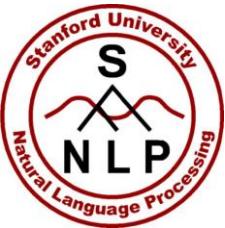


The word cloud illustrates the following key concepts:

- Probability**: A central concept, often associated with **sentences**, **grammar**, **model**, **first**, **information**, **state**, **speech**, **set**, **algorithm**, **words**, **language**, **sentence**, and **models**.
- Syntax**: Related to **grammar**, **state**, **algorithm**, **words**, **language**, and **sentence**.
- Semantics**: Related to **meaning**, **semantics**, **different**, **natural languages**, **representations**, **features**, **tags**, **processing**, **using**, **complex**, and **introduced**.
- Machine Learning**: Related to **training**, **classifier**, **flight**, **final**, **important**, **method**, **rule**, **morphological**, **either**, **start**, **learning**, **vector**, **similar**, and **role**.
- Information Extraction**: Related to **sequence**, **output**, **value**, **maximum**, **compute**, **subject**, **verb**, **feature**, **representation**, **human**, **corpus**, **consider**, **semantics**, **regular**, **relations**, **translation**, **given**, **number**, **test**, **show**, **dialogue**, **np**, **lexical**, **expressions**, **type**, **similarity**, **part-of-speech**, **observations**, **relation**, and **terms**.

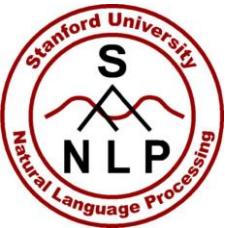
# Question Answering

# Summarization in Question Answering



# Text Summarization

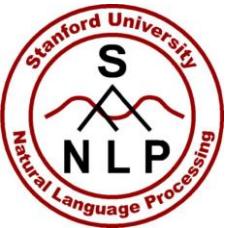
- **Goal:** produce an abridged version of a text that contains information that is important or relevant to a user.
- **Summarization Applications**
  - **outlines or abstracts** of any document, article, etc
  - **summaries** of email threads
  - **action items** from a meeting
  - **simplifying** text by compressing sentences



# What to summarize?

## Single vs. multiple documents

- **Single-document summarization**
  - Given a single document, produce
    - abstract
    - outline
    - headline
- **Multiple-document summarization**
  - Given a group of documents, produce a gist of the content:
    - a series of news stories on the same event
    - a set of web pages about some topic or question



# Query-focused Summarization & Generic Summarization

- Generic summarization:
  - Summarize the content of a document
- Query-focused summarization:
  - summarize a document with respect to an information need expressed in a user query.
  - a kind of complex question answering:
    - Answer a question by summarizing a document that has the information to construct the answer

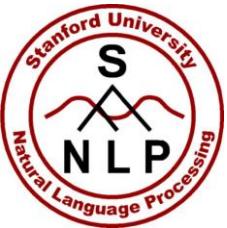


# Summarization for Question Answering: Snippets

- Create **snippets** summarizing a web page for a query
  - Google: 156 characters (about 26 words) plus title and link

A screenshot of a Google search results page. The search bar contains the query "what is die brücke?". Below the search bar, the word "Search" is followed by "About 5,910,000 results (0.28 seconds)".

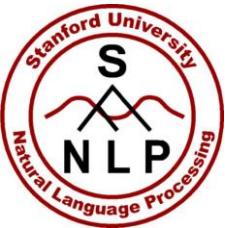
Everything	<a href="#">Die Brücke - Wikipedia, the free encyclopedia</a> <a href="http://en.wikipedia.org/wiki/Die_Brücke">en.wikipedia.org/wiki/Die_Brücke</a> Die Brücke (The Bridge) was a group of German expressionist artists formed in Dresden in 1905, after which the Brücke Museum in Berlin was named. Founding ... You've visited this page 5 times. Last visit: 4/16/12
Images	
Maps	
Videos	
News	<a href="#">Die Brücke (film) - Wikipedia, the free encyclopedia</a> <a href="http://en.wikipedia.org/wiki/Die_Brücke_(film)">en.wikipedia.org/wiki/Die_Brücke_(film)</a> Die Brücke (English: The Bridge) is a 1959 West German film directed by Austrian filmmaker Bernhard Wicki. It is based on the eponymous 1958 novel by ...
Shopping	
Applications	
More	<a href="#">Die Brucke - Die Brucke Art</a> <a href="http://www.huntfor.com/arthistory/c20th/diebrucke.htm">www.huntfor.com/arthistory/c20th/diebrucke.htm</a> Die Brucke was the association of artist expressionists from Dresden, Germany. ... Die Brucke made use of a technique that was controlled, intentionally ...



# Summarization for Question Answering: Multiple documents

Create **answers** to complex questions summarizing multiple documents.

- Instead of giving a snippet for each document
- Create a cohesive answer that combines information from each document



# Extractive summarization & Abstractive summarization

- Extractive summarization:
  - create the summary from phrases or sentences in the source document(s)
- Abstractive summarization:
  - express the ideas in the source documents using (at least in part) different words



# Simple baseline: take the first sentence

Google what is die brücke?

---

Search About 5,910,000 results (0.28 seconds)

---

Everything [Die Brücke - Wikipedia, the free encyclopedia](#)  
[en.wikipedia.org/wiki/Die\\_Brücke](http://en.wikipedia.org/wiki/Die_Brücke)

Images **Die Brücke** (The Bridge) was a group of German expressionist artists formed in Dresden in 1905, after which the Brücke Museum in Berlin was named. Founding ...

