case of ties, the sentence with greatest length is chosen.
- Parameters are fine-tuned through exhaustive search (grid search) using training set.

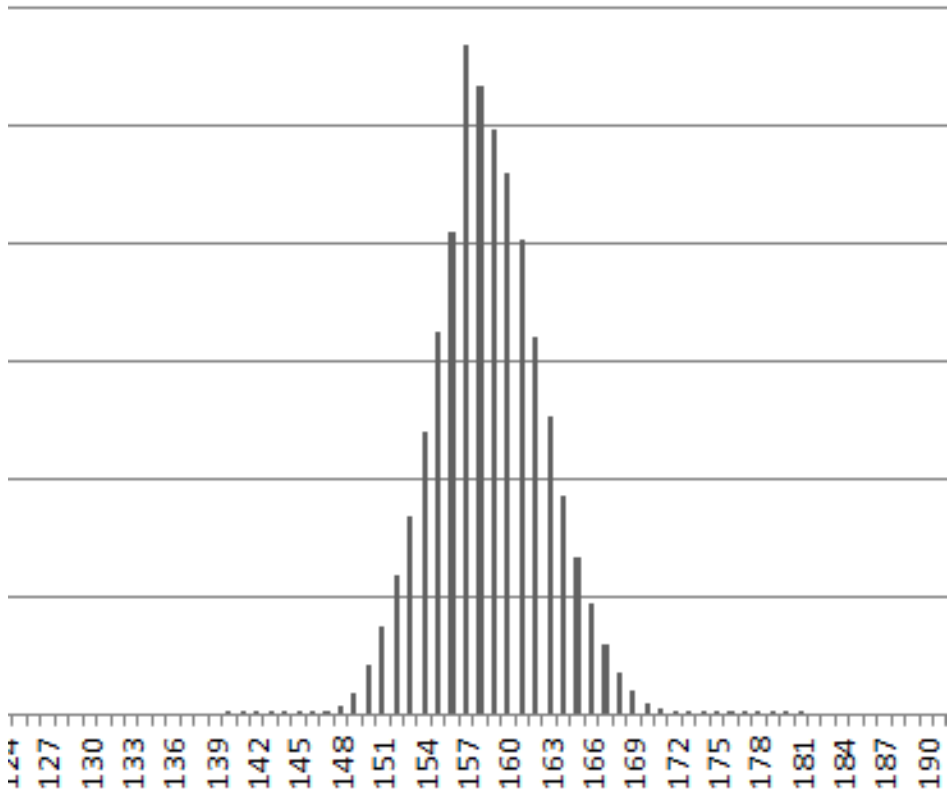
$\alpha = 1.0$, $\beta = 0.8$, $\gamma = 0.1$, $\delta = 0.8$, $\epsilon = 0.1$, $\lambda = 0.1$.

Percentile-based Evaluation (Ceylan et al. 2010) I

We compare against all possible 3-sentence extracts in the test set.

1. Bin all possible three-sentence combinations of each abstract.
   - 1,000 bins.
2. Normalise the resulting histograms.
3. Combine all histograms.
   - convolution.
4. The result approximates the probability density distribution of all three-sentence summaries in all abstracts.

Percentile-based Evaluation (Ceylan et al. 2010) II



Systems

L3 Last three sentences.

O3 Last three PIBOSO outcome sentences.

R Random.

O All outcome sentences.

PI Sentence position independent.

PD Sentence position dependent (our proposal).

Results

System	F-Score	95% CI	Percentile (%)
L3	0.159	0.155–0.163	60.3
O3	0.161	0.158–0.165	77.5
R	0.158	0.154–0.161	50.3
O	0.159	0.155–0.164	60.3
PI	0.160	0.157–0.164	69.4
PD	**0.166**	**0.162–0.170**	**97.3**

Towards Multi-document Summarisation

- Evidence suggests that a two-step process is promising (Sarker et al., ALTA 2012).
  1. Single document summarisation.
  2. Multi-document summarisation from the single-document summaries.
- Traditional clustering techniques seem to produce good clustering of references (Shash & Molla, unpublished).
- We are still looking at means to obtain the answer parts.
  - Topics as cluster centroids.
  - Overlap with the question.

Contents

Optimisation and NLP

Many NLP tasks are based on optimisation

- Text classification: minimise the classification error.
- Part of speech tagging: Find the optimal sequence of labels.
- Parsing: Find the most likely parse.
- Machine translation: Dual optimisation.
  - The target sentence must keep the most meaning.
  - The target sentence must try to follow the language model of the target language.

