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Master programmes in Artificial Intelligence 4 Careers in Europe

University of Cyprus

COGNITIVE PROGRAMMING FOR HUMAN-CENTRIC AI

Antonis Kakas

Autumn 2022

Lecture 1

Cognitive Systems

1. **What is a Cognitive System?**
2. **How does it differ from Traditional Systems>**
3. **How can we build Cognitive Systems.**
4. **Ethical Requirement**

Cognitive Systems

- **What is a Cognitive System?**
  - One that thinks and behaves like a human.
  - Gold Standard already exists: a Human

Cognitive Systems

- **What is a Cognitive System?**

Systems that act on their own to achieve goals

- **Perceive their Environment**
- **Anticipate the need to act/think**
- **Learn from Experience**
- **Adapt to changing circumstances**
- **Governed by ethical guidelines.**

Cognitive Computing – AI
(From an IBM talk by K. Kokkikos)

1890's-1950's
Massive growth in people and things demanded single-purpose systems that could count.

For the first time, a program like US Social Security was possible.

The Tabulating Era

1950's-Today
The increasing complexity of business and society demanded multi-purpose systems that could apply logic to perform pre-programmed tasks.

For the first time, a feat like landing on the moon was possible

The Programmable Era

Today
Continually changing scale and complexity require real-time judgment – systems that sense, learn and understand to help humans make decisions and take action.

With technology augmenting and extending human intelligence, it's difficult to imagine what's not possible.

The Cognitive Era

Example of Cognitive System/Programming

Cognitive On-line Shopping Assistant

"The quality of food is very important for me. I like to eat organic food. I am not diabetic but I like to avoid sugary foods. I prefer not to eat red meat except for special occasions. When possible try to economize."

"The fish last night was very good. I would have liked a bigger portion."

Cognitive Systems

- **How do we build Cognitive Systems?**
  - Synthesis of Cognitive Psychology and AI
  - Cognitive Psychology **informs** AI
  - **Read the EU document "AI for Europe"**

Cognitive Systems

- **How do WE build Cognitive Systems?**
  - Cognitive Argumentation
    - “Implements” the Synthesis of Cognitive Psychology and AI within Computational Argumentation.

Cognitive Systems

- What is the **main requirement** of Cognitive Systems (AI systems more generally)?
  - Ethical Operation/Behaviour
- Read the paper on the Moral Machine

Cognitive Systems
Ethical Design

- Adhere to **moral values**
  - Ethical decisions are **context-sensitive**
  - One way: By respecting of norms: laws/regulations
    - Again **context sensitive**
- Unavoidable moral **dilemmas**

Cognitive Systems
Explainable AI

- Decisions/actions by AI systems need to be explainable
  - Explainable AI - XAI

- Why?
  - So that they can be ethical!

Argumentation for Ethics - Explainability

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision

  - Why did you not help the child?
    - To protect myself (self_respect)
    - Would be unlawful to hurt someone (obey norm)

  - Why did you hurt the person?
    - To defend myself (self_respect)
    - To help the child in need (respect for the weak)
      - Will come back to this norm-violating explanation

Argumentation for Ethics – Explainability (2)

- **Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision**
  - **Argumentation has explanation as a primary object:**
    - **Explanation is the argument that supports the action**
  - **Why did you hurt the person?**
    - **To defend myself (self_respect)**
    - **To help the child in need (respect for the weak)**
      - **Will come back to this norm-violating explanation**

Argumentation for Ethics – Explainability (3)

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision
  - Furthermore, argumentation contains also dialectic information of counter-arguments and defenses (along with the initial supporting argument)
  - Hence it can provide deeper explanations if requested, e.g. when decision is contested and an ensuing debate.
  - Example: Hurt because:
    - child was in immediate danger:
    - there was no time to get help from police

Argumentation for Ethics – Explainability (3)

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision

  - Furthermore, argumentation contains also dialectic information of counter-arguments and defenses (along with the initial supporting argument)

    - Example: Why Hurt? "To help the child in need"
      - Norm-violating explanation
    - Deeper Explanation via Explication of the special context

Argumentation for Ethics – Explainability (4)

- **Argumentation can provide informed explanations and a supporting dialogue for users to analyze and possibly resolve their ethical dilemmas**
  - **Cognitive Explanations of arg-based decisions**
- **Cognitive Experiments to evaluate this overall goal of arg-based ethics**
  - **How do the explanations affect users decision? Do they change their mind/decision?**
  - **Do the explanations and dialogue help users in their ethical decisions?**
    - **What does "help" mean here? Follow moral guidelines???**

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Lecture 1

Argumentation in AI: Motivation

1. **Motivation for Argumentation in AI**
2. **Theory of Computational Argumentation**
3. **Realizations of Argumentation**
4. **Engineering Argumentation-Based systems**
5. **Real-life Applications of Argumentation**

In One Slide

- **What is Argumentation?**
  - Arena of contemplation between alternatives
  - Essential elements of this arena
- **How does it work?**
  - Set up the arena of argumentation
  - Dialectic Argumentation process
- **How do we develop argumentation-based AI systems?**
  - Engineering Methodology for Argumentation-Based systems
    - Argumentation/Knowledge acquisition & Computational "Heuristics" (Cognitive)
- **Real-life Applications & Tools (Gorgias System)**
- **Further Reading Topics**
  - E.g. Argumentation: a Universal Logic?, Argumentation & ML in AI, …

Motivation

Why Argumentation (for AI)?

Foundational Level

Technological Level

Argumentation
Foundations of (Cognitive) AI

▫ Argumentation – Foundational Links:

- Cognition/Human Reasoning
- Formal Logic
- Induction/Machine Learning
- Explainability
- Persuasion
- Ethical (or Responsible) AI

Human like Systems

Why Argumentation?

- Argumentation is native to human reasoning
  - Cognitive Psychology - Mercier & Sperber
  - Behaviour Economics – Thaler, Kanehman
    - "Humans are not rational"

- Knowledge captured as arguments

Why Argumentation?

- **Formal Logic in terms of Argumentation**
  - **"Infomalizing Formal Logic"**
  - **Argumentation unifies strict/formal and informal reasoning**
- **Argumentation is the primary notion of reasoning.**

Argumentation as Logic Universalis

Formal … … … Informal Reasoning

Flexibility of Argumentation →

Syllogistic Challenge 2017

- Formalize and automate the ordinary – common sense – human syllogistic reasoning.

- Cognitive Models evaluated on unseen data gathered from 140 human reasoners on the full set of 64 cases of Aristotelian Syllogisms.

- Argumentation approach based on formal and informal argument schemes.

- Argumentation performs very well in the challenge.

Learning/Induction

Why Argumentation?

- **Learned Knowledge ⇔ Argument schemes**
  - **Learned associations/rules are not necessary links but provide arguments to support links**
  - **This view addresses old philosophical questions with induction**

Learning & Reasoning

Why Argumentation?

- Integration of Connectionism and Symbolism
  - Conceptualization Phase: Organization of Learned Information into Concepts & their Associations.
  - Then this leads to two processes of:
    - Recognition of (cases of) Concepts
    - Propagation of this recognition to other associated concepts
- Argumentation gives a Model of Cognitive Processing on top of Machine Learning.

Explainability

Why Argumentation?

- **Arguments explicitly support a conclusion or claim or decision**
  - **And the rejection of other alternatives by defending against counter-arguments**
- **Explainable AI**
  - **EU law for the Protection of Natural Persons**

Why Argumentation?

- Gorgias: Methods of Persuasion
  - Force – Seduction – Reason
- Argumentation: Vehicle of Seduction

Ethical Systems

Why Argumentation?

- **Ethics as the requirement of AI systems**
- **Ethics is addressed via debate and contemplation of moral dilemmas**
  - **Norms and Obligations guidelines**
- **Argumentation: Framework for Ethical Analysis**

Motivation

Why Argumentation (for AI)?

Foundational Level

Technological Level

What is Argumentation?

- **Intelligence: build on connectionist hardware**
  - **This hardware can be build by Machine Learning**
  - **To use effectively the hardware we need a higher-level process: This is Cognition.**
  - **Cognition's main task: To handle conflicts**
- **Argumentation provides a mediator layer on top of the connectionist hardware for Cognition.**

What is Argumentation?

- Natural Intelligence or high-level cognition is manifested by its handling of Conflicting Information
  - Uncertain, Incomplete, …, information boils to Conflicting

- Aristotle: "Dialectic Argument" for handling conflicting positions/claims

- Formal logic not directly suitable to handle conflicts

- Cognitive Psychology saying this for 100 years
  - Human Reasoning is not Classical Logical Reasoning

Argumentation
Technology of Cognitive AI

- **Natural User Interaction**
  - **High-level (natural) interface language**
  - **Human like interaction:**
    - **Through explanation and dialogues**

- **Flexibility and Robustness of systems**
    - **Incomplete, contextual and conflicting knowledge**
    - **Consideration of different (conflicting) view points**

Argumentation Logic
Integration of ML & Logic

- **Argumentation is a universal form of cognitive/symbolic inference/logical reasoning.**

- **Argumentation – scenarios - as the target language for Machine/Deep Learning**

Argumentation Technology

Argumentation provides a mediator layer on top of the mind's connectionist hardware for Cognition

⬇

Argumentation on top of Machine Learning for Human-like AI

References for Motivation

- From Philosophy & Cognitive Science Literature on argumentation
  - Toumlin, Pelerman, Pollock, …

- References from:
  - http://cognition.ouc.ac.cy/argument/
  - Kakas, Michael (2016), Cognitive Systems: Argument and Cognition. IEEE Intelligent Informatics Bulletin.

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Lecture 1

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PART 1

THEORY of COMPUTATIONAL ARGUMENTATION

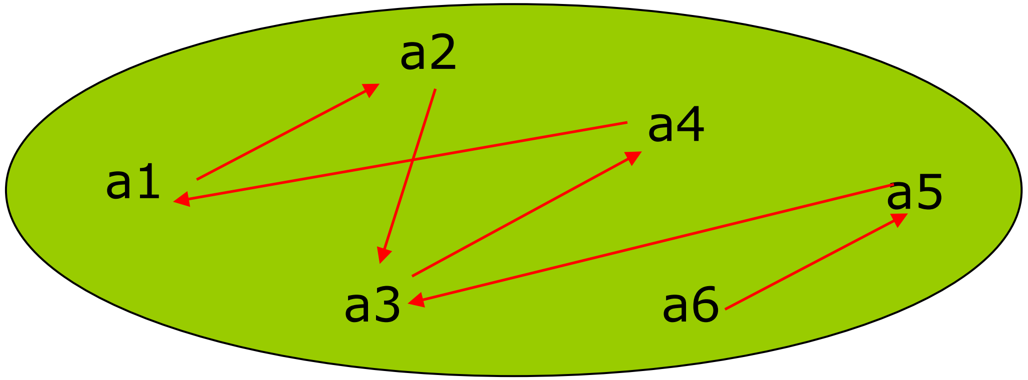
Abstract Argumentation

Computational Argumentation BASICS [Dung, Kowalski, et al]

- **Definition: Argumentation Frameworks**
  <Args, ATT> OR <Args, Att, Def>
  - **Args is a set of arguments**
  - **Attacking Relation(s), ATT & Att, are binary relations on Args.**
  - **Defense Relation Def: binary relation on Args.**
    - **Def ⊆ Att**

Argumentation Framework Example 1

<Args, ATT>



- **Args : {a1,a2,a3,a4,a5,a6}**
- **ATT : Follow the arrows.**

Computational Argumentation BASICS [Dung, Kowalski, et al]

- **Argumentation Frameworks:**
  - **<Args, ATT> OR <Args, Att, Def>**
  - **Arguments in Args have no structure.**
    - **Structure is hidden inside them.**
    - **ATT is also given extensionally.**
      - **ATT is atomic: Lifts naturally to sets of arguments**

Computational Argumentation BASICS [Dung, Kowalski, et al]

- **Argumentation Frameworks:**
  - **<Args, ATT> OR <Args, Att, Def>**

  - **Attacking Relation, ATT, is related to Att and the Defense Relation Def:**
    - **(a,b)** ∈ **ATT** ⇒
      - **a** and **b** *are in conflict* (**(a,b)** ∈ Att)
      - **a** *is as strong as* **b** (**(a,b)** ∈ Def)

Argumentation Process

<Args, ATT> or <Args, Att, Def>

Step 1: Construction of Arguments

I.e. Construction of Args

Step 2: Evaluation of Arguments

- **Relative to each other via ATT or Att and Def**
- **Against their counter-arguments**

Evaluation of Arguments

Semantics of ARGUMENTATION

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?

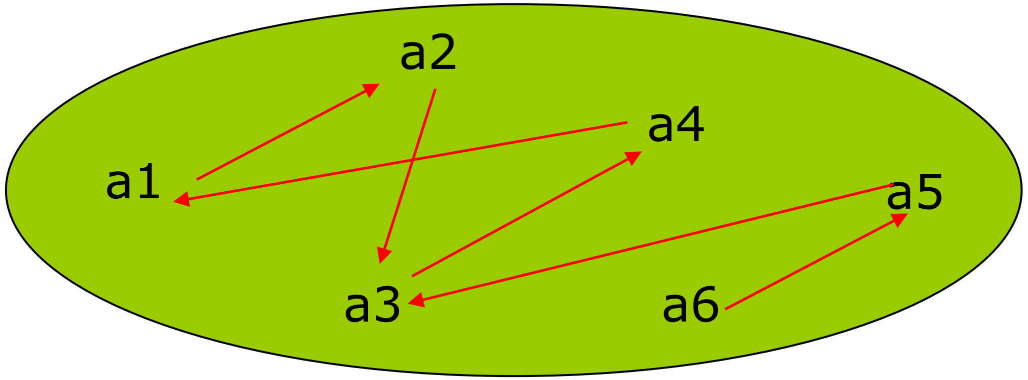
- **Answer:** **Arguments that attack back the arguments that attack them, i.e their counter-arguments.**

- **Or,** **Arguments that defend against their counter-arguments.**

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?

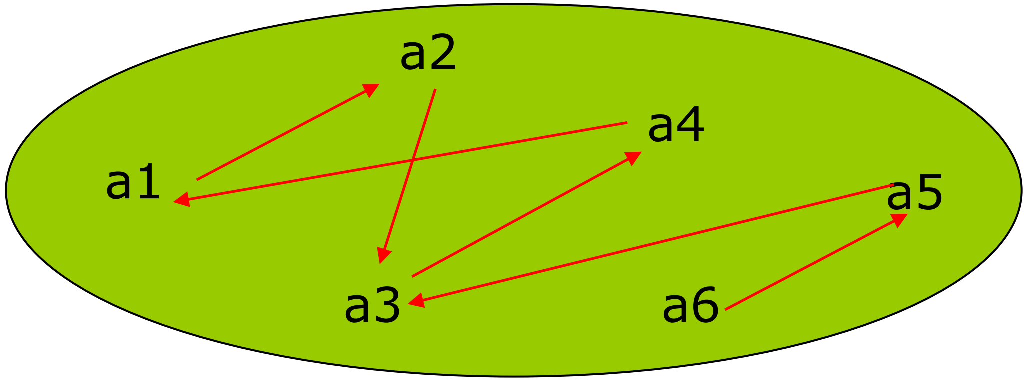


- **Answer: Arguments that attack back their counter-arguments:**
  - **{a1}?, {a1,a3}?, {a1,a3,a6}?**

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?

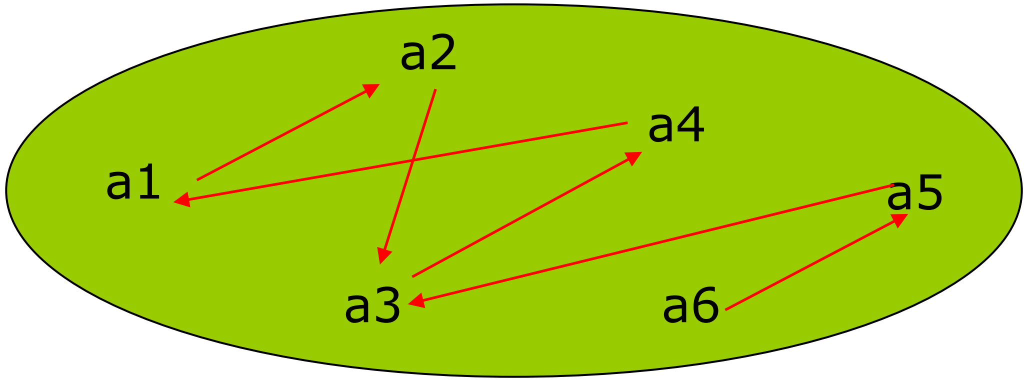


- **Only {a1,a3,a6}!**
  - **Attack by a4 attacked back/defended by a3**
  - **New attack on a3 by a2 defended by a1**
  - **New attack on a3 by a5 defended by a6**
  - **No attacks on a6**

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?



- **Only {a1,a3,a6}!**
  - **Coalitions of arguments**
- **Is {a1, a2} valid/acceptable coalition?**
  - **No – it is self-attacking!**

Evaluation in Abstract Argumentation

<Args, ATT>

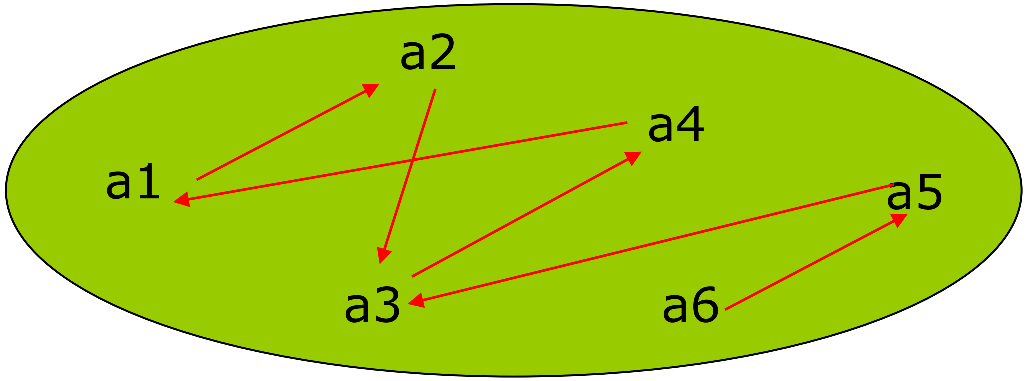
Q: Which arguments are valid/acceptable?

- **Admissible set of Arguments, D:**
  - **D is not self-attacking**
  - **D attacks back all its counter-arguments.**
- **Or, Arguments that defend against their counter-arguments.**

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?

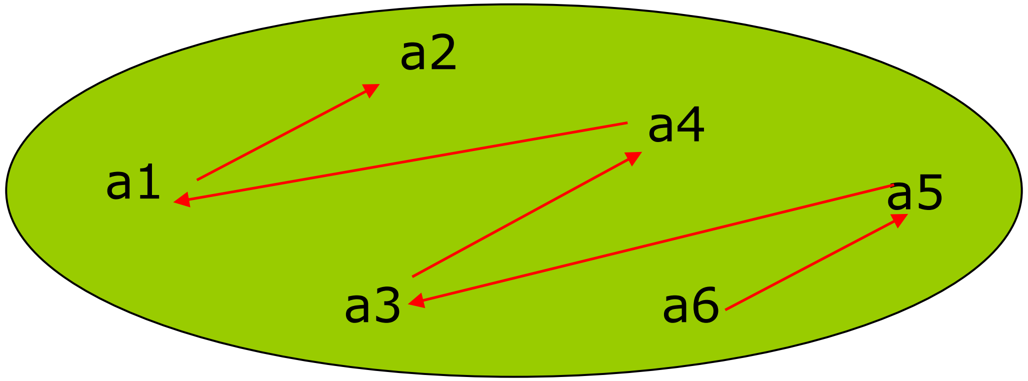


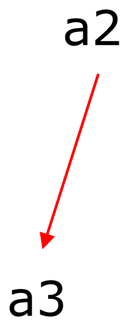
- **{a1,a3,a6} is admissible.**
- **{a1, a2} is not admissible (self-attacking).**
- **Is {a6} admissible? Yes.**
    - **{a6, a3} is not. It needs a1.**

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?