Maps

## Die Brücke

From Wikipedia, the free encyclopedia

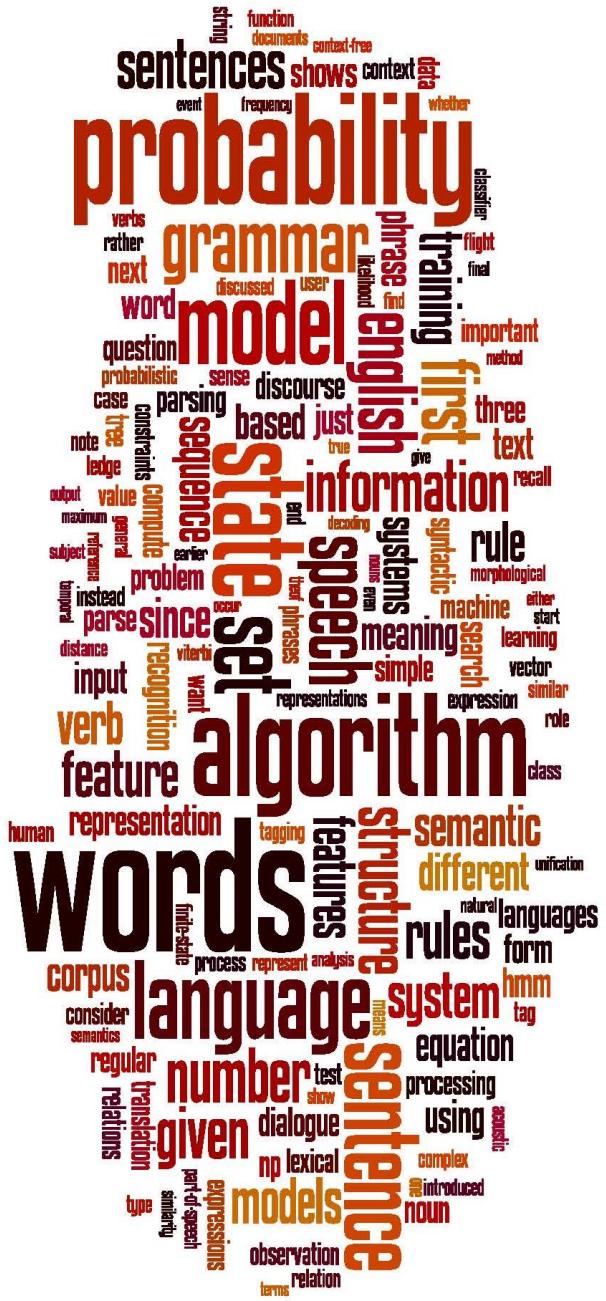
*For other uses, see [Die Brücke \(disambiguation\)](#).*

**Die Brücke (The Bridge)** was a group of German expressionist artists formed in Dresden in 1905, after which the **Brücke Museum in Berlin** was named. Founding members were [Fritz Bleyl](#), [Erich Heckel](#), [Ernst Ludwig Kirchner](#) and [Karl Schmidt-Rottluff](#). Later members were [Emil Nolde](#), [Max Pechstein](#) and [Otto Mueller](#). The seminal group had a major impact on the evolution of [modern art](#) in the 20th century and the creation of expressionism.<sup>[1]</sup>

Die Brücke is sometimes compared to the [Fauves](#). Both movements shared interests in [primitivist](#) art. Both

# Question Answering

# Summarization in Question Answering



# Question Answering

# Generating Snippets and other Single- Document Answers



# Snippets: query-focused summaries

Was cast-metal movable type invented in korea?

About 591,000 results (0.14 seconds)

[Movable type - Wikipedia, the free encyclopedia](#)

[en.wikipedia.org/wiki/Movable\\_type](http://en.wikipedia.org/wiki/Movable_type)

Jump to [Metal movable type](#): Transition from wood type to **metal** type occurred in 1234 ... The following description of the **Korean** font **casting** ... In the early fifteenth century, however, the **Koreans invented** a form of **movable type** that has ...

[History of printing in East Asia - Wikipedia, the free encyclopedia](#)

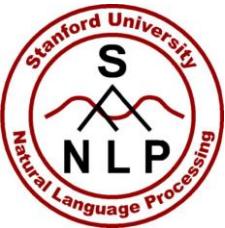
[en.wikipedia.org/wiki/History\\_of\\_printing\\_in\\_East\\_Asia](http://en.wikipedia.org/wiki/History_of_printing_in_East_Asia)

The following description of the **Korean** font **casting** process was recorded by the ... While **metal movable type** printing was **invented in Korea** and the oldest ...

[Korea, 1000–1400 A.D. | Heilbrunn Timeline of Art History | The ...](#)

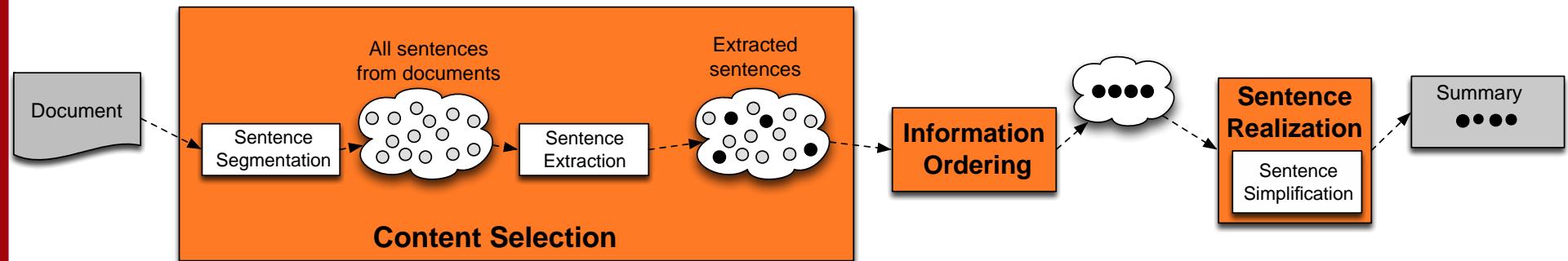
[www.metmuseum.org/toah/ht/?period=07&region=eak](http://www.metmuseum.org/toah/ht/?period=07&region=eak)

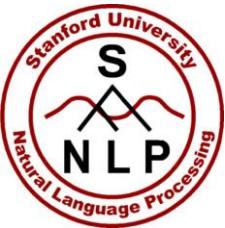
The **invention** and use of **cast-metal movable type** in **Korea** in the early thirteenth century predates by two centuries Gutenberg's **invention** of metal **movable type** ...



