Visualizing Poetic Space: Mapping Dante's Comedy

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ABSTRACT

Written in the early 1300s, The Dante's Comedy, stands at the threshold of the Medieval and the Renaissance ages. Both its grand universal scope and the intimate, vivid realism with which Dante portrays the souls he encounters, have captivated readers for seven centuries. In the Renaissance, the specificity of Dante's geometry lead figures such as Botticelli and Galileo to speculate on the exact topology of the Inferno. In the time since, artists from Blake to Rodin to Twombly have imagined and reimagined the landscapes and populations of Hell, Purgatory and Paradise. For poets and writers, the formal complexity, beauty and radical inventiveness of Dante's poetry has opened countless pathways for remaking and reconceiving the written word. This project draws inspiration specifically from Italo Calvino and Jorge Luis Borges, the great 20th century fabulists, each of whom regarded Dante as a touchstone for the visual and spatial imagination.

This project seeks to extend these speculations, inspirations and reimaginations into the emergent 21st century paradigms of knowledge generation: the three-dimensional interactive capabilities of the graphical user interface, and the n-dimensional dynamics of data transit. Built in JavaScript, using the Threejs 3-D library and a MongoDB database, this speculative map of Dante's poetic space serves as an environment for active, exploratory, deep and collaborative reading of the poem. My central questions are: How can poetic space be visualized? And how can such a visualization lead us to new modes of reading, understanding, imagination and expression.

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INTRODUCTION

> "Dante's poem is that panel whose edges enclose the universe. Yet I believe that if we were able to read it in innocence, (but that happiness is barred to us), its universality would not be the first thing we would notice, and still less its grandiose sublimity. We would, I believe, notice other, less overwhelming and far more delightful characteristics much sooner, perhaps first of all … the varied and felicitous invention of precise traits."
>
> —Jorge Luis Borges[1]

In his Prologue to "Nine Dantesque Essays," Borges fantasizes a magical work: a panel painting, an illustrated labyrinth, a microcosm of our universe whose surface encompasses all of history, past and future. Throughout the conically nested circles of hell, the evenly tapering cylindrical terraces of the Mountain of Purgatory, and the vast concentric spheres of the planetary heavens, Dante delineates a metaphysical space in which Borges can envision a place for every aspect of humanity. But within the vast space of these unseen realms, what Borges wants us notice above all else is Dante's intimate portrayal of humanity itself. That is the remarkable achievement of Dante's poem: that throughout its grand spatial design, humanity and the human soul shines through at every level.

Written during the first two decades of the 14th century (approximately 1306-1320[2]), Dante's *Comedy* recounts the seven-day journey of Dante the pilgrim through the Christian afterworlds and the Ptolemaic, earth-centric universe. Consisting of 100 cantos divided over three books—*Inferno, Purgatorio,* and *Paradiso*—its central subject is "the state of souls after death."[3] Throughout the poem Dante encounters souls from history, classical and biblical literature, and particularly the recently deceased of his home city of Florence. It is a journey through the sins, faults, tragedies, virtues and beauty of humanity, as well as a trip through the unseen realms of the earth, the planets, the stars, and beyond. The earliest readers and commentators recognized Dante's geometric precision and the deliberate clues with which he invites the reader to spatially reconstruct the terrain. In the Renaissance, mathematicians and cartographers, including Brunelleschi and Galileo strived to measure and visualize the dimensions of the *Inferno*. In the 19th century, artists such as Blake and Rodin responded to Dante's realism, and visualized specific souls of the *Inferno* through painting and sculpture. Two of the great fabulists of the 20th century, Borges and Calvino, hold Dante's poetic space as the chief model for imaginative world-building.

This was my inspiration for building a three-dimensional interactive visualization of Dante's Comedy: the fact that 700 ago, working at the limits of early 14th century Western science and mathematics, Dante used poetry to construct the most detailed and thorough map of the invisible that had ever been created. I regard my visualization as a speculative translation of the two fundamental aspects of Dante's world-building: the geometric specificity and exhaustiveness of

[1] Borges, 267
[2] Hollander, *Inferno*, xxiii
[3] Dante, Epistole XIII. 24

his spatial design of his invisible realms, and the equally striking intimate and beautiful realism with which he portrays its populations. My intention in creating this visualization is to extend Dante's poetic space into the emergent 21st century paradigms of knowledge generation: the three-dimensional interactive capabilities of the graphical user interface, and the n-dimensional dynamics of data transit. At the heart of this project is a desire to interrogate the concept of poetic space—as it existed for Dante's imagination and Renaissance minds that followed him, and how it may exist in the shifting fields of the contemporary imagination.