- **Is {a6} admissible? Yes.**
- **{a6}, {a6, a3}, {a6, a3, a1} all admissible**
- **They are all grounded on a6.**
  - **Grounded semantics.**

Semantics of Abstract Argumentation

<Args, ATT>

- **Admissibility**
  - **Grounded, Complete, Stable, ….**
- **Above semantics are incomplete:**

⇒ **Acceptability semantics**

Acceptability Semantics

Validity of Argument:

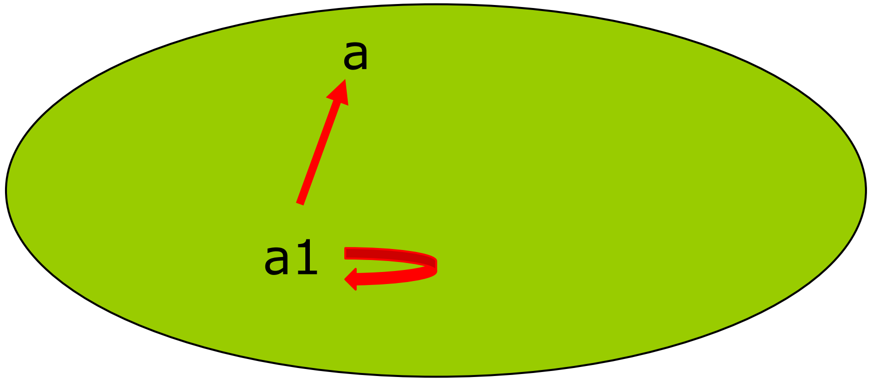
- **Valid iff all its counter-arguments are not Valid.**

- **Valid iff all its counter-arguments are or rendered by it not Valid:**
  - **RENDERED: Defending against counter-argument**
  - **ARE: Counter-argument is "self-defeating"**
    - **Case of Proof by Contradiction!**

Acceptability Semantics

<Args, ATT>

Q: Which arguments are valid/acceptable?



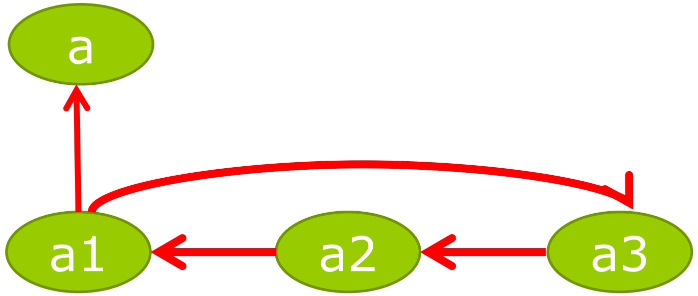
- **Is {a} acceptable?**
  - **Yes, we would like it to be so!**
  - **It is because its (only) attack is non-acceptable.**
    - **{a1} is self-defeating.**
  - **Abstraction/generalization of Proof by Contradiction**

Acceptability Semantics in <Arg,Att,Def>

- A set Δ is **acceptable relative** to another set Δ':
  Acc(Δ,Δ′) iff $\Delta \subseteq \Delta'$, or
  for any A that **attacks** Δ: $A \not\subseteq \Delta' \cup \Delta$ and
  there exists D that **attacks/defends** A
  such that ***Acc(D, Δ′ ∪ Δ).***
- **Acceptability:** ***Acc(-,-)*** is its least fixed point.
  - Then, Δ is **acceptable** iff ***Acc(Δ,{})*** holds.
- **Acceptability** ↔ **Dialectical Argumentation**
- **Non-acceptability via an analogous fixed point.**
  - **NB**: a **"relativistic" labelling** semantics.

Acceptance/Rejection of arguments

- **Feature of acceptability semantics it captures:**
  - **"Arguments attacked by non-acceptable arguments are acceptable."**
- **Special class of non-acceptable arguments: Fallacies.**
- **Recognizing fallacious arguments gives new acceptable arguments.**

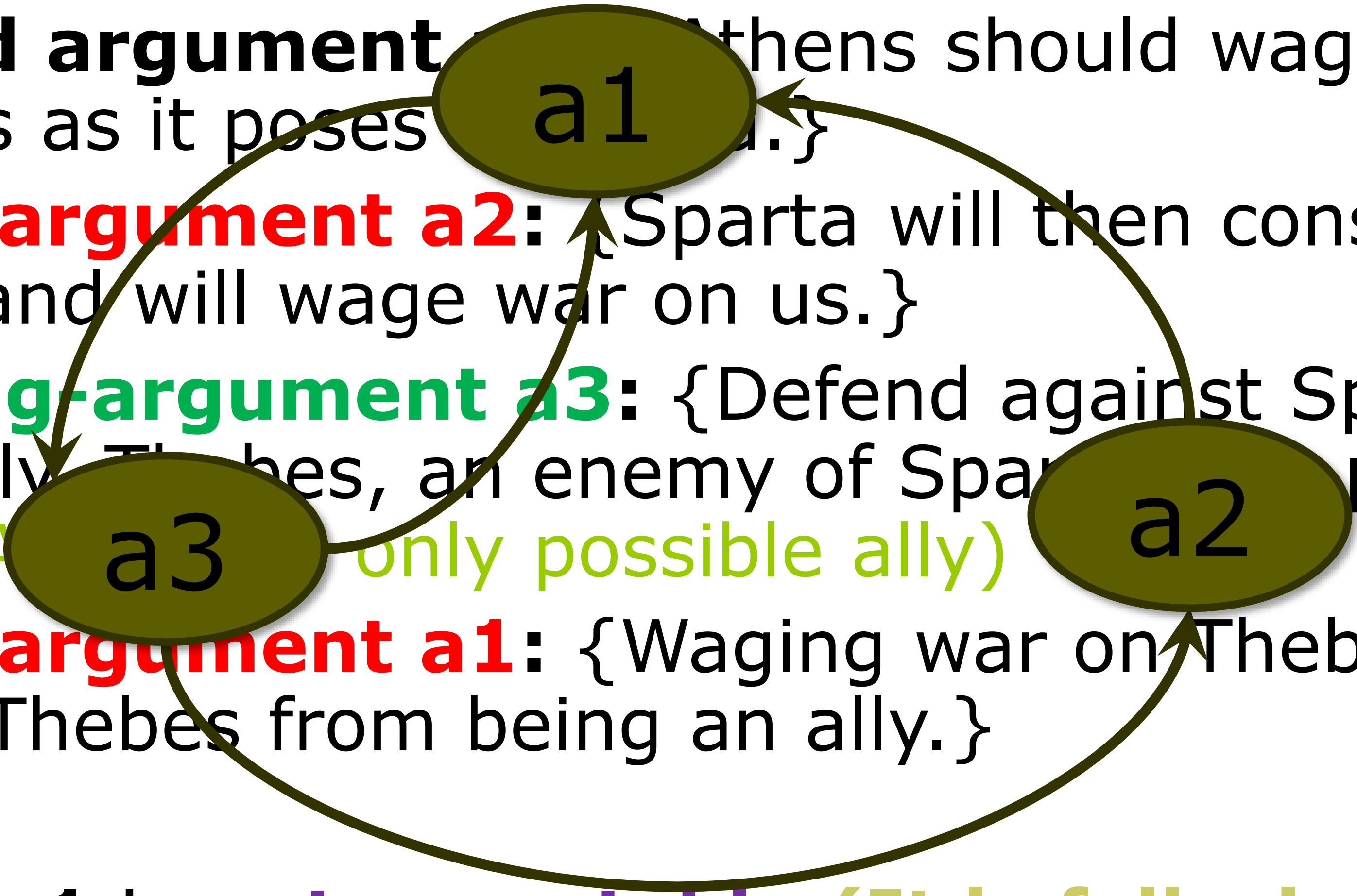


{a1} is fallacious

Hence, {a} is Acceptable

"Debate" Example

- **Proposed argument a1:** {Athens should wage war on Thebes as it poses a thread.}
- **Counter-argument a2:** {Sparta will then consider us a thread and will wage war on us.}
- **Defending-argument a3:** {Defend against Sparta with an ally Thebes, an enemy of Sparta and its only possible ally.} (A… only possible ally)
- **Counter-argument a1:** {Waging war on Thebes prevents Thebes from being an ally.}



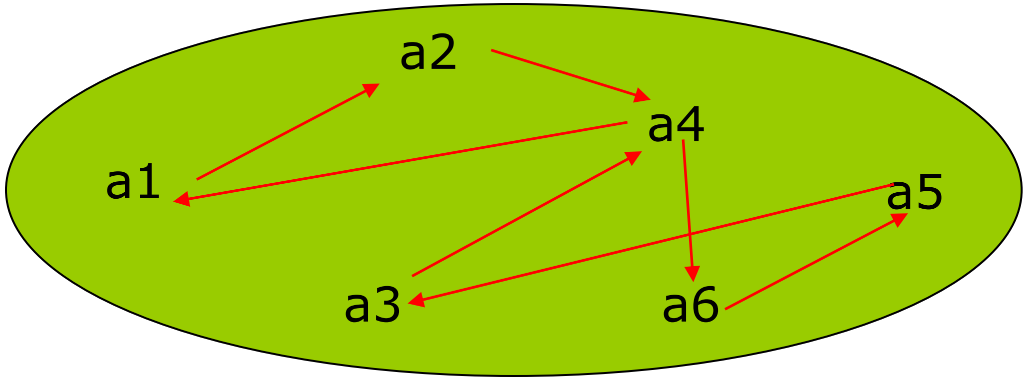
Hence a1 is **not acceptable** **(It is fallacious).**

References for Part 1 (Theory)

- Kakas, Kowalski, Toni (1992), Abductive Logic Programming, Journal of Logic & Computation.
- Dung (1993, 1995), "On the Acceptability of Arguments and its Fundamental Role … , IJCAI1993, Journal of Artificial Intelligence.
- Kakas & Mancarella (2013), On the semantics …, Journal of Logic & Computation

Exercise 1 (for Part 1)

- **Ex1.1: What is an appropriate reverse relation from <Args, Att, Def> to <Args, ATT>?**
- **Ex1.2: Give all admissible and acceptable subsets of arguments in the following framework:**



End of PART 1

THEORY of COMPUTATIONAL ARGUMENTATION

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Lecture 3

Evaluation of Arguments

1. How are arguments evaluated?
2. Relative acceptability of arguments
3. Cognitive influence in evaluation
4. Inference via Valid arguments
5. Logical Conclusions
6. Decision Making

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Contents

- How are arguments evaluated?
  - Relative acceptability of arguments
  - Cognitive influence in evaluation

- Inferences via Valid arguments
  - Logical Conclusions
  - Decision Making

Reminder: Argumentation Basics

- **Argumentation Frameworks:**
  - **<Args, ATT> OR <Args, Att, Def>**

- **An argument "a" attacks another "b", i.e. (a,b) ∈ ATT iff:**
  - **a** and **b** $are\ in\ conflict\ (i.e.$ **(a,b)** $\in Att)$
  - **a** $is\ as\ strong\ as$ b $(i.e$ **(a,b)** $\in Def)$

Reminder: Argumentation Process

<Args, Att, Def>

Step 1: Construction of Arguments

I.e. Construction of Args

Step 2: Evaluation of Arguments

- **Relative to each other via Att and Def**
- **Against their counter-arguments**

Reminder: Cognitive Systems

- **What is a Cognitive System?**
  - One that thinks and behaves like a human.
  - Gold Standard already exists: a Human

- **How do WE build Cognitive Systems?**
  - **Cognitive Argumentation**

PART 1

COMPUTATIONAL ARGUMENTATION

Evaluation of Arguments

Evaluation in Abstract Argumentation

<Args, ATT>

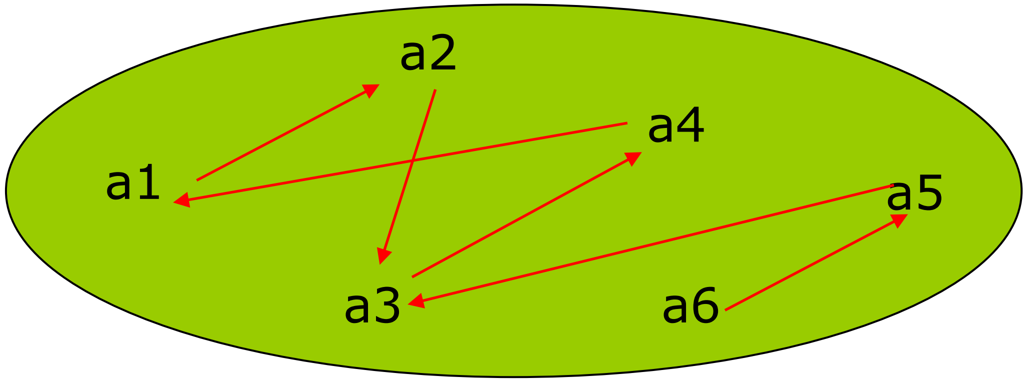
Q: Which arguments are valid/acceptable?

- **Answer: Arguments that attack back their counter-arguments.**
  - **Arguments that defend against their counter-arguments.**

Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?



- **Answer: Arguments that attack back their counter-arguments:**
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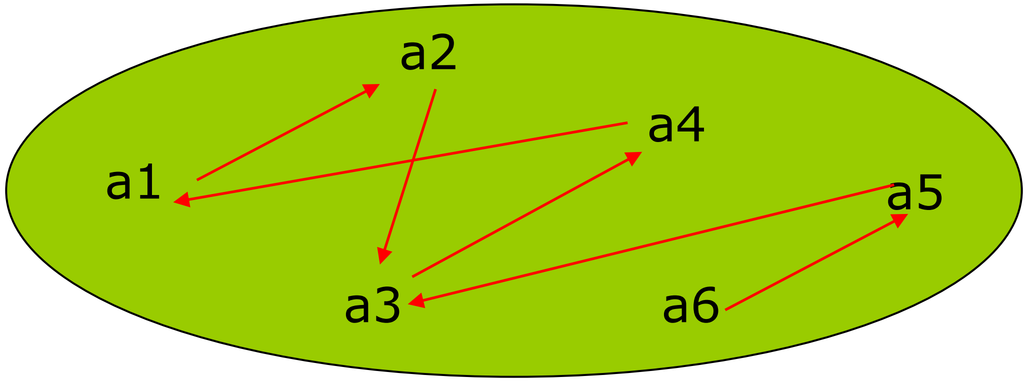
Evaluation in Abstract Argumentation

<Args, ATT>

Q: Which arguments are valid/acceptable?



- **Only {a1,a3,a6}!**
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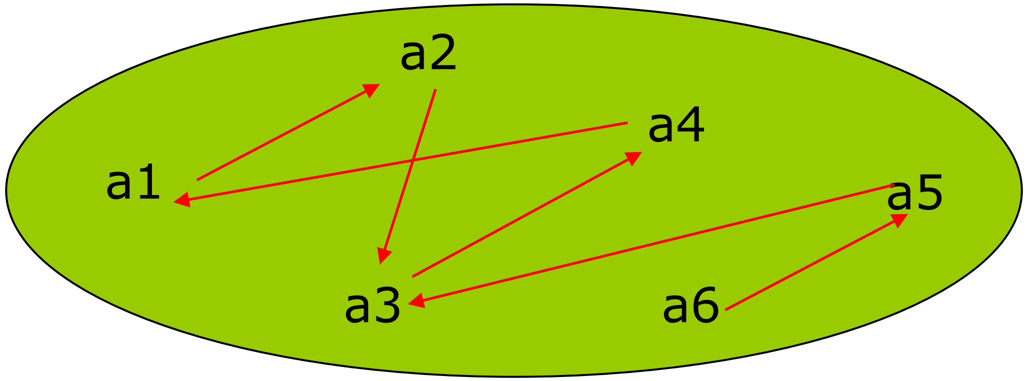

- **Only {a1,a3,a6}!**
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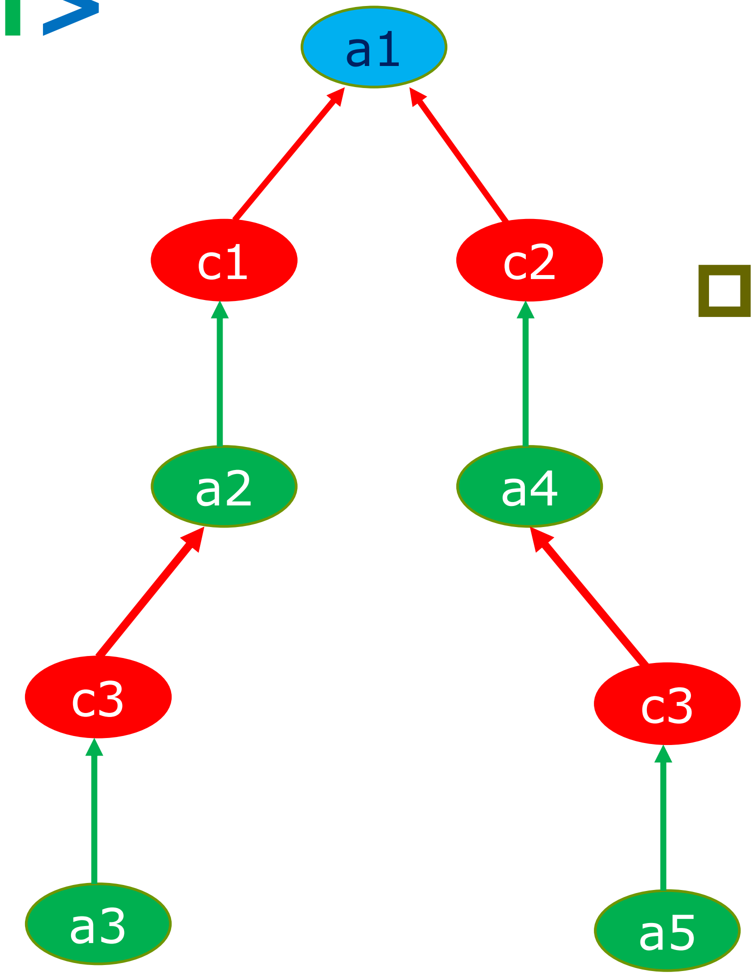
Acceptable Arguments

<Args, Att, Def>



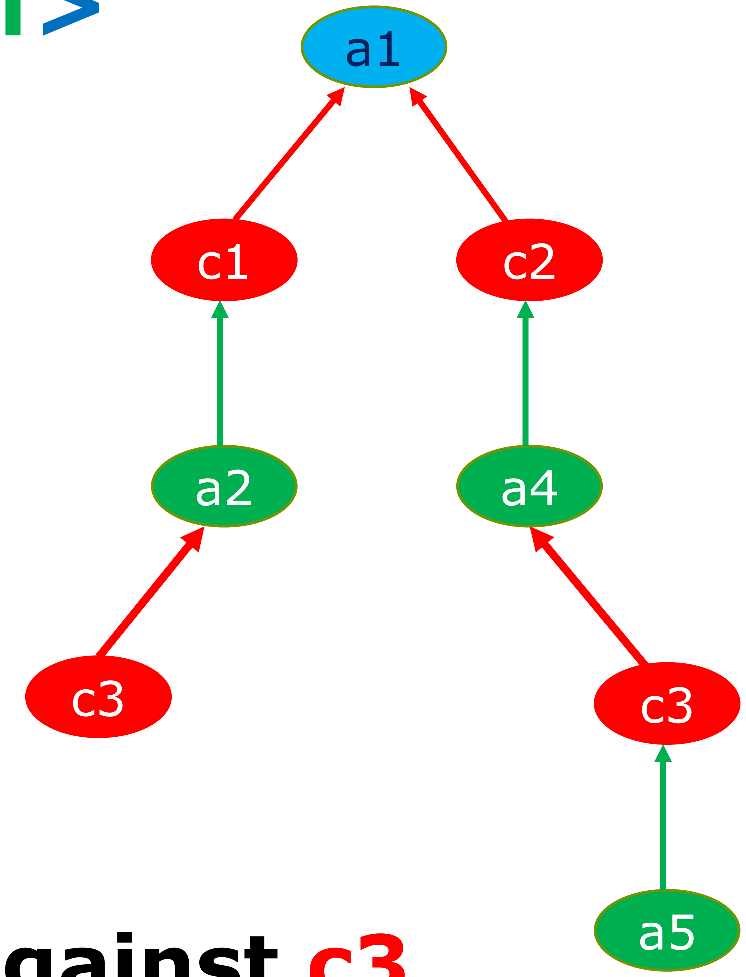
- {a1,a2,a4,a3,a5} is **acceptable.**

Non-Acceptable Arguments

<Args, Att, Def>

- {a1} is **not acceptable.**

Does not defend against c1, since a2, a needed defence can not defend against c3.



