Could AI Ever Match Gödel's Greatness?

(Part II of the Chapter; Part I is on "The Gödel Game," for IFLAI2)

Selmer Bringsjord

IFLAI2 2022

12/8/22

ver 1208221130NY

Selmer.Bringsjord@gmail.com

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Monographic Context
(yet again!)

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Gödel's Great Theorems (OUP)

by Selmer Bringsjord

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- Brief Preliminaries (e.g. the propositional calculus & FOL)
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Re Gödel's "God Theorem" …

Recommended Podcast :)

https://mindmatters.ai/podcast/ep81

The Ontological/Modal Argument Meets AI

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Gödel's version of Gödel falsified!

Anselm

Descartes

Leibniz

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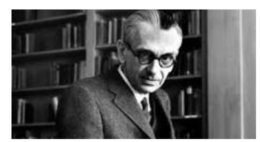
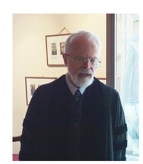
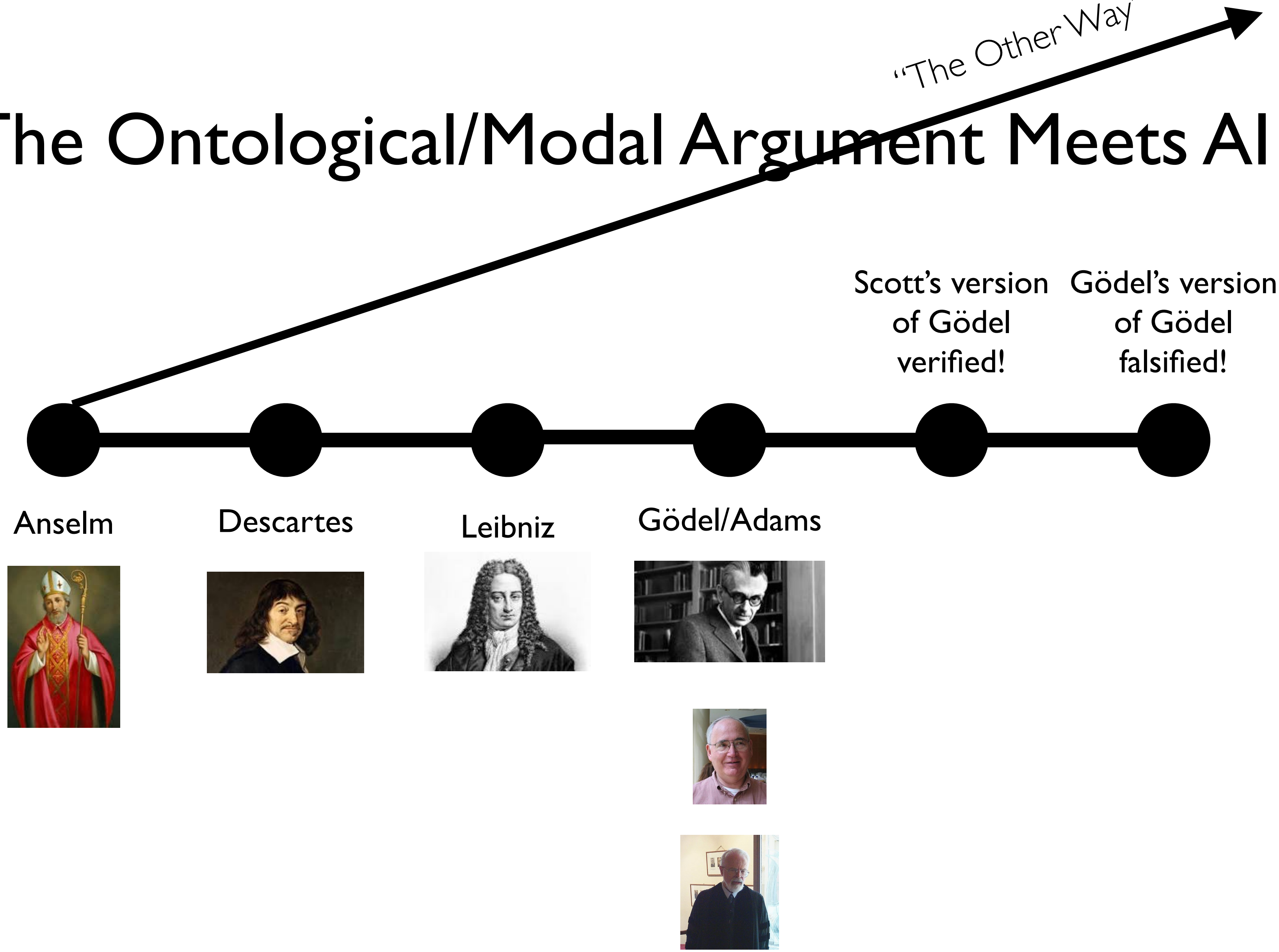




