NUS National University of Singapore

School of Computing

Computability and Efficiency

(Questions about Computability)

Video 6.5a

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Learn CT & Develop ITeMS

Fundamental Questions in CS…

In CS, we are interested in solving problems, especially with the help of computing devices.

Nature of problems & computation

- What is computation?
- Given any problem *P*, is *P* computable?

Can we design an algorithm to solve problem P in a systematic step-by-step manner and in a finite number of steps?


Computing is Everywhere!

Cool Things in Computing (in the last *few* years, as of 2008/9)

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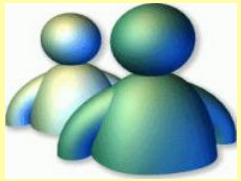
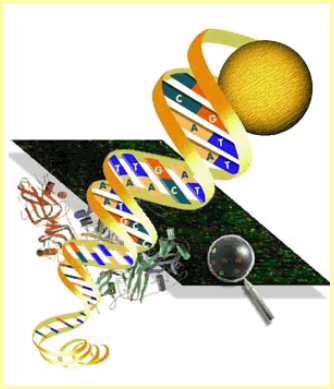
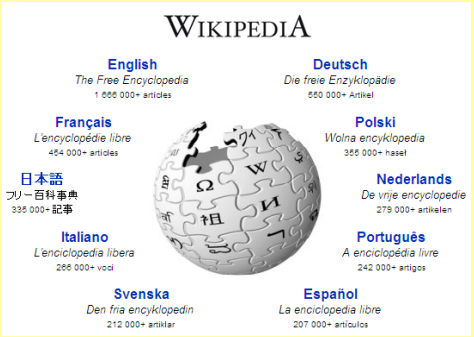
Note to self:
Needs update.







National Grid
NG
SINGAPORE

Cool Things done with CT

(*in the recent few years,* as of 2008/9)

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Note to self:
Needs update.

- Google, Yahoo, Excite
- VOIP, Skype,
- ebay, Amazon, Dell,
- World of Warcraft, neopets,
- MSN, QQ, Yahoo-Groups, Facebook, Twitter, Weibo,…
- Blogging, YouTube, Youku, Flicker,…
- Linux, Open Source Movement, Grid Computing,
- GoogleMap, Mapquest, GoogleEarth

Computing is everywhere…

CT and algorithms have automated many tasks that *used to be* done by human because they require human intelligence

- like storing and searching for information,
- tracking books in libraries,
- purchasing air tickets,
- ordering/delivery of food and goods,
- running manufacturing pipelines in factories

Computing is everywhere…

- Pokemon Go, Amazon Go,
- Whatsapp, WeChat, Line, Telegram,
- Facebook, Instagram, Twitter,
- Deepblue, Watson, AlphaGo, Wolfram Alpha,
- And data analytics, deep learning…

So, is everything computable?

After seeing all these wonderful things that are automated with algorithms, and all the apps and e-services that make our lives *more efficient* and *convenient*…

… we may be tempted to think, surely that…

Everything is Computable!

So, is everything computable?

Maybe, Everything is Computable!

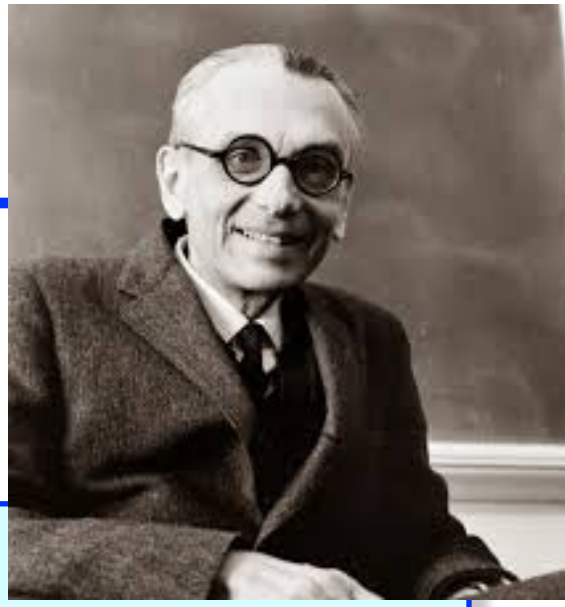
Maybe, it's just a matter of time before we find good algorithms for computing and automating everything! We just need to get smarter with our algorithms.

