Artificial Intelligence Learning companion

Zala Herga
Luka Bradeško
Outline

• Introduction to Cyc Artificial Intelligence
• Our approach towards “educating” a computer
• An example of the real world use
• 1984: Cyc project starts (Dr. Douglas Lenat)
  – In order to be able to think like humans do, the computer needs to have knowledge about the world and the language like humans do.
  – the only way for machines to know the meaning of human concepts is to teach them, one concept at a time, by hand.

• 1994: Cycorp is founded
  – To foster the growth of semantic modeling and machine reasoning they offer a no-cost license to its semantic technologies development toolkit to the research community
  – OpenCyc: available to everyone

• 2013: Cyc - 500k concepts, 17k relations, 10mio logical facts (bits of knowledge)
3-Stage Research Program for AI

1. Slowly hand-code a very large and very broad KB.

2. When enough knowledge is present, the system should actively help with the KA process. It should be faster to acquire more from texts, databases, [websites], interactive dialogues, etc.

3. To go beyond the frontier of human knowledge, the system will have to rely on learning by discovery, to expand its KB domain by domain.
WHAT IS BEHIND (CYC)

General Knowledge about Specific Domain

Specific data, facts, and observations about the domain
WHAT IS BEHIND (CYC)

Abstract concepts
Event ⊆ TemporalThing ⊆ Individual ⊆ Thing

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Space, time, causality
∀x, ∀y: ((causes x y) → (notLaterThan x y))
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∀x, ∀y: ((causes x y) → (notLaterThan x y))

Domain specific
∀x: ((isa x Person) → (thereExists y) (mother x y))

General Knowledge about Specific Domain

Specific data, facts, and observations about the domain
WHAT IS BEHIND (CYC)

Abstract concepts
Event \subseteq \text{TemporalThing} \subseteq \text{Individual} \subseteq \text{Thing}

Space, time, causality
\forall x, \forall y: ((\text{causes } x \ y) \rightarrow (\text{notLaterThan } x \ y))

Domain specific
\forall x: ((\text{isa } x \ \text{Person}) \rightarrow (\text{thereExists } y) (\text{mother } x \ y))

General Knowledge about Specific Domain

Specific data, facts, and observations about the domain

Specific facts
(spouse MargeSimpson HomerSimpson)
WHAT IS BEHIND (CYC)

Abstract concepts
Event ⊆ TemporalThing ⊆ Individual ⊆ Thing

Space, time, causality
∀x,∀y: ((causes x y) → (notLaterThan x y))

Domain specific
∀x: ((isa x Person) → (notCapableOf x Flying))

Specific facts
(spouse MargeSimpson HomerSimpson)
– *Education* event typically consists of many sub-events of *Learning* and *Teaching*
– Other types of education are *formal schooling*, *seminar series*, *online courses*, *science fair event*, etc.
– Primary function of an educational organization is to provide service of education
– Each *bird* is an air-breathing, warm-blooded, winged animal covered with feathers. Members of most, but not all, species of bird can fly.
– *Tangible objects* can’t be in 2 (disjoint) places at once
– *A stabbing* requires 2 co-temporal and proximate actors. The stabbing itself is a *purposeful action*
Example from KB

Collection: Education

on the term

isa: FirstOrderCollection

genls: Event-Organized, ServiceEvent

comment: "A specialization of ServiceEvent. Each instance of this collection is an event in which some Person receives some considerable quantity of knowledge which they did not have before. Any given Education event typically consists of many sub-events of Learning and Teaching. Education events differ from Training events in their typically longer duration, and in the fact that one may be 'trained' in practical skills rather than intellectual knowledge."

candidateProperSubSituationTypes: Teaching
definingMt: AgentMt
fieldConcerning: "(FieldConcerningFn Education)
peripheralConceptOfDomain: Analyst-PertinentConcept
properSubEventTypes: "Learning"
properSubEventTypes: "Learning"
properSubEventTypes: "Learning"
rdfURI: "http://dbpedia.org/resource/Education"
(rdfURIInNamespace Education DBPediaResourceNamespace "Education")
wikipediaArticleName-Canonical: "Education"

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Example from KB

Collection: Education

on the term

isa: *FirstOrderCollection*

role: *Event_Organized, ServiceEvent*

Mt: *OrganizationMt*
Direction: Backward

implies

(isa ?PUB Bar-DrinkingEstablishment)
(actsInCapacity-MainFunction ?PUB seller BuyingADrink))

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- Linguistic information *about* a set of hundreds of thousands of terms
- Language-independent
Cyc System Architecture

Knowledge Users

Knowledge Authors

Knowledge Entry Tools

External Data Sources

User Interface (with Natural Language Dialog)

Cyc

Reasoning Modules

Cyc Ontology & Knowledge Base

Interface to External Data Sources

Data Bases

Web Pages

Text Sources

Other KBs

Other Applications

Cyc API
WHAT IS BEHIND (CYC)

(Based on the slide by Doug Lenat)
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WHAT IS BEHIND (CYC)

Learning via natural language is faster than learning by discovery. The rate of learning increases as the amount of knowledge increases. However, there is a frontier of human knowledge that cannot be easily codified and entered by hand.

