What is Computer Science and it's limitations?

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What is Computer Science?

- A science
- A community
- A degree
- A religion?

What is Computer Science?

- Research areas
  - Compilers
  - Machine learning
  - Operating systems
  - Speech recognition
  - Vision

Computers can…

- Calculate, compute, sort, word process… follow any recipe/algorithm
- Simulate (model) real-world situations
- They create a "toy world" inside the computer, which (hopefully) has (some of) the structure of the real situation pictured, so that working with the model, we can make conclusions about the real situation.
- Especially, we can run "what if" scenarios: what would happen if things were different; and run the model ahead of time to make predictions.

Some examples…

- SPREADSHEETS: model of finances of company, past, present and future.
- DATABASES: e.g. of airline flights. Rows represent items (flights) and columns represent their properties (departure time, destination etc.) Database = model of system of flights.
- AIR TRAFFIC CONTROL: Picture of flights in the air; moving dots represent planes. (See lecture handout article 'The key to a new computer world view')

More examples…

- WEATHER and CLIMATE models: Run ahead of time to predict weather, global climate. Special difficulties of prediction (See lecture handout article "Climate science weathers storm")
- ECONOMIC models, GAMES, FLIGHT SIMULATORS, VIRTUAL REALITY etc
A problem…

• "The game world problem": the tendency to believe the simulation even when it's unreliable.

Limitations of computers
(what computers can NOT do)

1. IN-PRINCIPLE (logical) limitations

• For example the HALTING PROBLEM: Given a program and an input, can it be decided if the program with that input will halt (stop) or not? It is PROVABLE that there is no computer program for solving the halting problem. We say the halting problem is an UNCOMPUTABLE problem

• Similarly, by Gödel's theorem, not all mathematical truths can be generated by computer. Mathematics is too complex to be reduced to rules.

2. Limitations from Computational Complexity

• Some problems require too many steps to be solved on any real computer.

• Example: Playing chess by blind search
  - there are around 30 moves possible in chess, on average, at any stage - then 30 possible replies to each, 30 replies to each of them, etc. So to look $n$ steps ahead requires a search of $30^n$ chains of moves. This exponential growth gives enormous numbers for moderate $n$, called COMBINATORIAL EXPLOSION. (Real chess-playing programs evaluate moves and do not search through "unpromising" possible lines of play.)

3. Limitations through failure to imitate human thought.

• Example: LANGUAGE TRANSLATION
  - Simply using a dictionary to translate words and then rearranging grammar does not work. AMBIGUITY means context is needed to decide correct meaning.

• The middle one of these three sentences is ambiguous, but the other two aren't:
  1. The diners are ready to eat.
  2. The chickens are ready to eat.
  3. The cakes are ready to eat.

• World knowledge (of what eats what) is needed.