In the first part of this essay, "*Inferno*: Mapping the Metaphysical Real," I discuss the historical contexts of Dante's two pillars of world-building: mimetic realism and spatial geometry. First, I examine the historical, metaphysical and theological context of Dante's realism, so that we may better understand the mimetic processes that give imaginative life to the human souls (and demons) of the *Inferno*. Next, I examine the spatial dimension of Dante's world-building: how he employs the language of mathematics to map his imaginative space. I go on to discuss the extension of this space into the Renaissance imagination, and how Dante's poetic space functions as a platform for generating knowledge.

In the second part, "Reading as Visualization / Visualization as Reading," I investigate how Dante's poetic space may be harnessed and applied to the 21st century imagination. In the case of reading, I discuss Dante's and Calvino's conception of reading as an act of visualization, and how 21st century reading paradigms have imperiled and transformed this act. In the case of visualization, I assess the emergent dimensionality of the graphical user interface as well as the emerging field of Data Visualization in the context of Dante's metaphysics and speculative mathematics. In both cases, I discuss how my visualization strives to translate Dante's poetic space and speculate on the potentialities of poetic space in our time.

PART I: *INFERNO*: MAPPING THE METAPHYSICAL REAL

1.1 Geyron at the Limits of Mimetic Realism

Midway through the *Inferno,* Dante the pilgrim and his guide, the shade of the poet Virgil, face their steepest descent. They stand at the precipice of the Seventh Circle where the river Phlegthon—a river of blood—becomes a waterfall, dropping to the ditches of the Eighth Circle below. Up to this point, the two have managed to climb down increasingly steep ridges at the threshold of one circle to the next. Now, to venture any lower, they will need help. Virgil instructs Dante to untie a cord around his waist and toss it into the abyss. Dante, directly addressing the reader, prepares us for what will emerge:

> To a truth that bears the face of falsehood
> a man should seal his lips if he is able,
> for it might shame him, through no fault of his,
>
> but here I can't be silent. And by the strains
> of this Comedy — so may they soon succeed
> in finding favor — I swear to you, reader,
>
> that I saw come swimming up
> through that dense and murky air a shape
> to cause amazement in the stoutest heart,
>
> a shape most like a man's who, having plunged
> to loose the anchor caught fast in a reef
> or something other hidden in the sea, now rises,
> reaching upward and drawing in his feet.
>
> Canto XVI. ll. 124-136

It is the demon Geryon: a winged beast with lion paws, a scorpion-like tail, his back tattooed with rings and spirals, and the face of an honest man. With Virgil's assurance, Dante mounts Geryon by the shoulders, and they are flown down to the Eighth Circle where over a third of the *Inferno*'s cantos take place. Named *Malebolge* ("evil ditches"), the Eighth Circle, consists of its own ten sub-circles where every type of fraud (magic, prophecy, thieving, counterfeiting) finds its appropriate torment and punishment.

The great irony is that upon Dante's entry into the circles of fraud, he insists ("I swear to you, reader") on the truth of what he's telling. Canto XVII, which immediately follows, is devoted entirely to Geryon, described in baroque and vivid detail. Dante recounts the flight down in a hyper-realistic embodied mode. He clings to the neck of Geryon as the Demon leaps into the abyss, the rushing noise of the waterfall of blood beside them. Dante, awash with fear, shuts his eyes and tightens his thighs around Geryon's shoulders. He then attempts to gaze past Geyron to discern the new shapes of the Eighth Circle, but the blur and speed of flight is too much, and he nearly falls. Finally, Geyron alights, Dante and Virgil dismount, and the demon vanishes back up into the abyss "like an arrow from the string."

This episode, located at the central hinge of the *Inferno,* is the stuff of fantasy fiction—at least as we know it today. Why then does Dante preface it by claiming that it's true? In the context of the modern day fabulists, you could say that he knows he is about strain our suspension of disbelief, and he doesn't want to lose us. But Dante, writing in the early 1300s, comes out of the allegorical tradition of Medieval Romance, in which all characters and figures are merely stand-ins or symbols for the idea or lesson being told. Why strain so hard to maintain the reality of something so outlandish as a ride on the back of a mythical creature? The answer is that according to Dante, all of this *really* happened.