(Based on the slide by Doug Lenat)
WHAT IS BEHIND (CYC)

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(Based on the slide by Doug Lenat)
WHAT IS BEHIND (CYC)

1984

rate of learning

amount known

1000 person-years
30 real time years
~$98 million

Frontier of human knowledge

learning by discovery

learning via natural language

codify & enter each piece of knowledge, by hand

today

(CYC)

(CC)

(Based on the slide by Doug Lenat)
WHAT IS BEHIND (CYC)
rate of learning
amount known

(CYC) (Based on the slide by Doug Lenat)

Meaooww..!? I am alive!:)
TypeId: unknownID
Task: null
CycL: null

Hi there!

I am Curious Cat, and I'd like to learn to become your loyal personal assistant, and maybe a kind of friend.
TypeId: loginFirstScreen
Task: LoginTask
CycL: null

User: #$CuriousCatUser0
Server: http://shodan.ijs.si:80/
ProphetServer/

Register or Sign In

CC: These message bubbles can be scrolled.
How we do it - Crowdsourcing

Legend:
- Initialization
- KA loop

KA loop
KA Rules + KA Forms

RULE ENGINE

API

User ID, Location

Answer/Question

Question/Answer
Semantic Chat: Social Conversational Crowdsourcing

<table>
<thead>
<tr>
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<tbody>
<tr>
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- NL Generation (Cyc)
- Patterns
- Predefined options (menus)
- Knowledge guided input
- Free text input
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- **KB**
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## Semantic Chat: Social Conversational Crowdsourcing

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- NL Generation (Cyc)
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### Semantic Chat: Social Conversational Crowdsourcing

#### Questions

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#### Answers

- Predefined options (menus)
- Knowledge guided input
- Free text input
Levels of learning

• Learning new instances:
  – Person: Luka, Dane, Janez

• Learning new concepts
  – SlovenianPerson -> Person

• Learning new relations
  – [Person] ResidesInRegion [Region]

• Learning new rules
Levels of learning

• Learning new instances:
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• Learning new concepts
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Levels of learning

- **Learning new instances:**
  - Person: Luka, Dane, Janez
- **Learning new concepts**
  - SlovenianPerson -> Person
- **Learning new relations**
  - [Person] ResidesInRegion [Region]
- **Learning new rules**
Levels of learning

- **Learning new instances:**
  - Person: Luka, Dane, Janez

- **Learning new concepts**
  - SlovenianPerson -> Person

- **Learning new relations**
  - [Person] ResidesInRegion [Region]

- **Learning new rules**

- **Easy**
  - CC, Oren Etzioni et al. (TextRunner), Taylor M. et al. …

- **Trickier**
  - CC, Huairen Lin et al., Di Iorio et al., Mitchell, T. et al., …

- **Hard to do it right**
  - Oren Etzioni et al., Luis von Ahn et al., Eckert, K. et al., Mitchell, T. et al., …

- **Hard**
  - ?
Example: Instances

• Relation: (organizationHead [Person] [Organization])
  – Arg1Isa: Person
  – Arg2Isa: Organization
  – NL: “[Org] is headed by [Person].”

• Example: Inštitut Jožef šteфан is headed by ____.
  – User fills the pattern with i.e. „Imaginary Joe“
  – System implies: (isa ImaginaryJoe Person)
• Relation: (organizationHead [Person] [Organization])
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  – User fills the pattern with i.e. “Imaginary Joe”
  – System implies: (isa ImaginaryJoe Person)

I haven't heard of "Imaginary Joe" before. What kind of thing is it?
  – Typeld: newTerm
  – Task: OneCureTask
  – CycL: null

User: #$CuriousCatUser-1
Server: http://shodan.ijs.si:80/
ProphetServer/

Michael: Forza Coffee Company has cappuccino on the menu.
Example: Instances

- Relation: (organizationHead [Person] [Organization])
  - Arg1Isa: Person
  - Arg2Isa: Organization
  - NL: “[Org] is headed by [Person].”

