Extremely Long and Complicated-sounding Title for a Complex Topic

Roy G. Biv, Ph.D.

University of Connecticut, 2018

ABSTRACT

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Extremely Long and Complicated-sounding Title for a Complex Topic

Roy G. Biv

M.S., University of Connecticut, 20yy

B.S., University of Connecticut, 20xx

A Dissertation

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APPROVAL PAGE

Doctor of Philosophy Dissertation

Extremely Long and Complicated-sounding Title for a Complex Topic

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University of Connecticut

2018

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Chapter 1

Introduction

1.1 Background

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1.2 Outline of the Dissertation

This dissertation is organized as follows: In Chapter 2, Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper. .

We summarize and discuss the research impact of the proposed approaches in Chapter 3.

1.3 Publications

Journal papers that are accepted and published with primary authorship include [2]:

1. **R. G. Biv**, J. Doe, and L. O. Liam, "A Planning Algorithm for Getting Your Science Article Published in Three Weeks," *Superhumans, I-Tripley Transactions on*, vol. 47, no. 12, pp. 3256–3271, 2016.

Currently submitted journal papers with primary authorship include [3]:

1. **R. G. Biv** and L. O. Liam, "An Algorithm for Finishing the PhD in Two Months," *submitted to Super Science Articles, Sophisticated Journal of*, 2018.

Conference papers that are accepted and published with primary authorship include [5, 4]:

1. **R. G. Biv**, A. Pull, T. Burr, and L. O. Liam, "The Go-To Guide on Learning Everything Ever," in *2014 IoAP International Symposium on Graduation*, The Undersea City of Atlantis, Dec. 2014, pp. 659–664.

2. **R. G. Biv**, L. O. Liam, and F. N. Stein, "Evaluating the Value of a PhD in Uncertain Environments," in *1002nd International Research and Technology Symposium on Stuff*, Hill Valley, CA, June 2013.

Journal papers that are accepted and published with co-authorship include [6]:

1. J. Doe, **R. G. Biv**, F. N. Stein, and L. O. Liam, "Approaches to Obtain a High h-index," *Journal of Advanced Advances*, vol. 13, no. 1, pp. 50–67, 2017.

Conference papers that are accepted and published with co-authorship include [1]:

1. O. P. Aychdee, **R. G. Biv**, and L. O. Liam, "Programming methods for coding in three lines or less," in *Something Important, 2018 291st International Conference on.* Holy Toledo, BM: IoAP, July 2018.

Book chapters that are accepted and published with co-authorship include [7]:

1. M. Mouse, **R. G. Biv**, R. Hinges, and L. O. Liam, "Grad School Decision Support: Challenges and Applications," in *Booky McBook*, 2018.

Chapter 2

Another Complicated Title

2.1 Introduction

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Chapter 3

Conclusion

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Appendix A

Complicated Math Derivations

A.1 Addition

Here, we derive how the decimal representations of $\frac{1}{3}$ can sum to 1. Specifically,

$$1 = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} \tag{A.1}$$

$$\stackrel{?}{=} 0.333\ldots + 0.333\ldots + 0.333\ldots \tag{A.2}$$

The real numbers, called $\mathbb{R}$, is defined to be a set with the following properties.

1. $\mathbb{R}$ is a field. That means that for any x and y in $\mathbb{R}$, we can form the sum $x + y$, take additive inverses $-x$, take products xy, and take multiplicative inverses $1/x$ as long as x is not zero. The definition of a field holds that addition and multiplication satisfy all the usual properties: commutative, associative, distributive, etc. And there are special elements 1 and 0 so that $0 + x = x$ and $1x = x$.

2. There is a total ordering on $\mathbb{R}$. That means that for any x and y in $\mathbb{R}$, either $x \leq y$ or $y \leq x$. If both conditions hold, then $x = y$. The total ordering satisfies the following properties:

   - If $x \leq y$, then $x + z \leq y + z$
   - If $x \geq 0$ and $y \geq 0$, then $xy >= 0$

3. The Dedekind completeness properties. Here, we need a definition. Given a nonempty subset $S \subset \mathbb{R}$, z is an upper bound for S if for every $x \in S$, $x \leq z$. Property 3 states that for any nonempty subset of S that has an upper bound, S, it also has a least upper bound, which we denote as w. That means that if $z \leq w$ and z is also an upper bound for S, then $z = w$.