# Summarization: Three Stages

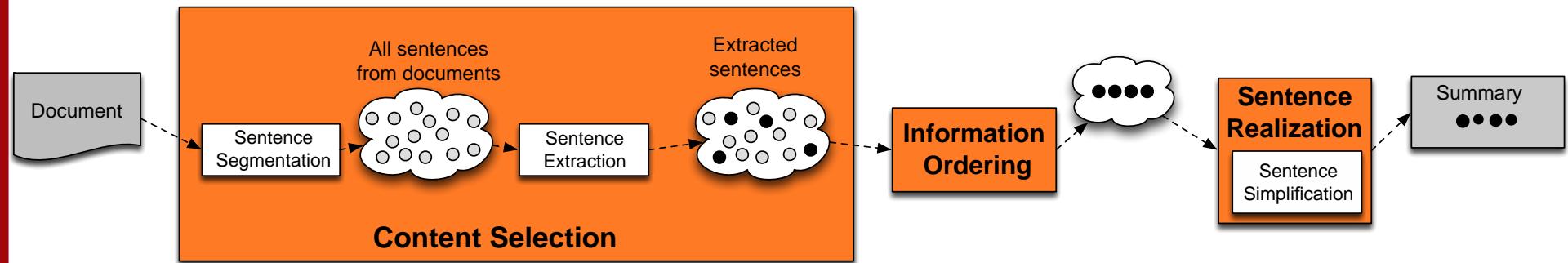
1. **content selection**: choose sentences to extract from the document
2. **information ordering**: choose an order to place them in the summary
3. **sentence realization**: clean up the sentences





# Basic Summarization Algorithm

1. content selection: choose sentences to extract from the document
2. information ordering: just use document order
3. sentence realization: keep original sentences





# Unsupervised content selection

H. P. Luhn. 1958. The Automatic Creation of Literature Abstracts.  
IBM Journal of Research and Development. 2:2, 159-165.

- Intuition dating back to Luhn (1958):
  - Choose sentences that have **salient** or **informative** words
- Two approaches to defining salient words
  1. **tf-idf**: weigh each word  $w_i$  in document  $j$  by tf-idf  

$$weight(w_i) = tf_{ij} \cdot idf_i$$
  2. **topic signature**: choose a smaller set of salient words
    - mutual information
    - log-likelihood ratio (LLR) Dunning (1993), Lin and Hovy (2000)

$$weight(w_i) = \begin{cases} 1 & \text{if } -2\log / (w_i) > 10 \\ 0 & \text{otherwise} \end{cases}$$



# Topic signature-based content selection with queries

Conroy, Schlesinger, and O'Leary 2006

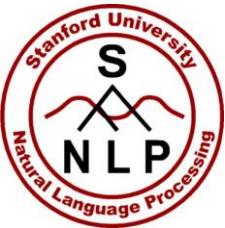
- choose words that are informative either
  - by log-likelihood ratio (LLR)
  - or by appearing in the query

$$weight(w_i) = \begin{cases} 1 & \text{if } -2 \log / (w_i) > 10 \\ 1 & \text{if } w_i \in \text{question} \\ 0 & \text{otherwise} \end{cases}$$

(could learn more complex weights)

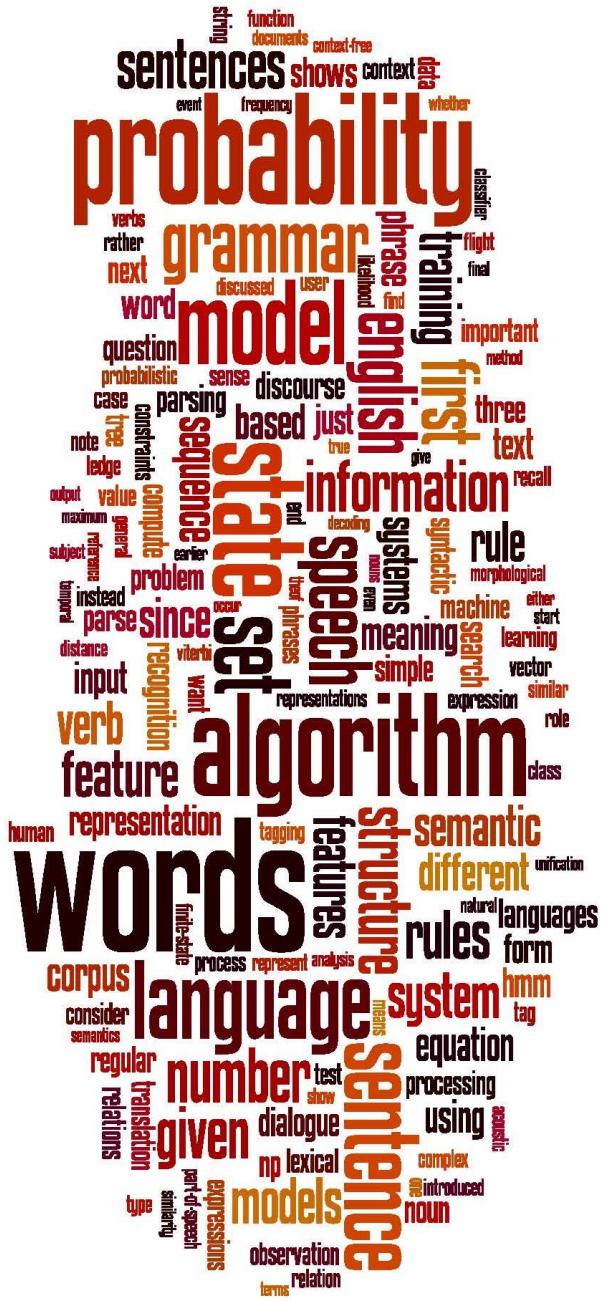
- Weigh a sentence (or window) by weight of its words:

$$weight(s) = \frac{1}{|S|} \sum_{w \in S} weight(w)$$



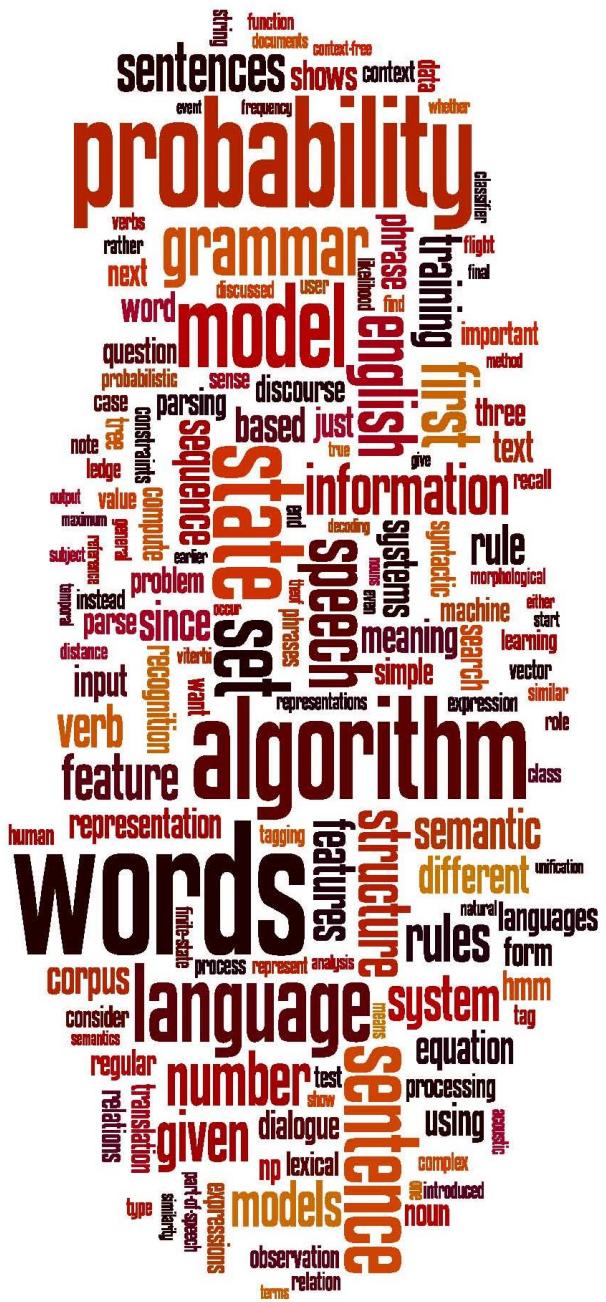
# Supervised content selection

- Given:
  - a labeled training set of good summaries for each document
- Align:
  - the sentences in the document with sentences in the summary
- Extract features
  - position (first sentence?)
  - length of sentence
  - word informativeness, cue phrases
  - cohesion
- Train
  - a binary classifier (put sentence in summary? yes or no)
- Problems:
  - hard to get labeled training data
  - alignment difficult
  - performance not better than unsupervised algorithms
- So in practice:
  - **Unsupervised content selection is more common**



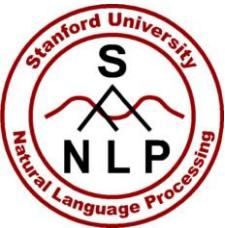
# Question Answering

# Generating Snippets and other Single- Document Answers



# Question Answering

# Evaluating Summaries: ROUGE



# ROUGE (Recall Oriented Understudy for Gisting Evaluation)

Lin and Hovy 2003

- Intrinsic metric for automatically evaluating summaries
  - Based on BLEU (a metric used for machine translation)
  - Not as good as human evaluation (“Did this answer the user’s question?”)
  - But much more convenient
- Given a document D, and an automatic summary X:
  1. Have N humans produce a set of reference summaries of D
  2. Run system, giving automatic summary X
  3. What percentage of the bigrams from the reference summaries appear in X?

$$ROUGE - 2 = \frac{\sum_{i=1}^n \min(count(i, X), count(i, S))}{\sum_{i=1}^n count(i, S)}$$



# A ROUGE example:

## Q: “What is water spinach?”

Human 1: Water spinach is a green leafy vegetable grown in the tropics.

