Artificial General Relativity

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Abstract

We (well, I) introduce a New Field In Science which we (I mean I) call Artificial General Relativity. We (here I really mean 'we') have all heard of General Relativity and how it revolutionized our understanding of the world around us. Einstein's work, although pivotal, failed in one crucial aspect: although it allowed us to describe *gravity and spacetime, it did not allow us to* control *them. In this paper I (switching to 'I' to avoid sounding pretentious with 'we') introduce Artificial General Relativity (AGR) which, when achieved, will allow us to control gravity and spacetime. I present a set of practical approaches to achieve AGR which serve as reasonable baselines for future work.*

I. Introduction

In the early 20th century Albert Einstein introduced the general theory of relativity, also known as General Relativity (GR) (Einstein, 1915, 1916). This pivotal work broke the mental barriers between space and time, demonstrating that they are incredibly intricately intertwined, interrelated, immersed, in the infinitely immense *spacetime*. This theory has allowed us to explain the majority of large-scale gravitational experiments thus far observed, as well as implying the existence of majorly-cool things like black holes. The latter has had major implications not just in Theoretical Physics, but also in Science-Fiction writing (Ferrie, 2016).

Central to GR are the Einstein Field Equations (EFE), which relate the spacetime geometry to the distribution of the matter it contains (Einstein, 1915):

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu} \qquad (1)$$

where $R_{\mu\nu}$ is the Ricci curvature tensor, R is the scalar curvature, $g_{\mu\nu}$ is the metric tensor, Λ is the cosmological constant, G is Newton's gravitational constant, c is the speed of light in vacuum, and $T_{\mu\nu}$ is the stress-energy tensor (Wikipedia, 2020a). In keeping with the best practices of scientific research, I disclose that I do not know the meaning of most of the terms I just introduced. However, what is important is to note is the equations' *structure* as well as the values which are *constants*: Λ, G, c, and π. We will come back to these equations below.

i. The First Shortcoming

A well-recognized shortcoming of GR is that it has not been able to be reconciled with Quantum Physics (von Neumann, 1955, Ferrie, 2017), eluding the dream of a Grand Unified Theory of Everything. More specifically, most quantum field theories are defined on a flat Minkowski space (Wikipedia, 2020b), which can cause inconsistencies with the curved spacetime of GR. Although quantum field theories have been developed for curved spacetime, these are only under specific conditions. The complete unification of these two main physical theories remains an open problem.

ii. The Second Shortcoming

A less known shortcoming of Einstein's GR is that it is a powerful *descriptor*, but not a *controller*. We are still unable to control the force of gravity during basketball games, the speed of the passage of time during finals, nor reduce the gravitational lensing effect during astronomical observations. In other words, we are passive observers of a partially-understood physical system. Einstein famously quipped that "god does not play dice with the universe"; perhaps that is true, but what if *we* could be the ones throwing the dice?

A common question readers may ask themselves is: *Why are the equations in (1) so complicated?* While the answer to this question is beyond the scope of the present work, we (yes, you and me) may ask ourselves a related question: *Can we make those equations simpler?* To quote Barack Obama: YES WE CAN!

II. CAstro Field Equations

I will simplify Equation 1 via the following steps.

1. **Get rid of the cosmological constant.** Einstein famously called Λ "the biggest blunder [he] ever made", so I will start by setting it 0.
2. **Just use matrices!** Tensors are hard to visualize, so let's just use matrices in $\mathbb{R}^4$ (3 spatial dimensions, and one for time)!

The above simplifications produce the CAstro Field Equations, or CAFE for short:

$$\hat{R} - \frac{1}{2} R \hat{g} = \frac{8\pi G}{c^4} \hat{T} \tag{2}$$

Where $\hat{R}$, $\hat{g}$, and $\hat{T}$ are all 4D matrices. I am now ready to present the first theoretical result of this paper.

Theorem 1. *The set of equations described in (2) are simpler than those described in (1).*

Proof. This proof is presented in two parts:
Number of terms: The system of equations in (1) has 10 terms, whereas the system of equations in (2) has 8.
Simplicity of terms: Both sets of equations use the same real-valued scalars, so it suffices to compare the non-scalar terms. In (1) they are all tensors, whereas in (2) they are all just 4D-matrices. Given that tensors generalize matrices, the result follows. □

In addition to Theorem 1, it goes without saying that CAFE is a strictly superior acronym to EFE.