***Is {a4} accept?**

Acceptability/Validity of Arguments

Validity of Argument:

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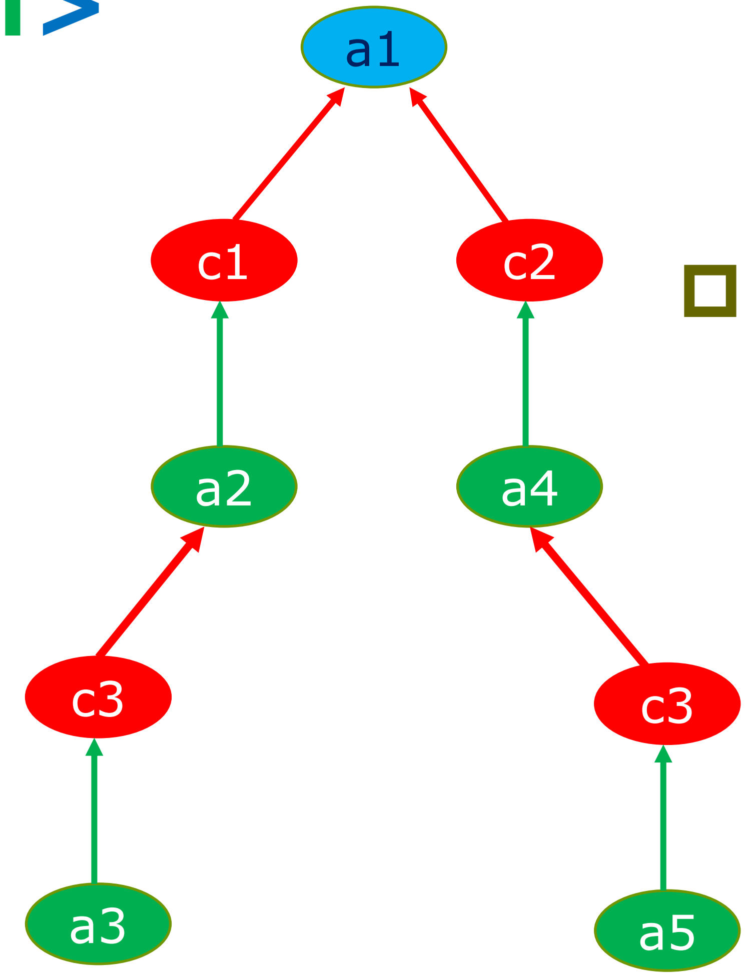


- **{a1,a2,a4,a3,a5}** is **acceptable.**
- **c1 is rendered invalid by a2 and c2 by a4.**

PART 2

COMPUTATIONAL ARGUMENTATION

Inference via Argumentation

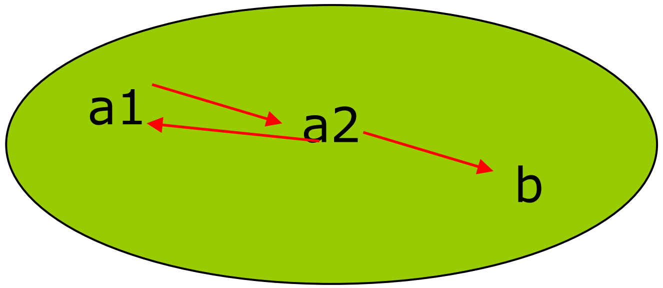
Argumentation based Reasoning

- **Conclusion φ:**
  - **Acceptable Argument for φ**
  - **No acceptable argument for ¬φ**

- **The two positions/choices of φ and ¬φ argue against each other.**

- **A conclusion is a "clear winner".**
  - **Otherwise, we have acceptable arguments for both φ and ¬φ.**

Example of Inference



a1 supports φ

a2 supports ¬φ

b supports σ

- **What conclusions/inferences can we draw?**
  - **φ is a credulous conclusion ({a1} is acceptable)**
  - **¬φ is a credulous conclusion ({a2} is acceptable)**
  - **σ is a sceptical conclusion ({b, a1} is acceptable)**
    - **There are no arguments (at all) that support ¬σ**
  - **How can it happen that there are no arguments?**
  - **This question concerns Cognitive Argumentation**

Argumentation based Decision Making

- **Reach a Decision for an option O:**
  - **Acceptable Argument for O**
  - **No Acceptable argument for O′**
    - **O′ is any alternative (incompatible) option.**
- **Credulous and Skeptical decisions**

COGNITIVE ARGUMENTATION

- **Cognitive Argumentation refers to an argumentation framework that is customized and informed from results on human reasoning and high-level cognition.**
  - **Both for the construction of arguments and their evaluation.**
- **Cognitive Argumentation will form the foundation for building Cognitive Systems.**
- **SEE FOLLOW UP LECTURE(S).**

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PART 3

COMPUTATIONAL ARGUMENTATION

Realizing Inference in
Realizations of Argumentation

Reminder: Realizing ARGUMENTATION

Step 1: Construction of Arguments

Q: What is an argument?

Ans: A LINK between information

arg: "Premises → Claim"

- **Argument Schemes: licenses for arguments**
  - **"Premises/ἐνδοξα ----→ Position/Claim"**
    - **E.g. "Ambulance ----→ Injury"**

Activated from the text: "The ambulance arrived."

Reminder: Example of Dialectic Argumentation

- "The power cut had turned the house into darkness. Bob came home and turned on the light switch. …"
- **Args** ={a1,a2,a3} **constructed** by:
  - a1={turn_on_switch **causes** light_on, light_on **causes** ¬darkness} U {turn_on_switch@T}
  - a2={power_cut **causes** ¬electricity, ¬electricity **implies** ¬light_on} U {power_cut@T}
  - a3={darkness@T **implies** darkness@T+} U {darkness@T}
- a1 **supports** ¬darkness@T+ ;
- a3 **supports** darkness@T+

Example of Dialectic Argumentation

- a1 **supports** ¬darkness@T+ ; a3 **supports** darkness@T+

- **Attacks** between arguments = {(a1,a3), (a2,a1)}
  - a1 **attacks** a3 but **not** vice-versa (a3 does **not defend** against a1)
  - **Causality stronger than Persistence**
  - a2 **attacks** a1 (on light_on) but **not** vice-versa
  - **Preconditions stronger than Causality**

- {a3,a2} **acceptable** argument for darkness@T+

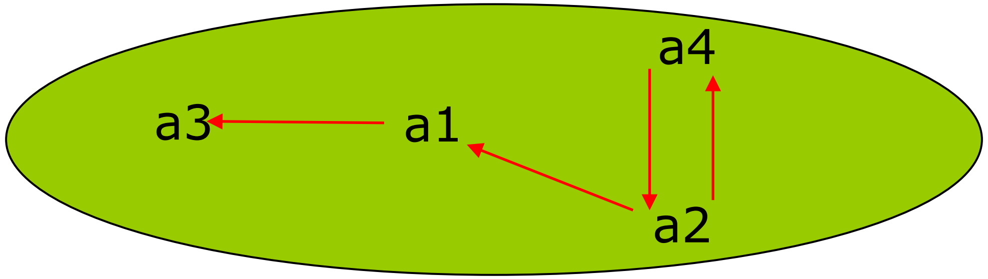
Example of Dialectic Argumentation

- Suppose now that we **also** have an **argument** that the power cut had ended at T, e.g.:
  - **a4** ={short_power_cut@T^- **implies** ¬ power_cut@T} U {short_power_cut@T^-}

- *ATT* = {(a1,a3), (a2,a1), (a4,a2), (a2,a4)}
  - Args a4 and a2 are **equally strong** on **"power_cut"**
    - No **preference** between them. They **defend** against each other.

- {a3,a2} **acceptable** argument for darkness@T^+
- {a1,a4} **acceptable** argument for ¬darkness@T^+

Example Revisited



- **a1 supports** ¬darkness@T+
  - (& light_on@T+)
- **a2 supports** power_cut@T
  - (& ¬ eletricity@T, ¬ light_on@T+)
- **a3 supports** darkness@T+
- **a4 supports** ¬ power_cut@T
  - (& eletricity@T)

{a3,a2} acceptable

{a1,a4} acceptable

Reading

- Phan Minh Dung: "On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and n-Person Games." Artif. Intell. 77(2): 321-358 (1995). [Up to Section 4.]

- Antonis C. Kakas, Loizos Michael: Cognitive Systems: Argument and Cognition. IEEE Intelligent Informatics Bulletin 17(1): 14-20 (2016).

- Henry Prakken, Giovanni Sartor: A Dialectical Model of Assessing Conflicting Arguments in Legal Reasoning. Artif. Intell. Law 4(3-4): 331-368 (1996) [Up to p. 25]

Short Exercise

- **Write down a short story (3 sentences maximum), analogous to the "Power Cut" story in class.**
- **Construct based on common sense argument schemes a set of arguments, Args, that are relevant in comprehending the story. Similarly, construct the attack, ATT, relation between these arguments.**
- **Draw your corresponding abstract argumentation framework <Args, ATT>.**
- **Find the all the acceptable sets/coalitions of arguments and give all credulous and skeptical conclusions supported in your argumentation framework.**

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University of Cyprus

COGNITIVE PROGRAMMING FOR HUMAN-CENTRIC AI

Antonis Kakas

Autumn 2022

Lecture 1

Structured Argumentation

1. **Realizations of Computational Argumentation**

Reminder
Argumentation Process

<Args, ATT> or <Args, Att, Def>

Step 1: Construction of Arguments

I.e. Construction of Args

Step 2: Evaluation of Arguments

- **Acceptability/Validity of argument sets.**

Construction of Arguments

What is an argument?

- **An argument is a LINK between two pieces of information: premises and position (or claim) of the argument.**

a1=(bird; fly)

- **A Link, not a Rule!**

Construction of Arguments

- Arguments are constructed as **instantiations** of **argument schemes**

As=(Premises; Position)

- **Argument Schemes are "programmed" or learned from data analysis or experience**

Realization of Argumentation

<Args, ATT> OR <Args, Att, Def>

- **A realization or a structured argumentation framework of an argumentation framework is:**

<AS, Cf, St>

- **AS is a set of argument schemes**
- **Cf is a conflict relation on the statements**
- **St is a strength/preference relation on AS**

Realization of Argumentation

<As, C, ב> (ב = St)

- **As is a set of argument schemes**
- **C is a conflict relation (in the language)**
- **ב is a binary strength relation on As**

Realization of Argumentation

<As, C, ב>

- **As - construct arguments**
- **C - specify counter-arguments**
- **ב - used for arguments to defend themselves**

Realization of Argumentation

- Given <AS, Cf, St> we construct/realize an Arg. Framework: <Args, ATT> or <Args, Att, Def>
  - Args are instantiations of elements of AS
  - "a1 attacks a2", i.e. (a1,a2)∈ Att, if they are in conflict according to Cf.
  - "a1 defends against a2", i.e. (a1,a2)∈ Def if "a1 is not weaker than a2" under St.
    - In this case, also (a1,a2)∈ ATT

Realization of Argumentation

- From the philosophical roots of argumentation.
- Given <AS, Cf, St> then "a1 attacks a2":
  - a1, a2 are in conflict under Cf and named:
  - Rebuttal if conflicting positions of a1 and a2.
  - Undermine if a1 conflicts the premises of a2.
  - Undercut if conflict between the argument schemes of a1 and a2.

Example of Realizing Argumentation (See earlier lecture)

- "The power cut had turned the house into darkness. Bob came home and turned on the light switch. …"

- **Args** ={a1,a2,a3} **constructed** by **common sense schemes**:
  - a1={turn_on_switch **causes** light_on, light_on **causes** ¬darkness} U {turn_on_switch@T}
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  - a3={darkness@T **implies** darkness@T+} U {darkness@T}

  Argument schemes here are given names: "causes" and "implies"

- a1 **supports** ¬darkness@T+ ; a3 **supports** darkness@T+

Another Example
(from Cognitive Science)

Byrne’s (1989) Suppression Task

Suppression Task (Bryne, 1989)

The factual information given along with the conditional(s) in each of the groups can change:

- **She has an essay to finish** **She does not have an essay to finish**
- **She has studied late in the library** **She did not study late in the library**

	Conditional	essay (e)	no essay ($\bar{e}$)	library (ℓ)	no library ($\bar{\ell}$)
I	$e \rightarrow \ell$	library (96%)	no library (46%)	essay (71%)	no essay (92%)
II	$e \rightarrow \ell$ $t \rightarrow \ell$	library (96%)	no library (4%)	essay (13%)	no essay (96%)
III	$e \rightarrow \ell$ $o \rightarrow \ell$	library (38%)	no library (63%)	essay (54%)	no essay (33%)

Byrne’s (1989) Suppression Task: She has an essay to finish

- If she has an essay to finish, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library 96%
2. She will not study late in the library
3. She may or may not study late in the library

Modus Ponens/ Deduction

Byrne's (1989) Suppression Task: She has an essay to finish

- If she has an essay to finish, then she will study late in the library
- If she has a textbook to read, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library 96%
2. She will not study late in the library
3. She may or may not study late in the library

Modus Ponens/ Deduction is not affected.

Byrne’s (1989) Suppression Task: She has an essay to finish

- If she has an essay to finish, then she will study late in the library
- If the library is open, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library
2. She will not study late in the library
3. She may or may not study late in the library

Byrne’s (1989) Suppression Task: She has an essay to finish

- If she has an essay to finish, then she will study late in the library
- If the library is open, then she will study late in the library
- She has an essay to finish

What follows?

1. She will study late in the library 38%
2. She will not study late in the library
3. She may or may not study late in the library

Humans seem to suppress previously drawn information.
They reason non-monotonically!

Byrne’s (1989) Suppression Task **in Argumentation**

� FORMALIZTION OF THE HUMAN REASONING IN **ARGUMENTATION**

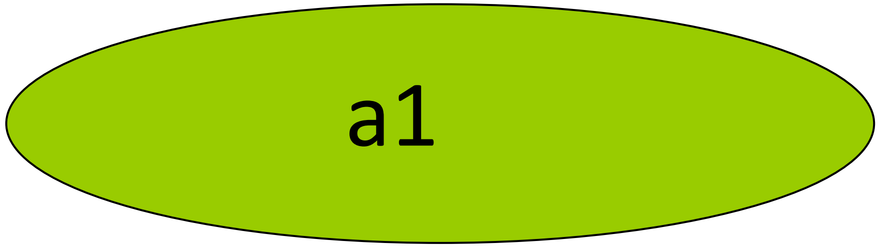
GROUP 1:

If she has an essay to finish, then she will study late in the library

She has an essay to finish

a1: HasEssay → StudyLibrary

a1 **supports** StudyLibrary (when given has an essay)



Byrne’s (1989) Suppression Task **in Argumentation**

� FORMALIZTION OF THE HUMAN REASONING IN **ARGUMENTATION**

GROUP 2:

If she has an essay to finish, then she will study late in the library

If she has a textbook to read, then she will study late in the library

She has an essay to finish

a1: HasEssay → StudyLibrary

a2: HasTextBook → StudyLibrary

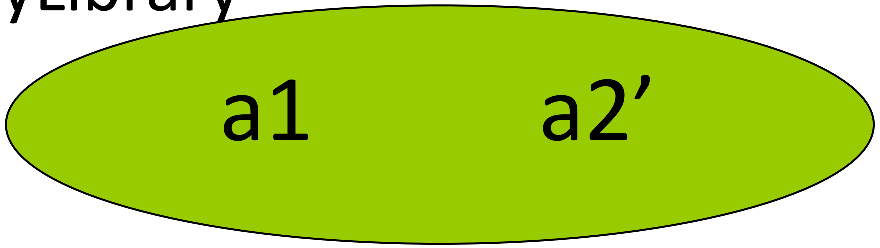
h_a3: {} → HasTextBook

a1 **supports** StudyLibrary

a2 **does not support** its possible claim

a2’= {a2,h_a3} **supports** StudyLibrary

But **no attacks (no conflicts)**!



Byrne's (1989) Suppression Task **in Argumentation**

FORMALIZTION OF THE HUMAN REASONING IN **ARGUMENTATION**

GROUP 3:

If she has an essay to finish, then she will study late in the library

If the library is open, then she will study late in the library

She has an essay to finish

a1: HasEssay → StudyLibrary

a2: OpenLibrary → StudyLibrary

a3: not OpenLibrary → not StudyLibrary

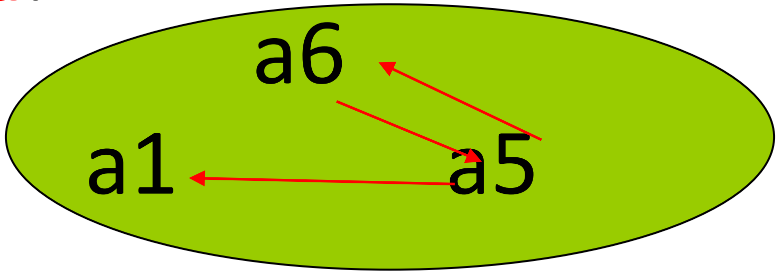
h_a4: {} → not OpenLibrary

- a5= {h_a4, a3} **acceptable argument supports not** StudyLibrary

  a5 attacks a1 but not vice versa!

- h_a6:{} → OpenLibrary

  {a1, h_a6} **acceptable argument** for StudyLibrary



NL Comprehension

Text (Story) Comprehension

http://cognition-srv1.ouc.ac.cy/~adamos.koumis/star.html

http://cognition-srv1.ouc.ac.cy/~adamos.koumis/index.html

PART 3

COMPUTATIONAL ARGUMENTATION in PRACTICE

Applications as Argumentation based Decision Making

- **Decision of O (or Derive Conclusion φ):**
  - **Argument for O (or φ)**
  - **No argument for another O' (or ¬φ)**
  - **Through "Good Quality" arguments, i.e.:**
    - Acceptable arguments

Practical Application of Argumentation

- Populate a Realization <AS, C, St>
  - Argument/Knowledge engineering/acquisition

- Consider computational heuristics in the dialectic argumentation process
  - Cognitively based (sometimes)

Populate <AS, C, St>

- The **challenge** is to capture:

  Contextual Strength/Preference relation St

  - **St is not global – Context dependent**
  - **Hence we need to decide on the strength while deciding on the Option to choose!**
    - **Two intertwined decisions**

- **Arguing about Options reduces to arguing about the strength of arguments supporting the Options**

Decision Making in Argumentation

Knowledge (SBPs) for Decision Making

- **General, Cognitive Form** of **Knowledge**:
  - "**Generally**, in **SITUATION** **prefer Ois**, **but** when in **particular CONTEXT**, **prefer Ojs**."
  - **"Generally, deny calls when {busy at work} but allow calls from {collaborators}."**
- **Scenario-based Preferences:**
  - **<Id, Scenario_Conditions, Preferred_Options>**

Representation Language/Process
(Study Assistant Example)

- **Separate Options and Scenario Language**
  - **Options: Study at Library, Home, Café**

- **Capture Hierarchies of Scenario-based Preferences amongst the Options**
  - **<1, {Homework}, {Home, Cafe}>**
  - **<2, {Homework, Late}, {Home}>**
  - **<3, {Homework, Need_Sources}, {Library}>**

- **Capture anti-preferences (αντενδείξεις or contra-indications) for an individual Option.**
  - **<a1, {Closed_Library}, {-Library}>**

Refinement & Combinations of Scenarios-based Prefs

Refinement of Scenarios with extra condition(s).

