

Can **Computer** Think as **Humans**?

Laura Kovács

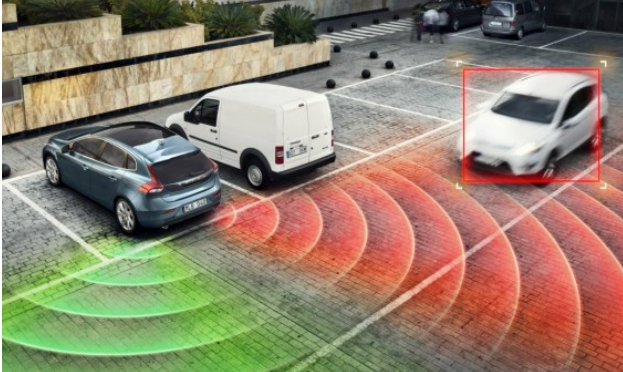


Can **Computer Programs** Think as **Humans**?

Laura Kovács



Why Care?




Software update
available

ACCEPT

CANCEL




Checking for Update... 

Unable to Check for Update

An **error** occurred while checking for a software update.

Cancel

Try Again

Checking for Update... 

Unable to Check for Update

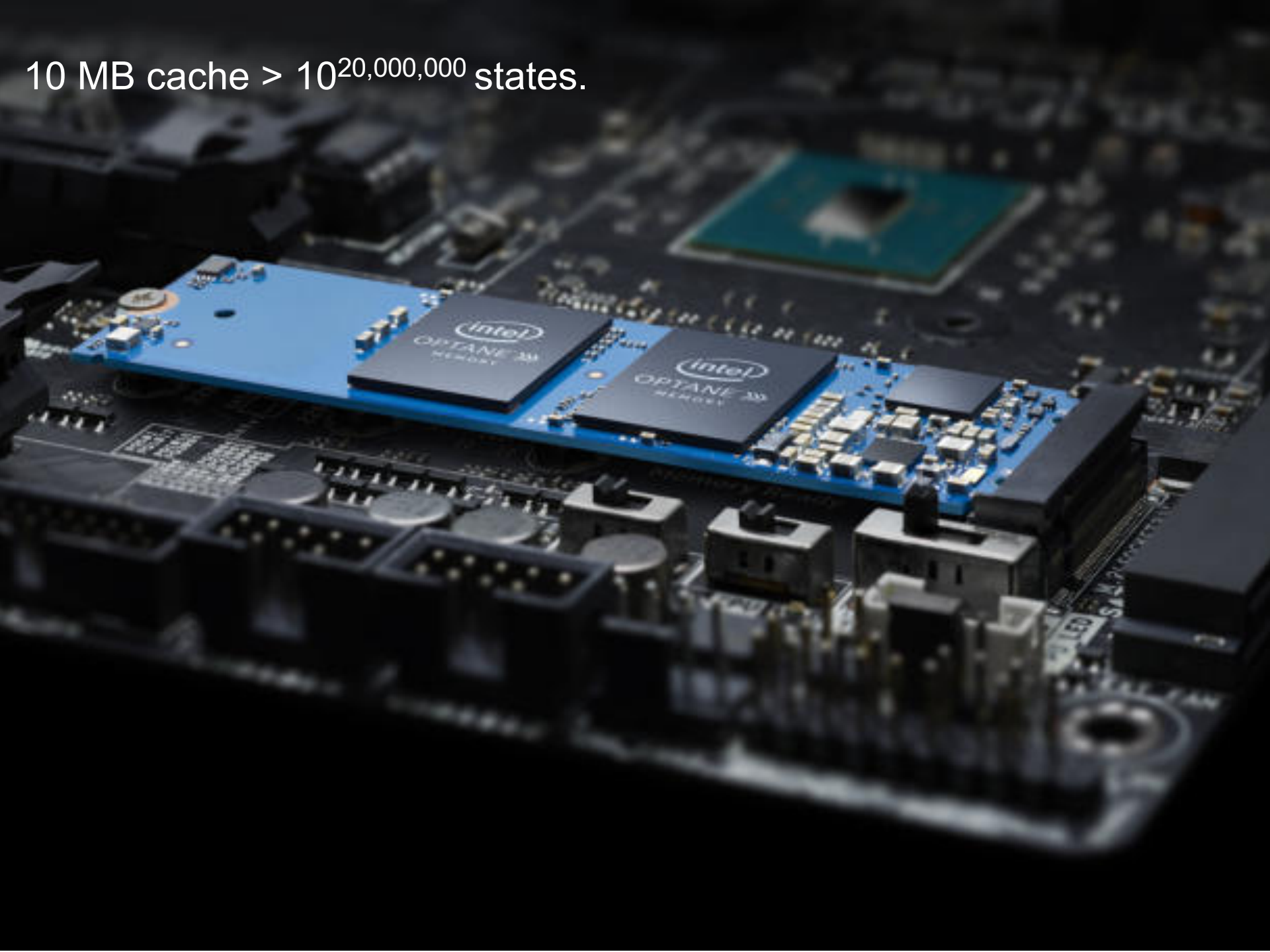
An error occurred while checking for a software update.

