

Computational Argumentation – Part I

Introduction to Computational Argumentation

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Learning goals

■ Concepts

- The need for processing argumentation
- Some general aspects of argumentation
- Benefits and challenges of computational argumentation



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■ Methods

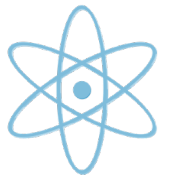
- First idea of the analysis and synthesis of arguments



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■ Associated research fields

- Argumentation theory
- Natural language processing



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■ Within this course

- First overview of the topics covered



Outline

I. Introduction to computational argumentation

II. Basics of natural language processing

III. Basics of argumentation

IV. Argument mining

V. Argument assessment

VI. Argument generation

VII. Applications of computational argumentation

VIII. Conclusion

a) Introduction

b) Argumentation

c) Computational argumentation

d) Tasks in computational argumentation

e) Conclusion

Welcome to the post-factual age

It was January 22, 2017...

<https://www.youtube.com/watch?v=VSrEEDQgFc8> (1:36 – 2:05)



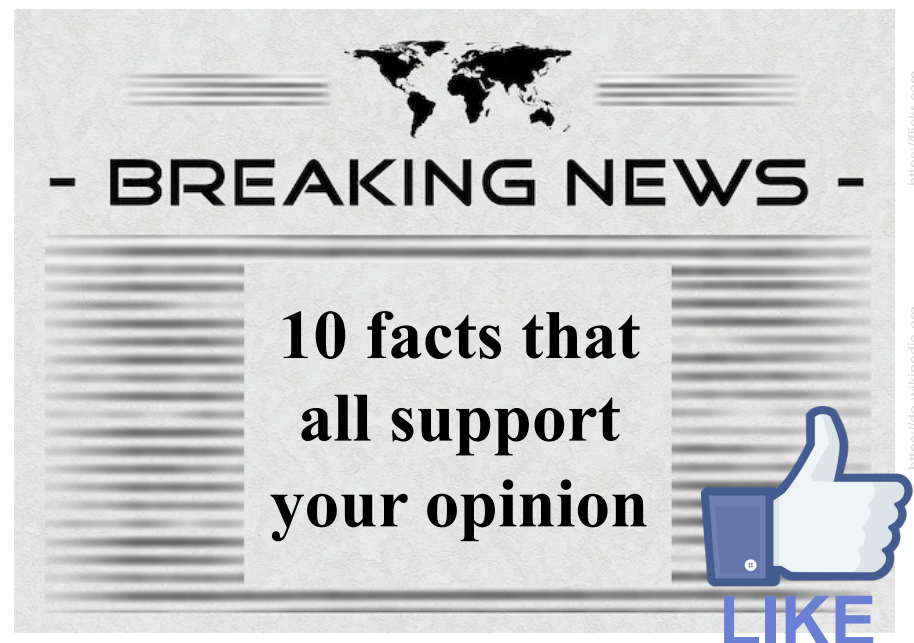
How could we end up there?

Filter bubbles



We get what fits our past behavior

Echo chambers



We share what fits our world view

So what does that mean?

Forming opinions in a self-determined manner
is one of the great problems of our time

Where truth is unclear, we need to compare *arguments*

Can computers help?

Example: Project Debater

<https://www.youtube.com/watch?v=nJXcFtY9cWY>



Need for studying? <https://chat.openai.com> (March 31, 2025)

In a few sentences, how would you argue in favor of taking an NLP course on computational argumentation?

Taking an NLP course on computational argumentation is valuable because it combines language processing with critical thinking, enabling students to analyze, generate, and evaluate arguments automatically. This field has applications in law, politics, and online discourse, helping detect fallacies, summarize debates, and improve AI-driven decision-making. Moreover, with the rise of misinformation, mastering argumentation through NLP is essential for developing tools that promote rational and evidence-based discussions.

Next section: Argumentation

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Why do people argue?

■ Causes of argumentation

(Freeley and Steinberg, 2009)

- A (possible) conflict of interests or positions
- No (clearly) correct answer or solution
- So: **Controversy**



■ Goals of argumentation

(Tindale, 2007)

- Persuasion
- Agreement
- Justification
- Deliberation

... and similar



What is argumentation?