The Ontological/Modal Argument Meets AI



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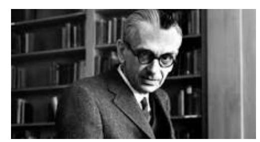

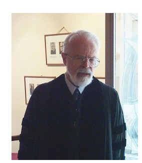

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Automating Gödel's Ontological Proof of God's Existence with Higher-order Automated Theorem Provers

Christoph Benzmüller[1] and **Bruno Woltzenlogel Paleo**[2]

Abstract. Kurt Gödel's ontological argument for God's existence has been formalized and automated on a computer with higher-order automated theorem provers. From Gödel's premises, the computer proved: necessarily, there exists God. On the other hand, the theorem provers have also confirmed prominent criticism on Gödel's ontological argument, and they found some new results about it.

The background theory of the work presented here offers a novel perspective towards a *computational theoretical philosophy*.

1 INTRODUCTION

Kurt Gödel proposed an argumentation formalism to prove the existence of God [23, 30]. Attempts to prove the existence (or non-existence) of God by means of abstract, ontological arguments are an old tradition in western philosophy. Before Gödel, several prominent philosophers, including St. Anselm of Canterbury, Descartes and Leibniz, have presented similar arguments. Moreover, there is an impressive body of recent and ongoing work (cf. [31, 19, 18] and the references therein). Ontological arguments, for or against the existence of God, illustrate well an essential aspect of metaphysics: some (necessary) facts for our existing world are deduced by purely a priori, analytical means from some abstract definitions and axioms.

What motivated Gödel as a logician was the question, whether it

A1	Either a property or its negation is positive, but not both: $\forall\phi[P(\neg\phi) \equiv \neg P(\phi)]$
A2	A property necessarily implied by a positive property is positive: $\forall\phi\forall\psi[(P(\phi) \wedge \Box\forall x[\phi(x) \supset \psi(x)]) \supset P(\psi)]$
T1	Positive properties are possibly exemplified: $\forall\phi[P(\phi) \supset \Diamond\exists x\phi(x)]$
D1	A *God-like* being possesses all positive properties: $G(x) \equiv \forall\phi[P(\phi) \supset \phi(x)]$
A3	The property of being God-like is positive: $P(G)$
C	Possibly, God exists: $\Diamond\exists x G(x)$
A4	Positive properties are necessarily positive: $\forall\phi[P(\phi) \supset \Box\, P(\phi)]$
D2	An *essence* of an individual is a property possessed by it and necessarily implying any of its properties: $\phi\ ess.\ x \equiv \phi(x) \wedge \forall\psi(\psi(x) \supset \Box\forall y(\phi(y) \supset \psi(y)))$
T2	Being God-like is an essence of any God-like being: $\forall x[G(x) \supset G\ ess.\ x]$
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A5	Necessary existence is a positive property: $P(NE)$
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Figure 1. Scott's version of Gödel's ontological argument [30].

Proceedings of the Twenty-Fifth International Joint Conference on Artificial Intelligence (IJCAI-16)

The Inconsistency in Gödel's Ontological Argument: A Success Story for AI in Metaphysics

Christoph Benzmüller*
Freie Universität Berlin & Stanford University
c.benzmueller@gmail.com

Bruno Woltzenlogel Paleo
Australian National University
bruno.wp@gmail.com

Abstract

This paper discusses the discovery of the inconsistency in Gödel's ontological argument as a success story for artificial intelligence. Despite the popularity of the argument since the appearance of Gödel's manuscript in the early 1970's, the inconsistency of the axioms used in the argument remained unnoticed until 2013, when it was detected automatically by the higher-order theorem prover

on the proof [Fuhrmann, 2016].