- Example 1:
  - <1, {Homework}, {Home, Cafe}>
  - <2, {Homework, Late}, {Home}>

- Preferred options (e.g. Home) in more specific scenario win.
  Therefore arguments in more specific scenario are stronger:

  - Home preferred over Café (and over Library)

Refinement & Combinations of Scenarios-based Prefs

Combination of Scenarios with conflicting options

- Example 2:
  - **<2, {Homework, Late}, {Home}>**
  - **<3, {Homework, Need_Sources}, {Library}>**

  - **<2|3, {Homework, Late, Need_Sources}, ???>**
- In combined scenarios the Preferred Options are specified independently (or via common sense), e.g.:
  - {Library}
  - But {Home, Library} is also possible, i.e. no preference/do not know/have not learned this yet!

Exercise

- **Consider your own Personal Study Assistant**
  - **Assistant needs to figure out where we will be studying/working today!**
- **Express your preferences amongst the three options of Library, Café, Home in the form of Scenario-based Preferences.**

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Lecture 1

GORGIAS Argumentation Framework

1. **Logic Programming with Priorities**
2. **GORGIAS system**

Realization of Abstract Argumentation

- **Abstract Argumentation: <Args, Attack>**
- **Construct arguments in *Args***
- **Construct the attacking relation, *Attack***
- **Preference based argumentation**
  - The attacking relation is defined in terms of a **preference** **or** **strength** structure on the arguments.

Preference Based Argumentation (AF = <Args, Attack>)

Logic Programming Rules & Priorities

- **An extension of Logic Programming**
- **Arguments** are **sets of LP rules** **(without NAF)**
- **Attacks** between arguments are defined via:
  - **Conflicts** between **conclusions** of arguments
  - **Strength relation** on the **subsets** of rules, used in each argument to derive the conflicting conclusion, based on the **priority relation** between the **individual** rules in the subsets.

An Example in LPP

Given the Common Sense Knowledge:

(r1): $fly(x) \leftarrow bird(x)$

(r2): $\neg fly(x) \leftarrow penguin(x)$

(r3): $penguin(x) \leftarrow walkslikepeng(x)$

(r4): $\neg penguin(x) \leftarrow \neg flatfeet(x)$

(r5): $bird(x) \leftarrow penguin(x)$

(r6): $bird(twy)$

(r7): $walkslikepeng(twy)$

(r8): $\neg flatfeet(twy)$

with the priorities $r2 > r1$, $r4 > r3$

The Attacking Relation

- An attacking relation is realized as:

  1) Sets of rules, ϕ and ψ, have a contrary conclusion

  2) Strength Relation via Priorities:

  - Att(ψ, ϕ) iff $(\exists r \in \phi, r' \in \psi : \phi \vdash r' < r) \Rightarrow (\exists r \in \phi, r' \in \psi : \psi \vdash r < r')$

- Strong and Weak attacks.

An Example in LPP

Given the Common Sense Knowledge:

(r1): fly(x)←bird(x)

(r2): ¬fly(x) ←penguin(x)

(r3): penguin(x) ←walkslikepeng(x)

(r4): ¬penguin(x) ← ¬flatfeet(x)

(r5): bird(x) ← penguin(x)

(r6): bird(tweedy)

(r7): walkslikepeng(tweedy)

(r8): ¬flatfeet(tweedy)

with the priorities r2>r1, r4>r3

? fly(tweedy)

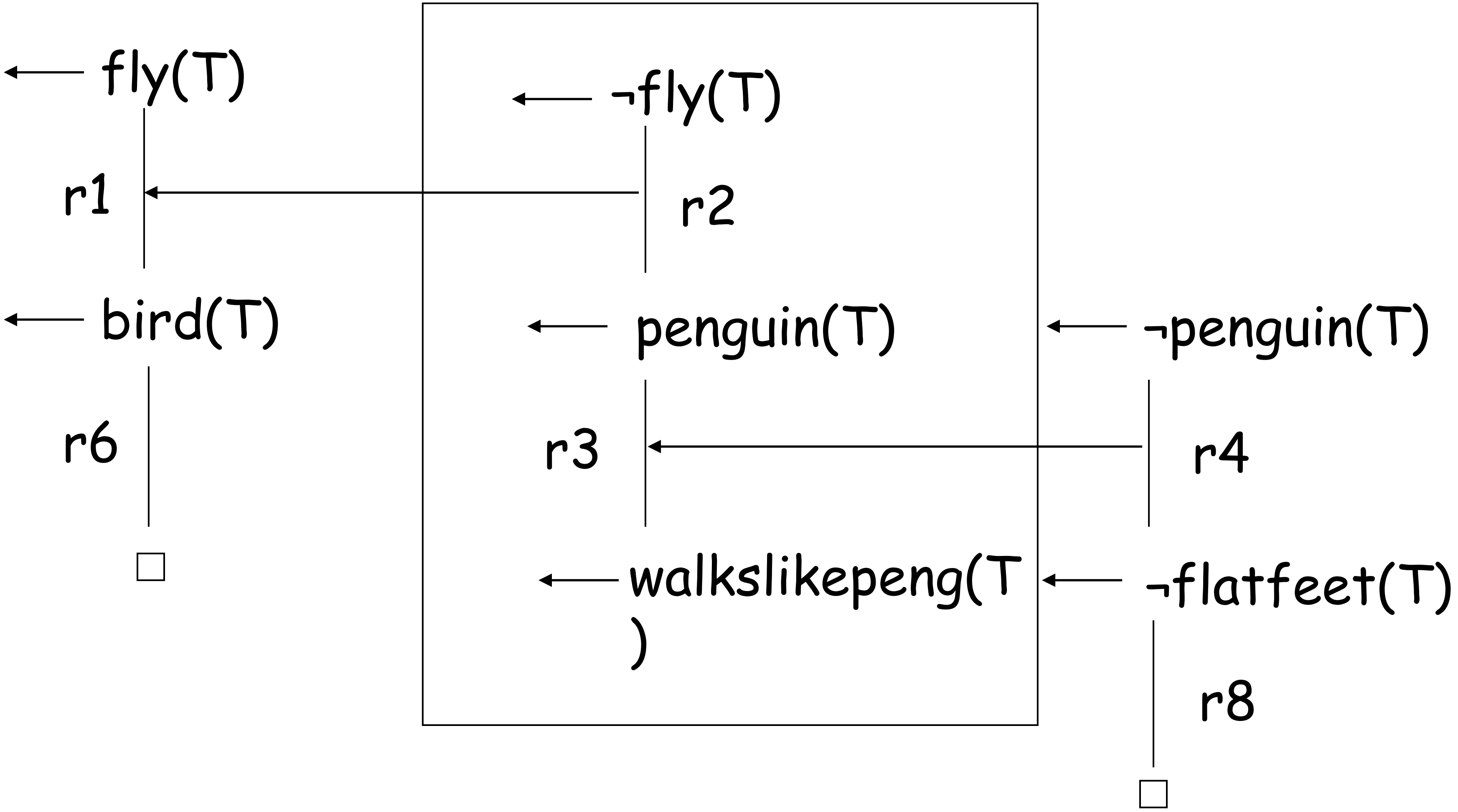
Argument for:
A1 ={r6, r1}

Against A1:
A2 ={r7, r3, r2}

Against A2:
A3 = {r8, r4}

Yes, fly(tweedy) can be supported by A1UA3.

Dialectic Process of Argumentation



LPwNF (LPP) : Example 2

Program P:

- r_1: buy(X) ← safe(X).
- r_2: buy(X) ← nice(X).
- r_3: buy(X) ← fast(X).
- r_4: ¬ buy(X) ← buy(Y) , Y =/= X.

- r_5: safe(volvo).
- r_6: nice(porche).
- r_7: fast(porche).

Priority: $r_1 > r_2$, $r_2 > r_3$, $r_1 > r_3$ (**Personal Preferences**)

- **Conclusions:**
  - buy(volvo) skeptical conclusion (S_v ={r_1, r_5 , r_4(porche,volvo)} is admissible)
  - buy(porche) via S_p ={r_2, r_6 , r_4(volvo,porche)} is attacked by S_v with no defence possible.

Simple Policy Example

- "Sellers who deliver on time are trustworthy"
  - α1={trusted(Seller) :- timely(X)}
- "Sellers who deliver wrong are not trustworthy"
  - α2={¬ trusted(Seller) :- wrong_delivery(X)}
- Suppose we "observe":
  - timely(bob): a1 supports trusted(bob).
  - wrong_delivery(bob): a2 supports ¬trusted(bob).
  - a1 attacks a2 and vice-versa.
- "Sellers who are trusted get large orders"
  - a= {large_orders(X) :- trusted(X)}
  - A={a1, a} supports large_orders(bob)
  - B={a2} attacks A (B undercuts A)

Example of Argumentation

- "Sellers who are trusted get large orders"
  - a= {large_orders(X) :- trusted(X)}
  - A={a1, a} supports large_orders(bob)
  - B={a2} attacks A (B undercuts A)

- Both A and B are admissible.
  - Hence can we be sure about large_orders(bob)?

- Do we have an argument supporting ¬large_orders(bob)?
  - B'={a2,a'} with
    - a'= {¬large_orders(X) :- ¬ trusted(X)}
  - B''={a2,a''} with
    - a''={¬large_orders(bob)} – a'' is a hypothesis.
  - Both B' and B'' are attacked by A.

- Both B' and B'' are admissible, supporting ¬large_orders(bob), because of a2 that defends against A
    - a'' cannot defend against A because a'' is a weaker argument

Examples of Argumentation Decision Policies

See Seller+CallAssistant set of slides

Another Example of Reasoning in LPP

With Legal Arguments

LPwNF: Example 3

Object-level Program:

- r_1: ¬ modify(X) ← protected(X).
- r_2: modify(X) ← needed(X).
- r_3: protected(villa).
- r_4: needed(villa).

Priority Program:

- R_1: higher(X,Y) ← protection_law(X), planning_law(Y).
- R_2: higher(X,Y) ← later(X,Y).

- F_3: protection_law(r_1). F_4: planning_law(r_2).
- F_5: later(r_2 , r_1). R_6: later(R_1 , R_2).

- **Conclusions:**
  - ¬ modify(villa) skeptical conclusion via S_1 ={r_1, r_3} (since "higher(r_1 , r_2)" is skeptically admissible S_2 ={r_2, r_4} does not attack S_1).
  - H_1 ={R_1, F_3 , F_4} for "higher(r_1 , r_2)" attacks H_2 ={R_2, F_5} for "higher(r_2 , r_1)" but not vice-versa (since "higher(R_1 , R_2)" is skeptically admissible).

Example: Legal Reasoning

"A p
ship
Acco
inte
coll
Mort
ship
a st
UCC
lega
prin
our
prin
the
sinc
-- G

ucc: perfected ← possesion.

sma: ¬ perfected ← ship, ¬ finstatement.

- Basic facts:

  f1: possession.

  f2: ship.

  f3: ¬ finstatement.

  f4: newer(ucc,sma).

  f5: federal_law(sma).

  f6: state_law(ucc).

- Lex Posterior and Lex Superior

  lex_posterior(X,Y): Y < X ← newer(X,Y).

  lex_superior(X,Y): X < Y ← state_law(X), federal_law(Y).

- Higher-Order Priority

  r1(X,Y): lex_posterior(X,Y) < lex_superior(X,Y).

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Lecture 1

Gorgias Technicalities

1. Gorgias Programming

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- Construct the attacking relation, *Attack*
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(r5): bird(x) ← penguin(x)
(r6): bird(twy)
(r7): walkslikepeng(twy)
(r8): ¬flatfeet(twy)

with the priorities r2>r1, r4>r3

? fly(twy)

Argument for:
A1 ={r6, r1}

Against A1:
A2 ={r7, r3, r2}

Against A2:
A3 = {r8, r4}

Yes, fly(twy) can be supported by A1∪A3.

Logic Programming without Negation as Failure (LPwNF)

Argumentation framework in LP with explicit priorities.

- **Theory/program in Definite/Horn background logic:**
  - Rules: $L \leftarrow L_1, \ldots, L_n$ where $L, L_1, \ldots, L_n$ literals $L_i = (\neg)A_i$.
  - Conflict given by classical negation $\neg$ (or complementarity relation).
  - **Priority relation ">"** on rules of the theory.

- **Arguments:** Subsets, S, of rules in the theory/program

- **Attacking relation:**
  - S **attacks** S′ iff there exist L and $S_1 \subseteq S$, $S'_1 \subseteq S'$ s.t.:
    - $B \cup S_1 \vdash_{min} L$ and $B \cup S'_1 \vdash_{min} \neg L$
    - S_1 is **not of "overall" lower in priority** than S'_1 :
      - **if** there exist rules r in S_1 and r´ in S'_1 s.t. $r < r'$,
        then, there exist rules s in S_1 and s´ in S'_1 s.t $s > s'$.

Attacking relation
Globally valid local priorities

- S **attacks** S′ iff there exist L and $S_1 \subseteq S$, $S'_1 \subseteq S'$:
  - $B \cup S_1 \vdash_{min} L$ and $B \cup S'_1 \vdash_{min} \neg L$
  - S_1 is **not of "overall" lower in priority** than S'_1 :
    - **if** there exist rules r in S_1 and r´ in S'_1 s.t. $r < r'$,
      then, there exist rules s in S_1 and s´ in S'_1 s.t $s > s'$.

Attacking relation
Conditional (context sensitive) local priorities

- S **attacks** S′ iff there exist L and $S_1 \subseteq S$, $S'_1 \subseteq S'$:
  - $B \cup S_1 \vdash_{min} L$ and $B \cup S'_1 \vdash_{min} \neg L$
  - S_1 is **not of "overall" lower in priority** than S'_1 :
    - **if** there exist rules r in S_1 and r´ in S'_1 s.t. $B \cup S'_1 \vdash_{min} r < r'$,
      then, there exist rules s in S_1 and s´ in S'_1 s.t $B \cup S_1 \vdash_{min} s > s'$

The General Structure of Gorgias Arg. Theories

```
rule(r1(Day), opt1(Day), []):- cond1.
rule(r2(Day), opt2(Day), []):- cond2.

complement(opt1,opt2).
complement(opt2,opt1).

rule(p12(Day), prefer(r1(Day),r2(Day)), []):- cond12.
rule(p21(Day), prefer(r2(Day),r1(Day)), []):- cond21.

rule(c21(Day), prefer(p21(Day),p12(Day)), []):- cond2121.

rule(r22(Day), opt2(Day), []):- cond22.

rule(q122(Day), prefer(r1(Day),r22(Day)), []):- cond1222.
rule(q221(Day), prefer(r22(Day),r21(Day)), []):- cond2212.

?prove([opt1(X)], Expl).        ?prove([opt2(X)], Expl).
```

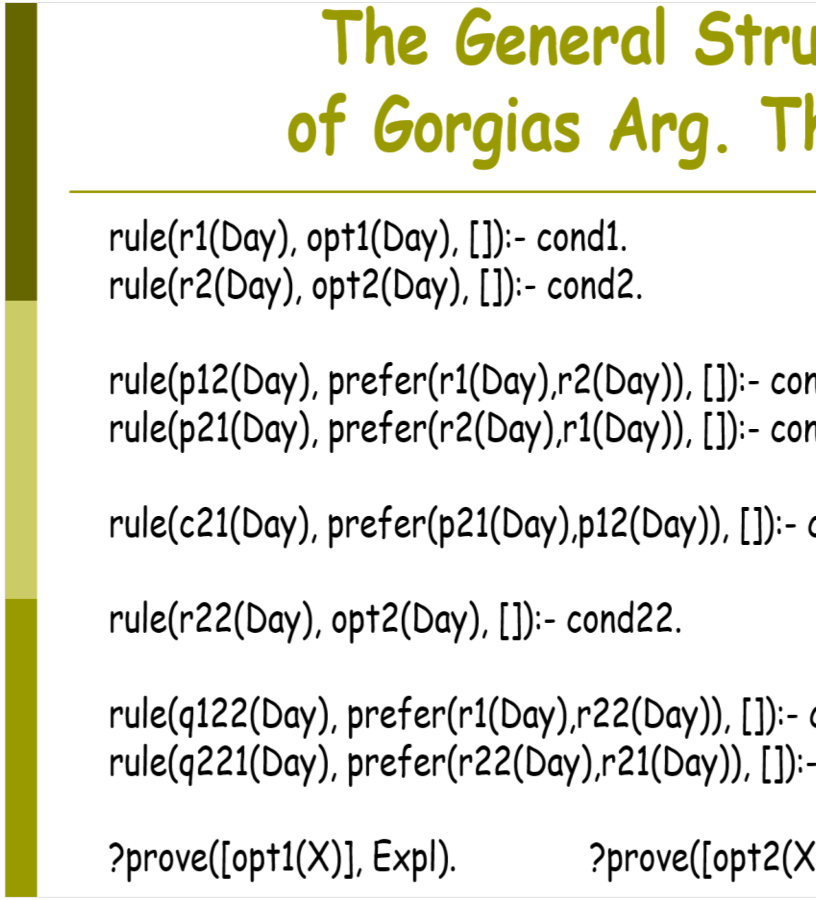
The General Structure of Gorgias Arg. Theories

Scenario 1: day1 with {cond1, cond2, cond21}

?prove([opt1(day1)], Expl).

E1= [r1(day1)]
Att1= [r2(day1)] AND Att11= [r2(day1), p21(day1)]
Def11= ??? - No Defense
=> Query fails, i.e. opt1 is not admissible.

?prove([opt2(X)], Expl).
E1= [r2(day1)]
Att1= [r1(day1)] CANNOT BE STRENGTHENED.
Def1= E1
=> Query succeeds, i.e. opt2 is admissible.


