



Center for  
**LifeLong  
Learning  
& Design**

University of Colorado at Boulder

**Wisdom is not the product of schooling  
but the lifelong attempt to acquire it.  
- Albert Einstein**

# **Foundations of Artificial Intelligence**

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## AI Questions in 1963 — and Before

- What is a computer? Is it just a “number factory”?
- Is it possible for computing machines to think?
- But doesn't a computer do exactly what it is told to do and no more?
- Is it true that a computer will be a chess champion because the computer is so fast that it can examine all possible moves and their consequences?
- What is a heuristic program?
- What are some unsolved problems of Artificial Intelligence?
- What are the limits of artificial intelligence?

# Claims

- Making computers intelligent helps us to understand intelligence.
- Intelligent computers are more useful computers.
- Intelligent computers have their own will.
- Intelligent computers will make mistakes.
- Intelligent computers will / should replace human beings (e.g.: expert systems, ABS, flight computers)
- Intelligent computers will / should empower and augment human capabilities (IA = Intelligence Augmentation, Einstein: “My pencil is cleverer than I”!)

**Students in CS 5582:**

.....

## An Example Dialog

Computer: What is "23 + 89"?

**User: 112**

Computer: Correct. What is "138 + 247"?

**User: 485**

Computer: Would you like help?

**User: Yes**

Computer: The correct result is 385.

## A Different Dialog with the Same System

Computer: What is “2+2”?

**User: Four**

Computer: Wrong! Would you like help? Answer with “yes” or “no”!

**User: 4**

Computer: I do not understand “4”.

**User: If you do not understand 4, how can I learn Math with you?**

Computer: Right.

## Examples of Understanding

I saw the Grand Canyon flying to new York.

I saw the man in the park with the telescope.

Question: What does the “**they**” refer to?

1. The city councilmen refused to give the women a permit for a demonstration, because **they** feared violence.
2. The city councilmen refused to give the women a permit for a demonstration, because **they** advocated violence.

# Artificial Intelligence -- Characterizations

## **Herbert Simon:**

Artificial Intelligence research is empirical and pragmatic, typically working with examples rather than theorems, and exemplifying the heuristics of learning by doing. In its essential reliance on weak methods and experiments instead of proof, it is adapted to the exploration of poorly structured task domains, showing considerable contrast in this respect to operations research or numerical analysis, which thrive best in domains possessing strong formal structure.

## **Patrick Winston:**

Artificial Intelligence is the study of ideas that enable computers to be intelligent.

## **Russell/Norvig:**

systems that

- think like humans
- act like humans
- think rationally
- act rationally

# Artificial Intelligence — Major Research Directions

## Artificial Intelligence

1. narrow sense: write the best program possible, no concern for the underlying mechanisms
2. cognitive simulation: simulate humans (taking constraints of human information processing into account)

*question: what does this mean for a chess program?*

## Artificial Intelligence

1. symbolic level
2. subsymbolic level (connectionism)



## AI as a loosing (or ubiquitous) Discipline — Examples

- symbolic integration: from Slagle's program ---> Macsyma ---> Mathematica
- dynamic memory structures: from IPL-V ---> LISP ---> Pascal
- memory structures ---> frames ---> object-oriented approaches ---> abstract data types
- production systems ---> rule-based systems ---> OPS-5
- nearly decomposable systems ---> closed subroutine, layers of abstraction
- powerful programming environments for exploratory programming: from Interlisp ---> ADA ---> personal workstations ---> graphical user interfaces ---> .....

## Version 1 of a Dialogue

**P:** Men are all alike.

**C:** In what way?

**P = Person**

**C = Computer Program**

**P:** They are always bugging us about something or other.

**C:** Can you think of a specific example?

**P:** Well, my boyfriend made me come here.

**C:** Your boyfriend made you come here?

**P:** He says, I am depressed much of the time.

**C:** I am sorry to hear that you are depressed.

**P:** It is true, I am unhappy.

**C:** Do you think coming here will help you not to be unhappy?

**P:** I need some help, that much seems to be certain.

**C:** What would it mean to you if you got some help?

**P:** Perhaps I could learn to get along with my mother.

**C:** Tell me more about your family!

## **GUS: A Travel Planning Assistant**

Computer: When do you want to leave?

**User: I must be in LA at 10:00am**

Computer: Continental Flight #342 arrives at 9:30am?

**User: What is the next flight?**

## Version 2 of a Dialogue with the same System

**P:** My mumble bzzz grumble grumble.

C: That's very interesting.

**P:** Ugh, you izzle flerp me.

C: What makes you think that I izzle flerp you?

**P:** Gorch.

C: Does that have anything to do with the fact that your mumble bzzz grumble grumble?

## Different Views about AI

**Person<sub>A</sub>: My students have programmed computers to solve mathematical problems, play games, even to understand some English.**

Person<sub>B</sub>: I know those programs and I don't feel that they really think. They only do what they are programmed to do. People are individuals with free will. They have creative intellects.

**Person<sub>A</sub>: Newborn babies do only what they are programmed to do by their genes and environments. And they never do anything very creative until programmed by parents, school and the culture at large.**

Person<sub>B</sub>: That's not being programmed! At least the children learn it themselves, by walking around, seeing, touching, feeling, loving. That's not being programmed. That's *experiencing*.

## Different Views about AI — Continued

**Person<sub>A</sub>:** Well, if you like. But we are beginning to make robots which can see, touch manipulate, make mistakes and learn while doing all that. The gap is closing.

Person<sub>B</sub>: Irrelevant. Even if computers were to show the same *outer* behavior as people, you can be sure that what is going on inside is totally different. As different as birds and airplanes. Birds and people feel. Airplanes and computers don't.

**Person<sub>A</sub>:** Birds and Airplanes *are* different. But the same science of aerodynamics helps us to understand both of them. It's only after people learned to make and fly airplanes that they knew what to look for in trying to understand birds. Perhaps we must first build thinking machines before we know the right questions to ask about thinking and feeling.