The in-depth analysis presented here substantially extends previous computer-assisted studies of Gödel's ontological argument. Similarly to the related work [Benzmüller and Woltzenlogel-Paleo, 2013a; 2014] the analysis has been conducted with automated theorem provers for classical higher-order logic (HOL; cf. [Andrews, 2014] and the references therein), even though Gödel's proof is actually formulated in higher-order *modal* logic (HOML; cf. [Muskens, 2006]

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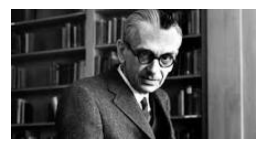

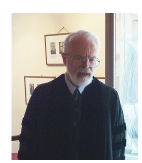

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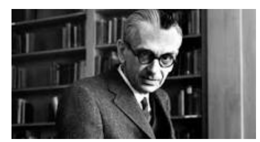

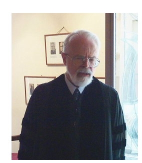

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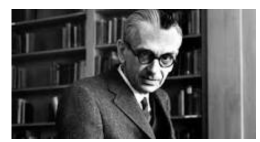

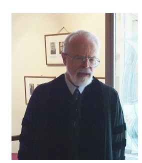

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- Analysis of Leibniz's (& Descartes') version: *Leibniz* by Robert Adams (1998). This book explains what Gödel took as "input," & sought to improve.
- Benzmüller & Paleo (2014) "Automating Gödel's Ontological Proof of God's Existence with Higher-order Automated Theorem Provers." An AI-based formal verification of the validity of the argument.
  - https://page.mi.fu-berlin.de/cbenzmueller/papers/C40.pdf
- "The Inconsistency in Gödel's Ontological Argument: A Success Story for AI in Metaphysics," also by B&P, 2016. An AI-based formal refutation of the argument.
  - https://www.ijcai.org/Proceedings/16/Papers/137.pdf
- Fitting, M. (2002) *Types, Tableaus, and Gödel's God*. Includes full formalization of (a version of) Gödel's proof of God's existence.
  - https://www.amazon.com/Types-Tableaus-Gödels-Trends-Logic/dp/9401039127
- "A (Simplified) Supreme Being Necessarily Exists — Says the Computer!," by C. Benzmüller.
  - https://www.groundai.com/project/a-simplified-supreme-being-necessarily-exists-says-the-computer/3
- "Computer-Supported Analysis of Positive Properties … In Variants of Gödel's Ontological Argument," Benzmüller & Fuenmayor, 2020.
  - https://arxiv.org/pdf/1910.08955.pdf

Are there invariants? Apparently.

