Automatically Extracting Sentences from Medline Citations to Support Clinicians’ Information Needs

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Poll Question #1

- What is your primary role in VA? “select all that apply”
  - student, trainee, or fellow
  - Clinician or clinical researcher
  - informatics researcher
  - Programmer or developer
  - Other

*Up to five answer options. Can be “select one” or “select all that apply”*
Poll Question #2

• Which best describes your research experience? *select one*
  – have not done research
  – have collaborated on research
  – have conducted research myself
  – have applied for research funding
  – have led a funded research grant
Poll Question #3

Do you know about information needs at the point of care? “select one”

– Yes
– No
Poll Question #3

• Would you be willing to participate or help in recruiting for an international survey on information needs? “select one”
  – Yes
  – No
Team

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The need to tackle information needs

• Two questions for every three patients and 70% unanswered
• Online health knowledge resources provide answers
• Finding relevant information incompatible with the busy clinical workflow
• Promising approach – automatic extraction and summarization
Major question types

Based on Ely’s taxonomy, questions are typically classified as:

• **Treatment: 43.7%**
  – Drug (dosage, efficacy, prevention, etc)
  – Other treatment

• **Diagnosis: 37.7%**
  – finding (sign/symptom/test) ➔ condition
  – condition ➔ finding (list, efficacy, accuracy, etc.)
  – name finding, orientation, etc.

• **Management: 9.2%**

• **Epidemiology: 5.9%**

• **Non-clinical: 3.8%**
A Brief History of Modern Question Answering: From Google to Watson

• Google – provides a list of documents that contain an answer

*I am a deeply religious person. I believe in the One that is Omniscient. Others call Her Google. My Existential Dilemma is if something cannot be found with Google, does it really exist?*

• Wolfram|Alpha – answers factual queries directly by computing the answer from structured data

• Watson – answers open domain questions based on information present in documents as well as databases
Medical Question Answering

• IBM Watson’s Jeopardy! being adapted for Doctor’s Dilemma.
• AskHermes – a proto-type online medical question answering system
• Medline Plus – Reliable, up-to-date health information, anytime, anywhere for public
• AskMayoExpert – Physician aided shared decision for evidence based care
• MedKS, MiPACQ, Infobot
“Is Drug D safe for a patient with problem P, if he is positive on test T and has history of undergoing treatment Tr?”

Information acquisition using **query translation** and **information retrieval**

Relevant literature abstracts, clinical guidelines and physician notes

English question

A paragraph answering the question along with references

Summarization using **sentence simplification** and **network analysis**
Examples of Different sources

- Medline abstracts
- Full-text of these abstracts
  - Pubmed Central (1 year embargo)
  - Elsevier, Oxford, etc.
    - http://text.soe.ucsc.edu/progress.html
- Medical Text books
- Wikipedia
- Medpedia
Query – Alzheimer's MeSH – Alzheimer Disease UMLS - C0002395_T04

PMIDS – 10026388, 10066203, and 1334 more

Eutils – (systematic[sb] OR Therapy/Narrow[filter]) AND Alzheimer Disease [MeSH]

Top 4 sentences:

- Evidence that free radicals may contribute to the pathological processes of cognitive impairment including Alzheimer's disease (AD) has led to interest in the use of vitamin E in the treatment of Alzheimer's disease and mild cognitive impairment (MCI). (PMID: 18646084)
- Finally, a randomized controlled trial questions the clinical benefit of atypical neuroleptics in Alzheimer's disease and a comprehensive review of pharmacological trials in mild cognitive impairment reports no benefit of any of the tested drugs on conversion rate to Alzheimer's disease. (PMID: 17354654)
- Efficacy and safety of donepezil, galantamine, and rivastigmine for the treatment of Alzheimer's disease: a systematic review and meta-analysis. (PMID: 18686744)
Query Processing

- Tokenization
- Lexical Normalization
- Dictionary Lookup
- Semantic groups
  - treatment
  - disorder
- Screened concepts mapped to MeSH
Algorithm 1: Information retrieval strategy to retrieve abstracts relevant to a particular treatment topic

\[
\text{pomidSET} \leftarrow []
\]
\[
\text{if topic not treatment type then}
\]
\[
\quad \text{goto END}
\]
\[
\text{end if}
\]
\[
\text{MIN PMIDS} = 100
\]
\[
\text{join} = \text{AND}
\]
\[
\text{BEGIN:}
\]
\[
\text{query} = \text{``}
\]
\[
\text{for each concept in the topic search do}
\]
\[
\quad \text{if concept is disorder or treatment then}
\]
\[
\quad \quad \text{query} = \text{query + join + mesh-form(concept) [MeSH]}
\]
\[
\quad \text{end if}
\]
\[
\text{end for}
\]
\[
\text{END1:}
\]
\[
\text{pomidSET} \leftarrow \text{eutils(systematic[sb] AND query)}
\]
\[
\text{pomidSET} \leftarrow \text{eutils(Therapy/Narrow[filter] AND query)}
\]
\[
\text{if } \text{pomidSET.size()} < \text{MIN PMIDS then}
\]
\[
\quad \text{pomidSET} \leftarrow \text{eutils(Therapy/Broad[filter] AND query)}
\]
\[
\text{end if}
\]
\[
\text{if } \text{pomidSET.size()} < \text{MIN PMIDS } \& \& \text{join=AND then}
\]
\[
\quad \text{join} = \text{OR}
\]
\[
\quad \text{goto BEGIN}
\]
\[
\text{end if}
\]
\[
\text{if } \text{pomidSET.size()} < \text{MIN PMIDS then}
\]
\[
\quad \text{query} = \text{topic}
\]
\[
\quad \text{goto BEGIN1}
\]
\[
\text{end if}
\]
\[
\text{END:}
\]
Algorithm 2: Information extraction method to retrieve semantic predications relevant to a particular treatment topic