■ Argument

- A claim (conclusion) supported by reasons (premises) (Walton et al., 2008)
- Conveys a stance on a controversial issue (Freeley and Steinberg, 2009)

Conclusion
Premises

Conclusion *The EU should allow rescue boats in the Mediterranean Sea.*

Premise 1 *Many innocent refugees will die if there are no such boats.*

Premise 2 *Nothing justifies to endanger the life of innocent people.*

- Often, some argumentative units are implicit (Toulmin, 1958)
- Most natural language arguments are defeasible (Walton, 2006)

■ Argumentation

- The usage of arguments to persuade, agree, deliberate, or similar
- Also includes rhetorical and dialectical aspects

Conclusion
Premises

Argumentative genres

▪ Written monologue

- Persuasive essays
- Opinionated articles/editorials
- Argumentative blog posts
- Customer and scientific reviews
- Scientific articles
- Law texts

... among others

▪ Written dialogue

- Comments to news articles
- Social media posts
- Online forum discussions
- eMail threads
- Online debates

... among others

▪ Spoken monologue (possibly transcribed)

- Political speeches
- Law pleadings

... among others

▪ Spoken dialogue (possibly transcribed)

- Classical debates
- Everyday discussions

... among others

▪ Notice

- The focus in this course is on *written* argumentation, i.e., argumentative texts.