III. To Quantum or not to Quantum?

In this section I directly address The First Shortcoming described in the introduction: how to reconcile GR with Quantum physics. Given that I am adopting the tried-and-tested approach of simplifying things, I make the following assumption.

Assumption 1. *Really small things behave exactly like really big things.*

Under this assumption, there is no longer any need for Quantum physics, and the inconsistency vanishes. I address two natural questions that may arise:

- *Isn't this a really strong assumption?* The vast majority of the world's population has never seen anything at the quantum scale. So: no.
- *Why didn't past physicists make this assumption?* Although I cannot say with certainty, I believe this may be a case of "mathiness" (Lipton and Steinhardt, 2019): as physics equations kept on getting harder and harder to understand, physicists had an incentive to continue making things more complicated.

IV. Artificial General Relativity

I now formally introduce Artificial General Relativity (AGR).

Definition 1. *A universe is described by Artificial General Relativity when Assumption 1 holds, and CAFE perfectly relates the geometry of the universe with the distribution of the matter it contains.*

A critic may naturally question: *could such a universe even exist?* Rather than taking this as a criticism, I invite readers to take this as an *invitation*: Let's build a universe where this holds!

This is the crux of the choice of the word 'Artificial': *we must create the universe that is consistent with AGR*. An astute reader may then observe that desire alone is not enough: what evidence do we have that this is even possible? Clune (2019) argued that Darwinian evolution can be viewed as a general-intelligence-generating algorithm, and serves as an existence proof that the concept of general-intelligence-generating algorithms can work. I follow a similar approach to introduce the second main theoretical result of this work.

Theorem 2. *There exists a universe that is described by AGR.*

Proof. The proof naturally follows by noting the following:

1. Our universe seems to largely be described by General Relativity
2. We have computers that can create virtual universes satisfying arbitrary mathematical equations
3. It has been argued multiple times that we actually live in a computer simulation (Wachowski and Wachowski, 1999, Google, 2020)
4. Theorem 1.

□

V. Experiments

In this section I provide some simulations and experiments as both proof-of-concept and as baselines for future work.

i. Simulation

In keeping with reproducible research, I made a colaboratory notebook where you can plug in CAFE equations and see colorful plots: https://tinyurl.com/s5bxbbs. I display a sample run with structured matrices in Figure 1, which results in structured projections. This provides empirical evidence for Theorem 2, its structural regularity, and will hopefully motivate others to develop more sophisticated simulations.

ii. Black holes

In this section I propose a novel way of presenting experimental evidence: interactively! As far as I know, this is the first time a Real Scientific Paper has presented an intereactive experimental section. As was previously mentioned, black holes are majorly-cool, so I would like to present method for approximate black holes in Algorithm 1. This method is based on the fact that black holes are simply mass that has been enormously compressed.

Algorithm 1 How to approximate a black hole

Input: Any physical object O
Input: A compressing device C
$\hat{O} \leftarrow O$
while You still have energy **do**
    $\hat{O} \leftarrow C(\hat{O})$
Return $\hat{O}$

As a simple application of this method, print this research paper, take the first page (this will be O), and crumple it as much as you can (your arms are acting as C). I guarantee the paper now has a stronger gravitational field. The stronger you are and the larger the paper you compress, the closer to a black hole it will be.

VI. Conclusion

Many believe that achieving Artificial General Intelligence (AGI) will solve all the world's problems (but how, specifically, is not clear). I claim something similar, but more ambitious: building a universe consistent with AGR will solve all the *universe's* problems (but it's not clear yet if it will be our universe or the new one). Artificial General Relativity, which I've introduced here backed by both theoretical results and convincing empirical evidence, promises to be an exciting new area of scientific thought. It is fitting that this is happening in 2020, the start of a new decade! I look forward to what new research in this field this decade will bring.