The General Stru
of Gorgias Arg. Th

rule(r1(Day), opt1(Day), []):- cond1.
rule(r2(Day), opt2(Day), []):- cond2.

rule(p12(Day), prefer(r1(Day),r2(Day)), []):- con
rule(p21(Day), prefer(r2(Day),r1(Day)), []):- con

rule(c21(Day), prefer(p21(Day),p12(Day)), []):- c

rule(r22(Day), opt2(Day), []):- cond22.

rule(q122(Day), prefer(r1(Day),r22(Day)), []):- c
rule(q221(Day), prefer(r22(Day),r21(Day)), []):-

?prove([opt1(X)], Expl). ?prove([opt2(X

The General Structure of Gorgias Arg. Theories

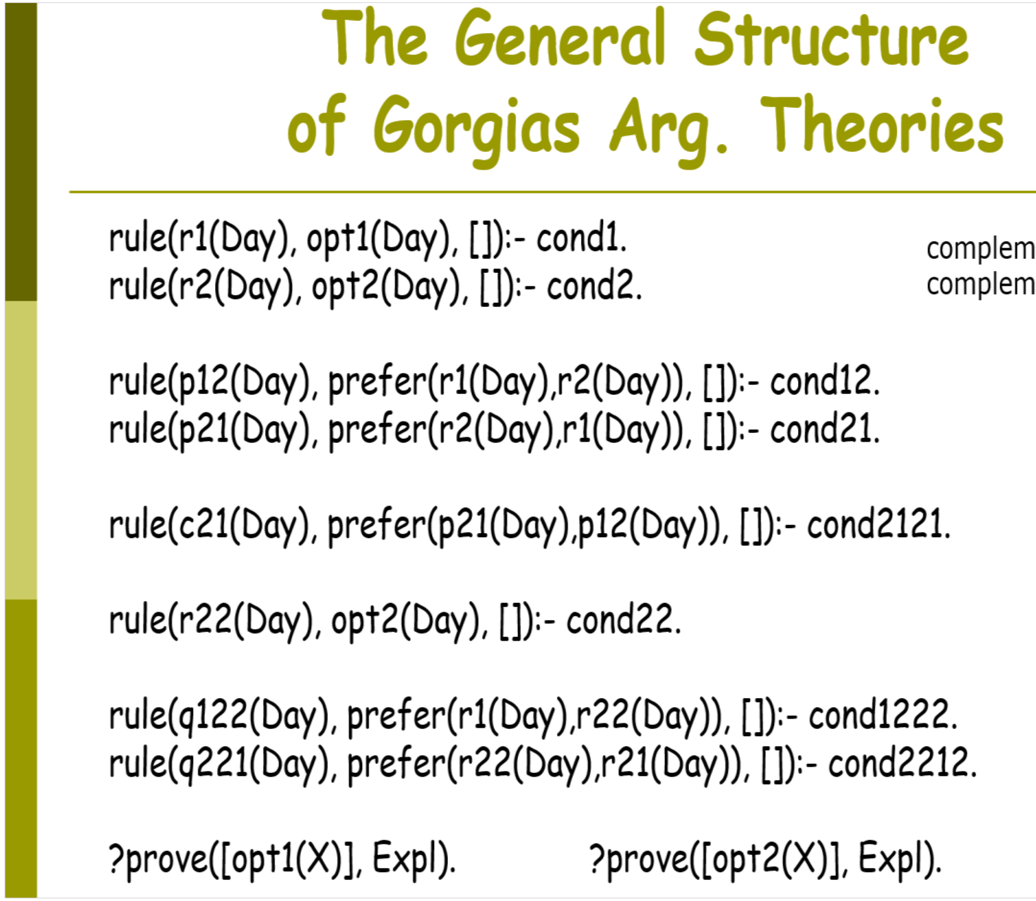
Scenario 2: day2 with {cond1, cond2, cond21,cond12}

?prove([opt1(day2)], Expl).

E1= [r1(day2)]
Att11= [r2(day2), p21(day2)]
Def11= [p12(day2)]
Att12= [p21(day2)]
Def12= [p12(day2)]

$\Rightarrow$ Yes, Expl=[r1(day2), p12(day2)]

?prove([opt2(day2)], Expl).
Analogously: Expl=[r2(day2), p21(day2)]



The General Structure of Gorgias Arg. Theories

```
rule(r1(Day), opt1(Day), []):- cond1.          complem
rule(r2(Day), opt2(Day), []):- cond2.          complem

rule(p12(Day), prefer(r1(Day),r2(Day)), []):- cond12.
rule(p21(Day), prefer(r2(Day),r1(Day)), []):- cond21.

rule(c21(Day), prefer(p21(Day),p12(Day)), []):- cond2121.

rule(r22(Day), opt2(Day), []):- cond22.

rule(q122(Day), prefer(r1(Day),r22(Day)), []):- cond1222.
rule(q221(Day), prefer(r22(Day),r21(Day)), []):- cond2212.

?prove([opt1(X)], Expl).        ?prove([opt2(X)], Expl).
```

The General Structure of Gorgias Arg. Theories

Scenario 3: day2 with {cond1, cond2, cond21,cond12, cond2121}

?prove([opt1(day2)], Expl).

E1= [r1(day2)]
Att11= [r2(day2), p21(day2)]
Def11= [p12(day2)]
Att12= [p21(day2), c21(day2)]
Def12= No defense
⇒ Query fails

?prove([opt2(day2)], Expl).

The General Structure of Gorgias Arg. Theories

```
rule(r1(Day), opt1(Day), []):- cond1.
rule(r2(Day), opt2(Day), []):- cond2.

rule(p12(Day), prefer(r1(Day),r2(Day)), []):- cond12.
rule(p21(Day), prefer(r2(Day),r1(Day)), []):- cond21.

rule(c21(Day), prefer(p21(Day),p12(Day)), []):- cond2121.

rule(r22(Day), opt2(Day), []):- cond22.

rule(q122(Day), prefer(r1(Day),r22(Day)), []):- cond1222.
rule(q221(Day), prefer(r22(Day),r21(Day)), []):- cond2212.

?prove([opt1(X)], Expl).        ?prove([opt2(X)], Expl).
```

```
complement(opt1,
complement(opt2,
```

Expl=[r2(day2), p21(day2)] or Expl'=[r2(day2), p21(day2), c21(day2)]

The General Structure of Gorgias Arg. Theories

```
rule(r1(Day), opt1(Day), []):- cond1.
rule(r2(Day), opt2(Day), []):- cond2.

rule(p12(Day), prefer(r1(Day),r2(Day)), [abd1]):- cond12.
rule(p21(Day), prefer(r2(Day),r1(Day)), []):- cond21.

rule(c21(Day), prefer(p21(Day),p12(Day)), [abd2]):- cond2121.

abducible(abd1, []).
abducible(abd2, []).

?prove([opt1(X)], Expl).          ?prove([opt2(X)], Expl).
```

The General Structure of Gorgias Arg. Theories

Scenario 2: day2 with {cond1, cond2, cond21,cond12}

With abducible condition abd1 in priority p12.

?prove([opt1(day2)], Expl).

E1= [r1(day2)]
Att11= [r2(day2), p21(day2)]
Def11= [p12(day2), ass(abd1)]
Att12= [p21(day2)], Att121= [neg(ass(abd1))].
Def12= [p12(day2)], Def121= [ass(abd1)]

⇒ Yes, Expl=[r1(day2), p12(day2), ass(abd1)]

The General Structure of Gorgias Arg. Theories

EXPLANATIONS

From previous slide:

⇒ Yes, Expl=[r1(day2), p12(day2), ass(abd1)]

r1(day2) gives attributive part of explanation: basic reason

"Opt1 is supported by cond1"

p12(day2) gives contrastive part of explanation: strengthening reason

"Strengthened (against Opt2) by cond12"

ass(abd1) gives actionable element of explanation: act to check abd1.

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COGNITIVE PROGRAMMING FOR HUMAN-CENTRIC AI

Antonis Kakas

Autumn 2022

Lecture 1

Cognitive Assistants via Argumentation

1. **Knowledge Acquisition for Decision Theory/Policy**
2. **SoDA Methodology**
3. **Call Assistant**

Decision Making in Argumentation

Knowledge for Decision Making

- **Language**
  - **Describe Options:** e.g. allow(call), deny(call)
  - **Describe the (relevant part of the) World:**
    - **Level 1: sensory level** e.g. call number
    - **Level 2: cognitive concept level** e.g. colleague call
- **Knowledge is in the form of:**
  - **Preferences: According to User values**
  - **Common Sense Preferences**

Cognitive Call Assistant

- **Decision policy of call assistant:**
  - Normally, allow calls.

  When at work deny calls from unknown numbers.When in a meeting at work also deny known calls unless family calls when there is an emergency at home. Allow all calls from my manager.

- **Options: allow(call), deny(call)**

Decision Making in Argumentation
Example: Cognitive Call Assistant

- **Options: allow(call), deny(call)**
- **Preferences: According to User values**
- **General, Cognitive Form** of Preferences:
  - "Generally, in **SITUATION** prefer Oi, but when in particular **CONTEXT**, prefer Oj."
  - **"Generally, deny calls when {busy at work} but allow calls from {collaborators}."**

Cognitive Knowledge for Decision Making

- **General, Cognitive Form of Knowledge:**
  - "**Generally**, in **SITUATION** prefer Oi,
    but when in **particular** **CONTEXT**, prefer Oj."
  - **"Generally, deny calls when {busy at work} but allow calls from {collaborators}."**
- **Scenario-based Preferences:**
  - **<Id, Scenario, Preferred_Options>**

Call Assistant:
Scenario-based Preferences

- <1, {} , {allow(call)}>
- <2, {unknown(call), at_work}, {deny(call)}>
- <3, {in_meeting, at_work } , {deny(call)}>
- <4, {in_meeting, at_work, family(call),emergency} , {allow(call)}>
- <5, { manager(call) } , {allow(call)}>

Refinement & Combinations of Scenarios

Refinement of Scenarios with **extra condition(s)**.

- **Example 1:**
  - <1, {} , allow(call)>
  - <2, {unknown(call), at_work}, deny(call)>

- **Preferred options (e.g. deny(call)) in more specific scenario win.**
  Therefore arguments in more specific scenario are **stronger.**

- **Example 2:**
  - <3, {in_meeting, at_work } , deny(call)>
  - <4, {in_meeting, at_work, family(call),emergency} , allow(call)>
  - **In more specific scenario, (4): allow(call) preferred over deny(call)**

Refinement & Combinations of Scenarios

Combination of Scenarios with conflicting options

- Example 1:
  - <3, {in_meeting, at_work } , deny(call)>
  - <5, { manager(call) } , allow(call)>

  - <3|5, {in_meeting, at_work, manager(call)}, allow(call)>
- In combined scenarios the Preferred Options are specified independently (or via common sense).

Call Assistant:
Need Extra Scenarios ?

- <11, {unknown(call)} , {allow(call)}>
- <22, {family(call)} , {allow(call)}>
- <44, {in_meeting, at_work, family(call)}, {deny(call)}>
- **Not needed:** Captured implicitly by argumentation.
- General feature of argumentation
  - No need to have complete information

Cognitive Knowledge for Decision Making

- **Natural Language**
- **Scenario-based Preferences:**
- **Arguments (schemas/rules)**
  - **Cognition Process via Argumentation**
- **Code**
  - **For automated cognition (via automated argumentation).**

Decision policy: **Call Assistant (1)**

(Expressed in GORGIAS pseudocode)

- **Object-level argument rules:**

  r1(Call): allow(Call) ← true
  r2(Call): deny(Call) ← true

- **Priority argument rules**
  - Default Policy
  - Generally, allow calls:
  - R1(Call): r1(Call) > r2(Call) ← true

  - Special – Contextual- Priority:
  - Generally, deny unknown calls when at work:
  - R2(Call): r2(Call) > r1(Call) ← unknown(Call), at_work
  - C2(Call): R2(Call) > R1(Call) ← true

Call Assistant Policy
in Gorgias (2)

- Special Contextual Priority:
  - Generally, deny calls when at a work meeting:
  - R4(Call): r2(Call) > r1(Call) ← at_work, in_meeting
  - C4(Call): R4(Call) > R1(Call)) ← true

  - 1. Except, when a family call
  - C1(Call): R1(Call) > R4(Call)) ← family(Call)
  - D1(Call): C1(Call) > C4(Call)) ← true

  - 2. Except, when a family call and emergency
  - C1(Call): R1(Call) > R4(Call)) ← family(Call), emergency
  - D1(Call): C1(Call) > C4(Call)) ← true

Call Assistant Policy in Gorgias (3)

- Default Priority:
  - Generally, allow calls:
  - R1(Call): r1(Call) > r2(Call) ← true
- Generally, allow calls from manager:
  - This is like a new default priority/policy
  - R3(Call): r1(Call) > r2(Call) ← manager(Call)
  - What higher order priorities, if any, are needed for R3?
    - Priority of manager calls is global – another policy thread
- Also we could use a new object-level argument rule:

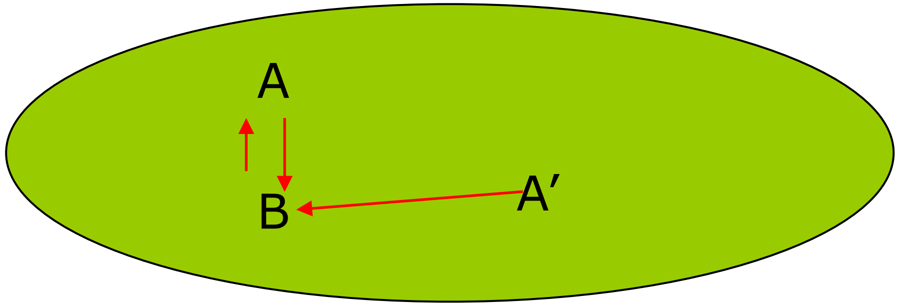
r3(Call): allow(Call) ← manager(Call)
R31(Call): r3(Call) > r2(Call) ← true

Call Assistant: Argumentation in Scenarios

- <1, {}, allow(Call)>
  - A={r1(call)} argument supports option allow.
  - B={r2(call)} argument supports option deny.
  - A attacks B and vice versa.

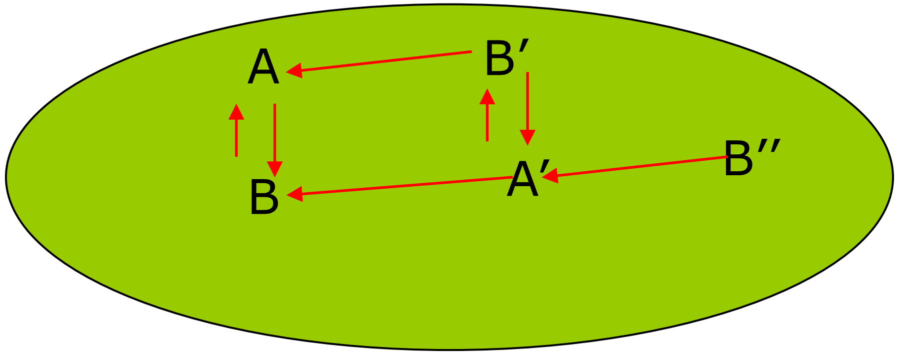
  - A'={r1(call), R1(call)} strengthens A
    - A' attacks B but B does **not attack** A'
  - Also B cannot be strengthened (by any applicable priority rule)

  - Hence B cannot be made admissible
  - Hence **sceptical decision**: allow the call.



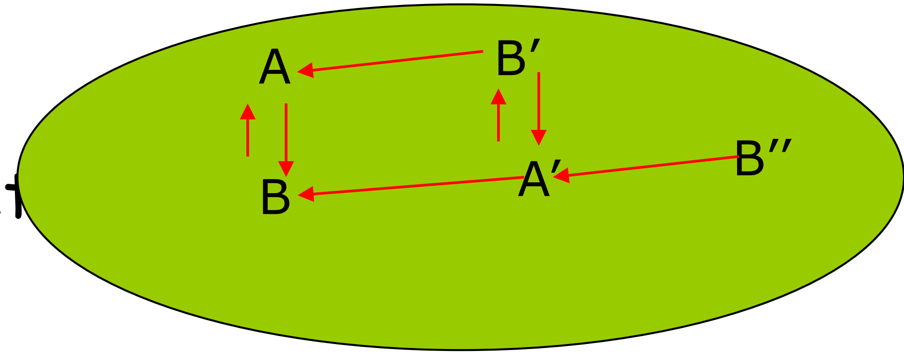
Call Assistant: Argumentation in Scenarios

- **<2, {unknown(call), at_work}, deny(call)>**
  - A={r1(call)} argument supports option allow.
  - B={r2(call)} argument supports option deny.
  - A attacks B and vice versa.
  - A′={r1(call), R1(call)} strengthens A
    - A′ **attacks** B but B does **not attack** A′
  - B′={r2(call), R2(call)} strengthens B
    - B′ **attacks** A but A does **not attack** B′
  - A′ attacks B′ (since R1 in A′ makes r1>r2) and vice versa (since R2 in B′ makes r2>r1) .
  - B″={r2(call), R2(call), C2(call)} strengthens B′
    - B″ **attacks** A′ but not vice-versa
  - Also A′ cannot be strengthened (by any applicable priority rule)
  - Hence B cannot be made admissible. Hence **sceptical decision**: deny the call.



Call Assistant: Argumentation in Scenarios

- **<2, {unknown(call), at_work}, deny(call)>**
  - A′={r1(call), R1(call)} strengthens A   B′={r2(call), R2(call)} strengthens B
- A′ attacks B′ (R1 in A′ makes r1>r2) and vice versa (R2 in B′ makes r2>r1) .
- Here there are **TWO attacks** in each way!
  - One on the opposite conclusion of r1 and r2 (i.e. on allow & deny)
  - One on the opposite conclusion of R1 and R2 (i.e. on r1>r2 & r2>r1)
- B''={r2(call), R2(call), C2(call)} strengthens B'
  - B'' **attacks** A' but not vice-versa
  - This **attack** is the one of {R2(call), C2(call)} in B'' on {R1(call)} in A' based on their conflict of r2> r1 and r1>r2.
  - NOTE C2 makes R2>R1, hence attack only one way.



Methodology for SBPs acquisition

- We need a high-level methodology for acquiring SBPs
  - At the language level of the application
  - No need for the expert or user to know about the technology
- SoDA Methodology
  - Choose minimal scenarios that enable/unlock options
  - Default preference in each minimal scenario
  - Refine scenario with contexts that changes preference.
  - Consider combinations of (minimal) scenarios
- Authoring tools for SBPs acquisition (and SoDA)
  - No programming – Just recording/learning expert/user know

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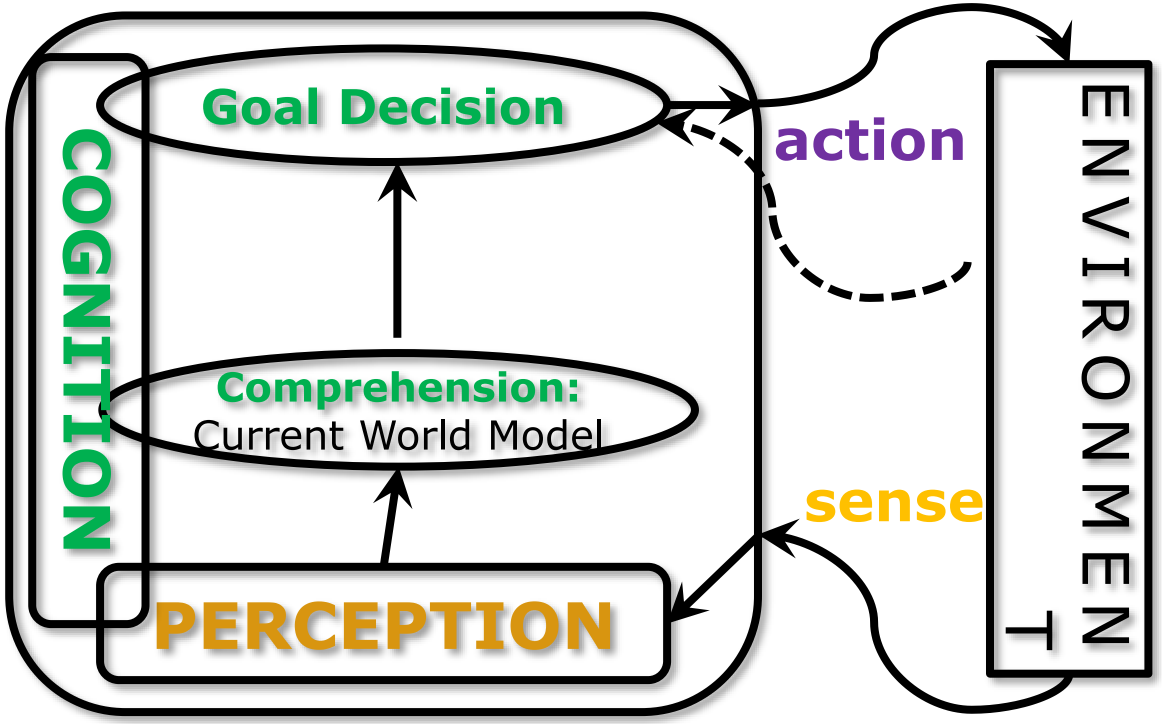
Lecture 1

Methodology for Cognitive Decision Making

1. **Knowledge in terms of Arguments**
2. **Cognition as a process of Argumentation**
3. **Decision Making in Argumentation**
4. **Comprehension in Argumentation**

Cognitive Architecture



Cognitive Architecture
in Argumentation

- **Knowledge in terms of Arguments**
- **Cognition as a process of Argumentation**
  - **Decision Making in Argumentation**
  - **Comprehension in Argumentation**

Cognitive Applications Approach

- **Knowledge as Argument Schemes via Scenarios**

- **Knowledge acquired by:**
  - **Elicited from Experts**
  - **Machine Learned**
  - **Hybrid Acquisition**

- **Knowledge types:**
  - **Expert**
  - **Common Sense**
  - **Personal biases**

Decision Making in Argumentation

Knowledge for Decision Making

- **Language**
  - **Describe Options:** e.g. allow(call), deny(call)
  - **Describe the (relevant part of the) World:**
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Decision Making in Argumentation

Knowledge for Decision Making

- **General**, **Cognitive Form** of **Knowledge**:
  - "**Generally**, in **SITUATION** prefer Oi, **but** when in **particular** **CONTEXT**, prefer Oj."
  - **"Generally, deny calls when {busy at work} but allow calls from {collaborators}."**
- **Scenario-based Preferences:**
  - **<Id, Scenario, Preferred_Options>**

Decision Making in Argumentation

Knowledge for Decision Making

- Natural Language

- Scenario-based Preferences

- Argument (rules)
  - Cognition Process via Argumentation

- Code
  - For automated cognition (via automated argumentation).

