CSEFRS / EUNEC

## Al Principles Potential & Limits in Education

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## Outline



- Potential et achievements
- Limitations & risks

# Focused specialized tasks (< 2010)</li> Success stories Data interpretation (> 2010) Data generation (> 2020) *data: texts, images, sound, music, vidéo, etc.*



#### Science > Techniques

#### Techniques > Science



## **Outline**



#### ► Reasoning

Demonstrate, decide, plan, diagnose, design, explain, predict



[INRIA]



#### Perceiving

Interpret signals from sensors about objects, people, sounds and scenes







#### Acting and Interacting

Move, navigate, manipulate objects Communicate and interact with others





## **AI Fonctions**

• Learning :

from examples, experiences, tutor instructions to

- Recognize objects, people and scenes
- Acquire know-how and skills
- Acquire knowledge, methods, models



Learning dexterous manipulation



## **AI Methods**





- John is partnered with Peter
- John is honest
- Peter is partnered with Tom
- Tom is dishonest



Is one of them an honest person partnered with a dishonest one?

- Deduction
- Abduction
- Induction
- Analogy

a & a entails b then b holds

b & a causes b then a is possible

## **Constraint networks**

[30,40]

[60,∞]

Dep.P

[10,20]

Dep.

[60,70]

[10,20]

7h00

Arr.P

[20,30]

[40,50]

- ▶ Peter goes to work by car (30 to 40') or by bus (at least 60')
- ▶ John gets there by bike (40 to 50') or motorcycle (20 to 30')
- This morning :
  - Peter left home between 7:10 and 7:20.
  - John arrived at work between 8:00 and 8:10
  - Peter arrived 10 to 20' after John had left
- Questions
  - Is the story coherent?
  - When did John leave?
  - Is it possible that he took his bike?
  - Does the story remain coherent if we learn that:
    - Peter's car was broken?
    - Peter and John met along the way?

Arr.J



find parameters  $w_i^{\downarrow}$  to minimize prediction error

## **Neural Networks**



#### **Convolution NN**

#### Prediction and Entropy of Printed English

By C. E. SHANNON

(Manuscript Received Sept. 15, 1950)

A new method of estimating the entropy and redundancy of a language is described. This method exploits the knowledge of the language statistics possessed by those who speak the language, and depends on experimental results in prediction of the next letter when the preceding text is known. Results of experiments in prediction are given, and some properties of an ideal predictor are developed.

"Anyone speaking a language possesses, implicitly, an enormous knowledge of the *statistics* of the language. Familiarity with the words, idioms, cliches and grammar enables him to fill in missing or incorrect letters in proof-reading, or to complete an unfinished phrase in conversation"

NL is regular => statistical induction From syntax to semantics ?

## LLM: word prediction



Shannon (1916 - 2001)

#### Words that appear in similar contexts are semantically close



#### [https://writings.stephenwolfram.com/]<sub>18</sub>

## Word embedding (projection)

To a word "rabat"  $\rightarrow$  a vector [rabat]  $\in \mathbb{R}^n$ 

Qualification

[morocco] + [capital] ~ [rabat]

[france] + [teacher] ~ [jules ferry]

Analogy

 $[berlin] - [germany] + [togo] \approx [lomé]$  $[boar] - [male] + [femelle] \approx [sow]$  $[best] - [good] + [bad] \approx [worst]$  $[Cu] - [copper] + [gold] \approx [Au]$ 

Similarity

[talk] . [gossip] > [talk] . [babble]

## Large Language Model



## **Pre-training**

#### Auto-supervised training

Anyone speaking a language possesses, implicitly, an enormous knowledge of the statistics of the language. Familiarity with the words, idioms, cliches and grammar enables him to fill in missing or incorrect letters in proof-reading, or to complete an unfinished phrase in conversation.



## **LLM Capabilities**

• Wide competences in NLP tasks:

translation, synthesis, analysis, comprehension, Q/A, dialogue & oral interactions, phonetics, versification, humor, proverbes, characterization of authors

- Emergence of unexpected abilities
  - common-sense
  - calculus
  - logic
  - mathematics
  - programming, planning, etc

Suppose  $g(x) = f^{-1}(x)$ ; g(0) = 5; g(4) = 7; g(3) = 2; g(7) = 9; g(9) = 6what is f(f(f(6)))?

