

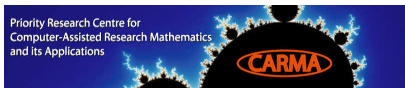
Computation in a Connected World

Dr Judy-anne Osborn

Tuesday 14 November 2017
EDGY Event, ICT337



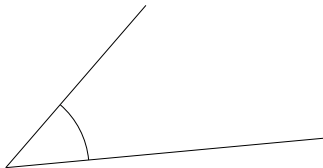
Priority Research Centre for
Computer-Assisted Research Mathematics
and its Applications



- ▶ **Tools change** the way we think: re problems, solutions and **us**
- ▶ Digital computation is changing the wide world, and
- ▶ Changing research

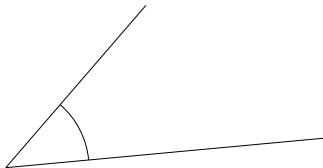
Tools influence how we think

Can I cut this angle in equal halves?



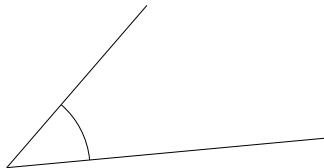
Tools influence how we think

Can I cut this angle in equal halves? **Yes!**



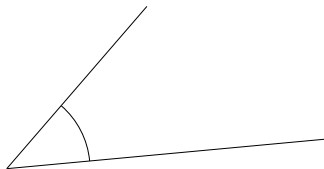
Tools influence how we think

Can I cut this angle in equal thirds?



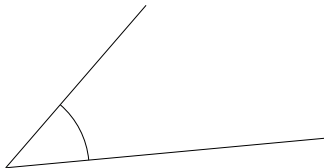
Tools influence how we think

Can I cut this angle in equal thirds? **No!** (*Pierre Wantzel, 1837*)



Tools influence how we think

Can I cut this angle in equal thirds? Actually, **Yes!** (*with Origami*)



NB: angle trisection with Origami by Rachel Thomas is at:

<https://plus.maths.org/content/trisecting-angle-origami>

This article was inspired by content on our sister site [Wild Maths](#), which encourages students to explore maths beyond the classroom and designed to nurture mathematical creativity. The site is aimed at 7 to 16 year-olds, but open to all. It provides games, investigations, stories and spaces to explore, where discoveries are to be made. Some have starting points, some a big question and others offer you a free space to investigate.



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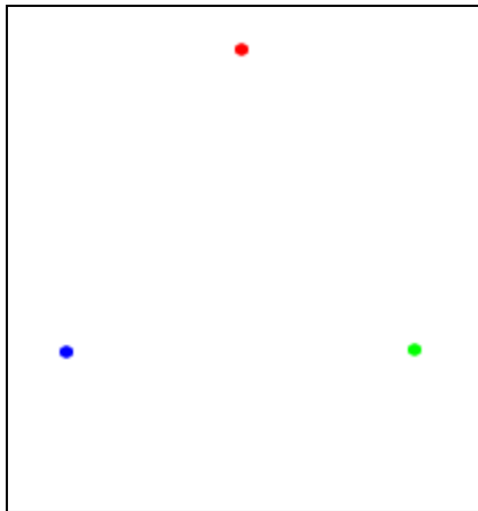
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wild@maths.org

Wild Maths is part of the family of programmes, including [NRICH](#) and [Plus](#), within the [Millennium Mathematics Project](#) at the University of Cambridge.

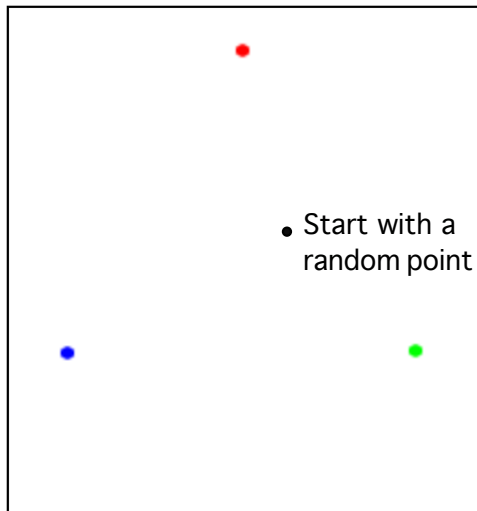
Tools influence what we can see

Eg, the Chaos Game:



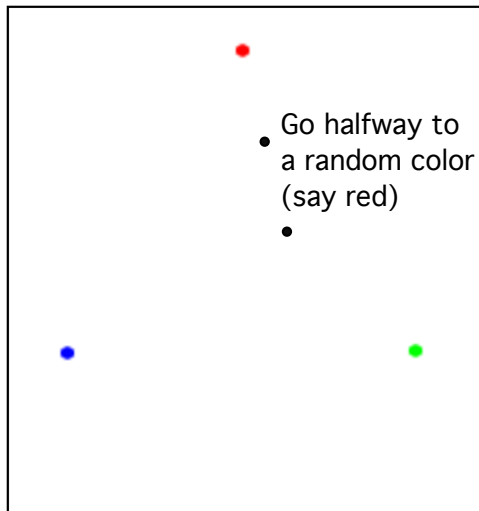
Tools influence what we can see

Eg, the Chaos Game:



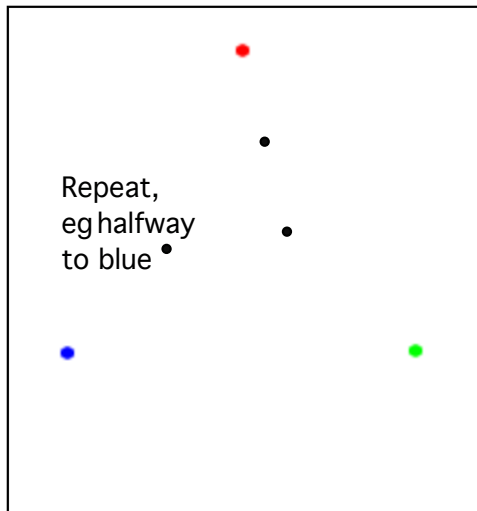
Tools influence what we can see

Eg, the Chaos Game:



Tools influence what we can see

Eg, the Chaos Game:



Tools influence what we can see

The screenshot shows a web browser window with the URL `www.shodor.org/interactivate/activities/TheChaosGame/`. The page title is "Interactivate" and the main heading is "The Chaos Game". Below the heading is a breadcrumb trail: "Shodor > Interactivate > Activities > The Chaos Game". There are four tabs: "Learner", "Activity" (selected), "Help", and "Instructor".

The main content area displays the text "Probabilities : values between 0.0 and 1.0". Below this is a central square canvas showing a fractal-like pattern of colored dots (red, green, blue) and lines. To the left of the canvas are controls for the number of dots and vertices:

- A dropdown menu showing "10 dots".
- An "Add:" button.
- A "Clear" button.
- A "Vertices" section with a "One More" button, a dropdown menu showing "3 vertices", and a "One Less" button.

To the right of the canvas is a "Probabilities" control panel with three rows, each containing a colored dot (red, green, blue) and a text input field with the value "1". Below these is a "Set Probabilities" button.

At the bottom of the interface, there is a "Go to full version" button and a "© Shodor" copyright notice.

Tools influence what we can see

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The main content area displays the text "Probabilities : values between 0.0 and 1.0". Below this is a central canvas showing a Sierpinski triangle fractal composed of red, blue, and green dots. To the left of the canvas are controls for the number of dots and vertices:

- 1000 dots
- Add:
- Clear:
- Vertices:
- One More:
- One Less:

To the right of the canvas is a "Probabilities" control panel with three input fields, each containing the value "1":

- Red:
- Green:
- Blue:

Below the input fields is a "Set Probabilities" button. At the bottom of the canvas area is a "Go to full version" button and a copyright notice "© Shodor".

Tools influence what we can see

The screenshot shows a web browser window with the URL `www.shodor.org/interactivate/activities/TheChaosGame/`. The page title is "Interactivate" and the main heading is "The Chaos Game". Below the heading is a breadcrumb trail: "Shodor > Interactivate > Activities > The Chaos Game". There are four tabs: "Learner", "Activity" (selected), "Help", and "Instructor".

The main content area displays the text "Probabilities : values between 0.0 and 1.0". Below this is a central visualization of a Sierpinski triangle, which is a fractal composed of smaller triangles. The top triangle is red, the bottom-left is blue, and the bottom-right is green. The fractal is composed of many smaller triangles, some of which are filled with the same color as their parent triangle.

On the left side, there are controls for the number of dots and vertices:

- "10000 dots :"
Add:
Clear
- Vertices:
One More
3 vertices :
One Less

On the right side, there is a "Probabilities" control panel:

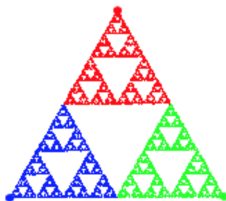
Probabilities	
●	<input type="text" value="1"/>
●	<input type="text" value="1"/>
●	<input type="text" value="1"/>

Below the probabilities panel is a "Set Probabilities" button.

