Alan Turing, the Imitation Game and Big Data

Frank Thuijsman

March 1, 2016
Alan Turing

June 23 ‘12, born London
‘31 - ‘34 King’s College (S)
‘35 - ‘36 King’s College (F)
‘36 computable numbers
‘38 PhD, Princeton
‘39 - ‘45 Bletchley Park
‘45 – ‘47 ACE/NPL, London
‘48 - ‘54 Manchester
‘50 computing machinery
‘52 convicted
June 7 ‘54, dies Wilmslow
ON COMPUTABLE NUMBERS, WITH AN APPLICATION TO THE ENTSCHEIDUNGSPROBLEM

By A. M. Turing.

[Received 28 May, 1936.—Read 12 November, 1936.]

The “computable” numbers may be described briefly as the real numbers whose expressions as a decimal are calculable by finite means.
Turing Machines
Turing Machines

1. Input: infinite squared tape
2. Finitely many non-empty
3. Finitely many symbols
4. Operator can read and write
5. ... can go L or R, one by one
6. Operator has a finite manual on what to do, consisting of finitely many “states”
Turing Machines: $x + y$

Starting here in state 1
Turing Machines: $x \cdot y$
Turing Machines: how many?
Turing Machines: countably many

Play movie
Turing: the Universal Machine

6. The universal computing machine.

It is possible to invent a single machine which can be used to compute any computable sequence. If this machine $U$ is supplied with a tape on the beginning of which is written the S.D of some computing machine $M$, 
Turing: the Universal Machine

Table of Turing machine $M$:

<table>
<thead>
<tr>
<th>Current state: $A$</th>
<th>Current state: $B$</th>
<th>Current state: $C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write</td>
<td>Move</td>
<td>Next state</td>
</tr>
<tr>
<td>1 R A</td>
<td>1 R B</td>
<td>1 R C</td>
</tr>
<tr>
<td>1 L A</td>
<td>1 L B</td>
<td>1 L C</td>
</tr>
<tr>
<td>tape symbol in blank</td>
<td>tape symbol is 0</td>
<td>tape symbol is 1</td>
</tr>
</tbody>
</table>

Control unit:

Print $S_k$, Erase Left, Right

Scanned symbol:

Code number of Turing machine $M$, Input to $M$, Output
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The “computable” numbers may be described briefly as the real numbers whose expressions as a decimal are calculable by finite means.
Turing Machines & the Halting Problem

There is **NO** program $P$ that can check for any program $Q$ and any input $I$, whether or not $Q$ halts on $I$.

**Argument:** Suppose program $P$ exists, then $P$ would:
- print **YES** if $Q$ halts on $I$, and next $P$ halts;
- print **NO** if $Q$ doesn’t halt on $I$, and next $P$ halts.

If $P$ exists, then we can also make a program $P^*$ which:
- prints **YES** if $Q$ halts on $Q$ and next $P^*$ prints 0,0,0,...;
- prints **NO** if $Q$ doesn’t halt on $Q$, and next $P^*$ halts.

**Does $P^*$ halt on $P^*$?** Answers **YES** and **NO** both fail!
Turing and Code Breaking

Play movie
The Enigma Machine

- Rotors
- Lampboard
- Keyboard
- Plugboard
The Enigma Machine
The Bombe
The Imitation Game
The Imitation Game

MIND
A QUARTERLY REVIEW
OF
PSYCHOLOGY AND PHILOSOPHY

I.—COMPUTING MACHINERY AND INTELLIGENCE

BY A. M. TURING

1. The Imitation Game.

I propose to consider the question, ‘Can machines think?’ This should begin with definitions of the meaning of the terms ‘machine’ and ‘think’. The definitions might be framed so as to
The Imitation Game

The new form of the problem can be described in terms of a game which we call the ‘imitation game’. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either ‘X is A and Y is B’ or ‘X is B and Y is A’. The interrogator is allowed to put questions to A and B thus:

C: Will X please tell me the length of his or her hair? object in the game to try and cause C to make the wrong identification. His answer might therefore be

‘My hair is shingled, and the longest strands are about nine inches long.’

We now ask the question, ‘What will happen when a machine takes the part of A in this game?’ Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace our original, ‘Can machines think?’
The Imitation Game
The Imitation Game

- Human
- Computer
- Interrogator
The Imitation Game

CAPTCHA

Completely Automated Public Turing test to tell Computers and Humans Apart
Ex Machina
What happened after Turing?
What happened after Turing?

**ARPANET**: 1969  
**Internet**: 1983/1993  
**Microsoft**: 1975, Bill Gates, Paul Allen  
**Apple**: 1976, Steve Jobs, Steve Wozniak, Ronald Bayne  
**Yahoo**: 1994, David Filo, Jerry Yang  
**Amazon**: 1994, Jeff Bezos  
**eBay**: 1995, Pierre Omidyar  
**Google**: 1997, Larry Page, Sergey Brin  
**Wikipedia**: 2001, Jimmy Wales  
**LinkedIn**: 2002, Reid Hoffman  
**Facebook**: 2004, Mark Zuckerberg  
**Twitter**: 2006, Noah Glass, Jack Dorsey
The World Wide Web
Cycling in New York City

Play movie
Cycling in New York City
What are we looking at?
What are we looking at?

<table>
<thead>
<tr>
<th>PIN</th>
<th>Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1234</td>
</tr>
<tr>
<td>#2</td>
<td>1111</td>
</tr>
<tr>
<td>#3</td>
<td>0000</td>
</tr>
<tr>
<td>#4</td>
<td>1212</td>
</tr>
<tr>
<td>#5</td>
<td>7777</td>
</tr>
<tr>
<td>#6</td>
<td>1004</td>
</tr>
<tr>
<td>#7</td>
<td>2000</td>
</tr>
<tr>
<td>#8</td>
<td>4444</td>
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<td>#9</td>
<td>2222</td>
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<td>#10</td>
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<tr>
<td>#11</td>
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<td>#12</td>
<td>3333</td>
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<td>#13</td>
<td>5555</td>
</tr>
<tr>
<td>#14</td>
<td>6666</td>
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<tr>
<td>#15</td>
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<td>1313</td>
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<td>#17</td>
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<td>#18</td>
<td>4321</td>
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<tr>
<td>#19</td>
<td>2001</td>
</tr>
<tr>
<td>#20</td>
<td>1010</td>
</tr>
</tbody>
</table>
What are we looking at?
Computing, Communication and Storage
AI and Big Data

IN LESS THAN 10 YEARS, CPUs ARE EXPECTED TO REACH THE PROCESSING POWER OF THE HUMAN BRAIN
The Internet of Things

Play movie

f.thuijsman@maastrichtuniversity.nl
People and the Internet
Digitisation of Matter
What will our future bring?
Humans need not apply ...
Further Viewing

1996

Breaking the Code

2011

Codebreaker: The Alan Turing Story

"...a truly awe-inspiring viewing experience."
- Sarah Cox, OnTheBox.com
Further Reading

Papadimitriou, 2003
Meet Papadimitriou next Summer!

24-28 July 2016
Maastricht
The Netherlands
GAMES2016.NL

View Details
Many thanks for your attention!

This presentation will be available at my website!