$$(\mathbf{Pos1}) \quad \forall R(Pos(R) \rightarrow \neg Pos(\bar{R}))$$

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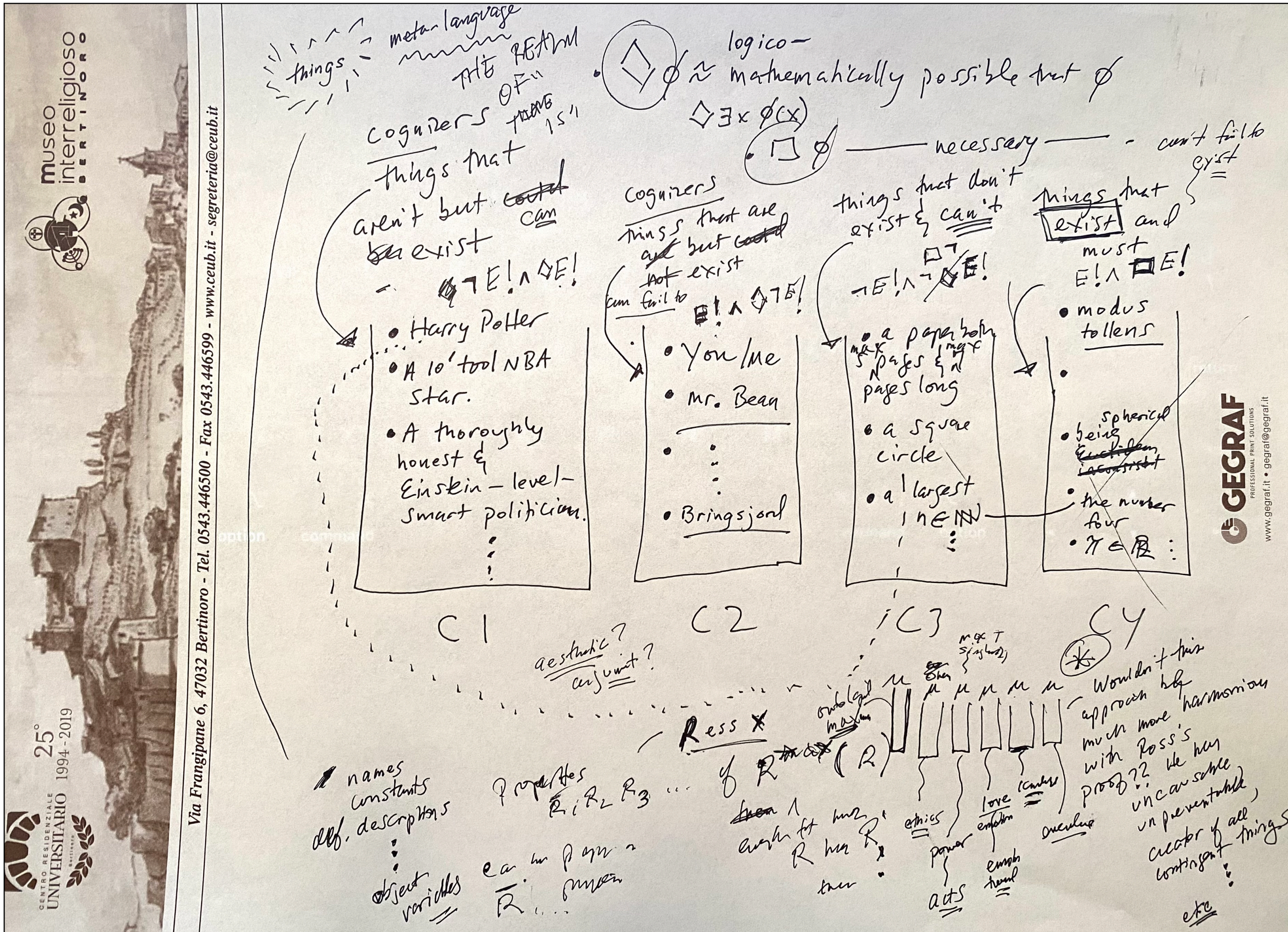
$$(\mathbf{Pos1}^{\star}) \quad \forall R \forall \delta \neq 0[GPPos(R^{\delta}) \rightarrow \neg GPPos(\bar{R})]$$

“The Other Way”



Gödel’s Either/Or …

The Question

Q* Is the human mind more powerful than the class of standard computing machines?

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(= finite machines)

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(= finite machines)

(= Turing machines)

(= register machines)

(= KU machines)

…

Gödel's Either/Or

"[E]ither … the human mind (even within the realm of pure mathematics) infinitely surpasses the power of any finite machine, or else there exist absolutely unsolvable diophantine problems."
— Gödel, 1951, Providence RI

PT as a Diophantine Equation

Equations of this sort were introduced to you in middle-school, when you were asked to find the hypotenuse of a right triangle when you knew its sides; the familiar equation, the famous Pythagorean Theorem that most adults will remember at least echoes of into their old age, is:

$$\text{(PT)} \quad a^2 + b^2 = c^2,$$

and this is of course equivalent to

$$\text{(PT')} \quad a^2 + b^2 - c^2 = 0,$$

which is a Diophantine equation. Such equations have at least two unknowns (here, we of course have three: a, b, c), and the equation is solved when positive integers for the unknowns are found that render the equation true. Three positive integers that render (PT') true are

$$a = 4,\ b = 3,\ c = 5.$$

It is *mathematically impossible* that there is a finite computing machine capable of solving any Diophantine equation given to it as a challenge (!).