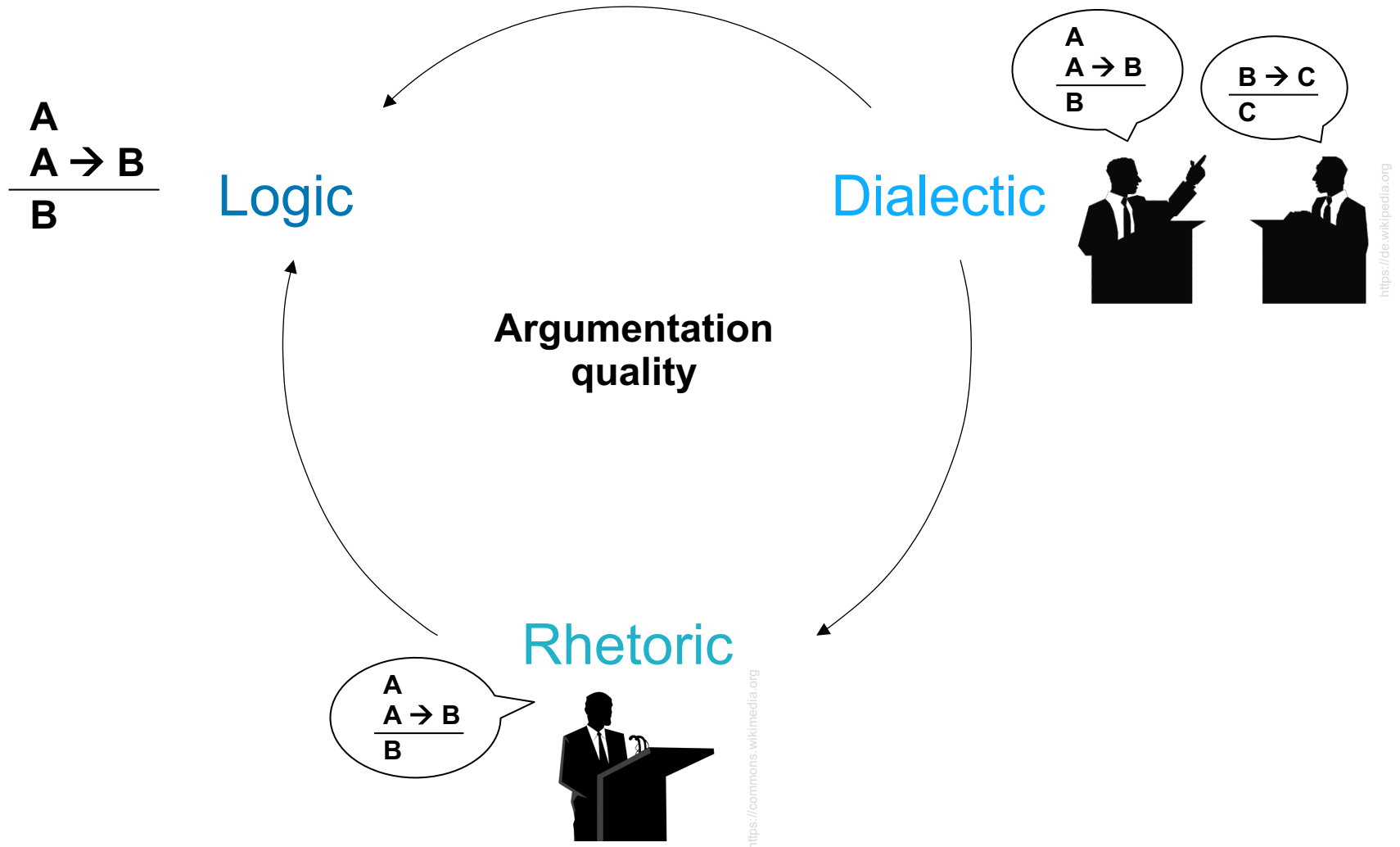


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What is *good* argumentation?



Who is involved in argumentation?

■ Author (or speaker)

- Argumentation is connected to the person who argues.
- The same argument is perceived differently depending on the author.

“ The EU should allow rescue boats. Many innocent refugees will die if there are no such boats. ”



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■ Reader (or audience)

- Argumentation often targets a particular audience.
- Different arguments and ways of arguing work for different readers.

“ According to a study in Nature from 2023, rescue boats do not increase the number of refugees who try. ”

<https://www.nature.com/articles/s41598-023-38119-4>



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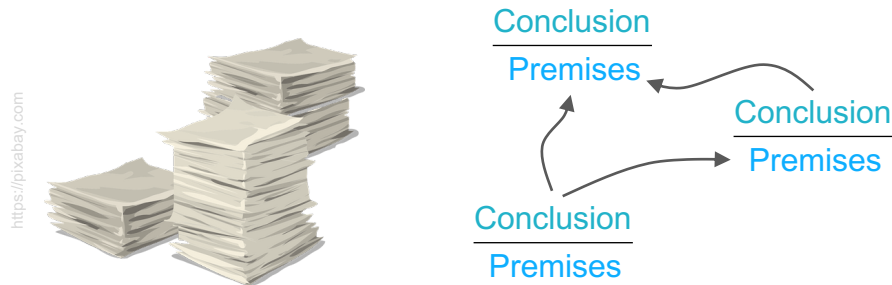
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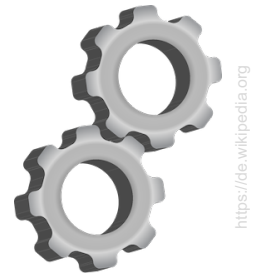
What is computational argumentation (within NLP)?

■ Computational argumentation

- The computational analysis and synthesis of natural language arguments
- Several different tasks, usually tackled with data-driven methods



$$(1 - \alpha) \cdot \frac{p(d) \cdot |D|}{|A|} + \alpha \cdot \sum_i \frac{\hat{p}(c_i)}{|P_i|}$$



■ Main research aspects

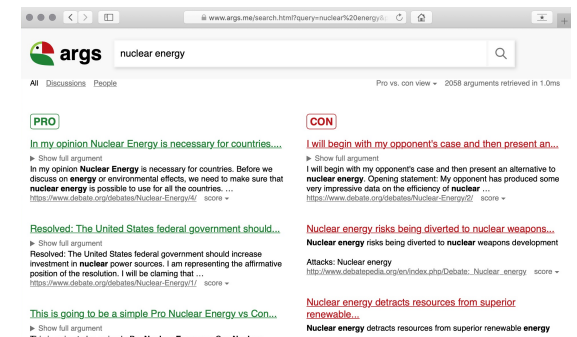
- **Models** of arguments and argumentation
- **Computational methods** for analysis and synthesis
- **Resources** for development and evaluation
- **Applications** built upon the models and methods