"The fiction of the *Divine Comedy* is that it is not fiction,"[4] wrote Charles Singleton, one of the first modern Dante scholars to put forth the notion that Dante considered the events of the *Comedy* to be real. Following Singleton, the scholar and translator Robert Hollander cites the *Convivio,* in which Dante distinguishes between poetic and theological allegory to elucidate what this non-fictional claim might mean. According to Dante*,* a poetic allegory, such as the 13th century *Romance of the Rose*, is a symbolic invention (a *falsity*) that carries *true* messages about Christian life. Theological allegory, on the other hand, like a story in *The Bible,* recounts *actual* historical events that also serve as models for Christian life. In his letter to the nobleman Cangrande della Scala, which serves a precis for the poem, Dante firmly situates the *Comedy* within the theological category. He distinguishes between the poem's allegorical meaning, as well as its "literal or historical" meaning[5]. Though Dante's wording is somewhat opaque—making an outright claim of theological truth would be heresy—it is clear, Hollander concludes, that Dante intended that his "seven-day visit to the afterworld is to be treated as historical fact."[6] Why make this claim? For Singleton and Hollander the main advantage is to foreground the striking realism of the poem.

In the *Inferno,* the realism of Dante's of mimetic representations are particularly palpable. Perhaps because it is the first region of the invisible realms that we encounter, or maybe because it is the closest realm to the living, there is an intimate and embodied physicality that is specific to the *Inferno*. Each landscape, denizen, and sound we encounter is transmitted through the vividly measured language of the senses. Dante wants us to hear, see, feel, smell, even touch the world he is depicting. Often, Dante employs a strategy of delayed sensory input, the kind all of us would experience upon encountering a new, dark world. At the entry to a new circle of Hell, Dante will hear or smell things first, and even ask Virgil to tell him what he is seeing. Then, only after his eyes adjust to the light or the strangeness of the scene, does he begin paint the landscape for reader's eyes. The sophistication of the vivacity and dimensionality of the phenomenological elements we encounter in the underworld clearly indicate that, at the very least, Dante wanted his readers to experience the worlds as if they were real.

But why would Dante want claim that it is true? What is at stake? Dante, writing in exile from the warring political factions of his home city of Florence, had radical ambitions on political and theological levels. His conscious choice to write the poem in vernacular Italian, as opposed to the church's Latin, is nothing less than an attempt to lay the groundwork for a new Italian state and

[4] Hollander, *Allegory*
[5] Dante, Epistole XIII. 24
[6] Hollander, *Allegory*

undermine the authority of the corrupt papacy. (600 years later, Dante seems to have succeed on this front. In the 20th century, when modern standard Italian was codified, it was based on the Florentine vernacular of the *Comedy*.) But even more radical than his use of the vernacular, is Dante's attempt to make poetry itself a theological basis for ontological and metaphysical transformation. What the meaning of "real" or "literal" meant to Dante, differs quite a bit from the western materialist ontologies of the past few centuries. For Dante, the *real* was not the materiality of the flesh, but a *realization* of something beyond it. In *The Metaphysics of Dante's Comedy,* Christian Moeves examines the nature of Dante's truth claims in the context of medieval metaphysics, using the metaphor of binary code:

> For the medieval understanding, the world is a long string of zeros, of no meaning in itself, unless one puts a "1" in front of it, endowing it with incalculable value and significance. That "1" is the "metaphysical subject" or ground of experience, which the Western tradition has variously called Being, Intellect, the One, the act of existence, pure Form, God, the Creator, or "the thought that thinks itself."[7]

To somewhat simplify Moeves' complex discourse, Dante conceives of the poetry of the *Comedy* as bridge between the 0 and 1. The earthly world, what we may call material reality, has no inherent truth value (or "realness") in Dante's worldview. Truth value is only achievable when the revelatory 1 joins the material 0, in a continuous, non-dualist, metaphysical real. Dante's radical assertion is that poetry could operate at this revelatory level. The traditional ecclesiastical view held, as Hollander puts it, that "all poets are liars."[8] Dante's great challenge, then, was to resituate the station of truth within the transformative sublimity of poetic language. Which brings us back to the threshold of Malebolge, the circle of fraud.

