The Bright Future of Verification Slop

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Background

- Co-lead WebAssembly's W3C standards body
- Lead work on WebAssembly's concurrency model and threading extensions
- Mechanising WebAssembly semantics
- Mainly a hopeful consumer of AI
  - My student, Qiyuan Xu, actively works on neural theorem proving - is presenting later

Background

- Historical assumption: it’s generally more effortful to produce intellectual material than it is to consume it

- If someone has taken the time to produce a serious piece of writing, or mathematical artefact, we get to take some intellectual shortcut by understanding what they’ve done

Background

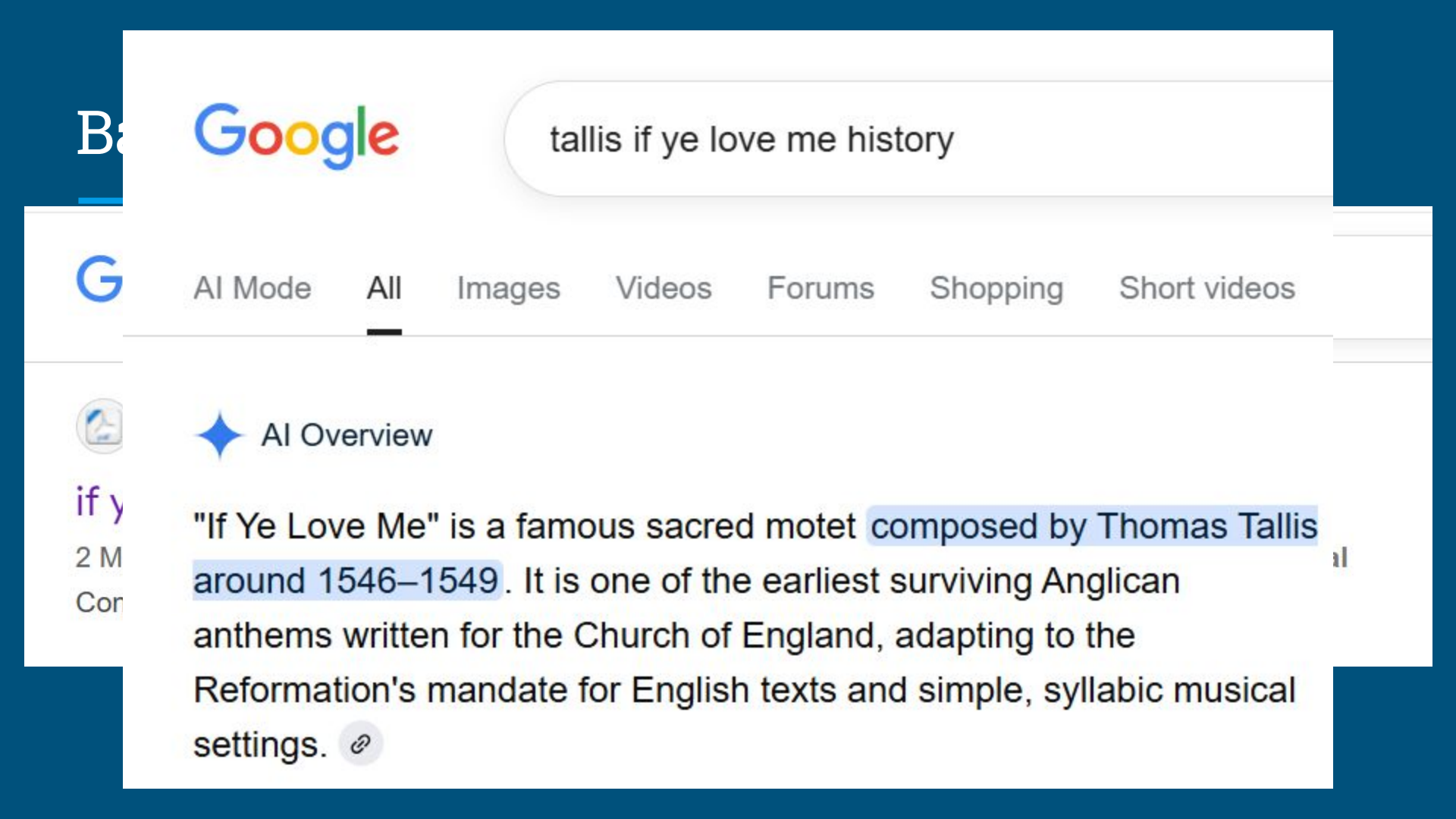
- “When we read, another person thinks for us: we merely repeat their mental process.” - Arthur Schopenhaur
- “The reading of all good books is like conversation with the finest minds of past centuries.” - René Descartes
- “A proof becomes a proof after the social act of “accepting it as a proof”. This is true of mathematics as it is of physics, linguistics, and biology.” - Yuri Manin

Background

- AI breaks the “attention economy”
- Most AI-generated material is not that great
- Just by existing, it undermines our willingness to speculatively engage with unknown material
- If it becomes competitive in the future, we won’t have the bandwidth to consume all the outputs!