Applications of computational argumentation

- **Debating technology** (Slonim et al., 2021)
 - **What.** Present arguments for controversial issue and argue for a stance towards the issue
 - **Why.** Support decision making
- **Argument search** (Wachsmuth et al., 2017)
 - **What.** Find arguments on controversial issues and oppose best pro's and con's
 - **Why.** Support self-determined opinion formation
- **Argumentative writing support** (Stab, 2017)
 - **What.** Assess quality of argumentative text and provide feedback to text
 - **Why.** Support learning of argumentative writing



https://flickr.com



(Wambagsans and Rietzsche, 2019)

Argument search: args.me



nuclear energy



All [Discussions](#) [News](#) [People](#)

Pro vs. con view ▾ 2018 arguments retrieved in 168.0 ms

PRO

We're dependent on thermal power and fuels so nuclear...

► Show full argument

We're dependent on thermal power and fuels so **nuclear energy** will be a useful hand of help. ... 1:<http://www.forbes.com...> 2:<http://www.cancer.gov...>
<https://www.debate.org/debates/Nuclear-Energy/4/> score ▾

The most up-to-date study, conducted at the Forsmark...

► Show full argument

The most up-to-date study, conducted at the Forsmark **nuclear** power facility in Sweden during 2005, shows that the plant was producing only 3.10 grams of CO2 per kilowatt per hour [1]. ... Sources: [1] ...
<https://www.debate.org/debates/Nuclear-Energy/1/> score ▾

Thermal energy causes the global warming which is the...

► Show full argument

Thermal **energy** causes the global warming which is the most important world discussion and the most dangerous natural disaster of our generation. ... I wish my best lucks to my opponent 1.<http://www.fi.edu...> ...
<https://www.debate.org/debates/Nuclear-Energy/4/> score ▾

CON

There are high protocol, likely classified, to protect...

► Show full argument

There are high protocol, likely classified, to protect the integrity of **nuclear** facilities in developed nations. ... Thank you!
<https://www.debate.org/debates/Nuclear-Energy/2/> score ▾

Nuclear energy risks being diverted to nuclear weapons...