… which means that the 10th of Hilbert's Problems is settled:

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Hilbert's problems

From Wikipedia, the free encyclopedia

Hilbert's problems are twenty-three problems in mathematics published by German mathematician David Hilbert in 1900. The problems were all unsolved at the time, and several of them were very influential for 20th-century mathematics. Hilbert presented ten of the problems (1, 2, 6, 7, 8, 13, 16, 19, 21, and 22) at the Paris conference of the International Congress of Mathematicians, speaking on August 8 in the Sorbonne. The complete list of 23 problems was published later, most notably in English translation in 1902 by Mary Frances Winston Newson in the *Bulletin of the American Mathematical Society*.[1]

David Hilbert

Contents [hide]

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10th	Find an algorithm to determine whether a given polynomial Diophantine equation with integer coefficients has an integer solution.	Resolved. Result: Impossible; Matiyasevich's theorem implies that there is no such algorithm.	1970

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Background

problem?[7] In his lecture, Gödel precisely defines diophantine problems, but we don't need to bother with all of the details here; we only need to appreciate the general structure of such a problem, and that can be achieved quickly as follows, given what was introduced in Chapter 2.

Each diophantine problem has at its core a polynomial $\mathcal{P}$ whose variables are comprised by two lists, $x_1, x_2, \ldots, x_n$ and $y_1, y_2, \ldots, y_m$; all variables must be integers, and the same for subscripts n and m. To represent a polynomial in a manner that announces its variables, we can write

$$\mathcal{P}(x_1, x_2, \ldots, x_k, y_1, y_2, \ldots, y_j).$$

But Gödel was specifically interested in whether, for all integers that can be set to the variables x_i, there are integers that can be set to the y_j, such that the polynomial equals 0. To make this clearer, first, here are two particular, simple equations that employ polynomials that are both instances of the needed form:

E1 $\quad 3x - 2y = 0$

E2 $\quad 2x^2 - y = 0$

All we need to do now is prefix these equations with quantifiers in the pattern Gödel gave. This pattern is quite simple: universally quantify over each x_i variable (using the now-familiar $\forall$), after which we existentially quantify over each y_i variable (using the also-now-familiar $\exists$). Thus, here are the two diophantine problems that correspond to the pair E1 and E2 from just above:

P1 $\quad$ Is it true that $\forall x \exists y(3x - 2y = 0)$?

P2 $\quad$ Is it true that $\forall x \exists y 2x^2 - y = 0$?

Great Paper!

Hilbert's Tenth Problem is Unsolvable
Author(s): Martin Davis
Source: *The American Mathematical Monthly*, Vol. 80, No. 3 (Mar., 1973), pp. 233-269
Published by: Mathematical Association of America
Stable URL: http://www.jstor.org/stable/2318447

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Accessed: 22/03/2013 11:53

Great Paper!

1. Diophantine Sets. In this article the usual problem of Diophantine equations will be inverted. Instead of being given an equation and seeking its solutions, one will begin with the set of "solutions" and seek a corresponding Diophantine equation. More precisely:

DEFINITION. A set S of ordered n-tuples of positive integers is called **Diophantine** if there is a polynomial $P(x_1, \cdots, x_n, y_1, \cdots, y_m)$, where $m \geqq 0$, with integer coefficients such that a given n-tuple $\langle x_1, \cdots, x_n \rangle$ belongs to S if and only if there exist positive integers $y_1, \cdots, y_m$ for which

$$P(x_1, \cdots, x_n, y_1, \cdots, y_m) = 0.$$

Borrowing from logic the symbols "$\exists$" for "there exists" and "$\Leftrightarrow$" for "if and only if", the relation between the set S and the polynomial P can be written succinctly as:

$$\langle x_1, \cdots, x_n \rangle \in S \Leftrightarrow (\exists y_1, \cdots, y_m) \, [P(x_1, \cdots, x_n, y_1, \cdots, y_m) = 0],$$

or equivalently:

$$S = \{\langle x_1, \cdots, x_n \rangle \mid (\exists y_1, \cdots, y_m) \, [P(x_1, \cdots, x_n, y_1, \cdots, y_m) = 0]\}.$$

Note that P may (and in non-trivial cases always will) have negative coefficients. *The word* "**polynomial**" *should always be so construed in the article* except where the contrary is explicitly stated. Also *all numbers in this article are positive integers* unless the contrary is stated.

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Great Paper!

Notice that this is a perfect fit with how we used formal logic to present and understand the Polynomial Hierarchy and the Arithmetic Hierarchy.