For Moeves as well as Hollander, the truth claims of Dante's Comedy hinge on us believing the Geryon episode. Did Dante really fly on Geryon's back? As Moeves' explication of medieval reality makes clear, Dante didn't *actually*, physically do it. But does he do it metaphysically? Do his words sustain their truth value (does the author maintain our suspension of disbelief) even at the poem's most outlandish point? Dante, upon entering the ten sub-circles of fraud, must prove that while these souls and demons are forever doomed by their falsehoods, the inventions of his poem are truths. These are the stakes in this central moment of the *Inferno*—as Dante crosses the threshold, mounts the shoulder of the beast of fraud, and goes for ride past a waterfall of blood. This is the place where his claims to theological and political truth may well collapse. And he knows it. This is where his concretely modeled 3-D poetic space can most easily flatten out into 2-D medieval allegory.

Dante's solution to this dilemma anticipates, or perhaps invents, the central mimetic law that 20th century fabulists such as Borges, Calvino, Kafka and Murakami adhere to: the stranger it is, the more deeply imagined and clearly drawn it must be. As Teodolinda Barolini writes, in an subtle revision of Singleton's take on Dante's fiction: "the Commedia is a nonfalse error…not a fiction that pretends to be true but a fiction that IS true."[9] This is the essential, radical conception of storytelling that emerges from the *Inferno*, one that I believe situates Dante as the great precursor

[7] Moeves, 170
[8] Hollander, *Allegory*
[9] Barolini, 13

to modern fabulists. Halfway through his journey through this invisible world, Dante finds himself on the threshold of losing his grip on the metaphysical real. The fact that Dante spends thirteen cantos (over a third of the poem) struggling through the pits and demons and broken bridges of the fraudulent is no coincidence. Here the subtle, tender realism of the early cantos are fire-tested in the hyperbolic fantasia of the Eighth Circle. Here Dante must stretch the embodied mimetic capacity of his language, the dimensionality of his poetic space, before he can enter the more distant, subtle and materially porous realms of Purgatory and Paradise. Through the circles of fraud, he must complete his fledgling experiment in emergent world-building.

1.2. Measuring Poetic Space

As Borges observes, world-building on the Dantean level, exists not only at the intimate mimetic scale of finely observed traits, but also on a grand spatial scale. "Dante's poem is that panel whose edges enclose the universe." The vast reach of the panel is due mainly to the scope of *Paradiso*, in which Dante, after his journey up the mountain of Purgartory, rises, first to the moon, then up through the Ptolemaic planetary system, and across the hinge of the universe to the Empyrean which enfolds all of space-time. By comparison, the geometry and topology of the Hell is quotidian. But that's the point, isn't it? Just as the *Inferno* exhibits a specifically embodied portrayal of its populations, Hell's topology has a similar specificity and exactitude. Again, perhaps because the *Inferno* is the first of the three books, Dante may have wanted to surround his readers in familiar state of reality. Or maybe, because Hell lies so close to the surface of the earth, its reality is just one uncanny valley down the road from our own.

Let's take a quick tour through the space of the *Inferno*. The poem begins in a "dark wood"—a strange and dreamlike place where Dante, in the middle of his life, at the age of 35, finds himself lost. Deep in this wood, after a leopard and other wild beasts block his way out, he encounters the spirit of Virgil. Virgil informs him of the journey he must undertake, and leads him to the gates of Hell. On March 25, 1300, 6PM Jerusalem time—sunset on Good Friday—Dante walks through the gates, under the surface of the Earth and into the Inferno. He is first greeted by the sounds of hands slapping and voices wailing in the whirling black air about him. Virgil tells him that he is hearing the sounds of the Neutrals angels. Only then does Dante, "all eyes" *(che riguardai)* begin to see the parade of these shades gathered marching under a flapping empty banner. Then "fixing his gaze" beyond them, he sees a crowd of souls standing the edge of a wide river. Dante sees a boat approaching, and the negotiation begins between Virgil and Charon, the demon ferryman, that brings Dante into the First Circle of Hell.