► Show full argument

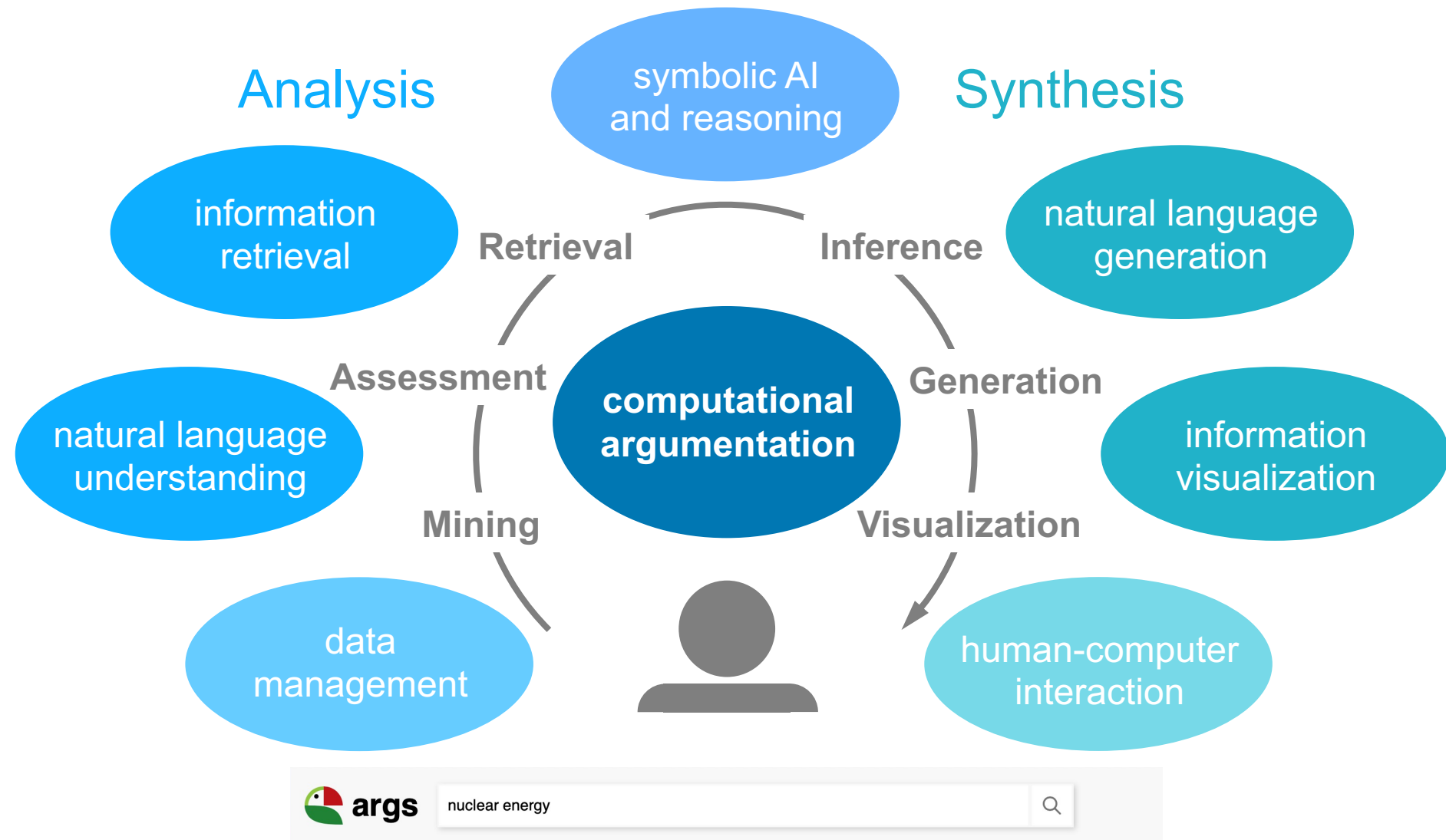
Nuclear energy risks being diverted to **nuclear** weapons development
http://www.debatepedia.org/en/index.php/Debate:_Nuclear_energy score ▾

Nuclear energy detracts resources from superior renewable...

► Show full argument

Nuclear energy detracts resources from superior renewable **energy**
http://www.debatepedia.org/en/index.php/Debate:_Nuclear_energy score ▾

Analysis and synthesis tasks

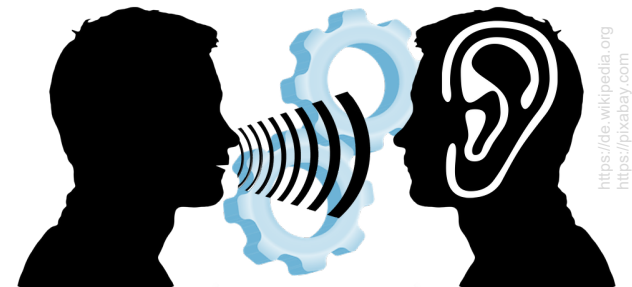


A natural language processing perspective

- **Natural language processing (NLP)** (Tsuji, 2011)
 - Methods for understanding and generating speech and human-readable text
 - From natural language to structured information, and vice versa

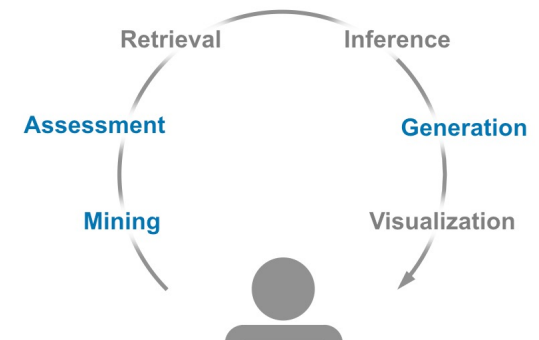
Analysis
Synthesis

- **Computational linguistics** (see <http://www.aclweb.org>)
 - Intersection of computer science and linguistics
 - **Technologies** for natural language processing
 - **Models** to explain linguistic phenomena, based on knowledge and statistics