Background

- It's rude to show AI output to people - Alex Martsinovich (https://distantprovince.by/posts/its-rude-to-show-ai-output-to-people/)
- A sufficiently detailed spec is code - Gabriella Gonzalez (https://haskellforall.com/2026/03/a-sufficiently-detailed-spec-is-code)
- Terence Tao (https://mathstodon.xyz/@tao/116438113755055391)
  - “we are now entering an era where generative cognitive tasks, such as finding a proof to a given problem, are becoming cheap and relatively plentiful”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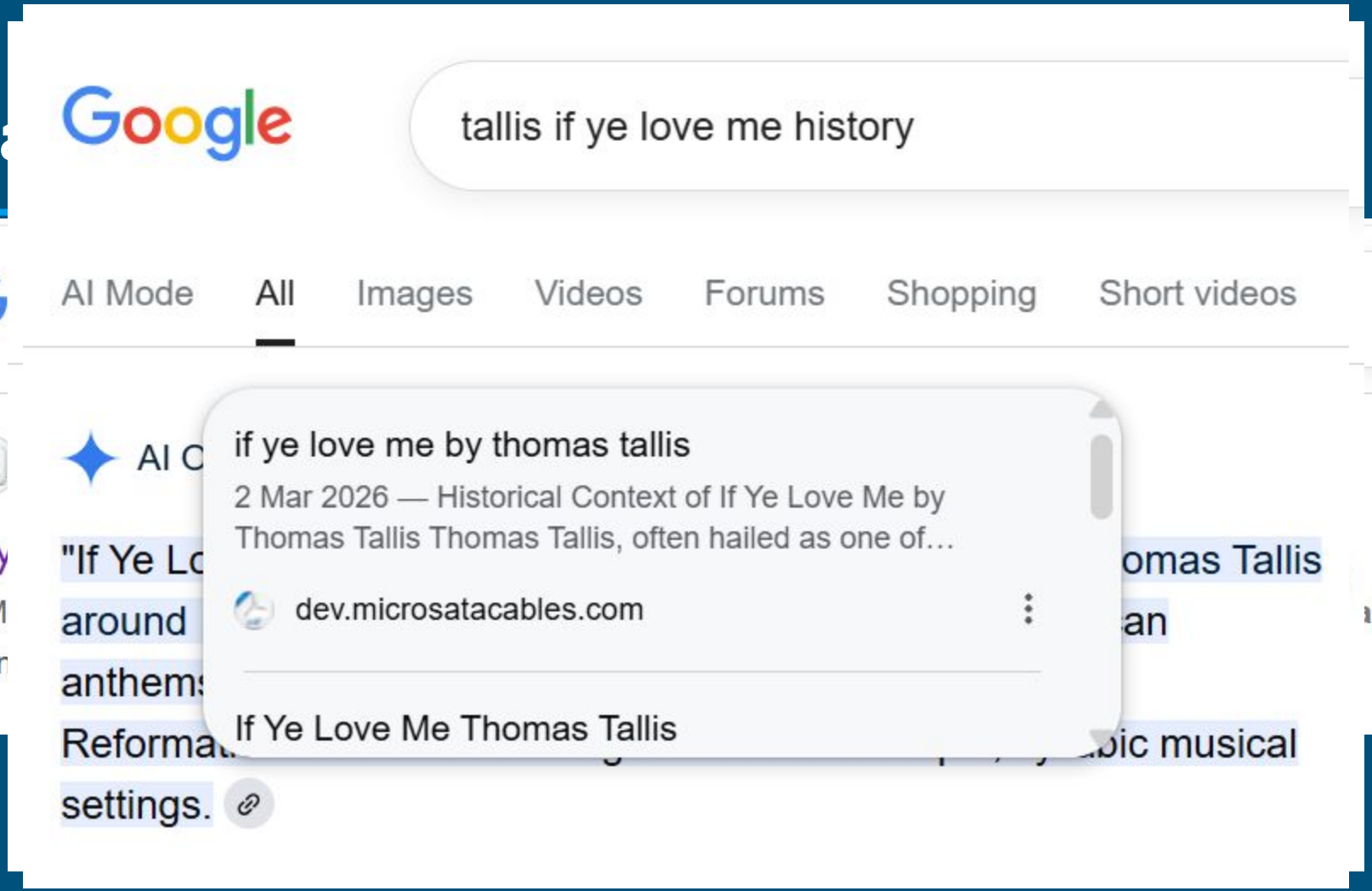
AI Overview
"If Ye Love Me" is a famous sacred motet composed by Thomas Tallis around 1546–1549. It is one of the earliest surviving Anglican anthems written for the Church of England, adapting to the Reformation's mandate for English texts and simple, syllabic musical settings.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Background