There are different ways to approach this problem, but one possible method is to use the fact that  $g(x) = f^{-1}(x)$  implies that f(g(x)) = x for any x in the domain of g. That is, applying f to both sides of the equation  $g(x) = f^{-1}(x)$  gives  $f(g(x)) = f(f^{-1}(x)) = x$ . This means that we can undo the effect of f by applying g, and vice versa. Using this idea, we can try to find f(6) by looking for the value of x such that g(x) = 6. From the given information, we see that g(9) = 6, so f(6) = f(g(9)) = 9. Similarly, we can find f(9) by looking for the value of x such that g(x) = 9. We see that g(7) = 9, so f(9) = f(g(7)) = 7. Finally, we can find f(7) by looking for the value of x such that g(x) = 7. We see that g(4) = 7, so f(7) = f(g(4)) = 4. Therefore, f(f(f(6))) = f(f(9)) = f(7) = 4.

[S.Dubeck]<sub>23</sub>

Within the duration of one year, a rabbit population first multiplies itself by a factor *a* and on the last day of the year *b* rabbits are taken by humans for adoption. Supposing that on first day of the first year there are *x* rabbits, we know that exactly 3 years afterwards there will be a population of 27x - 26 rabbits. What are the values of *a* and *b*?

Let's call the rabbit population after one year y. We know that y = ax - b. After two years, the population will be  $ay - b = a(ax - b) - b = a^2x - ab - b$ . After three years, the population will be  $a(a^2x - ab - b) - b = a^3x - a^2b - ab - b$ . We are given that this is equal to 27x - 26, so we have the equation:

$$a^3x - a^2b - ab - b = 27x - 26$$

We can rewrite this equation as:

$$a^3x - 27x = a^2b + ab + b - 26$$

Now we can factor out an x on the left side and a b on the right side:

$$x(a^3 - 27) = b(a^2 + a + 1 - 26/b)$$

We can see that a = 3 is a solution for the left side of the equation, so we can substitute that in:

$$x(0) = b(9 + 3 + 1 - 26/b)$$

This simplifies to:

$$0 = 13b - 26$$

Solving for b, we find that b = 2. So a = 3 and b = 2 are the values we are looking for.

[S.Dubeck]<sub>24</sub>

Can you write a proof that there are infinitely many primes, with every line that rhymes?

[S.Dubeck]<sub>25</sub>

Yes, I think I can, Though it might take a clever plan. I'll start by noting Euclid's proof, Which shows that primes aren't just aloof. Assume we have a finite list, Of primes, and that none have been missed. Multiply them all together, And add one, just to be clever. The result will be a number, That has no prime factors, oh wonder! But every number has a prime, That divides it, it's just a matter of time. So we've found a contradiction, And our finite list needs eviction. There must be infinitely many primes, And that's the end of my rhyming lines.

## **AI Methods**



### **Optimization & Constraints**

## **Outline**

✓What is AI ?

✓ History

✓ Fonctions & methods

Potential et achievements in AIED

Limitations & risks



[K.Holstein, The Dashboard, 2018]

- Use of powerful computational tools
  - graphical representation, visualization, simulation, virtual reality
  - gaming and serious games
  - networking, collaborative problem solving and learning
- Widely and cheaply scalable, in principle

## **Potential**

- Access to enormous repertoires of knowledge and data
  - Knowledge widely spread, cheaply searched
  - Knowledge highly dynamic no longer a stable, comforting, immutable reference
  - Web drowned in a noisy, corrupted flood of information
    - Distinction between knowledge and belief blurred
    - Information assessment, qualification and filtering strongly needed
- Fills weaknesses of schools and teachers (inadequately ?)
  - Shortage and lack of time
  - Insufficient training
  - Obsolete teaching practices and objectives

## **Achievements**

- A well established research area
  - IAIED society: active for 31 years
  - IJAIE: started in 1989, 34 volumes
- Numerous developments
  - Learning Management Systems (LMS)
  - Intelligent Tutoring Systems (ITS)
    - Knowledge-intensive
    - Strong industrial investments
    - Assessment: rather weak and partial

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## International Journal of Artificial Intelligence in Education

Official Journal of the International AIED Society



## Active e-learning for reading

Child "teaches" a social robot to read using a tablet to support a story-making game played by the child and robot



- domain model
- student model
- pedagogy model
- interface model

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## Teaching anatomy with the learner's movements



[J. Troccaz, Living Book of Anatomy]

## Winners Global Learning XPRIZE competition



[KitKitSchool.com]



[OneBillion.org]

## Teach a machine and learn how it works



[ARIN-561, USC]



[Lawrence Hall of Science, Berkeley, 2024]