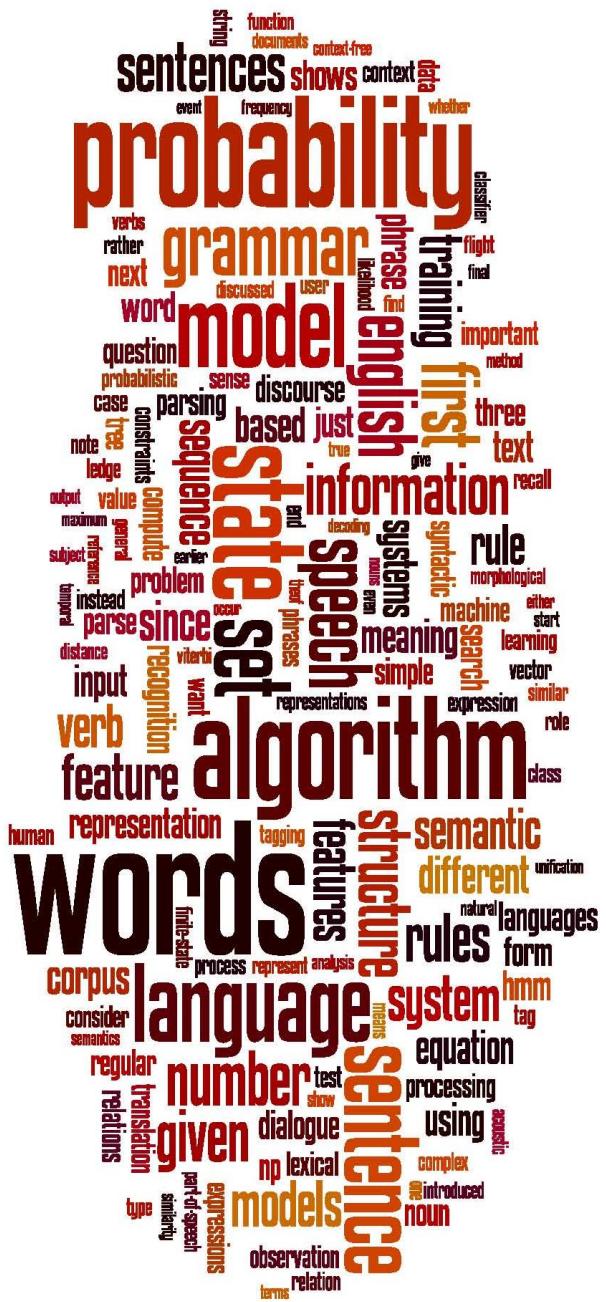
Human 2: Water spinach is a semi-aquatic tropical plant grown as a vegetable.

Human 3: Water spinach is a commonly eaten leaf vegetable of Asia.

- System answer: Water spinach is a leaf vegetable commonly eaten in tropical areas of Asia.

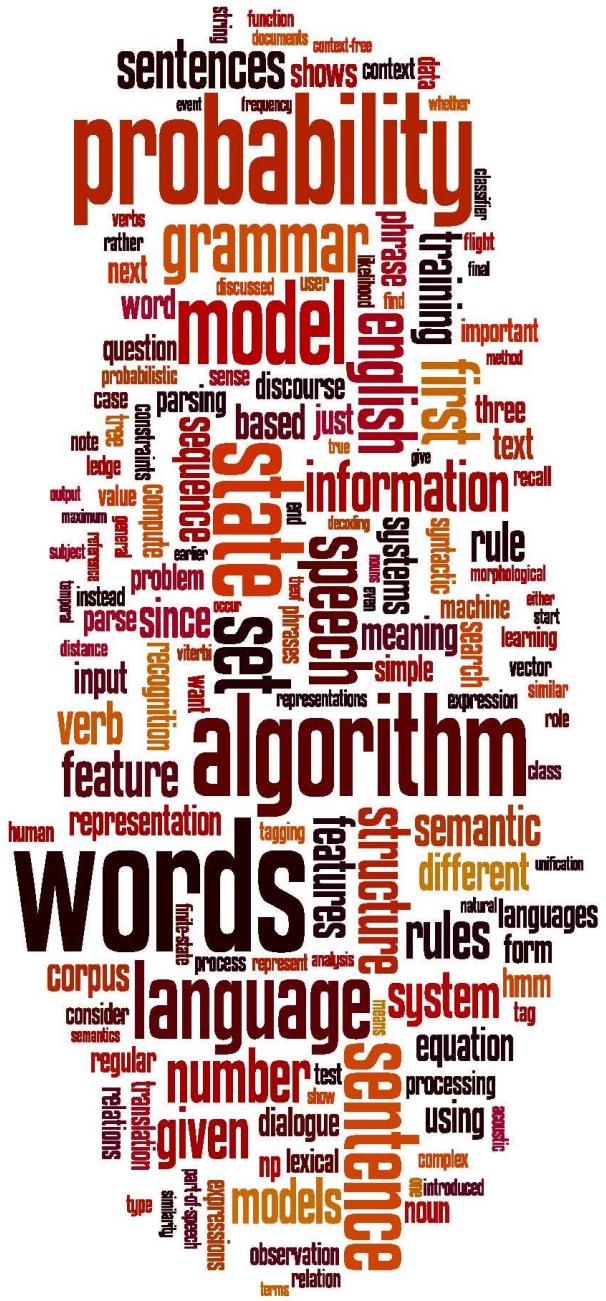
- ROUGE-2 =

$$\frac{3 + 3 + 6}{10 + 9 + 9} = 12/28 = .43$$



# Question Answering

# Evaluating Summaries: ROUGE



# Question Answering

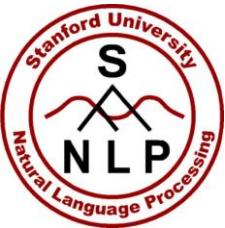
# Complex Questions: Summarizing Multiple Documents



# Definition questions

**Q:** What is *water spinach*?

**A:** Water spinach (*ipomoea aquatica*) is a semi-aquatic leafy green plant with long hollow stems and spear- or heart-shaped leaves, widely grown throughout Asia as a leaf vegetable. The leaves and stems are often eaten stir-fried flavored with salt or in soups. Other common names include *morning glory vegetable*, *kangkong* (Malay), *rau muong* (Viet.), *ong choi* (Cant.), and *kong xin cai* (Mand.). It is not related to spinach, but is closely related to sweet potato and convolvulus.