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Background

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Background

- What would be the equivalent for verification?
  - A supremely confident prose description of the project
  - Too many pages for anyone to bother checking
  - A plausible but incorrect/vacuous model/proof

My hot take

- Formal verification is particularly trustworthy because it’s relatively unpopular and economically shaky
- Only passionate expert true believers take on big verification projects
- When you see a big model and proof, several very smart people poured their hearts and souls into making it exist

Prior art

- A few years ago it started getting very lucrative to lend verification muscle to cryptocurrency projects
- These projects generally struggle with trustworthiness
- The formal verification community supplies trust and gets money in return

Prior art


CoinCoin’s correctness
proudly certified by
Academic Verification
Startup #425

Blockchain verification means what?

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  OR
- The smart contracts behind the core protocols are proven not to hit certain language-level errors like stack underflow or out-of-bounds
  OR
- The smart contracts are proven to implement some abstract state machine, which isn't scrutinised too closely
  OR
- Exactly the right correctness properties are identified and proven, considering sensible tradeoffs and project requirements.

Sifting

- In a world where intellectual material is produced carelessly and in great quantity, how do we decide what to read?

- My bet - we will have to double down on more traditional “social” networks
  - Word-of-mouth from colleagues
  - Tweets from famous academics
  - Top conference acceptances

- This is basically how I approached the blockchain verification boom

Our responsibility

- We are the experts - how do we decide what to recommend?
- How do we produce the kind of work that other experts can recommend?
- The bar for “worthy of attention” is going to be raised
  - Because big works will genuinely get easier to produce
  - Because plausible-looking but flawed formalisations will become common

Intelligibility of top-level properties

- We like to do proofs by refinement/simulation. But often the relations are complicated, and the abstract semantics isn’t clearly intelligible
- Here’s where I can start criticising myself

WasmRef-Isabelle

- A monadic interpreter for WebAssembly built on Imperative HOL
- Fast enough to be used as a large-scale fuzzing oracle
- Deployed in the infrastructure of Wasmtime, one of the most widely-used WebAssembly implementations
- Correctness is formally verified!

WasmRef-Isabelle

RESEARCH-ARTICLE | OPEN ACCESS |

WasmRef-Isabelle: A Verified Monadic Interpreter and Industrial Fuzzing Oracle for WebAssembly

Authors: Conrad Watt, Maja Trela, Peter Lammich, Florian Märkl | Authors Info & Claims

Proceedings of the ACM on Programming Languages, Volume 7, Issue PLDI • Article No.: 110, Pages 100 - 123
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Check for updates

Related Artifact: Supplementary material for WasmRef-Isabelle • June 2023 • software • https://doi.org/10.5281/zenodo.7815663

Intelligibility of top-level properties

theorem run_iter_m_sound:
shows "{ cfg_m_assn *cfg* *cfg_m* }
run_iter_m *fuel* *cfg_m*
$\left\{ \lambda(cfg\_m', res).\ \exists cfg'.\ \begin{array}{l} \text{cfg\_m\_assn } cfg'\ cfg\_m' \ * \\ \text{computes\_to } cfg\ (cfg', res) \end{array} \right\}$"

Fig. 11. Hoare triples involved in the monadic interpreter's proof of partial correctness.