- **Main NLP tasks in computational argumentation**
 - **Mining** arguments and their relations from text
 - **Assessing** various properties of arguments
 - **Generating** arguments and argumentative texts

Often, not all tasks need to be tackled in applications



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Overview of NLP tasks in computational argumentation

■ Argument(ation) mining

1. Segmenting a text into argumentative units
2. Classifying the types of units
3. Identifying relations between units or arguments

... along with variations and combinations of these

If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats.

■ Argument(ation) assessment

4. Detecting an argument's stance on an issue
5. Classifying an argument's scheme
6. Scoring or comparing argument quality

... along with other assessed properties

If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats.



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■ Argument(ation) generation

7. Summarizing arguments and debates
8. Creating and composing argumentative texts
9. Rewriting and countering arguments

... along with related non-argumentative language

Having rescue boats also may have negative effects. Even more people may die trying, believing that they may be rescued.

Task 1: Segmenting a text into argumentative units

■ Unit segmentation

- Argumentative units: Text segments with an argumentative function
Usually, the premises and conclusions of arguments
- **Task.** Given a text, split it into argumentative units and other parts

non-argumentative

argumentative

” If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats. Nothing justifies to endanger the life of innocent people. ”

■ How does it work?

- Typically approached with token-level sequence labeling
- Rather reliable within specific genres (F_1 0.72–0.82) (Ajjour et al., 2017)
- Unsolved across genres

Task 2: Classifying the types of units

■ Unit type classification

- Unit types: Roles in an argument, or claim and evidence types
Examples: (1) Roles: Thesis, conclusion, premise; (2) evidence types: Statistics, testimony, anecdote
- **Task.** Given an argumentative unit, assign one type from a set of types

Conclusion

” If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats. Nothing justifies to endanger the life of innocent people. ”

Premise

Premise

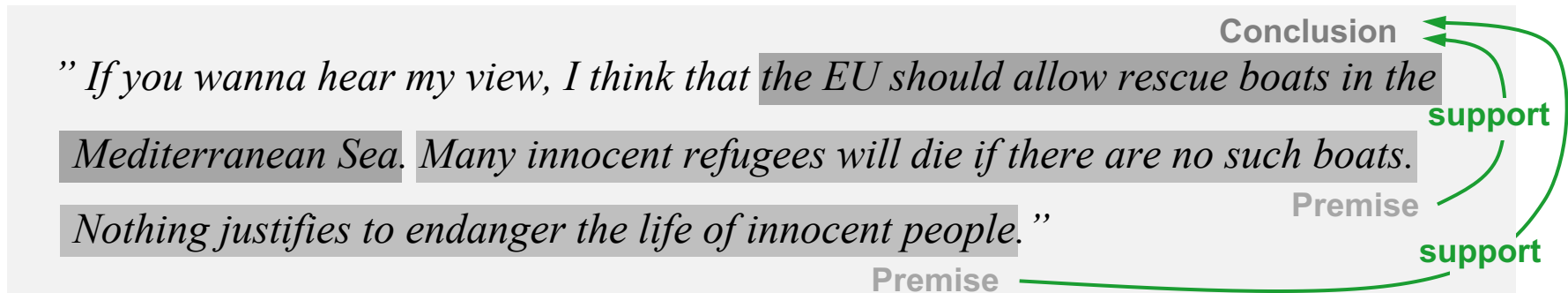
■ How does it work?

- Typically approached with span-level classification or sequence labeling
- Reliable on explicit argumentation, such as in essays (F_1 0.87) (Stab, 2017)
- Still rather reliable on user-generated content (F_1 0.80) (Morio et al., 2020)

Task 3: Identifying relations between units or arguments

▪ Relation identification

- Argumentative relations: Premise to conclusion, or argument to argument
Usually, support or attack, partly more fine-grained subtypes
- **Task.** Given two units/arguments, what relation holds between them, if any



▪ How does it work?