Cancel

Try again

WHY?

10 MB cache > $10^{20,000,000}$ states.



10 MB cache > $10^{20,000,000}$ states.



At most 10^{81} atoms
in the universe.



10 MB cache > $10^{20,000,000}$ states.

At most 10^{81} atoms
in the universe.



**How to Understand what a
Software Can Do?**

Understand what Software Can Do



I can't get no **satisfaction**:

- and I try ...
- and I try ...
- and I try ...
- and I try

[The Rolling Stones]

Understand what Software Can Do

Our Recipe, as of 1965:

Artificial Intelligence

based on

Math and Logic

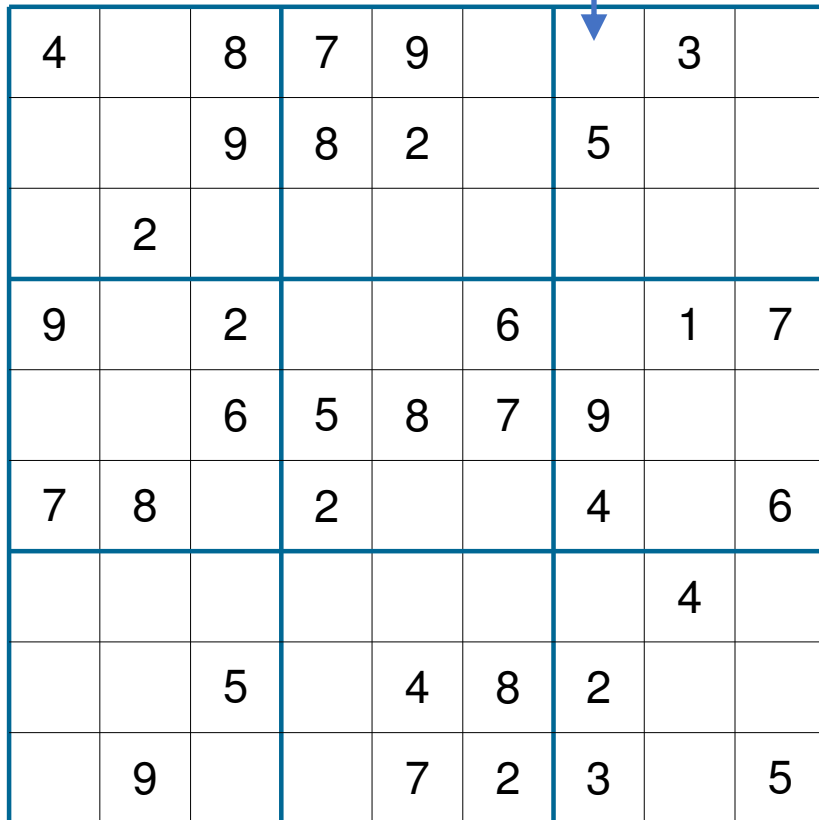
Software-based Reasoning replacing Human Reasoning

Example of Software-Based Reasoning

Solve Sudoku

a unique digit from 1..9,

hence not equal to 4, 8, 7, 9, 3



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | | 8 | 7 | 9 | | | 3 | |
| | | 9 | 8 | 2 | | 5 | | |
| | 2 | | | | | | | |
| 9 | | 2 | | | 6 | | 1 | 7 |
| | | 6 | 5 | 8 | 7 | 9 | | |
| 7 | 8 | | 2 | | | 4 | | 6 |
| | | | | | | | 4 | |
| | | 5 | | 4 | 8 | 2 | | |
| | 9 | | | 7 | 2 | 3 | | 5 |

Example of Software-Based Reasoning

Solve Sudoku

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | | 8 | 7 | 9 | | | 3 | |
| | | 9 | 8 | 2 | | 5 | | |
| | 2 | | | | | | | |
| 9 | | 2 | | | 6 | | 1 | 7 |
| | | 6 | 5 | 8 | 7 | 9 | | |
| 7 | 8 | | 2 | | | 4 | | 6 |
| | | | | | | | 4 | |
| | | 5 | | 4 | 8 | 2 | | |
| | 9 | | | 7 | 2 | 3 | | 5 |

Does it have a solution?