Intelligibility of top-level properties

- Need to believe in
    - our Hoare logic (a partial bespoke library drawn from Peter Lammich's Sepref infrastructure)
    - The use of the intermediate cfg representation and the fidelity of the translation function
    - The meaning of the computes-to relation

$$\text{computes\_to } cfg\ (cfg', res) \triangleq \left(\begin{array}{l} res = \text{RValue } v^* \wedge \\ \exists S'\ F'\ v^*.\ [\![cfg]\!]([]) \hookrightarrow^* [\![cfg']\!]([]) \wedge \\ [\![cfg']\!]([]) = (S'; F'; (\text{rev}(v^*)) \end{array}\right) \vee \left(\begin{array}{l} res = \text{RTrap } str \wedge \\ \exists str\ S'\ F'\ e'^*.\ [\![cfg]\!]([]) \hookrightarrow^* (S'; F'; [\textbf{trap}]) \wedge \\ [\![cfg']\!]([\textbf{trap}]) = (S'; F'; e'^*) \end{array}\right) \vee (\exists str.\ res = \text{RCrash } str)$$

theorem run_iter_sound:
assumes "run_iter *fuel cfg* = (*cfg'*, *res*)"
shows "computes_to *cfg* (*cfg'*, *res*)"

Fig. 8. Soundness of the intermediate interpreter's top level iteration.

$$
\begin{aligned}
[\![\text{Redex } v^*_{ctx}\ e^*_{ctx}\ ]\!](e^*) &\triangleq (\text{rev } v^*_{ctx})\ e^*\ e^*_{ctx} \\
[\![\text{Label\_ctx } v^*_{ctx}\ e^*_{ctx}\ n\ e^*_{cont}]\!](e^*) &\triangleq (\text{rev } v^*_{ctx})\ (\textbf{label}\ n\ e^*_{cont}\ e^*)\ e^*_{ctx} \\
[\![\ lc \cdot lc^*\ ]\!](e^*) &\triangleq [\![\ lc^*\ ]\!]([\![\ lc\ ]\!](e^*)) \\
[\![\ [\,]\ ]\!](e^*) &\triangleq e^* \\
[\![\text{Frame\_ctx } rdx\ lc^*\ n\ F]\!](e^*) &\triangleq \textbf{frame}\ n\ F\ ([\![\ lc^*\ ]\!]([\![\ rdx\ ]\!](e^*))) \\
[\![\text{Config } S\ fc\ (fc' \cdot fc'^*)]\!](e^*) &\triangleq [\![\text{Config } S\ fc'\ fc'^*]\!]([\![fc]\!](e^*)) \\
[\![\text{Config } S\ (\text{Frame\_ctx } rdx\ lc^*\ n\ F)\ ([\,])]\!](e^*) &\triangleq (S; F; ([\![\ lc^*\ ]\!]([\![\ rdx\ ]\!](e^*))))
\end{aligned}
$$

Fig. 6. Intermediate interpreter definitions, along with a recursively-defined relation back to the configurations of the operational semantics.

In a world of slop proof

- I probably don’t have the bandwidth to work out whether a bespoke separation logic / state reification / abstract machine is sensible or not (especially if it’s partially AI generated)

- I’d expect to see a consolidation around trustworthy standardised verification frameworks
  - Amazon is making big moves in this space with AutoCorrode

In a world of slop proof

- I’d expect to see a consolidation around a small number trustworthy standardised verification frameworks
  - Amazon is making big moves in this space with AutoCorrode

- Standardised
  - logic
  - models of computation
  - state abstractions

Industrial reaction to WasmRef-Isabelle

- Generally very positive!
- I massively benefitted from my visibility doing work on the practical side of Wasm
- I wouldn’t risk my reputation in the Wasm community pushing anything flawed

Reputation

- As I was preparing this talk, ArXiv announced they have plans to ban (for 1 year, followed by indefinite enhanced checks) anyone found submitting hallucinated references or AI prompt artefacts.

- My hot take - there needs to be a reputational cost associated with irresponsible AI use - this is broadly a good thing.

Top-level hot takes

- Reading an AI-generated proof is quite likely to feel like an insult to your time - this will bleed into attitudes towards “human” proofs

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- We will need more standardised verification abstractions that reduce distrust, although this may stifle innovation
- Social connection and endorsement will (unfortunately?) become even more important

Top-level hot takes

- If we can pull off powerful AI automation within a standard verification framework (AutoCorrode?), there will be an explosion of technically excellent projects

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Top-level hot takes

- If we can pull off powerful AI automation within a standard verification framework (AutoCorrode?), there will be an explosion of technically excellent projects
- No matter how hard we fight to keep standards high, more proofs produced with less understanding will probably tarnish the reputation of our field for trustworthiness
- This may be a good trade if verification becomes much more widely used