Over a 24-hour span, Dante makes the journey from the zero-circle of the Neutrals down to the black and icy floor of hell—the exact center of the Earth and of the Christian Universe—where Satan is pitched headfirst into the ground. During that time, Dante and Virgil move through the nine circles surrounding the central abyss that traces the path of Satan's fall. As they cross from circle to circle, each one arrives with a steeper descent, a narrower radius, and a harsher landscape than the one before it. The first few circles are wide sparsely populated plains. A

medieval castle lies in the meadows of the First Circle—a consolation for the unsaved but virtuous souls, like Virgil, who were born before the advent of Christ. The Second Circle grows darker, engulfed in storms. As they descend, the thresholds are guarded by more and more ferocious demons, and the punishments grow increasingly brutal. The swampy Styx, the second river of Hell, engulfs all of the Fifth Circle and the violent souls cast into it. At its far shore lies the wall of the city Dis, the gateway into Lower Hell. Within the wall, the third river, Phelgothon, marks the edge of the Seventh Circle, and flows like a waterfall down to the level below. The Eighth Circle, Malebolge, consists of its own ten distinct concentric circles with a series of bridges crossing over each ditch. (The bridges between the fifth and six ditch were all broken during Christ's harrowing of Hell—a fact that proves especially perilous to Dante's journey.) Far below, the cold despair and desolation of the the Ninth Circle lies in sharp contrast to the kinetic machinery of the Eighth's punishments. The floor of hell is covered by the fourth river of hell, the frozen Cocytus, made of Satan's tears.

Throughout the descent, the architectural and spatiotemporal details are carefully and strategically doled out with increasing specificity. At the beginning of the journey, Virgil notes the setting of the sun and the positioning of the stars in order to provide us with the proper date and time. In the early circles, the landscapes are dark but vivid, and little is mentioned about descents. We are getting our feet wet, and so is Dante as a world-builder. The first four circles are traversed quickly, in less than four cantos. At the shores of the river Styx the walls and ramparts of Lower Hell come into view, the pace slows, and the vividness increases. At the threshold to the Seventh Circle, Dante pauses to get used to the stench as Virgil explains distribution of punishment throughout the circles of hell. They then carefully climb down a rockslide from the Seventh Circle, cross the river Phelgyton, and proceed slowly through the forest of suicides. Soon, Geryon appears, and flies them down. At the entry to Eighth Circle, Dante spatial details grow much more exacting:

> There is a place in Hell called Malebolge,
> fashioned entirely of iron-colored rock,
> as is the escarpment that encircles it.
>
> At the very center of this malignant space
> there yawns a pit, extremely wide and deep.
> I will describe its plan all in due time.
>
> A path that circles like a belt around the base
> of that high rock runs round the pit,
> its sides descending in ten ditches.
>
> As where concentric moats surround a castle
> to guard its walls, their patterns clear
> and governed by a meaningful design,
>
> in such a pattern were these ditches shaped.
>
> Canto XVIII, ll. 1-13

This is our first full and clear aerial view of the concentric nested architecture of hell. At the other end of the Eighth Circle, as leave the ninth ditch, we get our first exact measurements. Virgil, chastising Dante for tarrying in his sorrows, says:

> In case you plan to count the sinners one by one,
> think: this hollow circles twenty-two miles round.
>
> The moon already lies beneath our feet.
> The time we are allotted soon expires…
>
> Canto XXIX Ill. 8 – 11

Soon after, in the tenth and final ditch of the counterfeiters:

> I would by now have started on my way
>
> to seek him out in this pit's bloated shapes,
> even though it runs eleven miles around
> and spreads not less than half a mile across.
>
> Canto XXX Ill. 84 – 87

From these two passage we learn that the ninth ditch of Malebolge has a 22-mile circumference, and tenth ditch is 11 miles around. Finally, we gain specific clues to the widths of the circles of Hell (its X and Z dimensions). What about the Y-dimensions, the height of the circles?

Those measures bookend the Ninth Circle. The descent from Malebolge to the icy floor of hell, while less dramatic than the ride on Geryon's back is no less surreal. Approaching the final abyss Dante thinks he sees a new set of towers at the threshold. The towers turn out to be the ancient giants, including Nimrod, Ephialtes and Antaeus. The giants stand with their feet down in the Ninth Circle, and their heads above the edge of the Eighth:

> Going farther on, we came upon Antaeus.
> Without the added measure of his head,
> he stood a full five ells above the pit.
>
> Canto XXXI ll. 112 – 114

This partial but specific measure gives us the potential distances between the bottom of the Eighth Circle and the central and final well of the Ninth. We get the depth and size of the lowest point in Hell from none other than Satan himself:

> The emperor of the woeful kingdom
> rose from the ice below his breast,
> and I in size am closer to a giant
> than giants are when measured to his arms.
> Judge, then, what the whole must be
> that is proportional to such a part.

