The ticking composite Mind

Henk Barendregt

Faculty of Science
Radboud University
Nijmegen, The Netherlands

Many *numerical problems* can be answered by computing

"What is the area of a circle with radius $4\,\mathrm{m}$?"

Answer: $4^2\pi\,\mathrm{m}^2 = 50.2654824\,\mathrm{m}^2$

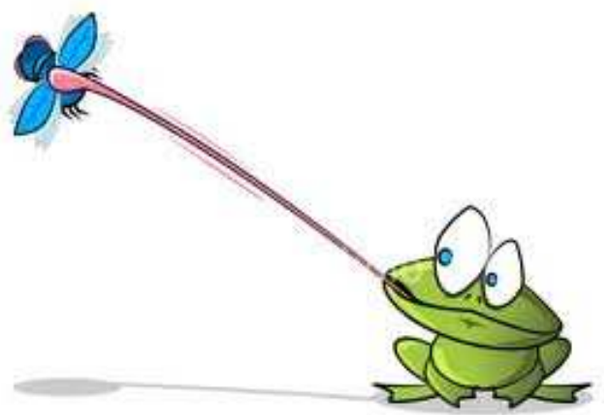
Also many *qualitative problems* may be answered by computing

"Are points $A = (x_1, y_1)$, $B = (x_2, y_2)$ and $C = (x_3, y_3)$ in $\mathbb{R}^2$ collinear

i.e. do they lie on a straight line?"

Answer: if and only if $(x_1 - x_3)(y_2 - y_3) = (x_2 - x_3)(y_1 - y_3)$

Also in animal life computations are needed: nature has evolved



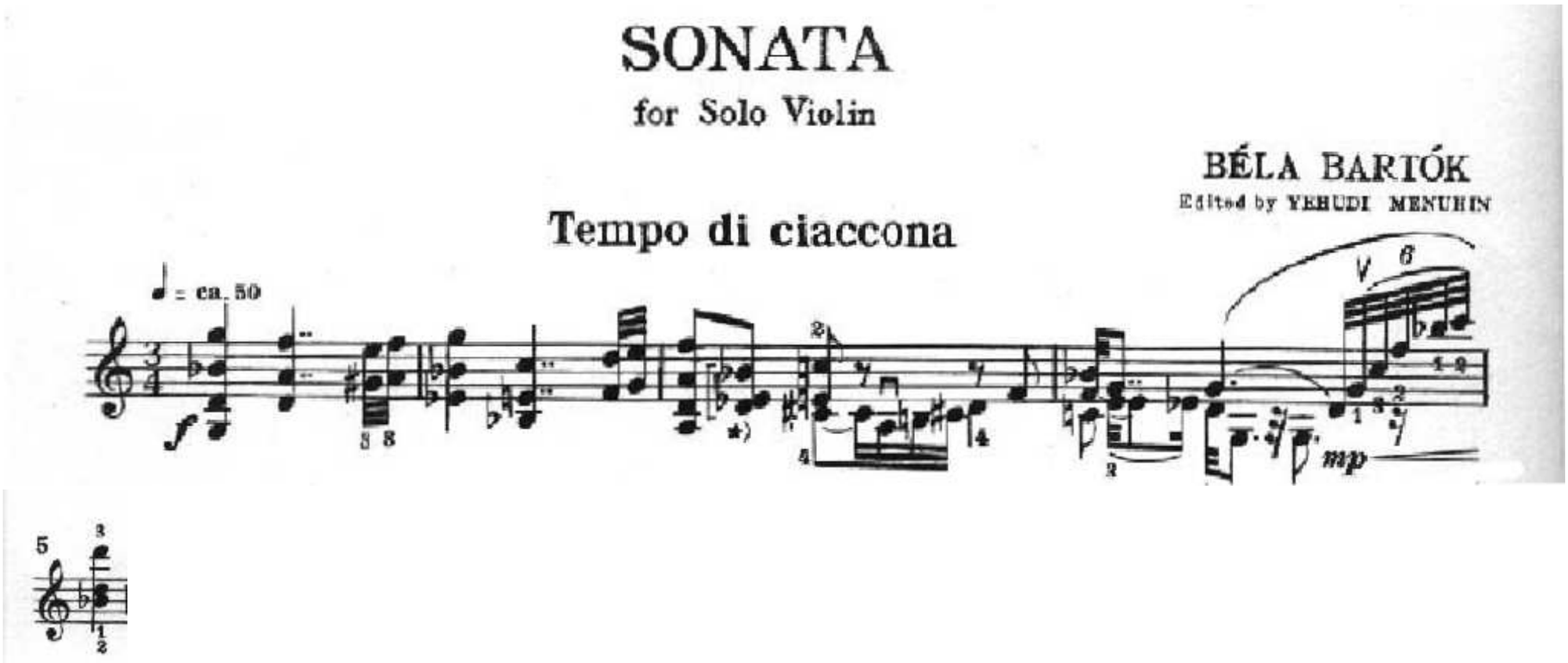
an electro-chemical computational model

Neural Net Synapse

These are programmed by trial and error
run in parallel and are remarkably efficient
need to be trained (by evolution via genes)

In the performing arts computations reach a next level

Bartok: Sonata, Ivry Gitlis violin, Presto (needs training via memes)



Leibniz (1646-1716) conjectured:

All properly stated problems can be answered by computing (calculemus!)