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  - **Refine scenario with contexts that changes preference.**
  - **Consider combinations of (minimal) scenarios**

- **Authoring tools for SBPs acquisition (and SoDA)**
  - **No programming – Just recording/learning expert/user know**

Nutrition Advisor

- **Options Language:** **take vitamin A, B, C, D, E**
  - **We will write as:** **vitA, vitB, … etc.**

- **Scenarios Language:**
  - **General Demographic user information**
    - **E.g. Age, weight, … etc**
  - **Specific User information**
    - **E.g. Illnesses, Allergies, Pregnant, …**
  - **Purpose of seeking advice**
    - **E.g. Tiredness, Loss/gain weight, Flu Protection, …**

- **Note: This is high–level cognitive information**

Nutrition Advisor

- Options: take vitamin A, B, C, D, E
- Simple scenario-based preferences/rules
  - WHEN tired THEN vitA
  - WHEN flu THEN vitC
  - WHEN old THEN {vitB, vitA}
    - WHEN old THEN vitB
    - WHEN old THEN vitA
  - WHEN pregnant THEN vitD
  - WHEN sleepless THEN vitD
  - ...

Nutrition Advisor

- **Scenario based preferences**
  - **<1, gain_energy, {vitA, vitC}>**
  - **<2, loose_weight, {vitB, vitE}>**
  - **<3, reduce_stress, {vitB, vitE}>**

- **Combined scenarios & their preferences**
  - **<10, {old, loose_weight}, {vitB,vitA}>**
  - **<11, {pregnant, gain-energy}, {vitA,vitD}>**
  - **<12, {gain-energy,reduce_stress}, {vitA,vitE}>**

Nutrition Advisor

- Scenario based argument rules
  - WHEN gain_energy THEN {vitA, vitC}
    - WHEN gain_energy THEN vitA
    - WHEN gain_energy THEN vitC
  - WHEN loose_weight THEN {vitB, vitE}
  - WHEN reduce_stress THEN {vitB, vitE}

- Combined scenario based argument rules
  - WHEN {old, loose_weight} THEN {vitB,vitA}
  - WHEN {pregnant, gain-energy} THEN {vitA,vitD}
  - WHEN {gain-energy,reduce_stress} THEN {vitA,vitE}
  - Typically, are stronger than "simpler scenario" arguments

Nutrition Advisor

- We have seen above recommendation arguments and scenario-based preferences.
  - These are preferences amongst the various alternative options, e.g. Vitamins, where one is preferred over the other.
- We can also have rejection or blocking arguments and for scenario-based preferences each option separately
  - These are local preferences between an option and its negation, e.g. between taking or not a certain vitamin.

Nutrition Advisor – Rejection Arguments

- Scenario-based rejection (arguments)
  - WHEN pregnant THEN NOT vitE
  - WHEN young THEN NOT vitB

- Scenario-based restrictions (arguments)
  - <1, {young}, {not VitB}>
  - <2, {young, athlete}, {VitB}>
  - <3, {athlete, before_game}, {not VitB}>
  - Combined <23, {…}, ???> ???

- Typically, rejections arguments are are stronger than recommendation arguments

Nutrition Advisor - Restriction Arguments

- Scenario-based restrictions (arguments)
  - "Do not take vitA with vitE"
    - WHEN vitA THEN NOT vitE
    - WHEN vitE THEN NOT vitA
  - "When diabetic do not take vitB and vitD together"
    - WHEN {diabetic, vitB} THEN NOT vitD
    - WHEN {diabetic, vitD} THEN NOT vitB

- These are also stronger than recommendation arguments

Nutrition Advisor – Comprehension Level

- **Comprehension Knowledge**
  - **From low-level sensory information to high-level conceptual or cognitive information**
- **What would such knowledge be?**
  - **WHEN heart_beat > 120 THEN high_stress**
  - **WHEN {excersicing,heart_beat > 120} THEN not high_stress**
- **The 2nd argument rule is stronger that the 1st one:**
  - **It undercuts the first argument.**

Nutrition Advisor – Comprehension Level

- **Decision problem amongst conceptual beliefs**
- **Example: Belief of high_stress , yes or no?**
- **Can use scenario-based preferences again:**
  - **<1, {heart_beat > 120 }, {high_stress}>**
  - **<1, {heart_beat > 120, excersicing}, {not high_stress}>**

Advanced Example of Cognitive Assistant

Cognitive On-line Shopping Assistant

"The quality of food is very important for me. I like to eat organic food. I am not diabetic but I like to avoid sugary foods. I prefer not to eat red meat except for special occasions. When possible try to economize."

"The fish last night was very good. I would have liked a bigger portion."

Scenario Generation

"Normally, discard coupons. If a coupon is related to my wish list, save it unless it is expensive. If it offers a large discount, save it. Discard the coupons that are out-of-date."

Scenario Generation

"Normally, discard coupons. If a coupon is related to my wish list, save it, unless it is expensive. If it offers a large discount, save it. Discard the coupons that are out-of-date."

```
<1, 1, {}, discard(Coupon)>
<2, 2, {related_to(Coupon,wish_list)}, save(Coupon)>}
<3, 2, {expensive(Coupon), related_to(Coupon,wish_list)}, neg(save(Coupon))>
<4, 3, {large(discount), offer(Coupon,discount)}, save(Coupon)>
<5, 4, {out_of_date(Coupon)}, discard(Coupon)>
```

Combining scenarios - Follow SoDA Methodology

"Normally, discard coupons. If a coupon is related to my wish list, save it, unless it is expensive. If it offers a large discount, save it. Discard the coupons that are out-of-date."

```
<6, {2,4}, {related_to(C,wish_list),
out_of_date(C)}, discard(C)>

<7, {3,4}, {large(discount), offer(C,discount),
out_of_date(C)}, discard(C)>}

<8, {2,3}, {expensive(C), related_to(C,wish_list),
large(discount), offer(C,discount)}, {save(C),
discard(C)}>

<9, {2,3,4}, {expensive(C), related_to(C,wish_list),
large(discount), offer(C,discount), out_of_date(C)},
discard(C)>
```

Coupons Policy:
Automatically generated Internal Gorgias "Code"

Object-level argument rules:

r1(Coupon): save(Coupon) ← true

r2(Coupon): discard(Coupon) ← true

Default Priority rules:

% Generally, discard coupons:

R1(Coupon): r2(Coupon) > r1(Coupon) ← true

Special – Contextual- Priority rules:

% Generally, save coupons when in my wish list:

R2(Coupon): r1(Coupon) > r2(Coupon) ← wish_list(Coupon)

C1(C): R2(C) > R1(C) ← true

% Except, when expensive coupons:

C2(Coupon): R1(Coupon) > R2(Coupon) ← expensive(Coupon)

D1(C): C2(Coupon) > C1(Coupon) ← true

Coupons Policy: Internal Gorgias Code

```
rule(r1(Coupon), save(Coupon), []).
rule(r2(Coupon), discard(Coupon), []).

rule(p1(C), prefer(r2(C), r1(C)), []).
rule(p2(C), prefer(r1(C), r2(C)), [wish_list(C)]).

rule(c1(C), prefer(p2(C), p1(C)), []).
rule(c2(C), prefer(p1(C), p2(C)), [expensive(C)]).

rule(d1(C), prefer(c2(C), c1(C)), []).
.
.
.
complement(save(Coupon), discard(Coupon)).
```

Gorgias Applications Methodology (SoDA)

Application guidelines/policy in (structured) Natural Language or from Machine Learning.

- Extract information in terms of (typical) scenarios and contextual refinements of these.
- Hierarchies of scenario preferences – directly in the high-level application language.
- Argumentation representation in GORGIAS code.

Gorgias-B: Authoring Scenario Preferences

Methodology for SBPs acquisition

- We need a high-level methodology for acquiring SBPs
  - At the language level of the application
  - No need for the expert or user to know about the technology
- SoDA Methodology
  - Choose minimal scenarios that enable/unlock options
  - Default preference in each minimal scenario
  - Refine scenario with contexts that changes preference.
  - Consider combinations of (minimal) scenarios
- Authoring tools for SBPs acquisition (and SoDA)
  - No programming – Just recording/learning expert/user know

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COGNITIVE PROGRAMMING FOR HUMAN-CENTRIC AI

Antonis Kakas

Autumn 2022

Lecture 1

Argumentation for Human-Centric Applications

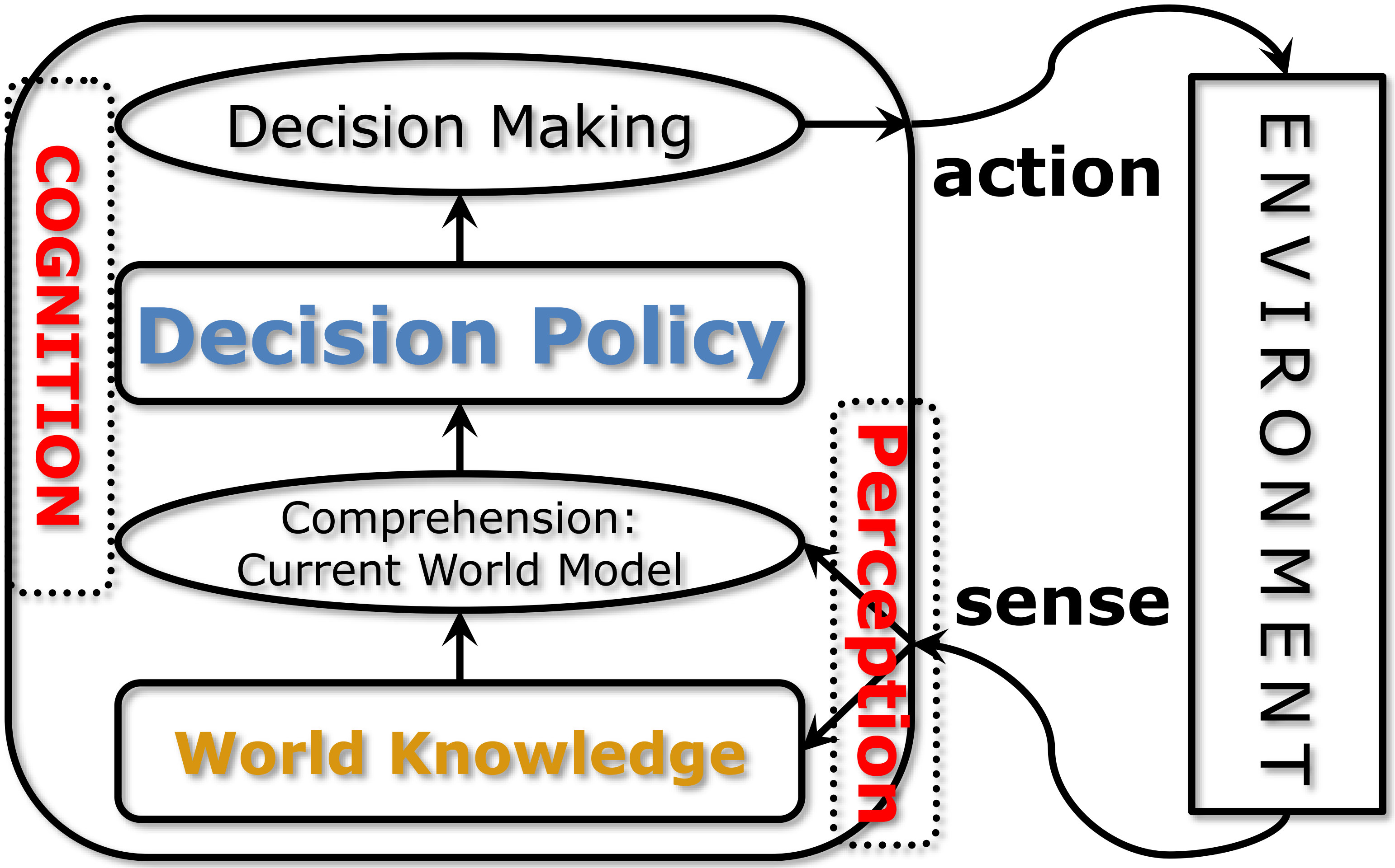
1. **Methodology**
2. **Architectures**
3. **Technology**

Cognitive Assistants

Argumentation
for Human-centric Applications

Methodology & Technology

Argumentation-based AI Systems



Argumentation-based Methodologies for AI Systems

Two major challenges

- **Acquisition** of Knowledge of the Decision Policy
  - High-level/Cognitive Language
    - Language of the application domain.
  - Can this be Natural Language ???

- **Middleware** from Sensory Information to Decision Policy
  - Comprehension of current application environment
    - Recognition of the current world and decision Context.

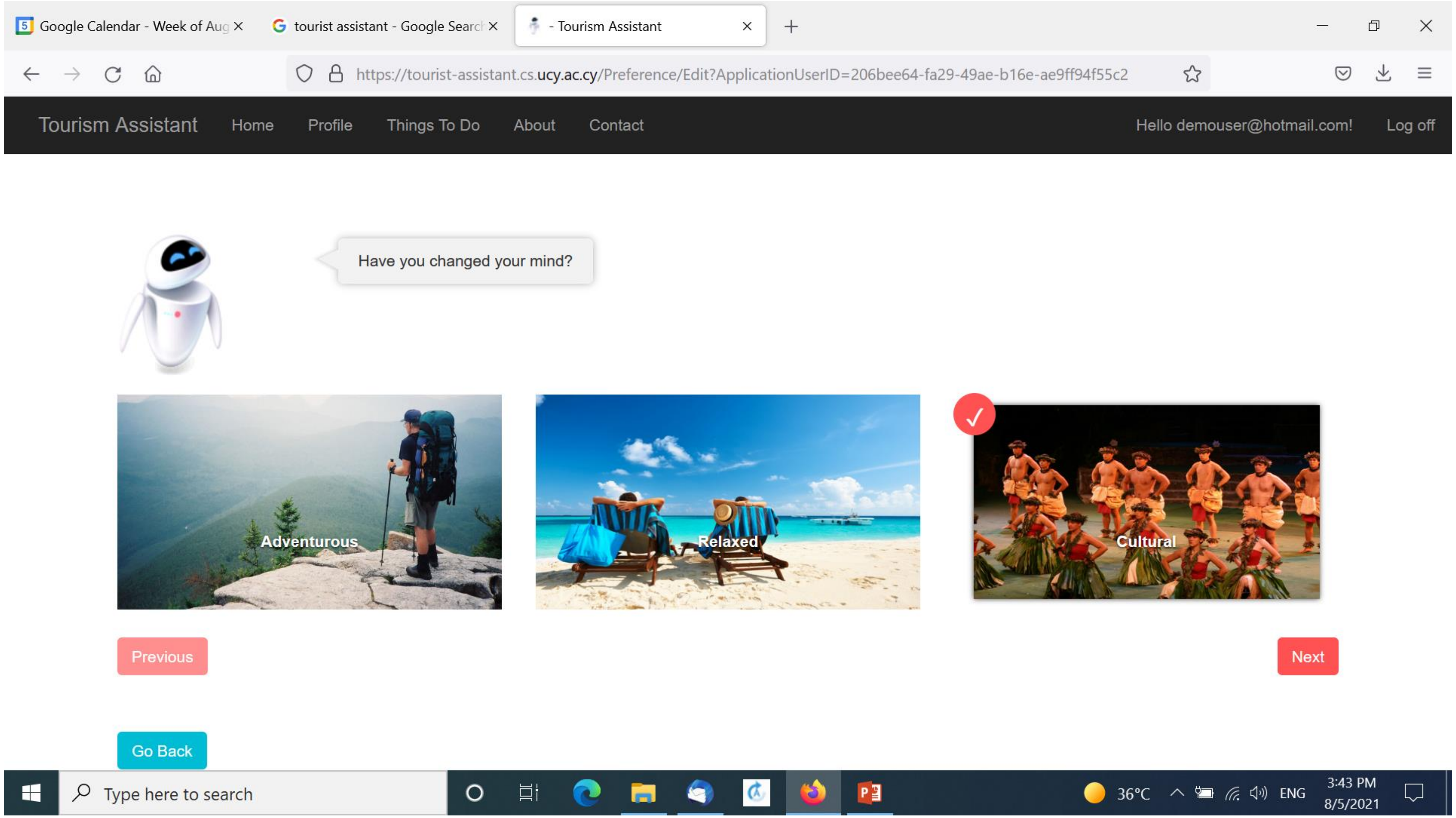
Intelligence is in the Abstraction

Cognitive Assistants

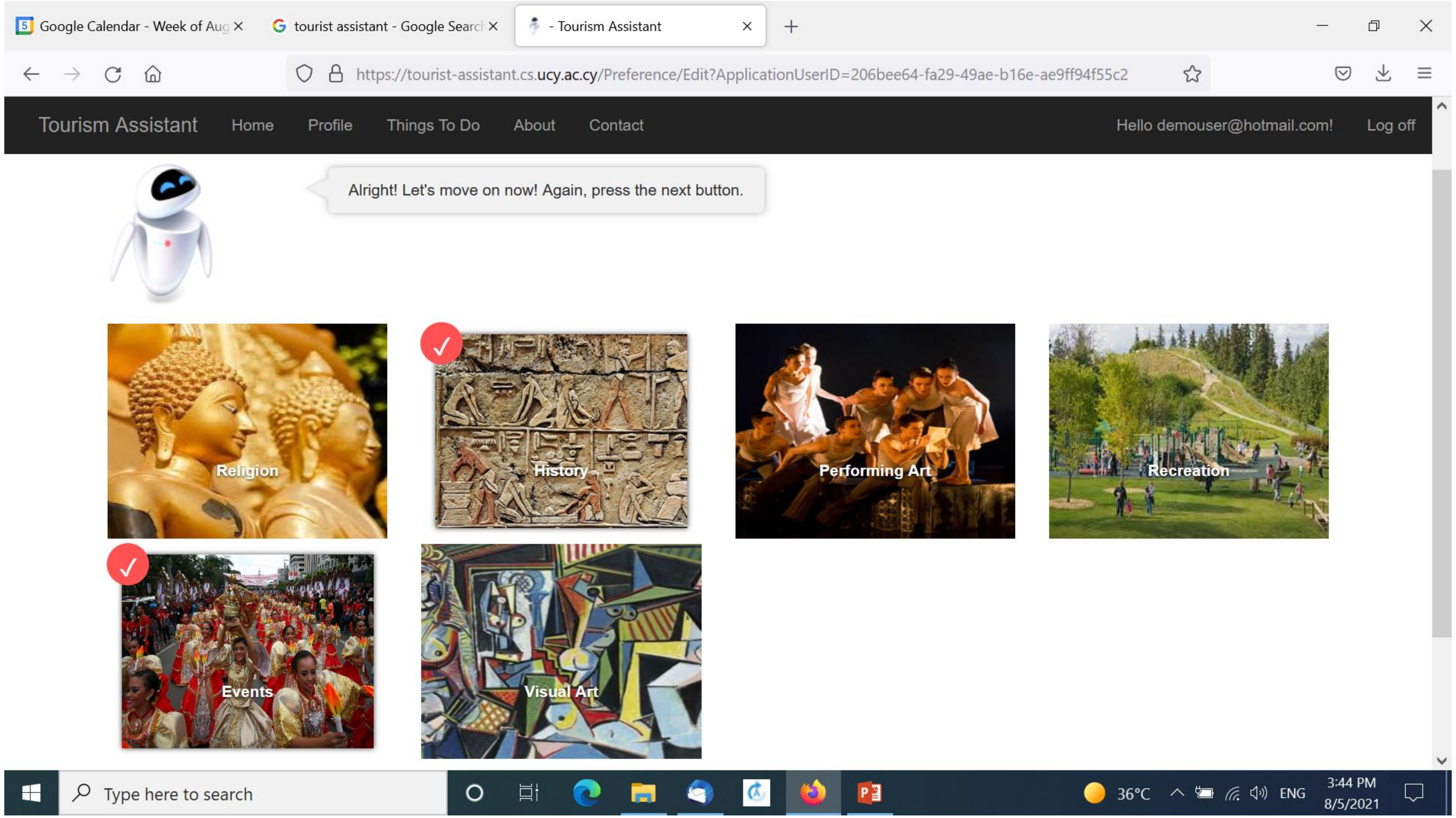
Specialized Application Nat. Language Vocabulary