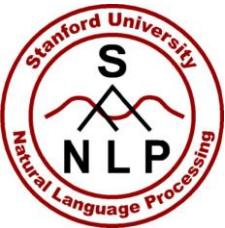
# Medical questions

Demner-Fushman and Lin (2007)

**Q:** In children with an acute febrile illness, what is the efficacy of single medication therapy with acetaminophen or ibuprofen in reducing fever?

**A:** Ibuprofen provided greater temperature decrement and longer duration of antipyresis than acetaminophen when the two drugs were administered in approximately equal doses.

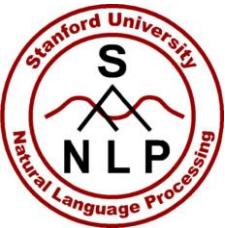
*(PubMedID: 1621668, Evidence Strength: A)*



# Other complex questions

Modified from the DUC 2005 competition (Hoa Trang Dang 2005)

1. How is compost made and used for gardening (including different types of compost, their uses, origins and benefits)?
2. What causes train wrecks and what can be done to prevent them?
3. Where have poachers endangered wildlife, what wildlife has been endangered and what steps have been taken to prevent poaching?
4. What has been the human toll in death or injury of tropical storms in recent years?

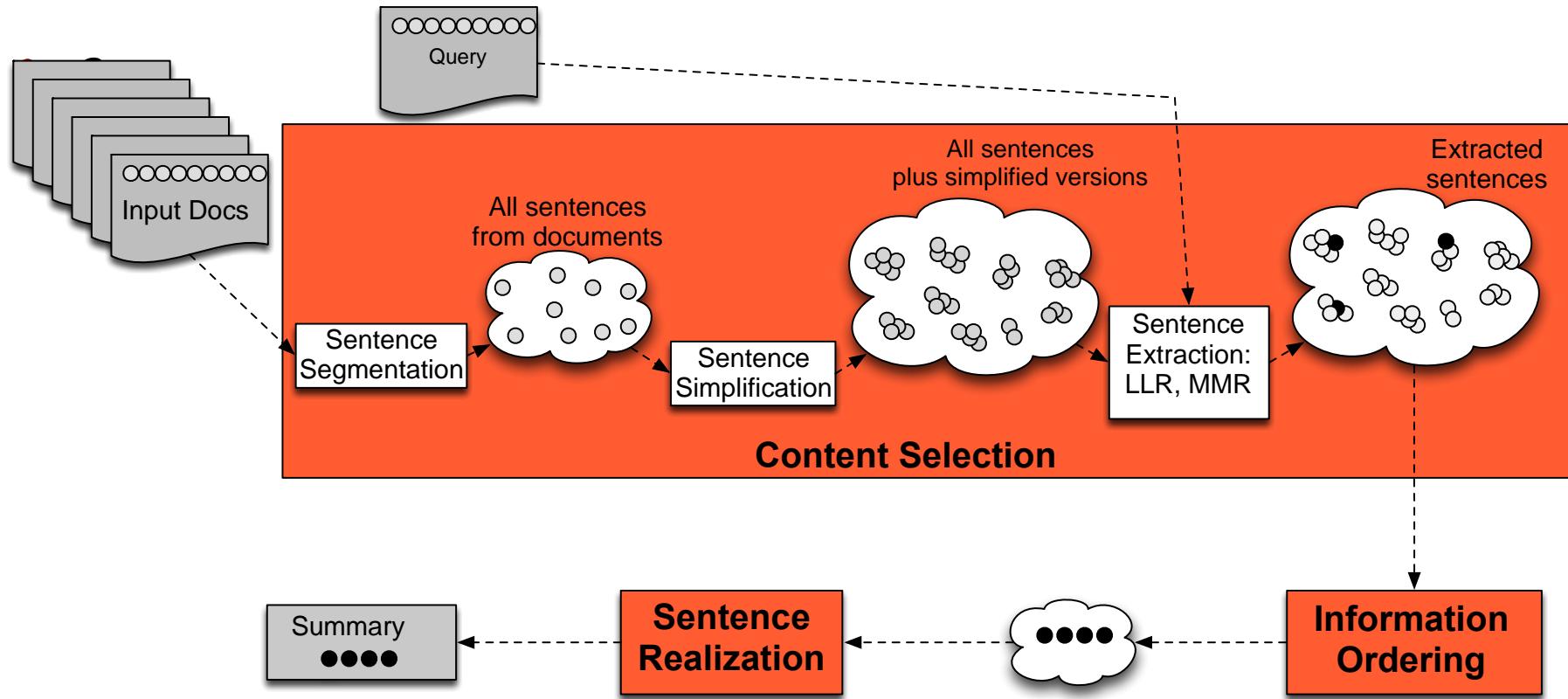


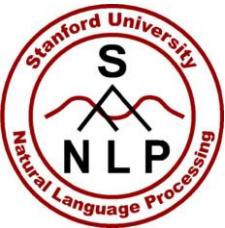
# Answering harder questions: Query-focused multi-document summarization

- The (bottom-up) snippet method
  - Find a set of relevant documents
  - Extract informative sentences from the documents
  - Order and modify the sentences into an answer
- The (top-down) information extraction method
  - build specific answerers for different question types:
    - definition questions
    - biography questions
    - certain medical questions



# Query-Focused Multi-Document Summarization





# Simplifying sentences

Zajic et al. (2007), Conroy et al. (2006), Vanderwende et al. (2007)

Simplest method: parse sentences, use rules to decide which modifiers to prune  
 (more recently a wide variety of machine-learning methods)