- Diverse techniques from pair classification to graph-based optimization
- Semi-reliable for explicit argumentation (F_1 0.73) (Stab, 2017)
- Unsolved for "hidden" argumentation, even hard for humans (Al-Khatib et al., 2017)

Task 4: Detecting an argument's stance on an issue

■ Stance detection

- **Stance:** Someone's position towards a target, such as an issue or claim
Stance is pro or con, sometimes also none or neutral
- **Task.** Given a unit/argument, classify the stance it conveys on a given target
Conceptual overlap with relation classification

Pro towards rescue boats

Conclusion

"If you wanna hear my view, I think that the EU should allow rescue boats in the

Mediterranean Sea. Many innocent refugees will die if there are no such boats.

Premise

Nothing justifies to endanger the life of innocent people."

Premise

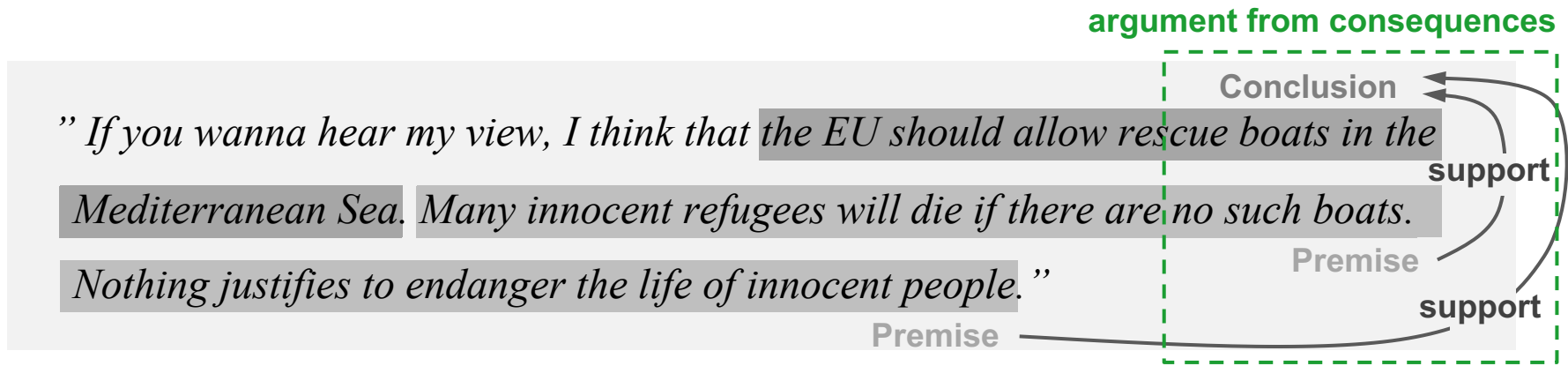
■ How does it work?

- Usually supervised classification of conclusion-topic pairs
- State of the art models the full debate graph (accuracy 0.83) (Barrow et al., 2021)
- Focus on confident cases allows boosting accuracy (0.94) (Bar-Haim et al., 2017)

Task 5: Classifying an argument's scheme

■ Scheme classification

- **Argumentation scheme.** Form of inference from premises to conclusion
Several schemes exist, such as argument from cause to effect, expert opinion, analogy, ... (Walton et al., 2008)
- **Task.** Given conclusion and premises, assign a scheme from a scheme set



■ How does scheme classification work?

- Usually supervised one-against-others classification
So far, only done for a small set of very frequent schemes
- Some schemes easy, e.g., *argument from example* (accuracy 90.6)
- Others hard, e.g., *argument from consequences* (62.9) (Feng and Hirst, 2011)

Task 6: Scoring or comparing argument quality

■ Argument quality assessment

- Argument quality: Logical, rhetorical, or dialectical strength of an argument
- **Scoring.** Given a unit/argument, rate it on a given scale
- **Comparison.** Given two units/arguments, decide which one is better

The diagram illustrates argument quality assessment. It features a central text box with an argument and several evaluation criteria in colored ovals. The argument text is: "If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats. Nothing justifies to endanger the life of innocent people." The text is split into three lines. The first line is labeled "Premise" and has a score of "acceptability: 4 / 5". The second line is also labeled "Premise". The third line is labeled "Premise". The evaluation criteria are: "cogent?", "effective?", "reasonable?", "acceptable?", "clear?", and "relevant?". An arrow points from the "Premise" label to a comparison box.

cogent? effective? reasonable?