Optimisation in Machine Learning

Many ML tasks are about optimising parameters

$$\arg\min_{\theta} J(h_\theta(X), Y)$$

- J Cost (error) function.
- θ Machine Learning parametres.
- $h_\theta(X)$ Hypothesis function.
- X Inputs.
- Y Observed results.

Optimisation in Classification Tasks

Hypothesis function in Logistic Regression

Sigmoid (logistic) function

$$h_\theta(X) = \frac{1}{1 + e^{-\sum_i \theta_i x_i}} = \frac{1}{1 + e^{-\theta^T X}}$$

Cost function in Logistic Regression

Cross entropy

$$J(h_\theta(X), Y) = -\frac{1}{m}\left[\sum_{i=1}^{m} y^{(i)} \log(h_\theta(x^{(i)}) + (1 - y^{(i)}) \log(1 - h_\theta(x^{(i)}))\right]$$

Query Based Summarisation I

A summary sentence S_i must maximise its similarity with the question

$$\arg\max_S \sum_i CosSim(S_i, Q)$$

A summary sentence S_i must minimise its similarity with other summary sentences

$$\arg\min_S \sum_{i,j} CosSim(S_i, S_j)$$

Query Based Summarisation II

Maximal Marginal Relevance (Carbonell & Goldstein, 1998)

Greedy approach

- Each iteration, select the sentence S_i with highest MMR score.

$$MMR = \lambda(CosSim(S_i, Q)) \\ -(1-\lambda)\max_{S_j \epsilon S}(CosSim(S_i, S_j))$$

Single-document Summarisation

Information contents in summary sentences must be maximal

- The sum of all weighted concepts in a summary must be maximal.

$$\arg\max_S \sum_{c \in C_S} w(c)$$

- This is the knapsack problem (NP-hard).

Readability in summary sentences must be maximal

- We've seen some aspects of readability above ...
- ... now we need to express them as a problem of optimisation.

Query-based Multi-document Abstractive Summarisation

The summary must fit the question topics best

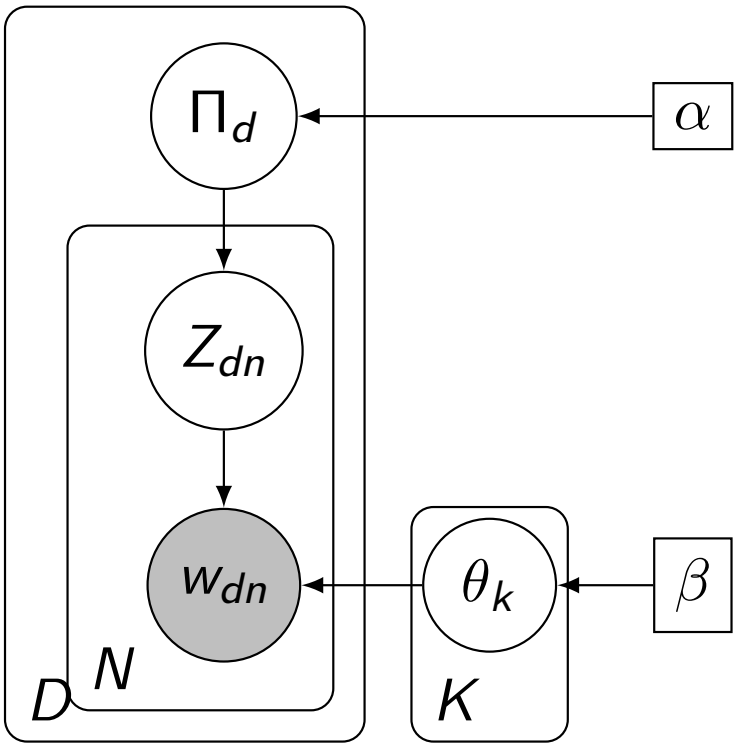
1. Fitting to cluster centroids.
2. Topic modelling (LDA) variants.