	Many	y LMS & ITS products
MagicSchool.ai		SchoolAl
Education Copilot		Gradescope
ELI5/Owlfit		Fireflies ai
Blackboard	Teach Support studou	nt
Canvas	Assist teache	otter.ai
Moodle		AutoTutor
ActiveMath		QuillBot
iTalk2Learn		Grammarly
ALE	KS Duolingu	JO

## **Automated Planning for an LMS**

- Given learning domain & goals, synthesize a plan as a network of tasks adapted to student with timing and progression to achieve the goals
- Plan updated in a receding horizon closed-loop feedback



#### [Castillo et al., Automatic generation of planning domains for e-learning, 2009]

## **Automated Planning for AIED**

- Learning Objects Repository: ontology of components and classes, hierarchy and dependency constraints, importance, difficulty, timing, resources (educational knowledge description standard ANSI/IEEE 2007)
- User profile: academic history, performance levels in languages and other areas, learning style, support environments
- Extracted planning domain: educational actions, tasks and methods

```
(:task AI-DFS
:parameters (?student)
(:method Pragmatic
  :precondition (learning-type ?student pragmatic)
  :tasks (
        (MULTIPLE-AIDFS-Algorithm ?student)
        (AIDFS-Examples ?student)
        (AIDFS-Properties ?student)
        (AIDFS-Lecture ?student)))
 (:method Theorist
  :precondition (learning-type ?student theorist)
  :tasks (
(AIDFS-Properties ?student)
        (MULTIPLE-AIDFS-Algorithm ?student)
       (AIDFS-Examples ?student)
        (AIDFS-Lecture ?student))))
 [Castillo et al., Automatic generation of planning domains for e-learning, 2009]
```

## **Automated Planning for AIED**

- Learning Objects Repository: ontology of components and classes, hierarchy and dependency constraints, importance, difficulty, timing, resources (educational knowledge description standard ANSI/IEEE 2007)
- User profile: academic history, performance levels in languages and other areas, learning style, support environments
- Extracted planning domain: educational actions, tasks and methods
- Generated plan: network of tasks with timing and progression for a given student and learning goals
- Experiments: with an LMS (Moodle), a LOR in informatics (about 50) components), a few students (17, of 6 different styles) and adapted plans (40 to 50 learning actions with and w/o deadlines)

[Castillo et al., Automatic generation of planning domains for e-learning, 2009]

## **Automated Planning for AIED**

- Advantages
  - Ease formalizing LOR metadata and learning goals
     ⇒ enabling technology for the adoption of standards.
  - Immediate design of learner-centered plans: increase teacher productivity, allowing to focus on building richer LORs and courses.
  - Takes into account all metadata defined by instructors  $\implies$  improved quality and adaptation of plans
  - Based on standard LMS metadata  $\implies$  automation technology easily adoptable in other LMS

## **Outline**

✓What is AI ?

✓ History

✓ Fonctions & methods

✓Potential et achievements in AIED

Limitations & risks

## Limitations

- State-of-the-art current limitations
  - Unreliable, faulty models
  - Narrow and brittle knowledge
  - Lack of qualification of likeliness of assertion
- Fundamental limitations
  - No absolute rationality

*"We deliberate not about ends, but means" [Aristotle]* 

If intelligence is the capability of (1) choosing one's goals, and (2) acting for the best to reach them, then AI can help only for (2)

• Al is "intelligence w/o thoughts", which is critical for an educator



#### Ethics

- Data: biases, privacy, fairness, transparency, trustworthiness, ownership
- Pedagogy: dignity, autonomy, agency, what is assessed
- Amplify "education-as-a-business", driven by market rules
- May easily manipulate the learner
- May augment dubious existing practices, e.g.,

Alternatively, AI may allow for better continuous monitoring, feedback and assessments

- Al very good at exams; grading an unappealing chore to teachers
- Alternatively, AI may empower the teacher

## **Desirable perspectives**

- Teaching assistant: help assemble and organize resources, support students, monitor progress, moderate groups and forums
- Parents adviser: about the domain, the pedagogy, the student
- Lifelong mentor, virtual pear and digital twin
- Al for educational research: modeling how learning works
- ► AI to improve how we teach
- Al to reassess what we teach
  - More about the fundamentals then the techniques
    - Problem solving
    - Reasoning, using knowledge, querying, modeling the world
    - Social awareness
    - Using AI machines
  - Priority: educating responsible citizens for the world of tomorrow rather than training for the demands of market