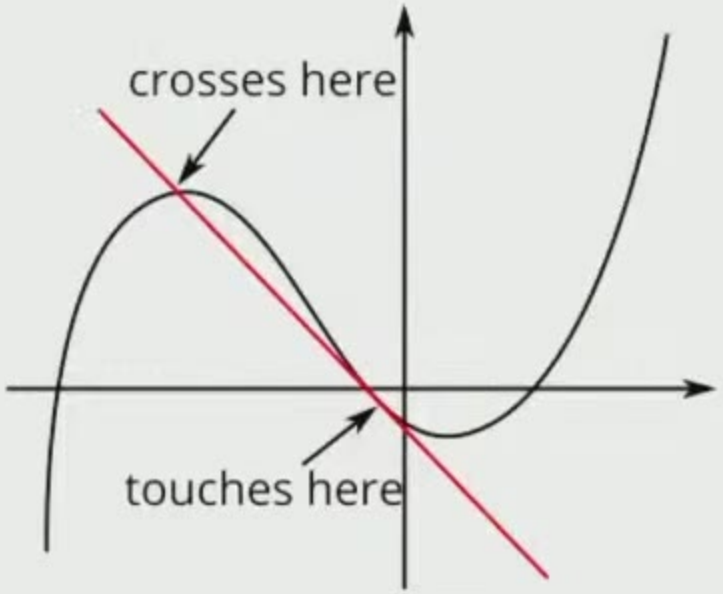
Touching Points of Cryptography and AI



Moti Yung

AI and Cryptography ????

- Crypto is theory-oriented, precise, clean notions of security, have Proofs which explain security of primitives, etc. (...then comes the messy implementations)...
- AI: practice oriented, approximation, computing that has no exact explanation but it works well…

So, what do they have in common???????

I will argue: It's not a "Match Made in Heaven" But "it's not Hell" either to find connections!

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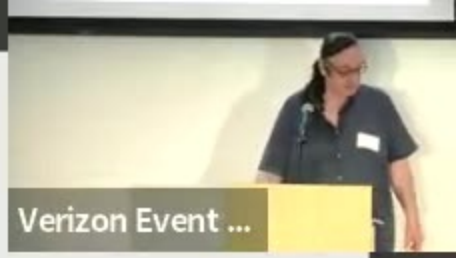
Talk about AI and Cryptography ????

- In [Crypto 23] Scott Aaronson gave a talk about Cryptography and AI, claiming he is an expert in neither…

- Why now? AI is in the process of development where due to investment in algorithms, storage, hw, and other computing resources, it is solving problems that are meaningful…

- Like any technology, it needs protection, & protection of various sorts needs cryptography!
- AI works very well [we don't always know why]-- until attacks start!



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I will cover some points of interest in the intersection of AI and Cryptography

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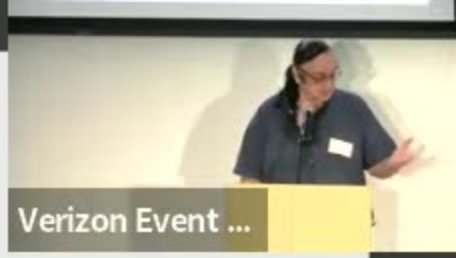

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01
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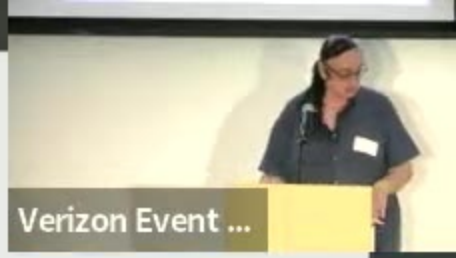

AI and Crypto: First Touching Point
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- Pragmatic View of early Machine Intelligence: The Turing Test (leave philosophy aside and let us be pragmatic!!)
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- Philosophical foundations: Theory of the Human Mind: is the brain a computer?
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- Goals: Let computing Systems Think like humans, Act like humans, be rational (already some contradiction here!)
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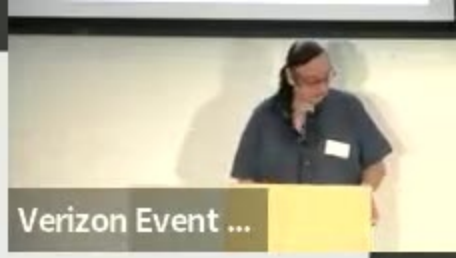

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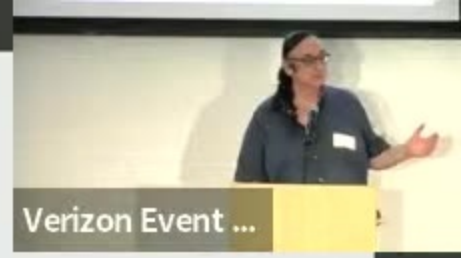

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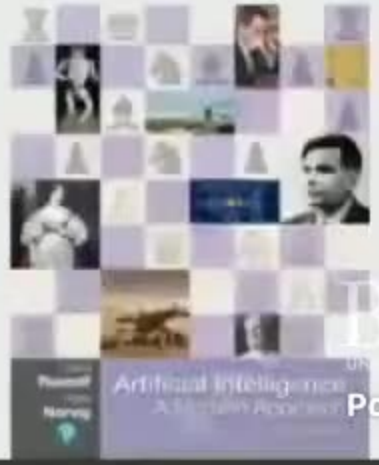

