Theoretical computer science

with Dr Clément Canonne

Talking *points*

Knowledge & Comprehension

1. What is theoretical computer science?
2. What do you think is meant by 'future-proofing'?
3. What are the differences between privacy and anonymity?
4. How does differential privacy (DP) work?

Application

5. Which of the following do you think are the most, and least, likely to use DP? Rank them and explain your reasoning:
   - Social media platforms
   - Banks
   - Hospitals/healthcare systems
   - Government data (such as census records)
   - Shopping sites
   - Dating apps

Analysis

6. Why can it be challenging to theoretically test data privacy measures? And how does DP engage with this challenge?

Evaluation

7. Clément is interested in examining how to build public trust in data privacy. How do you think the relationship between public perception and data privacy has changed in recent years? How do you predict it might change in the future?
8. Think about how computing has changed in recent decades, and how it is predicted to develop in the future (e.g., artificial intelligence, quantum computing). What sorts of questions do you think theoretical computer scientists will tackle in the future?

Activity

Here is a version of Einstein's riddle for you to solve, to demonstrate how accurate conclusions about individuals can be derived from seemingly anonymous information.

This is the scenario:

- There are four houses in a row, numbered 1 to 4, left to right.
- The houses are four different colours: black, blue, red and white.
- The houses are each inhabited by one person, whose names are: Bruce, Fatiha, Hannah and Sean.
- Each person has a different favourite animal: butterflies, dolphins, horses and turtles.
- Each person uses a different bank: Banko, BestBank, BigSaver and BigSpender.

And here is some publicly available information – the 'outputs' of a survey:

- Fatiha lives in the first house.
- The second house is painted black.
- There are two houses between the person who banks with Banko and the person who banks with BestBank.
- There is one house between Sean's house and the person who banks with BigSaver (who is to the left).
- There is one house between the person who likes horses and the red house (which is to the right).
- Bruce lives directly to the left of the person who likes turtles.
- There are two houses between the person who likes horses and the person who likes butterflies (who is to the right).
- The person who banks with Banko lives somewhere to the right of the person who banks with BigSpender.
- There is one house between the person who banks with BigSaver and the white house (which is to the right).

Use the outputs above, together with logic and deduction, to fill in the table on the next page. (The answers are on the next page but give the riddle a go before looking!)

Use the grid at the top of the next page to make deductions. For instance, the first 'output' above tells you that Fatiha lives in House 1. So, you can fill in the cell where the column labelled Fatiha on the top axis meets the row labelled House 1 on the side axis. This also tells you that Fatiha does not live in any other house and that nobody else lives in House 1, so you can put an 'X' in each corresponding square.

Reflection:

This exercise shows that, even though the data did not directly tell you information like who banks with which bank, it can be deduced. Following on from this exercise, think about:

- How could the addition of 'random noise' make deduction impossible in the exercise above? What would this 'random noise' look like?
- How could this 'noise' still allow for the overall outputs about the data to remain the same – and still remain the same if one of the individuals was removed? (Is this possible to simulate within this puzzle?)

	Banko	BestBank	BigSaver	BigSpender	Butterflies	Dolphins	Horses	Turtles	Bruce	Fatiha	Hannah	Sean	Black	Blue	Red	White
House 1																
House 2																
House 3																
House 4																
Black																
Blue																
Red																
White																
Bruce																
Fatiha																
Hannah																
Sean																
Butterflies																
Dolphins																
Horses																
Turtles																

	House 1	House 2	House 3	House 4
Colour				
Name				
Animal				
Bank				

Photo *montage*

Above: *Data privacy aims to control and protect how personal information is collected and used by others.*
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Left: *Dr Clément Canonne says building strong skills in mathematics and physics is fundamental to theoretical computer science.*
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Answers
House 1: Blue, Fatiha, Horses, BestBank;
House 2: Black, Bruce, Dolphins, BigSaver;
House 3: Red, Hannah, Turtles, BigSpender;
House 4: White, Sean, Butterflies, Banko