<b>appositives</b>	Rajam, <del>28, an artist who was living at the time in Philadelphia</del> , found the inspiration in the back of city magazines.
<b>attribution clauses</b>	Rebels agreed to talks with government officials, <del>international observers said Tuesday</del> .
<b>PPs without named entities</b>	The commercial fishing restrictions in Washington will not be lifted unless the salmon population increases [ <del>PP to a sustainable number</del> ])
<b>initial adverbials</b>	<del>"For example", "On the other hand", "As a matter of fact", "At this point"</del>



# Maximal Marginal Relevance (MMR)

Jaime Carbonell and Jade Goldstein, The Use of MMR, Diversity-based Reranking for Reordering Documents and Producing Summaries, SIGIR-98

- An iterative method for content selection from multiple documents
- Iteratively (greedily) choose the best sentence to insert in the summary/answer so far:
  - **Relevant**: Maximally relevant to the user's query
    - high cosine similarity to the query
  - **Novel**: Minimally redundant with the summary/answer so far
    - low cosine similarity to the summary
- Stop when desired length

$$\hat{S}_{MMR} = \max_{s \in D} / sim(s, Q) - (1 - / ) \max_{s \in S} sim(s, S)$$



## MMR Details

$$\text{MMR} = \arg \max_{D_i \in R \setminus S} \left[ \lambda \text{Sim}_1(D_i, Q) - (1 - \lambda) \max_{D_j \in S} \text{Sim}_2(D_i, D_j) \right]$$

**D<sub>i</sub>:** Documents in the collection C

**Q:** Query,

**R:** Relevant documents in C,

**S:** Current result set

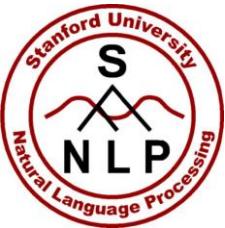
- Constructs the result set incrementally
- User-tunable diversity through  $\lambda$  parameter
- High  $\lambda$  = Higher **accuracy**
- Low  $\lambda$  = Higher **diversity**



# MMR Example

$S =$

	$d_1$	$d_2$	$d_3$	$d_4$	$d_5$	$q$
$d_1$	1	0.11	0.23	0.76	0.25	0.91
$d_2$		1	0.29	0.57	0.51	0.90
$d_3$			1	0.02	0.20	0.50
$d_4$				1	0.33	0.06
$d_5$					1	0.63
$q$						1

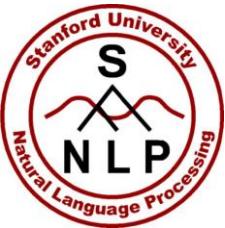


# First Iteration

Currently our result set  $S$  is empty. Therefore the second half of the equation, which is the max pairwise similarity within  $S$ , will be zero. For the first iteration, MMR equation reduces to:

$$\text{MMR} = \arg \max (\text{Sim} (d_i, q))$$

$d_1$  has the maximum similarity with  $q$ , therefore we pick it and add it to  $S$ . Now,  $S = \{d_1\}$ .



## Second Iteration

Since  $S = \{d_1\}$ , finding the maximum distance to an element in  $S$  to a given  $d_i$  is simply  $\text{sim}(d_1, d_i)$ .

For  $d_2$ :

$$\text{sim}(d_1, d_2) = 0.11$$

$$\text{sim}(d_2, q) = 0.90$$

$$\text{Then MMR} = \lambda 0.90 - (1-\lambda)0.11 = 0.395$$

Similarly MMR values for  $d_{3, 4, 5}$  are 0.135, -0.35 and 0.19 respectively. Since  $d_2$  has the maximum MMR, we add it to  $S$ . Now  $S = \{d_1, d_2\}$ .



## Third Iteration

This time  $S = \{d_1, d_2\}$ . We should find max. of  $\text{sim}(d_i, d_1)$  and  $\text{sim}(d_i, d_2)$  for the second part of the equation.

For  $d_3$ :

$$\max\{\text{sim}(d_1, d_3), \text{sim}(d_2, d_3)\} = \\ \max\{0.23, 0.29\} = 0.29$$

$$\text{sim}(d_3, q) = 0.50$$

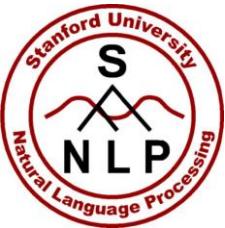
$$\text{MMR} = 0.5 * 0.5 - 0.5 * 0.29 = 0.105$$

Similarly, other MMRs are calculated as:

$$d_4: -0.35, d_5: 0.06$$

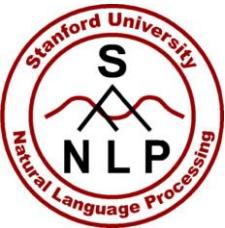
$d_3$  has the maximum MMR, therefore

$$S = \{d_1, d_2, d_3\}.$$



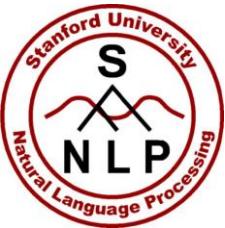
# LLR+MMR: Choosing informative yet non-redundant sentences

- One of many ways to combine the intuitions of LLR and MMR:
  1. Score each sentence based on LLR (including query words)
  2. Include the sentence with highest score in the summary.
  3. Iteratively add into the summary high-scoring sentences that are not redundant with summary so far.