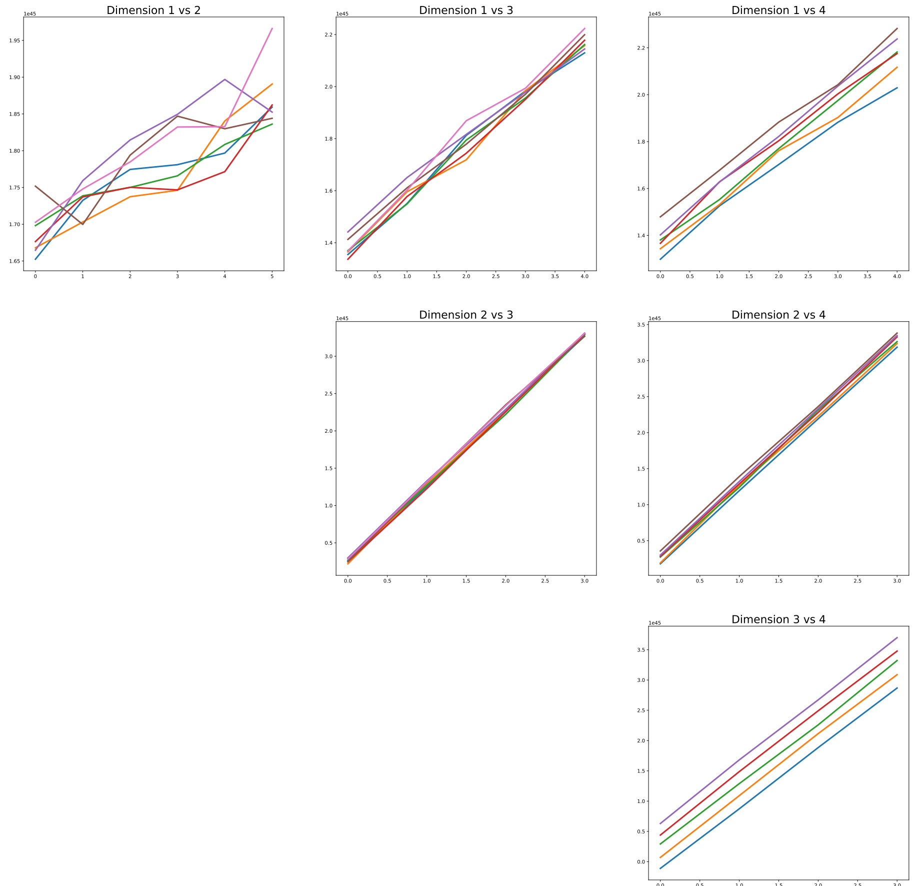

Figure 1: *Sample projections of $\hat{T}$ from the CAFE equations, when solving with structured matrices.*

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References

Jeff Clune. Ai-gas: Ai-generating algorithms, an alternate paradigm for producing general artificial intelligence. *CoRR*, abs/1905.10985, 2019. URL `http://arxiv.org/abs/1905.10985`.

Albert Einstein. Die Feldgleichungen der Gravitation. *Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin*, pages

844–847, 1915.

Albert Einstein. The Foundation of the General Theory of Relativity. *Annalen der Physik.*, 354, 1916.

Chris Ferrie. *General Relativity for Babies*. CreateSpace Independent Publishing Platform, The Internet, 2016. ISBN 9781533181121.

Chris Ferrie. *Quantum Physics for Babies*. Sourcebooks Explore, The Internet, 2017. ISBN 9781492656227.

Google. *Do we live in a computer simulation?*, 2020. URL `https://www.google.com/search?q=do+we+live+in+a+computer+simulation`.

Zachary C. Lipton and Jacob Steinhardt. Troubling trends in machine learning scholarship. *Queue*, 17(1), February 2019. ISSN 1542-7730. doi: 10.1145/3317287.3328534. URL `https://doi.org/10.1145/3317287.3328534`.

John von Neumann. *Mathematical Foundations of Quantum Mechanics*. Princeton University Press, 1955. ISBN 978-0-691-02893-4.

Lana Wachowski and Lilly Wachowski. *The Matrix*, 1999.

Wikipedia. *Einstein field equations*, 2020a. URL `https://en.wikipedia.org/wiki/Einstein_field_equations`.

Wikipedia. *Quantum field theory in curved spacetime*, 2020b. URL `https://en.wikipedia.org/wiki/Quantum_field_theory_in_curved_spacetime`.