- Example: Inštitut Jožef štefan is headed by ___.
  - User fills the pattern with i.e. „Imaginary Joe“
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Example: Concepts

- Relation: \((\text{havingFoodOrDrinkAtEvent} \ ?\text{Person} \ ?\text{Visit} \ ?\text{FoodOrDrink})\)
  - \(\text{Arg1Isa: Person}\)
  - \(\text{Arg2Isa: Visit}\)
  - \(\text{Arg3Genl: FoodOrDrink}\)
  - \(\text{Pattern: "[Person] had [FoodOrDrink] at his [visit of place]."}\)

- Example: Luka had ___ on his visit of Egoist on 18 Sept.
  - \(\text{Answer: Strange coffee}\)
  - \(\text{System implies: (\text{subclass StrangeCoffee FoodOrDrink})}\)
• Relation: (havingFoodOrDrink ?Person ?Visit ?FoodOrDrink)
  – Arg1Isa: Person
  – Arg2Isa: Visit
  – Arg3Genl: FoodOrDrink
  – Pattern: “[Person] had [FoodOrDrink] at his [Visit of place].”

• Example: Luka had ___ on his visit of Egoist on 18 Sept.
  – Answer: Strange coffee
  – System implies: (subclass StrangeCoffee FoodOrDrink)

Example: Luka Bradeško had a coffee with milk at his or her 15:11:40, September 14, 2012 visit to Egoist Lounge Bar.

Luka Bradeško had [food and drink] at his or her 19:07:18, September 18, 2012 visit to Egoist Lounge Bar.

I don’t know  Next  Enough about
• Relation: (havingFoodOrDrinkAtEvent ?Person ?Visit ?FoodOrDrink)
  – Arg1Isa: Person
  – Arg2Isa: Visit
  – Arg3Genl: FoodOrDrink
  – Pattern: “[Person] had [FoodOrDrink] at his [Visit].”

Example: Luka had ___ on his visit of Egoist on 18 Sept.
  – Answer: Strange coffee
  – System implies: (subclass StrangeCoffee FoodOrDrink)

Egoist Lounge Bar has take-away.
The cheapest coffees with cream in the Slovenian city of Ljubljana cost 1.5 euros in Egoist Lounge Bar.
Luka Bradeško had a coffee with milk at his or her 15:11:40, September 14, 2012 visit to Egoist Lounge Bar.

Ok

Luka Bradeško had [food and drink] at his or her 19:07:18, September 18, 2012 visit to Egoist Lounge Bar.

Strange Coffee

I don’t know  Next  Enough about...
Example: Concepts

- Relation: (havingFoodOrDrinkAtEvent ?Person ?Visit ?FoodOrDrink)
  - Arg1Isa: Person
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- Example: Luka had ____ on his visit of Egoist on 18 Sept.
  - Answer: Strange coffee
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Example: Concepts

- Default positioning the graph is not accurate enough.
- Better positioning with asking more questions
  - Is Strange coffee type of Drink?
  - Is Strange coffee type of Coffee?
- Better positioning based on string presentation.
  - Because of word “coffee” in Strange coffee we can ask directly whether it is a type of Coffee
• Default positioning the graph is not accurate enough.

• Better positioning with asking more questions
  – Is Strange coffee type of Drink?
  – Is Strange coffee type of Coffee?

• Better positioning based on string presentation.
  – Because of word "coffee" in Strange coffee we can ask directly whether it is a type of Coffee or Drink.
How to Motivate users to teach

Many possible approaches

• Currently we are trying with making it useful for the users with acting as a personal assistant

• Points

• Providing the gained knowledge back to its users
How to Motivate users to teach

EXAMPLE (DEMO)
Knowledge capture and social suggestion during an SF restaurant visit by Luka Bradeško.

Michael: bahn mi is a type of product that is made by kopalnica.
Knowledge capture and social suggestion during an SF restaurant visit by Luka Bradeško
This is a new location to CC, so it asks about it, prompting with likely answers.
This is a new location to CC, so it asks about it, prompting with likely answers.

Ok. I am trying to figure out our location. Please wait until flagman stops waving...

Where are we? Are we at L’Ardoise (2.0m)

Yes

L’Ardoise:
L’Ardoise is [type of place].

Michael: bahn mi is a type of product that is made by...
Ok. I am trying to figure out our location. Please wait until flagman stops waving...