He wanted to construct:

a universal language L for stating problems precisely

a machine M for answering these problems by computing

The first question Leibniz wanted to ask to M is said to be

"Does God exist?"

Quite daring around 1700 to ask this question to a machine!

Restricted to mathematical problems, there is such an L

Restricted to *numerical problems* and some qualitative ones there is such an M:

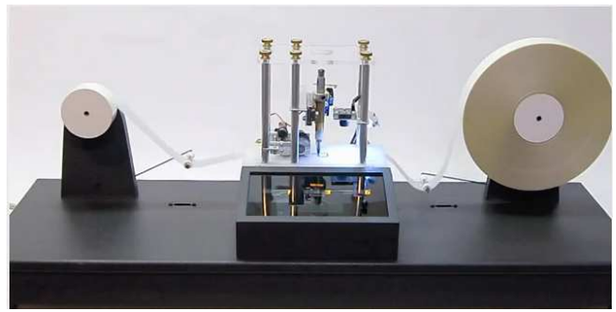
A computer with a software package like Mathematica or Maple

However, Turing [1936]: for *qualitative mathematical problems* M is impossible

How did Turing prove his negative result?

How could it have so much positive spin off?

Turing did the following



- ! Gave a well-motivated analysis of computability via *Turing Machines* (TM)
  an idealized class of machines (with infinite memory)
- !! Constructed a *universal Turing Machine* UTM that can simulate any TM
  via software (*programs*)
- ! Formulated the *halting problem* (HP) that cannot be decided by any TM
  argument like liar paradox
- ! Concluded *qualitative mathematical problems* cannot be decided by any TM
  as the HP is one of them

Therefore Leibniz's ideal cannot be fulfilled in general for mathematical problems

leave alone for philosophical problems

Based on introspection: computing is done in *discrete* steps

from input to output (action)

The machine M transforms an input (i in I) into an action (a in A)

$$i? \xrightarrow{M} a$$

The same input may give rise to different actions (over time)

Turing introduced a set S of *states* indicating how to react to an input

$$(i, s) \xrightarrow{M} (a, s')$$

The machine, given input and state, may choose action and (a new) state

M is given as a finite table of transitions $(i, s; a, s')$

Although states form a mathematical abstraction, you know them well:

emotions and other mind-states

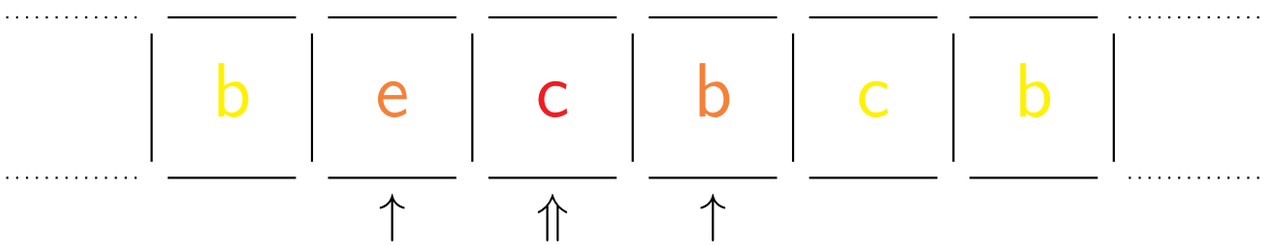
M and has a two-sided infinite memory tape

with cells containing nothing (a blank) or a symbol $i \in I$

and also has a Read/Write device ('head') placed on one of the cells

An (*instantaneous*) *configuration* (at a given moment)

is the information on the tape & the position of the head

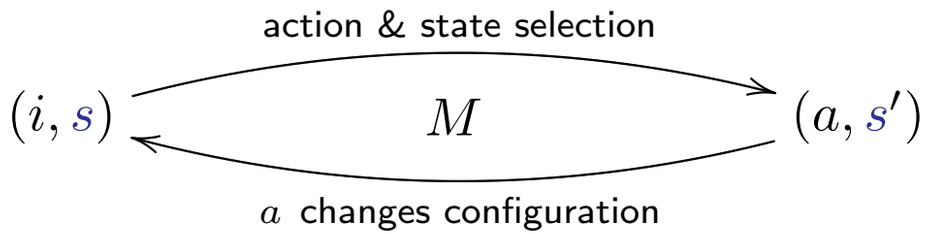


⇑		position of read/write head	Actions	
↑		potential next position of head	L	⇑ goes left
red	letter	focus of attention	R	⇑ goes right
orange	letters	potential focus of attention	W(c')	overwrite c by c'
yellow	letters	out of attention		