"If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats. Nothing justifies to endanger the life of innocent people."

Premise
acceptability: 4 / 5

acceptable? clear? relevant?

more acceptable than

■ How does it work?

- Several techniques, from supervised learning to graph-based analyses
- Diverse results, general feasibility open

Inherent subjectiveness is a main problem

"It's the main job of the EU to save people's lives, no matter whether they belong here."

Task 7: Summarizing arguments and debates

▪ Argument summarization

- Summary: A short(er) text covering the key points from one or more long(er) texts in a coherent fashion
- **Task.** Given one or more argumentative texts, create a summary

” If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats. Nothing justifies to endanger the life of innocent people. ”



”Without rescue boats, many innocent refugees will die.“

▪ How does that work?

- Extractive approaches rather *analyze*, e.g., to rank units (Alshomary et al., 2022)
- Abstractive approaches often use language modeling (Syed et al., 2021)

Task 8: Creating and composing argumentative texts

■ Argument generation

- **Creation.** Given an issue, generate a unit or argument discussing it
- **Composition.** Given a stance on an issue and a pool of units/arguments, phrase a text with arguments supporting the stance

Units may also be retrieved or generated on-the-fly. Other variations of the task also exist.

**Pro towards
rescue boats**



*” If you wanna hear my view, I think that **the EU** should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats. While having such boats may make even more people die trying, nothing justifies to endanger the life of innocent people. Got it? “*

■ How does that work?

- Recycle topics and predicates in new claims, using parsing and classification (Bilu and Slonim, 2016)
- Compose premises and conclusions in learned ways (El Baff et al., 2019)
- Construct unit from other units using language models (Gurcke et al., 2021)

Task 9: Rewriting and countering arguments

▪ Argument rewriting and countering

- **Rewriting.** Given an argument, rephrase it with changed properties
- **Countering.** Given an argument, generate an argument that attacks it

Counterargument may oppose to an argument's conclusion, to a premise, or to the inference between them

The EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no such boats.



Having rescue boats also may have negative effects. Even more people may die trying, believing that they may be rescued.

▪ How does that work?

- Retrieve compose, and rephrase argument units (Hua et al., 2019)
- Generate new arguments with conditioned language models (Alshomary et al., 2023)
- Align rewriting behavior of LLM using reinforcement learning (Ziegenbein et al., 2024)

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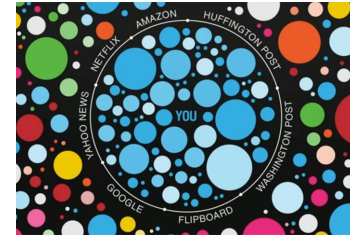
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Conclusion

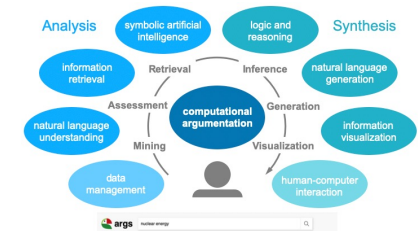
■ Argumentation

- Of ever increasing importance in the "post-factual age"
- Arguments along with rhetorical and dialectical aspects
- Used to persuade or agree with others on controversies



■ Computational argumentation

- Computational analysis and synthesis of arguments
- Important applications, such as argument search
- So far (and here), NLP in the focus



■ Main tasks in computational argumentation

- Mining of argumentative units, roles, and relations
- Assessment of stance, framing, quality, ...
- Generation of summaries, arguments, counters, ...

If you wanna hear my view, I think that the EU should allow rescue boats in the Mediterranean Sea. Many innocent refugees will die if there are no rescue boats



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