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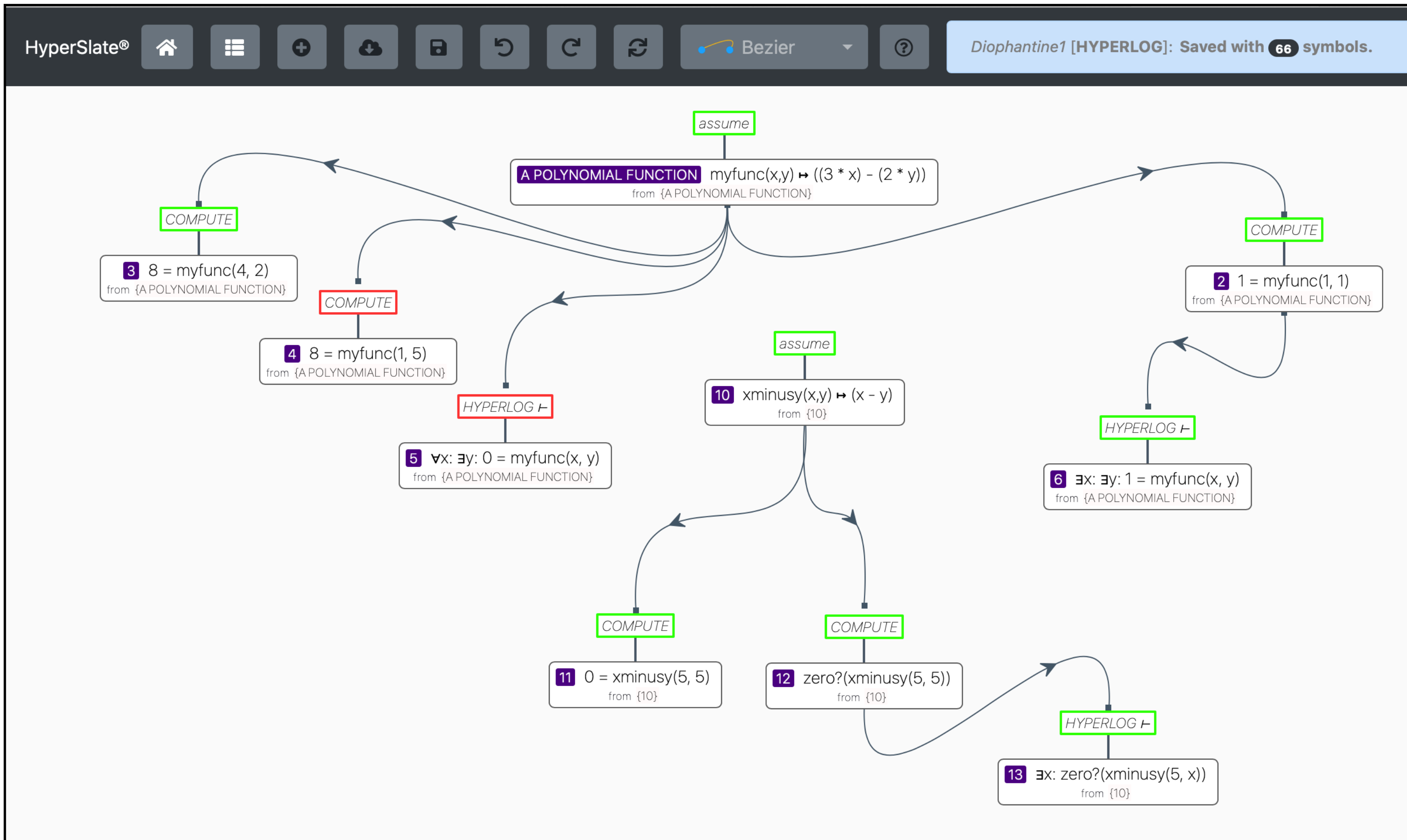
Diophantine "Threat" in the New Programming Language Hyperlog®

(Another IFLAI**2** Topic/Technology)



The Crux

$\exists \mathcal{P}$ s.t. no human mind could ever decide $\forall x_1 \forall x_2 \cdots \forall x_k \exists y_1 \exists y_2 \cdots \exists x_j (\mathcal{P}(x_1, x_2, \ldots, x_k, y_1, y_2, \ldots, y_j)$?

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Earlier Gödelian Argument for the "No."