Where are we? Are we at L'Ardoise (2.0m)

Yes

L'Ardoise:
L'Ardoise is [type of place].

restaurant

Michael: bahn mi is a type of product that is made by

07188 L'Ardoise

This is a new location to CC, so it asks about it, prompting with likely answers
Because it knows what a restaurant is, it can ask relevant questions... and understand the answers.
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Because it knows what a restaurant is, it can ask relevant questions... and understand the answers.

I don't know

Is music played at L'Ardoise?

Yes

Thanks for teaching me that Music is played at L'Ardoise.

[style of music] is played at L'Ardoise.

Ethno ambient | Ok | I don't know
Because it knows what a restaurant is, it can ask relevant questions... and understand the answers.

Yes

Thanks for teaching me that Music is played at L'Ardoise.

[style of music] is played at L'Ardoise.

Ethno ambient

I haven't heard of "Ethno ambient" before. What kind of thing is it?
Because it knows what a restaurant is, it can ask relevant questions... and understand the answers.
Thanks for teaching me that Music is played at L'Ardoise.

Ethno ambient

I haven't heard of "Ethno ambient" before. What kind of thing is it?

Because it knows what a restaurant is, it can ask relevant questions... and understand the answers.
Because it knows what a restaurant is, it can ask relevant questions... and understand the answers.
Including, of course, what Luka ate. This is useful for learning about the world, and for learning about Luka.
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Including, of course, what Luka ate. This is useful for learning about the world, and for learning about Luka.

Thanks for teaching me that Ethno ambient is played at L’Ardoise.

L’Ardoise is friendly to [person type by eating habits].

I don’t know

Luka Bradeško had [item of food or drink] at its 03:14:25, September 30, 2012 visit to L’Ardoise.

traditional duck

O
Thanks for teaching me that Ethno ambient is played at L’Ardoise.

L’Ardoise is friendly to [person type by eating habits].

I don’t know

Luka Bradeško had [item of food or drink] at its 03:14:25, September 30, 2012 visit to L’Ardoise.

Including, of course, what Luka ate. This is useful for learning about the world, and for learning about Luka
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Michael: bahm mi is a type of product that is made by L’Ardoise.
I haven't heard of "traditional duck" before. What kind of thing is it?

duck meat

Thanks for teaching me that Luka Bradeško had a traditional duck at its 03:14:25, September 30, 2012 visit to L'Ardoise.

Traditional ducks cost [numeric value] dollars at L'Ardoise.

Understanding the answer, again, drives a useful, conversational follow-ups. In this case, it asks about the price.
It stores everything it learns in a user-specific context in its knowledge base, and can use it to help other users.
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Why is it asking Luka about baguettes? It’s because it learned from another user that they’re a common part of French cuisine, and that’s what L’Ardoise serves.
Easy to Add New Places, Events
Easy to Add New Places, Events

Thanks for teaching me that Harry Belafonte is playing in the Late Night Groove at Blue Note.

The date of the Late Night Groove at Blue Note is [date].

November 16, 2012

Thanks for teaching me that the Late Night Groove at Blue Note will occur on October 16, 2012.

[style of music] will be played on the Late Night Groove at Blue Note.

Jazz

I also know that Jazz music will be played on the Late Night Groove at Blue Note.

Jazz

The Late Night Groove: The Late Night Groove at Blue Note will occur on October 16, 2012. The Late Night Groove at Blue Note happens in Blue Note. Jazz music will be played on the Late Night Groove at Blue Note. Harry Belafonte will be playing in the Late Night Groove at Blue Note.
Cappuccino costs [numeric value] euros at Egoist Lounge Bar.

I also know that The cheapest cappuccino in the Slovenian city of Ljubljana costs 0.9 euros in Caffe Famel.

Luka Bradeško did its 02:24:58, October 1, 2012 visit to Egoist Lounge Bar together with [person].

Cappuccino

Thanks for teaching me that Luka Bradeško had cappuccino at its 02:48:32, October 1, 2012 visit to Caffe Famel.

Does Luka Bradeško prefer the cappuccino at Caffe Famel over the cappuccino at Egoist Lounge Bar?

Yes  No  I don’t know  Enough at
Can suggest things proactively

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<td>OKCatActionTask</td>
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<td>Restaurants</td>
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I think you should maybe experience **Hot Horse**.

**because:** Hot Horse serves **fast food cuisines**, and is a **fast food restaurant**. **You like** fried food. Hot Horse has **french fries** on the menu.

Dist: **2 kilometers**. Score: 8,32

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User: #$CuriousCatUser$

Server: http://shodan.ip:80/ProphetServer
Janez Starc, a friend of Luka: CC wants to know about its users so it asks him what things he likes.
Janez Starc, a friend of Luka: CC wants to know about its users so it asks him what things he likes.
Janez Starc, a friend of Luka: CC wants to know about its users so it asks him what things he likes.