At the bottom of the main content area, there is a "Go to full version" link and a "© Shodor" copyright notice.

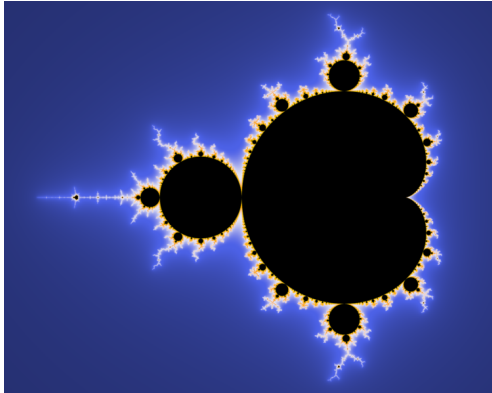
Tools influence what we can see

We can see the Sierpinski Triangle emerge from the Chaos Game because computers can do about 1000 000 000 things per second.



We can now see things we could never see before

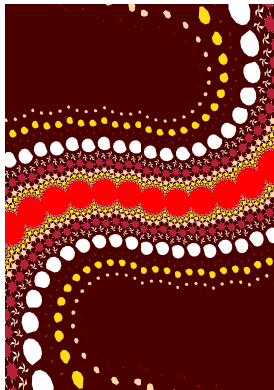
Eg, the Mandelbrot Set



Comes from iterating $z_{n+1} = z_n^2 + c \dots$

We can now see things we could never see before

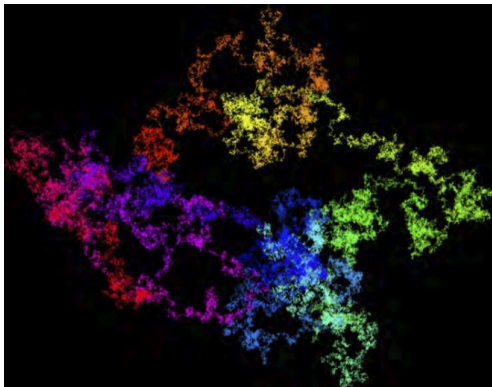
Eg, more examples of where an algorithm gets stuck or not



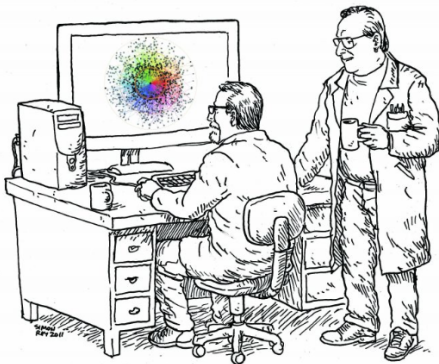
Jon Borwein, Scott Lindstrom, Anna Schneider, Brailey Sims, Matt Skerritt

We can now see things we could never see before

Eg, Pi in base 4



The digits are North, South, East and West



"Sometimes it is easier to see than to say."

What implications, for a Connected World?



What implications, for a Connected World?



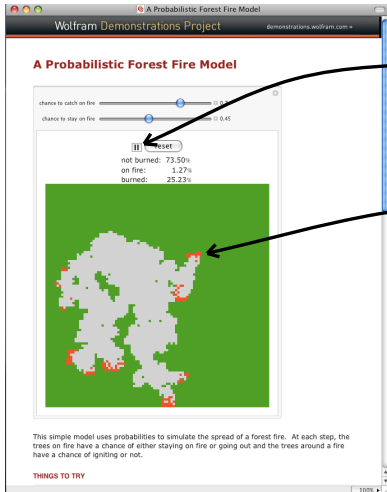
How do we get from anywhere to anywhere?

What implications, for a Connected World?



How do we get from anywhere to anywhere? Ask google maps!

Eg. "Computers" can now do: bushfire modelling



The 'forest' burns



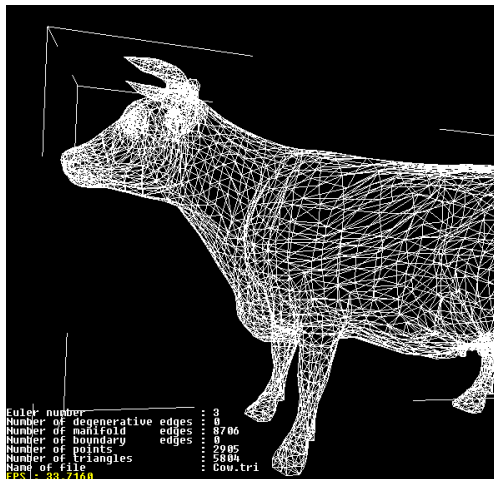
<http://demonstrations.wolfram.com/>

Eg. “Computers” can now do: predictive flood modelling



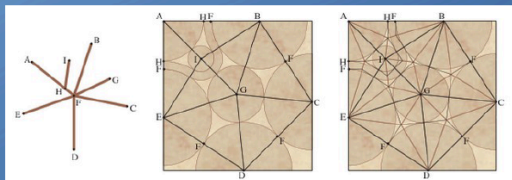
[https://www.researchgate.net/publication/309683426_ ANUGA-the_FREE_Ocean_Impact_model/figures?lo=1](https://www.researchgate.net/publication/309683426_ANUGA-the_FREE_Ocean_Impact_model/figures?lo=1)