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Applied Mathematics and Computation

Volume 176, Issue 2, 15 May 2006, Pages 516-530

A new Gödelian argument for hypercomputing minds based on the busy beaver problem ☆

Selmer Bringsjord, Owen Kellett, Andrew Shilliday, Joshua Taylor, Bram van Heuveln, Yingrui Yang, Jeffrey Baumes, Kyle Ross

Show more

https://doi.org/10.1016/j.amc.2005.09.071

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Abstract

Do human persons hypercompute? Or, as the doctrine of *computationalism* holds, are they information processors at or below the Turing Limit? If the former, given the essence of hypercomputation, persons must in some real way be capable of infinitary information processing. Using as a springboard Gödel's little-known assertion that the human mind has a power "converging to infinity", and as an anchoring problem Rado's [T. Rado, On non-computable functions, Bell System Technical Journal 41 (1963) 877–884] Turing-uncomputable "busy beaver" (or Σ) function, we present in this short paper a new argument that, in fact, human persons can hypercompute. The argument is intended to be formidable, not conclusive: it brings Gödel's intuition to a greater level of precision, and places it within a sensible case against computationalism.

But need to read over the break …

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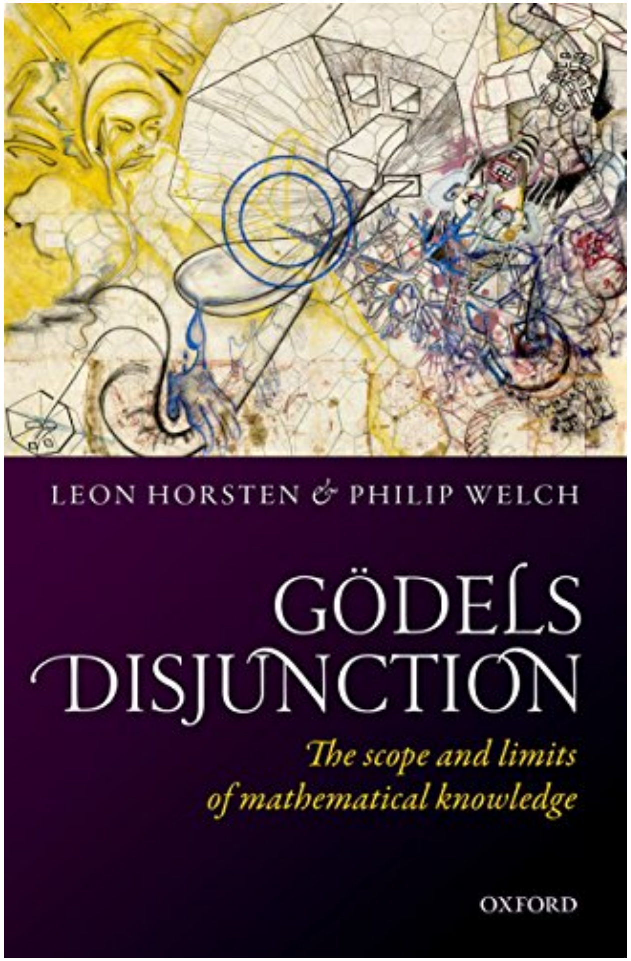

A New One Coming! — in …

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Will AI Match (Or Even Exceed) Human Intellligence?

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No. **Yes.**

I: "Negative" enumerative induction for $\neg \exists year_k(\text{AI} = \text{HI}@year_k)$ from $\text{AI} \neq \text{HI}@year_{1958} \wedge \ldots \wedge \text{AI} \neq \text{HI}@year_{2021}$. Plus the proposition that AI is in fact not improving — relative to the intellectual stuff that matters most.

Will AI Match (Or Even Exceed) Human Intellligence?


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4: And finally, the sledgehammer is used: *phenomenal consciousness.*

Og på det glade merknaden for Selmer (men ikke for Bill), er forelesningene våre nå fullført … men …

Finally, finally, …

Gödel-vs-AI "Scorecard"

The Particular Work	Nutshell Diagnosis	Beyond AI?

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⋆Philosophical Reasoning	Undeniably beyond foreseeable AI.	Yes

And now let's wrap up with extensions etc.

. . .

Med nok penger, kan logikk løse alle problemer.