if topic not treatment type then
goto END
end if

subjects ← []
objects ← []
for each concept in the topic search do
    if concept is disorder then
        objects ← objects + concept
    else if concept is treatment then
        subjects ← subjects + concept
    end if
end for

if subjects.size() == 0 && objects.size() > 0 then
    return predications whose object’s CUI is one of the objects’ CUIs
else if subjects.size() > 0 && objects.size() > 0 then
    answers ← predications whose object’s CUI is one of the objects’ CUIs AND subject’s CUI is one of the subjects’ CUIs
    if answers.size() > MIN_ANSWERS then
        return answers
    end if
    return answers + predications whose object’s CUI is one of the objects’ CUIs OR subject’s CUI is one of the subjects’ CUIs
else if subjects.size() > 0 then
    return predications whose subject’s CUI is one of the subjects’ CUIs
else then
    return predications whose object’s name is one of the objects’ UMLS preferred
Sentence Ranking

• Exclude sections (i.e., *objectives, selection criteria, and methods*) that typically do not contain background statements or study conclusions

• Adapted the TextRank algorithm to rank the sentences retrieved
  – each unique sentence is a vertex in a graph
  – each pair of sentences is connected with an edge whose weight is determined by the cosine word similarity between the sentences

• This approach allows us to not only take into account the similarity between the query and the sentence, but also that among the individual sentences
Case Study Evaluation

• Treatment of two conditions:
  – *depression* and
  – *Alzheimer’s disease*

• Topics selected after the system was developed
Attributes of the sentences assessed

- *Topic-relevant* sentences describe one or more treatment alternatives for the condition of interest.
- *Conclusive* sentences comprise a statement about one or more treatment alternatives for the condition of interest, either as background information (e.g., current state of knowledge) or study conclusion.
- *Comparative* sentences contrast two or more treatment approaches for the condition of interest.
- *Contextually-constrained* sentences include specific clinical situations in which a treatment alternative is applicable.
Examples

(1) **Not topic-relevant**: “There is insufficient randomized evidence to support the routine use of antidepressants for the prevention of depression or to improve recovery from stroke.” (Pubmed ID: 15802637)

(2) **Conclusive and contextually-constrained**: “There is marginal evidence to support the use of tricyclic antidepressants in the treatment of depression in adolescents, although the magnitude of effect is likely to be moderate at best.” (Pubmed ID: 10908557)

(3) **Comparative**: “Escitalopram versus other antidepressive agents for depression.” (Pubmed ID: 19370639)

(4) **Conclusive and comparative**: “We found no strong evidence that fluvoxamine was either superior or inferior to any other antidepressants in terms of efficacy and tolerability in the acute phase treatment of depression.” (Pubmed ID: 20238342)

(5) **Not topic-relevant**: “Observational studies suggest that some preventive approaches, such as healthy lifestyle, ongoing education, regular physical activity, and cholesterol control, play a role in prevention of AD.” (Pubmed ID: 16529393)
# Case study ratings

<table>
<thead>
<tr>
<th>(kappa = 0.78)</th>
<th>Depression / N</th>
<th>Alzheimer’s / N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevant abstract</td>
<td>92.6%</td>
<td>84.5%</td>
</tr>
<tr>
<td>Relevant sentence</td>
<td>95.6%</td>
<td>88.4%</td>
</tr>
<tr>
<td>Conclusive</td>
<td>31.2%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Comparative</td>
<td>17.9%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Contextually-constrained</td>
<td>44.0%</td>
<td>6.4%</td>
</tr>
</tbody>
</table>
Results contd...

• In both case studies, most of the non-relevant sentences were related to the condition of interest, but the focus was on the diagnosis or prevention [sentences (1) and (5)]

• In both case studies, the TextRank probability was not associated significantly with relevant or conclusive

• Conclusive sentences were located closer to the end of the abstract than non-conclusive sentences (0.51 vs. 0.26; p < 0.00001)
Discussion

• High rate of relevant sentences
• Only about one third of the sentences retrieved included a conclusive statement
• Conclusive sentences were located much closer to the end of the abstract than non-conclusive sentences. The percentage of structured abstracts (with conclusion section) in Medline increased from 2.4% in 1992 to 20.3% in 2005
• Sentences with treatment and comparative predications (e.g., treatment A HIGHER_THAN treatment B) may be more likely to be conclusive sentences
• A small percentage of the sentences retrieved by the system compared treatment alternatives
• Although almost half of the sentences in the depression case study contained contextual constraints, a much smaller fraction of these sentences were retrieved for Alzheimer’s disease
Limitations and Future work

• Generalizability of our findings
• Further studies are needed to identify a threshold that achieves optimal recall for IR
• Broadening from treatment to other predications
• Full-fledged measurement study for overall recall
• Facilitate a tighter definition of relevancy
Conclusion

For the two case studies, the system retrieved a high percentage of topic-relevant sentences. Yet, a smaller percentage of sentences were conclusive, comparative, or contextually constrained. Overall, this seems to be a feasible approach to constructing context-specific semantic knowledge summaries to support clinicians’ patient care decision-making.
Figure 1: Overview of the methods proposed
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Questions?

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