Eg. "Computers" can now do: animation



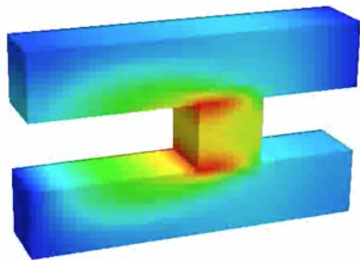
https://www.researchgate.net/publication/309683426_ANUGA-the_FREE_Ocean_Impact_model/figures?lo=1

Eg. "Computers" can now do: computational origami



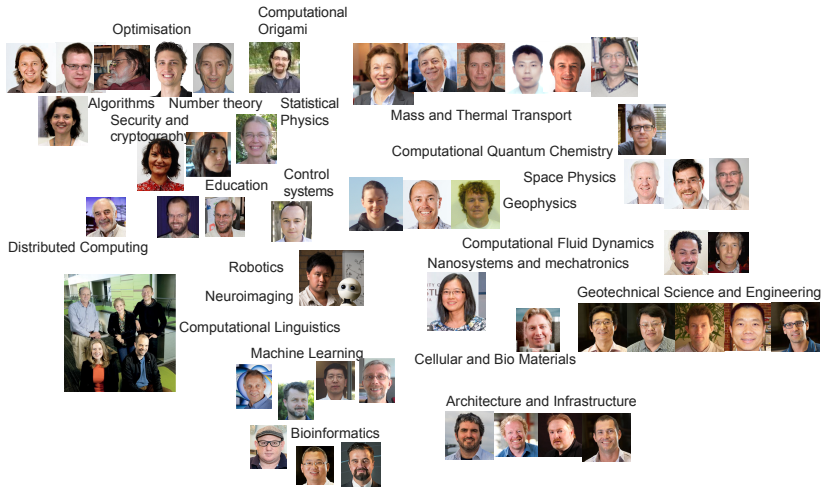
Origami Design Secrets, by Robert Lang

Eg. “Computers” can now: visualize heat from motion



From CARMA researcher Bishnu Lamichhane (finite element methods)

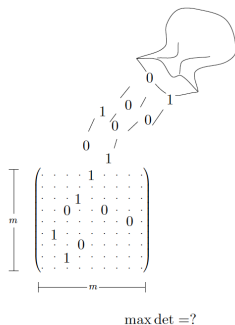
Sample: UoN Research Groups & People into Computation



A practical warning: computers still can't do everything!

Eg from my own research:

Order	max det	Time
1	1	<i>fast</i>
2	1	<i>fast</i>
3	2	<i>fast</i>
4	3	<i>fast</i>
5	5	<i>fast</i>
6	9	<i>order of days</i>
7	32	<i>order of years</i>
8	56	<i>order of the age of the Universe</i>



A moral warning (why we need computational education)

Cathy O'Neil's book "Weapons of Math Destruction" describes Mathematical Algorithms (hidden in code) that cause

- ▶ global financial instability
- ▶ inequitable access to college
- ▶ unfair discrimination in the criminal justice system
- ▶ unfair discrimination in access to health insurance
- ▶ unfair discrimination in access to employment
- ▶ social media filter bubbles possibly undermining democracy

Back on the bright side



Some quotes about computation from CARMA members

I use computation a lot in my research. Usually it suggests conjectures which might later turn into theorems. Also, I find that I make a lot of mistakes which are picked up by a computer as computer programs are rather unforgiving of mistakes or imprecision in definitions.

Professor Richard Brent

Current and expected advances in mathematical computation and scientific visualization make it now possible to do (teach, learn) mathematics in many varied and flexible ways.

the late Professor Jonathan Borwein

Some quotes about computation from CARMA members

Working on problems gives [students] the opportunity to engage in genuine mathematical activity. This can be challenging, engaging, creative and immensely rewarding.

The use of GAUSSian [Computational] tools can greatly assist in working and thinking mathematically.

Dr Malcolm Roberts

Questions?