Now, let $f(n)$ be a real-valued function on the integers. Then the statement $\lim_{n\to\infty} f(n) = a$ means that for any real number ϵ such that $\epsilon > 0$, there exists an integer $M > 0$ such that if $n > M$, then $|f(n) - a| < \epsilon$.

Here is a short proof that if $\lim_{n\to\infty} f(n) = a$ and $\lim_{n\to\infty} f(n) = b$, then $a = b$. Suppose the contrary, so that $a - b \neq 0$. Then, by the definition of the limit, we can choose integers M_1 and M_2 so that if $n > M_1$, then $|f(n) - a| < \frac{a-b}{2}$, and if $n > M_2$, then $|f(n) - b| < \frac{a-b}{2}$. Choose n to be larger than both M_1 and M_2. Then, we have a contradiction, for the conditions $|f(n) - a| < \frac{a-b}{2}$, and $|f(n) - b| < \frac{a-b}{2}$, cannot both be simultaneously satisfied.

Now we get into decimals. Let f be a function from the integers (denoted by $\mathbb{Z}$) into the set of symbols $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$, with the following property: for some $M \in \mathbb{Z}, M > 0, f(n) = 0$ if $M > n$. Such a function f is a decimal representation.

For a decimal representation f, we can define the partial sum $P(n)$ as follows:

$P(n)$ is the finite sum

$$f(M)10^M + f(M-1)10^{M-1} + \cdots + f(-n)10^{-n}. \tag{A.3}$$

We can finally define the value of f to be $\lim_{n\to\infty} P(n)$, should this limit exist.

Here is why the limit exists. The sequence $P(n)$ is a Cauchy sequence, which means that $\lim_{n\to\infty} P(n) - P(n+k) \to 0$ for $k > 0$. We can see that as follows. Given $\epsilon > 0$, choose n such that $10{-}n < \epsilon$. Then,

$$P(n) - P(n+k) = f(-n-1)10^{-n-1} + \cdots + f(-n-1)10^{-n-k} < 10^{-n}. \tag{A.4}$$

Hence the sequence $P(n)$ has an upper bound, and, thus, a least upper bound. It should be easy to see that this least upper bound is the limit of the $P(n)$ sequence.

Now, we have enough of a foundation to prove $0.333\ldots + 0.333\ldots + 0.333\ldots = 1$. Expressed rigorously, $0.999\ldots$ is the decimal representation given by $f(n) = 0$ if $M \geq 0$, and $f(n) = 9$ if $M < 0$. $P(n)$ is defined similarly.

Proof: First, we show that 1 is an upper bound for $P(n)$ inductively, by showing that $1 - P(n) = 10^{-n}$. For $n = 0$, $P(n)$ is the one term sum 0, and $1 - 0 = 10^0$. Now suppose the result is true for some $n = k$, and we want to show the result for $n = k+1$. $P(k+1) = P(k) + 9(10^{-k-1})$, so

$$1 - P(k+1) = 1 - P(k) - 9(10^{-k-1}) \tag{A.5}$$

$$= 10^{-k} - 9(10^{-k-1}) \tag{A.6}$$

$$= 10^{-k-1}. \tag{A.7}$$

Since $1 - P(n) \geq 0$ for all integers n, 1 is an upper bound for $P(n)$.

To show $P(n)$ is a least upper bound, consider the real number $1 - \epsilon$ for some $\epsilon > 0$. Choose n so that $10^{-n} < \epsilon$. Then, $P(n) > 1 - \epsilon$ by the result of the previous paragraph; hence $1 - \epsilon$ cannot be an upper bound for $P(n)$. Thus, 1 is the least upper bound for $P(n)$ and $0.999\ldots = 1$. Q.E.D.

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[1] O. P. Aychdee, R. G. Biv, and L. O. Liam, "Programming methods for coding in three lines or less," in *Something Important, 2018 291st International Conference on*. Holy Toledo, BM: IoAP, July 2018.

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