Janek Starc likes [cuisine].

french food
Janez Starc, a friend of Luka: CC wants to know about its users so it asks him what things he likes. Janez Starc likes [cuisine].
It understands that he likes French food, and suggests the nearby French place it learned about from Luka.
It understands that he likes French food, and suggests the nearby French place it learned about from Luka.
It suggests you nearby places you might like. Janez is interested, so he selects L’Ardoise.

Janez Starc likes [cuisine].

french food

I also know that L’Ardoise serves French food.

Janez Starc likes [food].

I don’t know

Next  None  Enough about Janez

Luka: Luka Bradeško did Luka Bradeško 3:14:25,
It suggests you nearby places you might like. Janez is interested, so he selects L’Ardoise.

Janez Starc likes [cuisine].

I also know that L’Ardoise serves French food.

Janez Starc likes [food].

food  I don’t kn

Next  None  Enough about Ja

Luka: Luka Bradeško did Luka Bradeško 3:14:25, 01846 L’Ardoise
It suggests you nearby places you might like. Curious Cat tells him about it, automatically generating NL content from its knowledge base.
Curious Cat tells him about it, automatically generating NL content from its knowledge base.
It suggests you nearby places you might like. Since individual users, like Luka, may be unreliable or make mistakes, CC tries to get independent verification.
L’Ardoise does not have **snail** on the menu.

Ok

**Is it true that:** "L’Ardoise is a **restaurant**."?

Yes  No  I don’t know  Next

---

Since individual users, like Luka, may be unreliable or make mistakes, CC tries to get independent verification.
It suggests you nearby places you might like. Since individual users, like Luka, may be unreliable or make mistakes, CC tries to get independent verification.

L’Ardoise does not have snail on the menu.

Ok

Is it true that: L’Ardoise is a restaurant?“Yes

Enough about L’Ardoise

Luka: Luka Bradeško did Luka Bradeško 3:14:25,
Is it true that: "L’Ardoise is a restaurant."?

Yes

Is it true that: "Ethno ambient is played at L’Ardoise."?

Yes  No  I don't know  Next

Enough about L’Ardoise
Is it true that: "L’Ardoise is a restaurant."

Yes

Is it true that: "Ethno ambient is played at L’Ardoise."

Yes  No  I don't know  Next

Enough about L’Ardoise

Luka: Luka Bradeško did Luka Bradeško 3:14:25
It suggests you nearby places you might like. Curious Cat integrates finding out about a user in a way that makes it compelling and sticky into a natural conversation; and that makes positive, revenue-generating interactions possible.
Curious Cat integrates finding out about a user in a way that makes it compelling and sticky into a natural conversation; and that makes positive, revenue-generating interactions possible.
Curious Cat integrates finding out about a user in a way that makes it compelling and sticky into a natural conversation; and that makes positive, revenue-generating interactions possible.

Thanks for teaching me that Janez Starc likes pop music.

Janez Starc likes [movie].
It does this in a way that uses and enhances social connections.
It does this in a way that uses and enhances social connections.
And it can interact with the user via gesture, typing and speech to capture knowledge.

Thanks for teaching me that Janez Starc has expert knowledge about tennis.

Janez Starc has had formal education in [field of study].
And it can interact with the user via gesture, typing and speech to capture knowledge.
Thanks for teaching me that Janez Stanc has expert knowledge about tennis.

Luka: Luka Bradeško did Luka Bradeško 3:14:25

L’Ardoise
Thanks for teaching me that Janez Starc has expert knowledge about tennis.

Janez Starc has had formal education in [field of study].
Thanks for teaching me that Janez Starc has expert knowledge about tennis.

Janez Starc has had formal education in [field of study].

computer science | Ok | I don’t know

Next | Enough about Janez Starc
computer science

Thanks for teaching me that Janez Starc has had formal education in computer science.

Janean Starc has [higher education degree] in computer science.

I don't know  Next  Enough ab
How it can be used in education

- Used as a knowledge assessor of its users
- Acting as a study companion
  - By providing the knowledge back to its users
  - By acting as a Encyclopedic question answering system
How it can be used in education

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User: #$CuriousCatUser0
Server: http://shodan.ijs.si:80/
ProphetServer/

miosis meiosis

Michael: The name (SSID) of Forza Coffee Company Wi-Fi is FORZA.
How it can be used in education

• Used as a knowledge assessor of its users

• Acting as a study companion
  – By providing knowledge back to its users
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Prototype available on Play