The summary must be most readable

Find the word extracts that are most likely produced by language models:

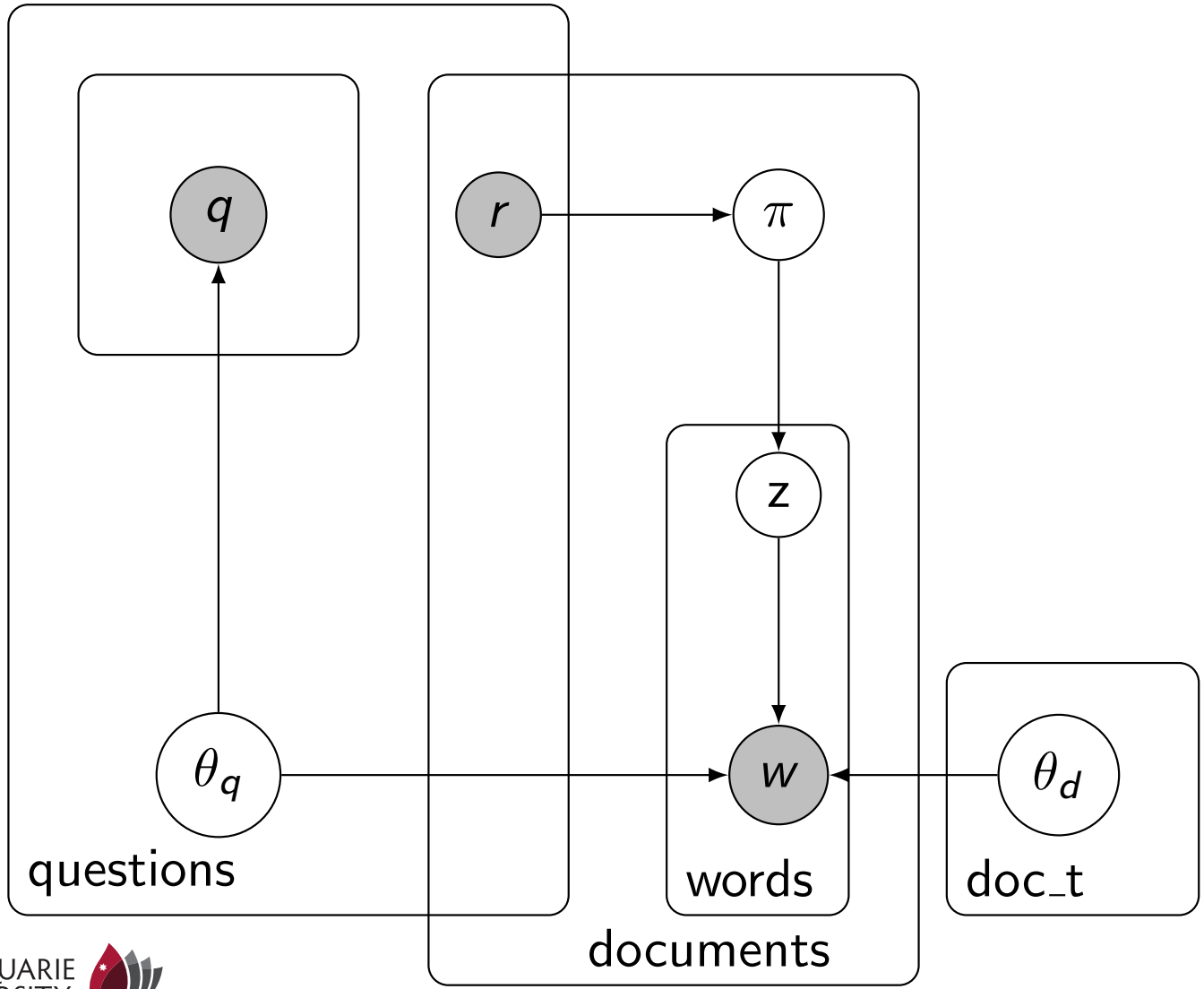
1. Word sequences (e.g. 2-grams).
2. Best likely parse (e.g. the k-minimum spanning tree in a graph).

Latent Dirichlet Allocation



- Π_d : topic probability distribution for document d.
- Z_{dn}: actual topic selected for word n in document d.
- θ_k: word probability distribution for topic k.
- α, β: hyperparameters.

Possible LDA Variant for Query-focused Summarisation



Summary

- Evidence Based Medicine (EBM) is an important problem that medical doctors face.
- EBM can benefit from Natural Language Processing (NLP) in general, and text summarisation in particular.
- Text summarisation, like many NLP tasks, relies on optimisation.
- We need expertise on optimisation techniques!

Summary

- Evidence Based Medicine (EBM) is an important problem that medical doctors face.
- EBM can benefit from Natural Language Processing (NLP) in general, and text summarisation in particular.
- Text summarisation, like many NLP tasks, relies on optimisation.
- We need expertise on optimisation techniques!

Questions?

Further information about our research:
`http://web.science.mq.edu.au/~diego/medicalnlp/`