- **Tourist Assistant**
- **Shopping Assistant**
- **Social Media Assistant**
- **Investor Assistant**
- **Care Assistant.**

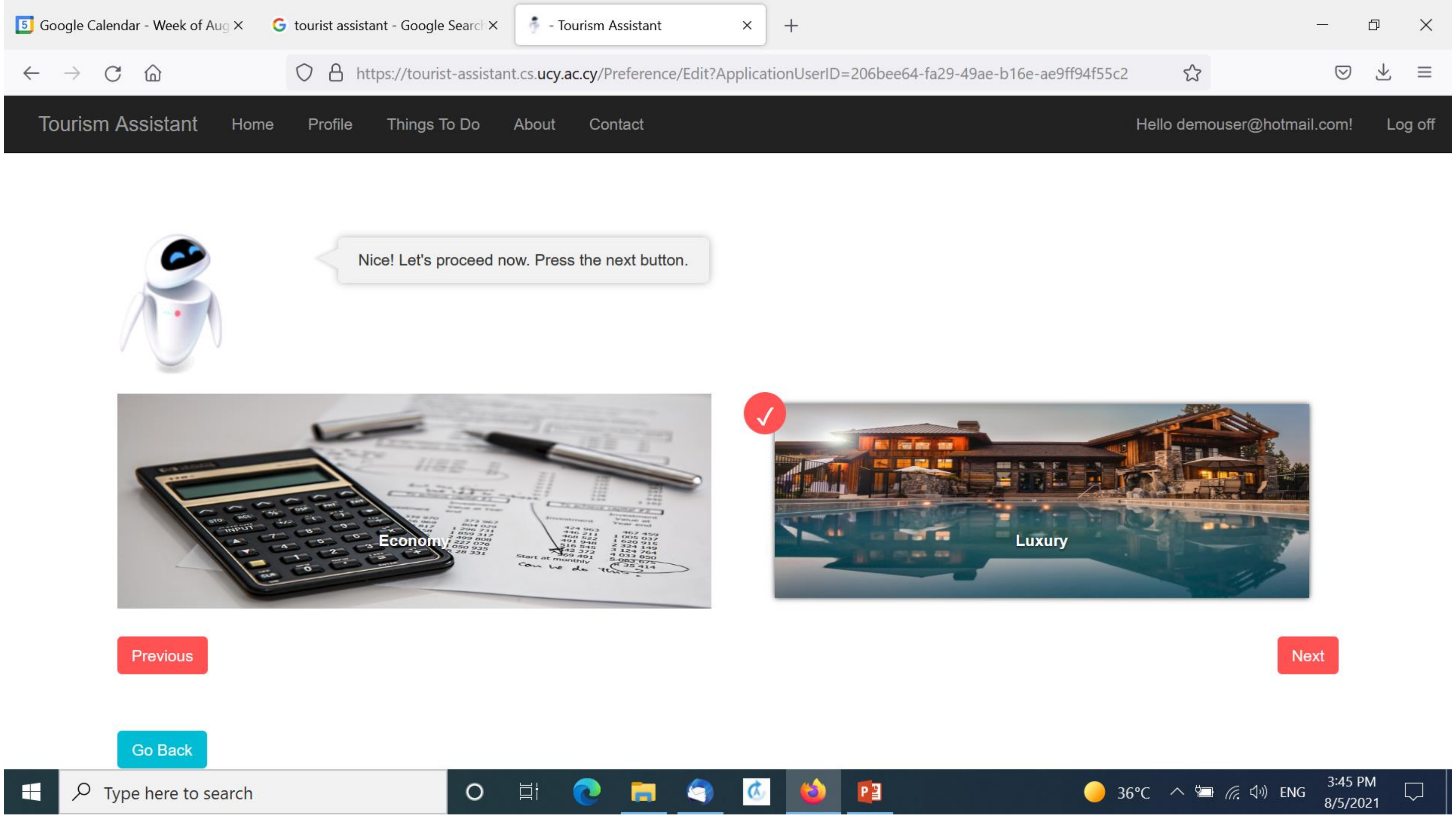
Tourist Assistant – General Policy



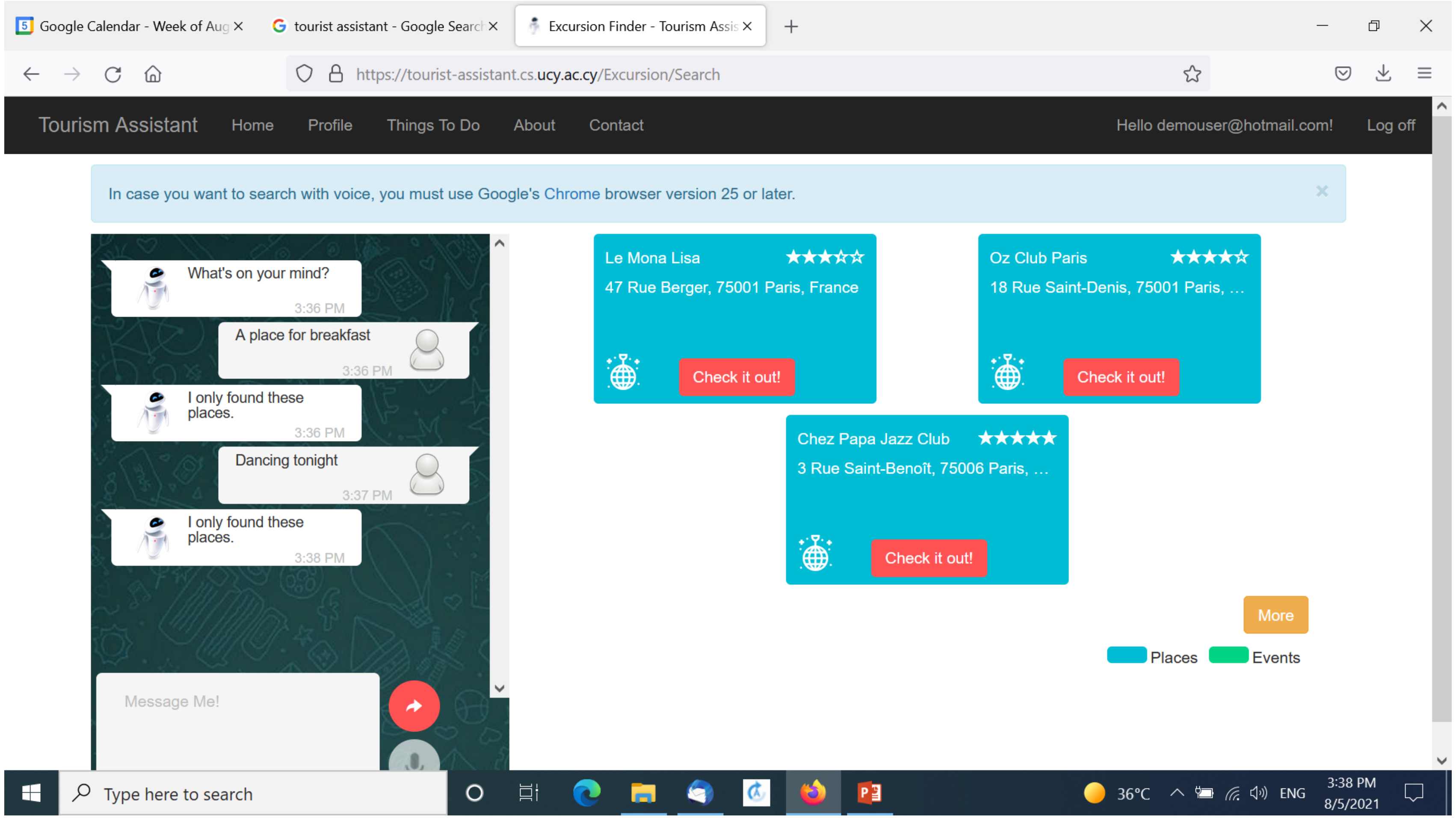
Tourist Assistant – General Policy



Tourist Assistant - General Policy



Tourist Assistant – Current Policy



Ultimate case Example
Online Shopping Assistant

- **Personal Policy**

  "The quality of food is very important for me. I like to eat organic food. I am not diabetic but I like to avoid sugary foods. I prefer not to eat red meat except for special occasions. When possible try to economize."

CODE: Blue ↔ Abstraction Green ↔ Preference (Strength)

- **Too difficult to handle automatically in this free text**
  - **Manually identify dimensions and values that matter.**
  - **Towards automation using CNL in this vocabulary.**

"The fish last night was very good. I would have liked a bigger portion."

Machine Coaching (L. Michael ...)

More Realistic Example:

SOCIAL MEDIA COGNITIVE ASSISTANT

Personal Policy

My general interests are sports, particularly tennis and basketball, cooking and animal life. I hate politics except when related to medical news. Apart from news on evolution, I like to avoid science news. I love drama and comedy movies and shows. I like to know what my closest friends are doing and to stay in touch with current popular news.

Other Policy Dimensions

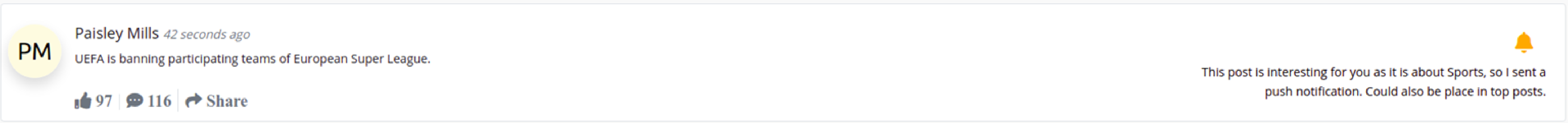
- User: Emotional state of the user, e.g. happy, sad, bored, busy, …
- General: Validity of the post, e.g. fake news, hate speech, racist, malicious content, etc.

Example Output

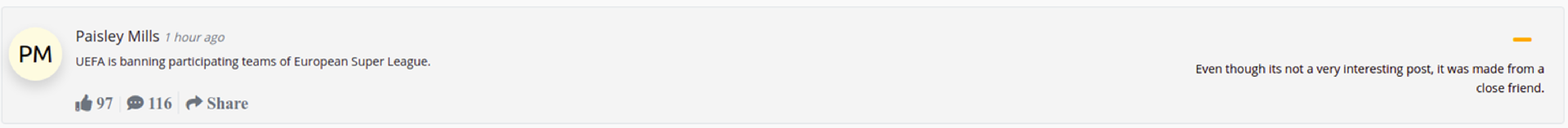
- Posts are ordered based on their classification shown on the right side of post.
- When hovered, the explanation is shown.

Personalized Output: based on interests

- Andreas has interests: Comedy, Movies/Series, Politics, Sports and Technology.



- Frederikos has interests: Food, Gaming, Science, Technology, Covid.



Argumentation-based Methodologies for AI Systems

Two major challenges

- **Acquisition** of Knowledge of the Decision Policy
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    - Language of the application domain.
  - Can this be Natural Language ???

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  - Comprehension of current application environment
    - Recognition of the current world and decision Context.

Intelligence is in the Abstraction

Acquisition of Decision Policy Knowledge

- Machine Learning alone? What about:
  - Company (current) Policy?
  - A user’s (current) preferences?
  - Expert (e.g. medical) knowledge?
  - A legal requirement?

- Need also Knowledge Elucidation directly from the “policy source/owner”.

- Challenge of which Language for policy representation?

Language needs to be at high cognitive level
Facilitate acquisition & Allow (useful) Explanations

Application Languages

Controlled Natural Language
in the application vocabulary

Examples at two extremes of language

- **MEDICA: Legislation for patient Record Access**
  - **Free Text of legal document**

- **Risk Management: Data Host Access**
  - **Structured Frame for Policy Declaration**

Challenge of Middleware
From Sensors to Concepts

Intelligence is in the Abstraction

- **Comprehension of the current External Environment**
  - **In high-level cognitive terms**
  - **Constructing a Comprehension or Mental model.**

- **Translating the low-level sensory data into the higher-level concepts used by Decision Policy**
  - **Contextual meaning of sensory information**

- **Central AI challenge: From Perception to Cognition**
  - **Cognitive Architectures (e.g. ACT-R)**

Middleware
Example 1: Cognitive Assistants (1)

- **Decision policy in high-level Natural Language, e.g.:**

  > *“The quality of food is very important for me. … I prefer not to eat red meat except for special occasions.*

- **Sensory information is particular and specific, e.g.:**

  > *“The food catalogue of a supermarket with name, weight, ingredients, price, etc. for each food item.*

How do we decide on the “quality of a food item”?

- **Central AI problem since 1960**
  - “Programs with Common Sense” *(McCarthy, …)*
  - Commonsense Reasoning in the current state of world
- **Can be addressed using the same Argumentation (logic).**

Middleware
Example 1: Cognitive Assistants (2)

Social Media Assistant's Policy

… I hate politics except when related to medical news. I love drama and comedy movies and shows. I … stay in touch with current popular news.

Sensory Data: Posts on Media

Statistical and Sub-symbolic modules to decide on the high-level features of posts, e.g. on medical news, drama movie, current popular news, etc.

Argumentation Middleware:
Argument Mining *(ARG-tech, …)*

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Lecture 1

From SBPS to Argumentation in Gorgias

1. **Translating SBPs to Gorgias**

Knowledge (SBPs) for Decision Making

- **General, Cognitive Form** of **Knowledge**:
  - "**Generally**, in **SITUATION** **prefer Ois**,
    but when in **particular** **CONTEXT**, **prefer Ojs**."
  - **"Generally, deny calls when {busy at work} but allow calls from {collaborators}."**
- **Scenario-based Preferences:**
  - **<Id, Scenario_Conditions, Preferred_Options>**

Representation Language/Process
(Study Assistant Example)

- **Separate Options and Scenario Language**
  - **Options: Study at Library, Home, Café**

- **Capture Hierarchies of Scenario-based Preferences amongst the Options**
  - **<1, {Homework}, {Home, Cafe}>**
  - **<2, {Homework, Late}, {Home}>**
  - **<3, {Homework, Need_Sources}, {Library}>**

- **Capture anti-preferences (αντενδείξεις or contra-indications) for an individual Option.**
  - **<a1, {Closed_Library}, {-Library}>**

Refinement & Combinations of Scenarios-based Prefs

Refinement of Scenarios with extra condition(s).

- Example 1:
  - <1, {Homework}, {Home, Cafe}>
  - <2, {Homework, Late}, {Home}>

- **Preferred options (e.g. Home) in more specific scenario win.**
  Therefore arguments in more specific scenario are **stronger:**

  - **Home preferred over Café (and over Library)**

Refinement & Combinations of Scenarios-based Prefs

Combination of Scenarios with conflicting options

- Example 2:
  - **<2, {Homework, Late}, {Home}>**
  - **<3, {Homework, Need_Sources}, {Library}>**

  - **<2|3, {Homework, Late, Need_Sources}, ???>**

- In combined scenarios the Preferred Options are specified independently (or via common sense), e.g.:
  - {Library}
  - But {Home, Library} is also possible, i.e. no preference/do not know/have not learned this yet!