Example of Software-Based Reasoning

Solve Sudoku

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 8 | 7 | 9 | 5 | 6 | 3 | 2 |
| 6 | 3 | 9 | 8 | 2 | 1 | 5 | 7 | 4 |
| 5 | 2 | 7 | 3 | 6 | 4 | 1 | 8 | 9 |
| 9 | 5 | 2 | 4 | 3 | 6 | 8 | 1 | 7 |
| 1 | 4 | 6 | 5 | 8 | 7 | 9 | 2 | 3 |
| 7 | 8 | 3 | 2 | 1 | 9 | 4 | 5 | 6 |
| 2 | 6 | 1 | 9 | 5 | 3 | 7 | 4 | 8 |
| 3 | 7 | 5 | 6 | 4 | 8 | 2 | 9 | 1 |
| 8 | 9 | 4 | 1 | 7 | 2 | 3 | 6 | 5 |

Does it have a solution?

Yes, in less than 1 second.

Example of Software-Based Reasoning

Solve Sudoku

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 8 | 7 | 9 | 5 | 6 | 3 | 2 |
| 6 | 3 | 9 | 8 | 2 | 1 | 5 | 7 | 4 |
| 5 | 2 | 7 | 3 | 6 | 4 | 1 | 8 | 9 |
| 9 | 5 | 2 | 4 | 3 | 6 | 8 | 1 | 7 |
| 1 | 4 | 6 | 5 | 8 | 7 | 9 | 2 | 3 |
| 7 | 8 | 3 | 2 | 1 | 9 | 4 | 5 | 6 |
| 2 | 6 | 1 | 9 | 5 | 3 | 7 | 4 | 8 |
| 3 | 7 | 5 | 6 | 4 | 8 | 2 | 9 | 1 |
| 8 | 9 | 4 | 1 | 7 | 2 | 3 | 6 | 5 |

Does it have a solution?

Yes, in less than 1 second.

Is this the only solution?

Yes, in less than 1 second.

Example of Software-Based Reasoning

Solve Sudoku

a unique digit from 1..9,
hence not equal to 4, 8, 7, 9, 3

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 8 | 7 | 9 | 5 | 6 | 3 | 2 |
| 6 | 3 | 9 | 8 | 2 | 1 | 5 | 7 | 4 |
| 5 | 2 | 7 | 3 | 6 | 4 | 1 | 8 | 9 |
| 9 | 5 | 2 | 4 | 3 | 6 | 8 | 1 | 7 |
| 1 | 4 | 6 | 5 | 8 | 7 | 9 | 2 | 3 |
| 7 | 8 | 3 | 2 | 1 | 9 | 4 | 5 | 6 |
| 2 | 6 | 1 | 9 | 5 | 3 | 7 | 4 | 8 |
| 3 | 7 | 5 | 6 | 4 | 8 | 2 | 9 | 1 |
| 8 | 9 | 4 | 1 | 7 | 2 | 3 | 6 | 5 |

- **Instrument** the software with properties of Sudoku

24,057 properties

- AI-based **solving** over Sudoku rules

Understand what Software Can Do

- **Teach** the software,
using rule-based **software reasoning**
- Let the software **reason/think**
along the rules it **knows**

Can Computer Programs Reason as Humans?

- Much **faster**
- Work with **huge** data sets
- More **consequent**



Can Computer Programs Reason as Humans?

```
vampire --bash -- 88x23  
e232-000:vampire lkovacs$ ./vampire -fsr off -awr 4:1 GRP140-1.p --show_active on -t 20
```

Every nonempty set of real numbers that is bounded below has a greatest lower bound.



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... but, crucially depends on **how humans instrument!**

... yet, **humans do not fully understand** what they taught!

Can Computer Programs Reason as Humans?

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- Work with **huge** data sets
- More **consequent**



Software will do what we like it to do.

... but, crucially depends on how humans instrument!

... yet, humans do not fully understand what they taught!



Informatics

Computing is too Important to Be Left to Men

Workshop

TUtheSky, December 3, 2019