(terminology suggestive for sequel)

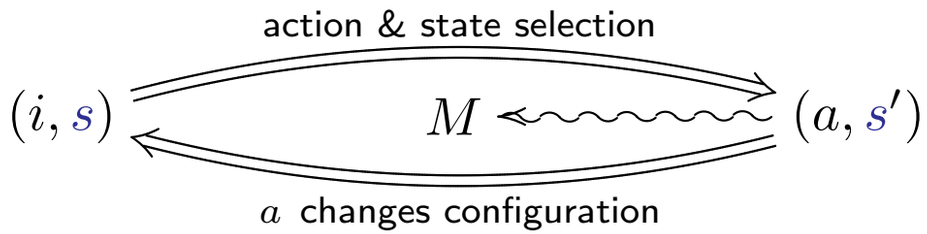
Actions modify configuration

The two phases of M combine as follows



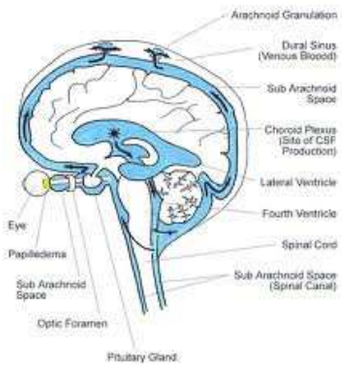
Improvements:

	machine	animal	human
memory	disc, flash	associative	Idem
	random access memory, cache	attended, pre-conscious	Idem
I/O	sensors & actuators	senses & motorcontrol	Idem
transition	via table	via neural net	Idem
states			mindfulness



Life science

Overcoming biological noise efficiently [7]



Crucial role for states (including emotions) (i, s)

Need for state-change and state-preservation:

many neuropeptides (~ 100)

volume transmission (CSF [1,4], oxytocin [5], β-endorphin [6])

Mental health

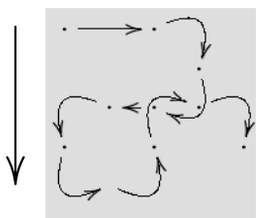
Fundamental instability of mind

`greed, hatred`

Craving for symptomatic stabilization (with side-effects!)

`mindfulness`

Decreasing frequency of addictive states by



`dynamical system view`

$\rightarrow$ sensory restriction

$\rightarrow$ mental restriction: attention on present input

$\rightarrow$ concentration: attention and preconscious coincide

$\rightarrow$ reflection: taking distance from states (emotions)

$\rightarrow$ observing vicious circle: deautomatization

Discreteness

attentional blink
psychological refractory period
memory search retrieval
thalamo-cortical pulse
phenomenology

Future research: how do some processes within processes take place?

Forms of consciousness

core-conscious
pre-conscious
un-conscious ('subliminal conscious')

Operational definitions given in [3]

States

Mathematical necessity

Determining cognition and behaviour

[1] Agnati, Fuxe. Volume transmission as a key feature of information handling in the central nervous system possible new interpretative value of the Turing's B-type machine. *Prog Brain Res*, 125, 2000, 319.

[2] Barendregt, Raffone. Conscious cognition as a discrete, deterministic, and universal Turing Machine process. Alan Turing - His Work and Impact. Eds. Cooper and van Leeuwen, Elsevier, 2012.

[3] Dehaene, Changeux, Naccache, Sackur, Sergent. Conscious, preconscious, and subliminal processing: a testable taxonomy. *Trends in Cognitive Sciences*, 10(5), 2006, 204-211.

[4] Veening, Barendregt. The regulation of brain states by neuroactive substances distributed via the cerebrospinal fluid. A review *Cerebrospinal Fluid Research*. 7(1), 2010.

[5] Veening, de Jong, Barendregt. Oxytocin messages via the cerebrospinal fluid: behavioral effects; a review. *Physiology & Behavior*, 101(2), 2010, 193-210.

[6] Veening, Gerrits, Barendregt (Submitted). β-Endorphin: Effects by volume transmission via the cerebrospinal fluid; a review

[7] Zylberberg, Dehaene, Roelfsema, Sigman. The human Turing machine: a neural framework for mental programs. *Trends in Cognitive Sciences*, 2011, 15(7), 293-300.

Charles Koechlin (1867-1950) *Au loin*, Op. 20

Lidia van der Vegt — English Horn

Bart Coenen — Piano

Presentation of the Distinguished Lorentz Fellowship Award

Alexander Rinnooy Kan

Chair of the NIAS-Lorentz Advisory Board

Robert Schumann (1810-1856) *Romances 1 & 3*, Op. 94

Lidia van der Vegt — Oboe

Bart Coenen — Piano