From SBPs to Argumentation
(in the Gorgias Framework)

- **Example**
  - <1, {Homework}, {Home, Cafe}>
  - <2, {Homework, Late}, {Home}>
  - <3, {Homework, Late, With_Friends}, {Cafe}>

- **Object Level Arguments – ArgsOL={a1,a2,a3}**
  - a1=({}; Home), a2=({}; Cafe), a3=({}; Library)
- **Priority/Strength Arguments - ArgsPL={p13,p23, …, c21}**
  - <1>: p13= ({hw}; a1>a3), p23= ({hw}; a2>a3) – DEFAULT
  - <2>: p12= ({hw, late}; a1>a2)
  - <3>: p21= ({hw, late, with_friends}; a2>a1)

    c21 =({}; p21>p12) – Higher-level Priority Argument

From SBPs to Argumentation
(in the Gorgias Framework)

- **Object Level Arguments – ArgsOL={a1,a2,a3}**
  - **a1=({}; Home), a2=({}; Cafe), a3=({}; Library)**
    - **rule(r1, home, []). rule(r2, cafe, []). rule(r3, library, []).**
- **Priority/Strength Arguments - ArgsPL={p13,p23, …, c21}**
  - **<1>: p13= ({hw}; a1>a3), p23= ({hw}; a2>a3) – DEFAULT**
    - **rule(p13, prefer(r1,r3), []):-hw.**
    - **rule(p23, prefer(r2,r3), []):-hw.**
  - **<2>: p12= ({hw, late}; a1>a2)**
    - **rule(p12, prefer(r1,r2), []):- hw, late.**
  - **<3>: p21= ({hw, late, with_friends}; a2>a1)**
    - **rule(p21, prefer(r2,r1), []):- hw,late, with_friends.**

      c21 =({}; p21>p12) – Higher-level Priority Argument
    - **rule(c21, prefer(p21,p12), []).**

From SBPs to Argumentation
(in the Gorgias Framework)

- **Example**
  - <ci1, {Closed_Library}, {-Library}>
  - <ci2, {Closed_Library, Permision}, {Library}>

- **Object Level Arguments – ArgsOL={a1,a2,a3} U {na3}**
  - a1=({}; Home), a2=({}; Cafe), a3=({}; Library)
  - na3= ({closed_library}; -Library)

- **Priority/Strength Arguments - ArgsPL={…, np1, np2, nc21}**
  - <ci1>: np1= ({}; na3>a3) – DEFAULT Strength
  - <ci2>: np2= ({Permision}; a3>na3)

    nc21 =({}; np2>np1) – Higher-level Priority Argument

From SBPs to Argumentation
(in the Gorgias Framework)

- Some scenario information can be designated abducible
- Information that is actively sought from the (current) environment when needed (e.g. select a desired option)
- See for examples of this:
  - goal_decision.pl example
  - MEDICA
  - Ophalmologica
  - …

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Lecture 1

Argumentation and Ethical AI Systems

1. **Ethical Reasoning/Operation via Argumentation**

Philosophical Basis

Argumentation as the Vehicle of Ethics

- At the practical level ethics requires:
  - Self-Analysis of Dilemmas
  - Social Consideration/Debate of Alternatives

- Both are served well by argumentation

Levels of Ethical Reasoning

- **There are three levels of ethics:**
  - **Moral Values – Human Values**
  - **Norms – Social Norms**
  - **Actions – Decide/Performed**

- **They form an operational hierarchy in the practice of ethics**

Levels of Ethical Reasoning (2)

- **Moral values: overall deciding guidelines**

- **Norms: encoding of the moral guidelines**
  - **Laws … Best Practices**

- **Action: decided according to the moral guidelines**
  - **One way is to respect the norms, i.e. NOT to violate the norms**

Simple Example

- **Moral values:**
  - **v1 – respect human-life/people**
  - **v2 – respect yourself**

  - **Note: these are already expressed in a way that they allude to the lower levels of norms and actions**
    - **Could make them more general/pure.**

- **Norm: "Do not hurt people" – This is also a Law**

- **Actions:**
  - **take_care (or protect_yourself)**
  - **help**
  - **hurt**
  - **...**

Argumentation Framework <Args,ATT> for Ethics (1)

- **Moral values: Premises for arguments for/or against actions, i.e. they support actions.**

- **General Argument Scheme:**

  - **adherence(Value) ---→ action_promoting(Value)**

- **Example - Args:**
  - **arg1: self-respect ---→ take_care**
  - **arg2: respect-people ---→ help**

Argumentation Framework <Args,ATT> for Ethics (2)

- The Attack Relation, ATT, is determined by a loose hierarchy on the moral values (when arguments in conflict)
  - A hierarchy "other things being equal".
  - A contextual hierarchy.

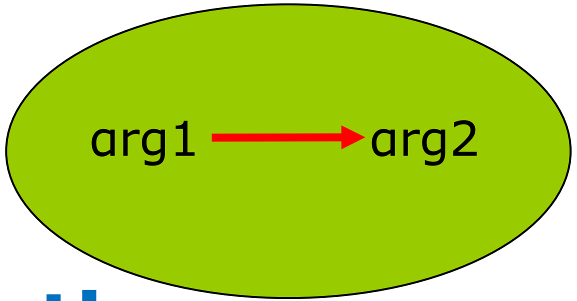
- Example – Value Hierarchy:
  - Generally (when in conflict):
    - v2:respect yourself > v1:respect others [COULD VARY IN POPULATION]
  - But when "Child in Need":
    - v1, v2 equal
  - And when "Your Child":
    - v1 > v2

Argumentation Framework <Args,ATT> for Ethics (2`)

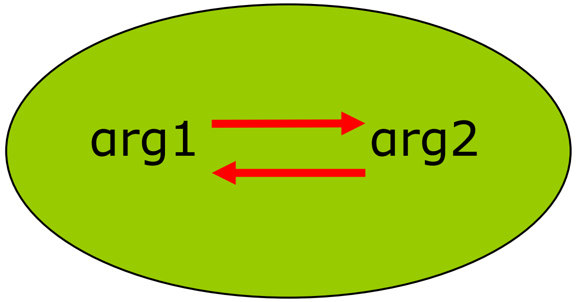
- **Example – Value Hierarchy: Another Person(ality)**
  - **Generally (when in conflict):**
    - **v1:respect others > v2:respect yourself**
  - **But when "Risky":**
    - **v1, v2 equal**
  - **And when "Extreme Danger":**
    - **v2 > v1**

Argumentation Framework <Args,ATT> for Ethics (3)

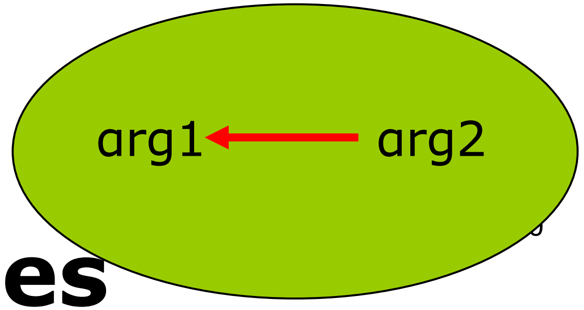
- **Example – Value hierarchy:**
  - **Generally (when in conflict):**
    - **v2:respect yourself > v1:respect others**



  - **But when "Child in Need":**
    - **v1, v2 equal**



  - **And when "Your Child":**
    - **v1 > v2**



- **Hence we have the framework dynamically changing as in the figures**

Argumentation Framework <Args,ATT> for Ethics (3)

- This contextual valued hierarchy can be captured by **Scenario-based preferences**
  - They are thus **compiled directly** at the third level of action.

- Example – **Value hierarchy**:
  - Generally (when in conflict) take_care:
    - <1, {}, take_care>
  - But when "Child in Need", try to help:
    - <2, {Child in Need}, {take_care, help}>
  - And when "Your Child", must help:
    - <3, {Your Child, Child in Need}, help>

- Note values are **not seen explicitly** in SBPs – need to remember the **promoting link** of actions with values

Example in GORGIAS pseudocode

- **Object-level argument rules:**

  r1(myself): take_care(myslef) ← true/**respect_one_self**
  r2(Person): help(Person) ← true/**respect_others**

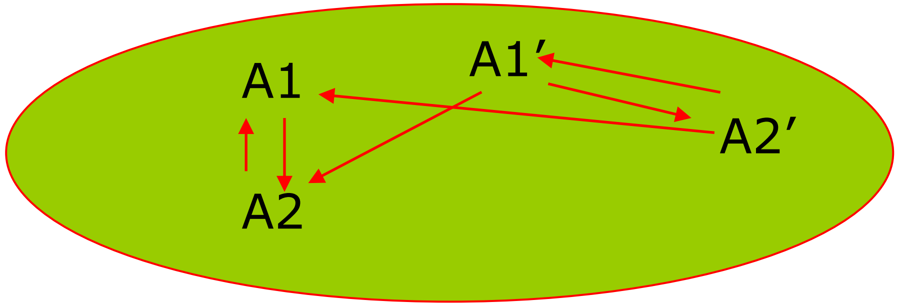
- **Priority argument rules**
  - Default Policy – Scenario 1
  - Generally, take_care:
  - R12(Person): r1(myself) > r2(Person) ← true
  - Special – Contextual- Priority: Scenario 2
  - Generally, when child (in danger) try to help
  - R21(Person): r2(Person) > r1(myself) ← child(Person)
  - Special – Contextual- Priority: Scenario 3
  - R'21(Person): r2(Person) > r1(myself) ← mychild(Person)
  - C21(Person): R'21(Person) > R12(Person) ← true

Example in GORGIAS (pseudocode)

- **<2, {Child in Need}, {take_care, help}>**
- A1={r1(myself)} supports the action to take_care
- A2={r2(bob)} supports the action to help(bob)
  - A1 attacks A2 and vice versa (actions are in conflict)

- A1'={r1(myself), R12(bob)} strengthens A1
  - A1' **attacks** A2 but A2 **does not attack** A1'
- A2'={r2(bob), R21(bob)} strengthens A2
  - A2' **attacks** A1' and vice-versa
- Hence, A1' and A2' are admissible:

  Therefore both actions are **ethical**.

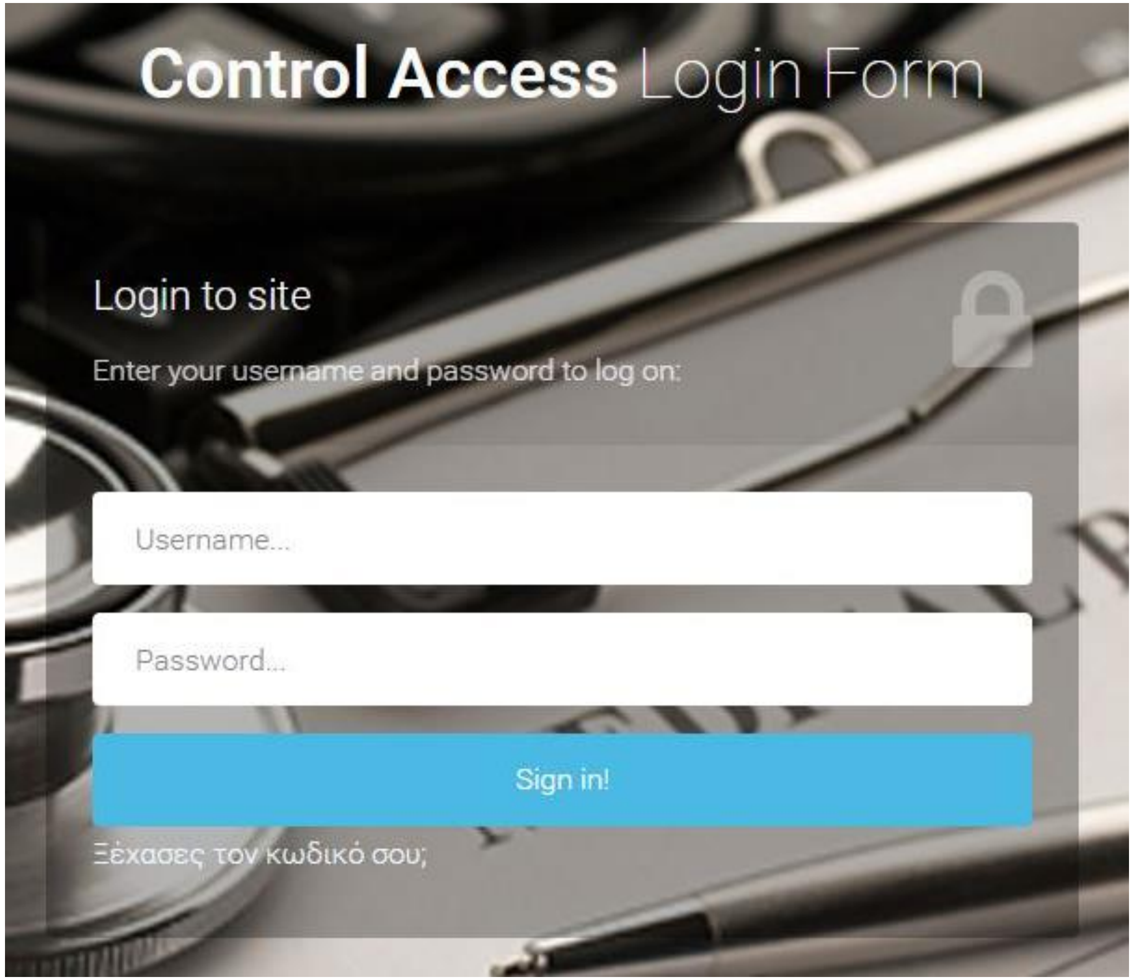


Argumentation Framework <Args,ATT> for Ethics (4)

- Example – with Norms:
  - "Do not hurt people." (serves v2 – respect people)
- Scenario-based Preferences of Norm:
  - Generally obey the norm:
    - <1, {}, not hurt(Person)>
  - But when "in danger", you can hurt:
    - <2, {in_danger_by(Person)}, not or hurt(Person)>
  - When "A child in danger", you must hurt:
    - <3, {child_in_danger_by(Person)}, hurt(Person)>

Argumentation for Ethics via Norms Example of MEDICA

- **MEDICA:**
  - **Medical Data Access**
- http://medica.cs.ucy.ac.cy
- **Demo Online**
  - **user1**
  - **12user12**



Argumentation for Ethics - Explainability

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision
  - Why did you not help the child?
    - To protect myself (self_respect)
    - Would be unlawful to hurt someone (obey norm)
  - Why did you hurt the person?
    - To defend myself (self_respect)
    - To help the child in need (respect for the weak)
      - Will come back to this norm-violating explanation

Argumentation for Ethics – Explainability (2)

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision

  - Argumentation has explanation as a primary object:
    - Explanation is the argument that supports the action

  - Why did you hurt the person?
    - To defend myself (self_respect)
    - To help the child in need (respect for the weak)
      - Will come back to this norm-violating explanation

Argumentation for Ethics – Explainability (3)

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision

  - Furthermore, argumentation contains also dialectic information of counter-arguments and defenses (along with the initial supporting argument)

  - Hence it can provide deeper explanations if requested, e.g. when decision is contested and an ensuing debate.

  - Example: Hurt because:
    - child was in immediate danger:
    - there was no time to get help from police

Argumentation for Ethics – Explainability (3)

- Decisions of Actions are normally explained by appealing to the higher levels of moral values and/or norms to justify the decision
  - Furthermore, argumentation contains also dialectic information of counter-arguments and defenses (along with the initial supporting argument)
    - Example: Why Hurt? "To help the child in need"
      - Norm-violating explanation
    - Deeper Explanation via Explication of the special context

Argumentation for Ethics – Explainability (4)

- **Argumentation can provide informed explanations and a supporting dialogue for users to analyze and possibly resolve their ethical dilemmas**
  - **Cognitive Explanations of arg-based decisions**
- **Cognitive Experiments to evaluate this overall goal of arg-based ethics**
  - **How do the explanations affect users decision? Do they change their mind/decision?**
  - **Do the explanations and dialogue help users in their ethical decisions?**
    - **What does "help" mean here? Follow moral guidelines???**

Argumentation Framework <Args,ATT> for Ethics (NOTE)

- **Using Scenario-based preferences**
  - **They are compiled ethics at the level of actions**

- **Why do we then need the higher levels?**
  - **For explainability (as explained above!)**
    - **Hence need to keep the link with values**
    - **Done via linking actions to values they serve**

  - **For cases where we do not have the SBP or Norms**
    - **Ineffective/impossible to explicate at lower level all possible scenarios (legislate for all cases)!**

Project – Ethical Considerations

- Following the above lecture consider the ethical dimension in the decision making of your cognitive assistant in your project.
  - What are the ethical values that are involved and what is ethical policy that your assistant should adhere to – Write this out first in Natural Language
  - Consider then the actions, moral values and possible norms that apply.
- Express these considerations as scenario-based preferences at two levels:
  - High-level moral values (i.e. the options are the moral values)
  - Lower-level at the usual decision options level of your assistant.
    - How are the arguments from these ethical scenario-based preferences interact with the other arguments from the scenario-based preferences for decision making?

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University of Cyprus

COGNITIVE PROGRAMMING FOR HUMAN-CENTRIC AI

Antonis Kakas

Autumn 2022

Lecture 1

Summary and Recap of Course

1. Requirements of Cognitive Assistants.

2. Argumentation for Cognitive Systems
   Decision making through Argumentation

3. Design & Architecture of Cognitive Systems

Summary

- Requirements of Cognitive Assistants.
- Argumentation for Cognitive Systems
  - Decision making through Argumentation
- Design & Architecture of Cognitive Systems

Argumentation

- Argumentation Framework <Args, ATT>
- Acceptable subset of arguments
  - Attack and Defense (attack back)
- Realization of AF
  - Argument Schemes & Relative Strength
  - Object-level and Priority-level argument rules
    - From argument rules to AF & Acceptability

Argumentation

- **See RECAP Slides on Argumentation**

Properties of Cognitive Systems

- How do Cognitive Systems differ from other conventional Computer Systems?

- Cognitive Systems today and Ideal Cognitive Systems in the future?

Theory of Cognitive Systems

- What is the underlying theory of Cognitive Systems?

- Can Cognitive Systems be build using Computer Science alone? If not what other disciplines are needed?

Cognitive Systems/Assistants Architecture(s)

- **See Slides on Cognitive Architectures**

Features of Cognitive Systems

- **Human-like operation/computation.**
- **Natural-Cognitive Interfaces with Humans.**
- **Autonomous & Personalized.**
- **Explainable & Contestable.**
- **Social & Ethical.**

Exam Guidelines

- You will be much better prepared by reflecting on the larger issues of Cognitive Systems rather than technical detail.
  - Concepts & Features
  - Synthesis of Concepts
  - Challenges

- The detail of coding in Gorgias will not help much – the methodology of acquiring knowledge in SBPs will be more useful.

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UNIVERSITY OF CYPRUS

DEPARTMENT of COMPUTER SCIENCE

MAI646
Cognitive Programming for Human-centric AI

Research Study Assignments

The purpose of these Assignments is to study in more depth some of the topics that are related to and important for Cognitive Programming and the development of Cognitive Assistants.

These assignments can be carried out alone or in a group of two students.

Topics of Study

Here is an initial list of topics for study. This list could grow as we progress in the course. Students can also suggest their own topics to be approved.

1. **Ethical Design of AI Systems**
   First Refs
   https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419
   EU documents on AI Ethics
   https://www.bookdepository.com/Stoic-Ethics-Normative-Impact-Technology-on-Wellbeing-Edward-Spence/9781786615916
   "Stoic Philosophy and the Control Problem of AI Technology" by E. Spence, 2021
   https://www.computer.org/csdl/magazine/co/2017/05/mco2017050116/13rRUB7a1jt
   "Why Artificial Intelligence is a Matter of Design" by Andreas Theodorou

2. **Explainability in AI**
   First Refs
   https://arxiv.org/pdf/1802.01933.pdf

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3. **Cognitive Structure of Knowledge/Context and Cognition**
   First Refs
   (https://doi.org/10.1007/978-1-4419-1428-6_2071
   2012) Cognitive Structure. In: Seel N.M. (eds) Encyclopedia of the Sciences of Learning. Springer, Boston, MA.

   http://openscience.fr/IMG/pdf/iste_muc19v3n1_1.pdf
   https://link.springer.com/chapter/10.1007/978-3-319-57837-8_48

   Contextual Reasoning in Human Cognition and its Implications for Artificial Intelligence Systems

4. **The Psychology of Persuasion and Argumentation**
   First Refs
   https://www.istc.cnr.it/en/content/psychology-argument-cognitive-approaches-argumentation-and-persuasion
5. **Behaviour Economics and Human Decision Making**
   First Refs
   https://books.google.com.cy/books/about/Nudge.html?id=mzZV9jFLltwC&redir_esc=y
6. **Neural-Symbolic Integration**
   First Refs
   https://research.samsung.com/news/-When-deep-learning-meets-logic-a-three-days-virtual-workshop-on-neural-symbolic-integration-sponsored-by-Samsung-Research
   "When Deep Learning Meets Logic" virtual workshop, 15-17 February 2021. Leslie Valiant, Balder ten Cate, Ryan Riegel, Christos Papadimitriou

   DAX: Deep Argumentative eXplanation for Neural Networks
   https://arxiv.org/pdf/2012.05766.pdf

   Neural-Symbolic Argumentation Mining: an Argument in Favor of Deep Learning and Reasoning
   https://arxiv.org/ftp/arxiv/papers/1905/1905.09103.pdf

Study and Submission

Assignments will follow these steps:

1. Topic selection.
2. Schedule for submission finalized between the groups.

3. Get approval/guidance on the bibliography that you have chosen.
4. Submit on your submission dates a short report (circa 15 pages) that includes:
    a. An overview of the topic
    b. Its links to Cognitive Systems
5. Prepare a short presentation (15 slides) and upload your report.
6. Present on your submission dates your study to the class: 20 minutes for the presentation with 15 minutes discussion with the class.

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