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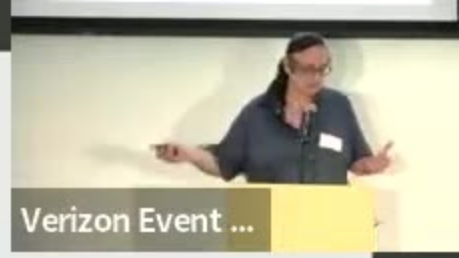

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02

Modern AI and Cryptography
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Berkeley
UNIVERSITY OF CALIFORNIA

02

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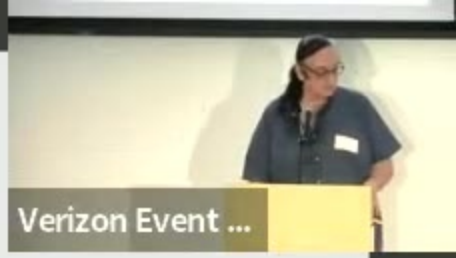

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- In General people talk about:
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- Blackbox probing of a model→ learning a model (resembles cryptanalysis or learning a cipher from probes) [Crypto'20: Carlini, Jagielski, and Mironov; Eurocrypt'24: Shamir et al.].

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Federated Learning and variants

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Touching Point 8

- Using AI/ML in Cryptanalysis in general (Thanks to Elie Bursztein for this part)

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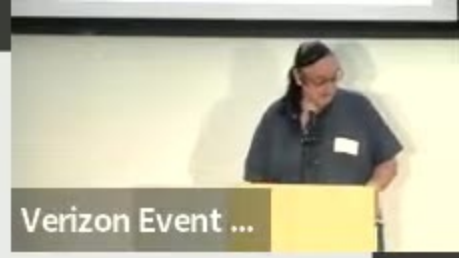
Touching Point 9

- Using Cryptographic Protections to modify models and attacks on data
- The case of Reliable AI.
  - Attacks on Data are very strong, attacker can do everything to inputs…
  - What if data manipulation is limited:
  - Sources **sign the data items**? One cannot add data only drop some….

- **Deniz Koyuncu, Alex Gittens, Bülent Yener, Moti Yung**:

Deception by Omission: Using Adversarial Missingness to Poison Causal Structure Learning. KDD 2023

The work shows that learning a causal structure (DAG of causal dependencies) can be attacked with targeted non-random missingness only (i.e. even when data is signed by reliable source)!



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This is a current challenge. What a solution can attempt to do using AI and Cryptography??

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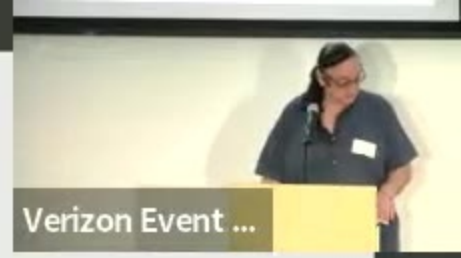

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What can Cryptographic methods add to AI understanding/ Theory of AI?

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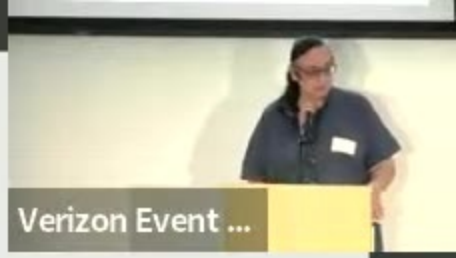
What can Cryptographic methods add to AI understanding/ Theory of AI?

FOCS 22: Shafi Goldwasser, Michael P. Kim, Vinod Vaikuntanathan, Or Zamir:
Planting Undetectable Backdoors in Machine Learning Models.

- Planting Backdoor by a server learning a model (assuming digital signature scheme)
- Indistinguishability between backdoored model and clean model under cryptographic assumption.

So: Cryptographic computational complexity assumptions tell us something about modeling malicious errors!

Touching Point 12: a non technical one



What are the societal impact & implications of AI and Cryptography?

- Cryptography makes remote interactions safe and automates transactions (e.g., cryptocurrency replacing physical payments)
- AI makes human-like missions automated (e.g., recommendation systems automate planning of daily life).

So: Together and in combination, how life/ work/ society/ is going to evolve as traditional face to face human transactions and traditional human experts are being misplaced?

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Conclusions

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So… I hope I convinced you…

- Many ways for AI and Cryptography to touch each other.
- I just chose some points I worked on/ heard about/ like/ think about in general/ and still do not know much about.
- Some problems are heavily investigated, some other important ones are ignored.
- The notion of touching points is open ended, and I am sure this is not an exhaustive list (AI is in a fast path of change).
- The field connecting AI and Crypto is young (embryonic, in fact): Find your own new point! I think it is fascinating!
- Noted: it does not matter what sub-field of cryptography one works in, AI will touch or be touched by it!

So:

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Session II: Decentralized AI, Cryptography & Confidential Compute

Decentralized Confidential AI: Federated Learning with Confidential Computing

Chester Chen
Senior Manager
Nvidia

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