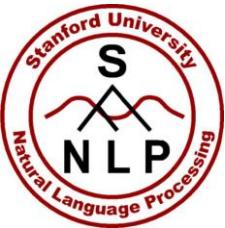
# Information Ordering

- Chronological ordering:
  - Order sentences by the date of the document (for summarizing news)..  
(Barzilay, Elhadad, and McKeown 2002)
- Coherence:
  - Choose orderings that make neighboring sentences similar (by cosine).
  - Choose orderings in which neighboring sentences discuss the same entity  
(Barzilay and Lapata 2007)
- Topical ordering
  - Learn the ordering of topics in the source documents



# Domain-specific answering: The Information Extraction method

- a good **biography** of a person contains:
  - a person's **birth/death, fame factor, education, nationality** and so on
- a good **definition** contains:
  - **genus** or **hyponym**
    - *The Hajj is a type of ritual*
- a **medical answer about a drug's use** contains:
  - **the problem** (the medical condition),
  - **the intervention** (the drug or procedure), and
  - the **outcome** (the result of the study).



# Information that should be in the answer for 3 kinds of questions

## Definition

<b>genus</b>	The Hajj is a type of ritual
<b>species</b>	the annual hajj begins in the twelfth month of the Islamic year
<b>synonym</b>	The Hajj, or Pilgrimage to Mecca, is the central duty of Islam
<b>subtype</b>	Qiran, Tamattu', and Ifrad are three different types of Hajj

## Biography

<b>dates</b>	was assassinated on April 4, 1968
<b>nationality</b>	was born in Atlanta, Georgia
<b>education</b>	entered Boston University as a doctoral student

## Drug efficacy

<b>population</b>	37 otherwise healthy children aged 2 to 12 years
<b>problem</b>	acute, intercurrent, febrile illness
<b>intervention</b>	acetaminophen (10 mg/kg)
<b>outcome</b>	ibuprofen provided greater temperature decrement and longer duration of antipyresis than acetaminophen when the two drugs were administered in approximately equal doses



# Architecture for complex question answering: definition questions

S. Blair-Goldensohn, K. McKeown and A. Schlaikjer. 2004.  
Answering Definition Questions: A Hybrid Approach.

"What is the Hajj?"  
(Ndocs=20, Len=8)



The Hajj, or pilgrimage to Makkah [Mecca], is the central duty of Islam. More than two million Muslims are expected to take the Hajj this year. Muslims must perform the hajj at least once in their lifetime if physically and financially able. The Hajj is a milestone event in a Muslim's life. The annual hajj begins in the twelfth month of the Islamic year (which is lunar, not solar, so that hajj and Ramadan fall sometimes in summer, sometimes in winter). The Hajj is a week-long pilgrimage that begins in the 12th month of the Islamic lunar calendar. Another ceremony, which was not connected with the rites of the Ka'ba before the rise of Islam, is the Hajj, the annual pilgrimage to 'Arafat, about two miles east of Mecca, toward Mina...

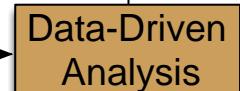


### 9 Genus-Species Sentences

The Hajj, or pilgrimage to Makkah (Mecca), is the central duty of Islam.  
The Hajj is a milestone event in a Muslim's life.  
The hajj is one of five pillars that make up the foundation of Islam.  
...



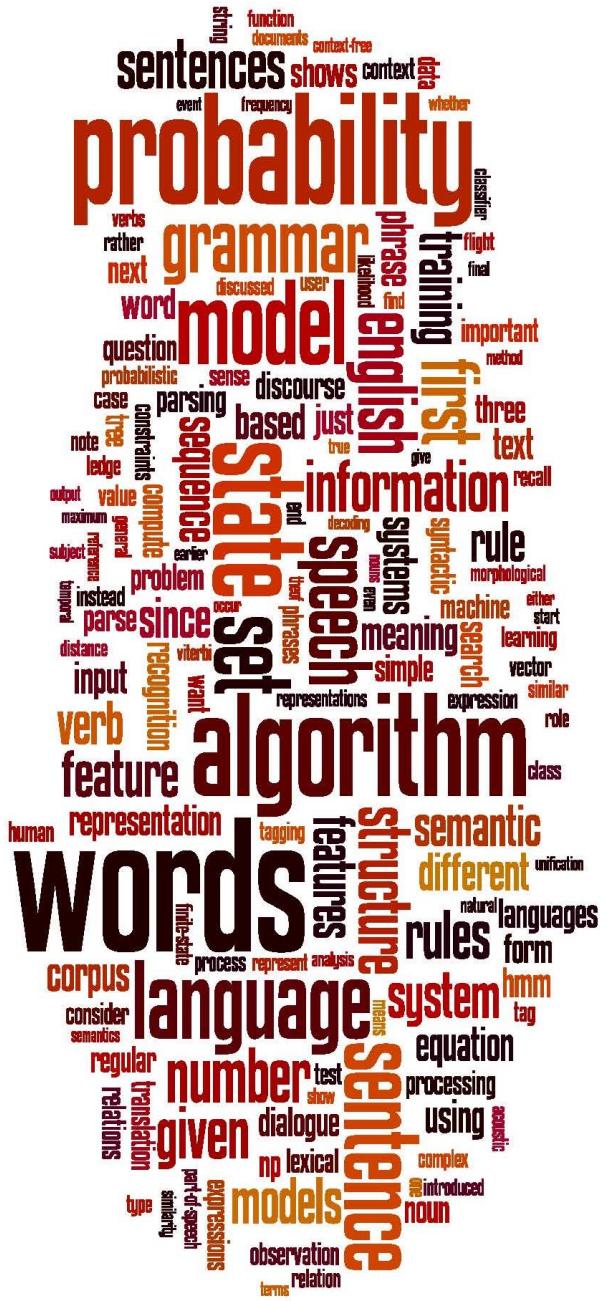
Sentence clusters,  
Importance ordering



Definition  
Creation

Sentence clusters,  
Importance ordering

Data-Driven  
Analysis



# Question Answering

# Answering Questions by Summarizing Multiple Documents