That's all.

Computability

Is Everything Computable?

Is Everything Computable?



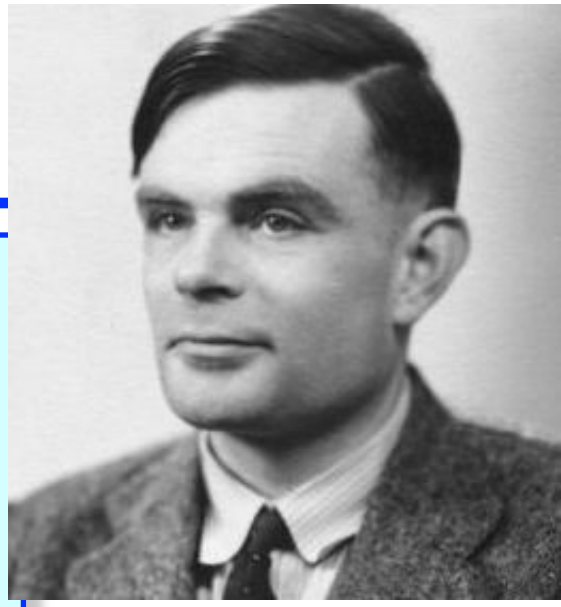
Kurt Godel, in 1931, dashed the dream, (*indirectly*).

Theorem 1: (Godel, 1931)
There are always some mathematical truths in any mathematical system of sufficient complexity, that cannot be proved to be true within the system.

Theorem 2: (Godel, 1931)
If a system can be proved to be complete using its own logic, then there will be a theorem in the system that is contradictory.

https://en.wikipedia.org/wiki/Kurt_G%C3%B6del

Computability Dream…



Alan Turing, in 1936, developed the notion of *computability*, based on a machine (now called a Turing Machine).

A problem is *computable* if it can be computed on a Turing machine.

Theorem: (Turing, 1936)

There are problems that are not computable.

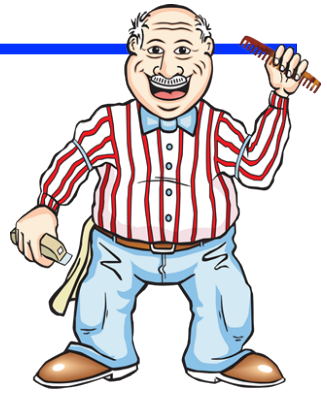
https://en.wikipedia.org/wiki/Alan_Turing

The Story of Barber Q

Barber Q

Story of Village Barber Q

In a village, there is a barber Q, who made a decree that goes like this…



Barber Q

"I will cut the hair of anyone in village V who does not cut his/her own hair, and no one else."

(decree-Q)

Story of Village Barber Q (2)

"I will cut the hair of anyone in village V who does not cut his/her own hair, and no one else." **(decree-Q)**

We don't cut our own hair

I will cut your hair.

Peter, Tom, and Betty

Barber Q

Story of Village Barber Q (3)

"I will cut the hair of anyone in village V who does not cut his/her own hair, and no one else." **(decree-Q)**

Aaron and James

Barber Q

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Story of Village Barber Q (4)

"I will cut the hair of anyone in village V who does not cut his/her own hair, and no one else." **(decree-Q)**

Wow, my hair is getting long…

Barber Q

Just as he started to cut his own hair, **he had to stop himself**.

WHY? ('cos of decree-Q)

Story of Village Barber Q (5)

"I will cut the hair of anyone in village V who does not cut his/her own hair, and no one else." **(decree-Q)**

Then, **by decree-Q**, I must cut my hair.

No. I cannot cut my own hair.

1. I cannot cut my hair.
2. I must cut my hair.

This is so contradictory!

HELP!

Barber Q

Story of Village Barber Q (6)

"I will cut the hair of anyone in village V who does not cut his/her own hair, and no one else." **(decree-Q)**

This is called the Village Barber Paradox.

This paradox uses "*self-referencing*".

(decree-Q), made by Q, applies to *everyone* in the village; including to barber Q himself.

Barber Q

(End of video 6.5a)

If you want to contact me,

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