Canto XXXIV ll. 28 – 33

In this last Canto of the Inferno we get a final invitation to reconstruct the sizes and heights of the Ninth Circle. We have our potential Y-coordinates. We can use the giants' proportions to calculate the drop from the edge of the Eighth Circle to the beginning of the well of the ninth, and Satan's proportions to measure its lowest depth. What is most important here, though, is Dante's instruction for us to "Judge." Perhaps he should have just said, "now that you've made it through this first invisible world of mine, please take out your compasses and rulers and a clean sheet of paper." To which the reader might say, "Can we get a longitude and latitude?"

Dante doesn't disappoint. He and Virgil exit Hell in the strangest of ways. They climb over the frozen body of Satan into an opening in the rock below him. As they complete the descent, it inverts and becomes an ascent: Satan who lies head down at the bottom of hell suddenly seems to be standing, with Dante and Virgil standing above him. At this point they have crossed the center of the Earth, and gravity has switched from one direction to another. In Dante's universe, the earth is a sphere, but only the top half of that sphere is where humankind lives. The bottom hemisphere (the Austral hemisphere) is where the Mountain of Purgatory awaits them, surrounded by sea. In the final lines of the *Inferno* they climb through a small passage way, toward the surface of the other side of the Earth. When they arrive at the shores of Purgatory, Virgil is explicit about their geographical location. They at the exact antipode of Jerusalem.

'You are now beneath the hemisphere
opposite the one that canopies the landmass --
and underneath its zenith that Man was slain

Canto XXXIV ll. 112 – 114

Immediately following, in the last lines of the poem, we get the final flourish of world-building: an origin story. Virgil tells us how the topology of Hell and Purgatory came into being. Satan's fall from heaven (keep in mind that he is enormous) pierced the earth at the exact point of Christ's crucifixion. Satan then plowed through the solid rock inside the planet—creating the concentric circles of hell and leaving its central abyss in Satan's wake. Satan is thus stuck at the (0,0,0) point of the Earth, with the abyss drawing a perfect line from Jerusalem to him. The mountain of Purgatory—a terraced inversion of Hell—formed from the matter displaced by Satan's impact. The geological physicality and three-dimensional spatial realism of this final image of the *Inferno* makes it impossible not to visualize these shapes on a global scale—to re-imagine the formation of the two invisibles world within and upon the earth.

1.3. Mapping the *Inferno*

The impact (literally) of the final world-building image of Satan's fall—along with the explicit measurements and invitations to reconstruct—extended deeply into the imaginations of the mathematicians and cartographers of the next three centuries. Particularly from 1450 to 1600, at the height of the Renaissance: charts, maps, and geographical theories on the exact dimensions of Hell abounded[10]. In *Mismapping the Underworld,* John Kleiner examines the Renaissance obsession with mapping Hell. The most famous early figures are the architects Antonio Manetti and Filippo Brunelleschi whose efforts to reconstruct Hell are recounted in Vasari's *Lives of the Artists*. Though Brunelleschi's plans are lost, the model offered by the Florentine Manetti became the renaissance gold standard. In Manetti's model Limbo is 405 15/22 miles beneath the surface of the earth, and is 87 ½ miles wide. The Second Circle is 405 miles below Limbo and 75 miles across. Two of the earliest surviving maps from the late 15th century, by Girolamo Benivieni and Cristoforo Landino, were based on Manetti's calculations. In the 16th century, a Sienese scholar, Allesandro Vellutello, famously challenged the model. He argued that the previous model grossly overestimated the size of hell. Whereas Manetti calculated the length of its y-axis to be the full radius of the earth (3,400miles by his estimate), Vellutello put forth a much smaller model that was only 315 miles deep.[11]

This debate reached its apex in 1588 when a young Galileo Galilei, at the age of the 32, seeking to secure his first professorship, delivered a series of lectures on the geometry of the *Inferno*. As Mark Peterson recounts in *Galileo's Muse*, these lectures were intended to be somewhat of spectacle. Galileo delivered them to the Florentine Academy, and played to the ongoing rivalry between Manetti's (and Dante's) home city of Florence and Vellutello's home city of Lucca. He played to the home crowd. Galileo supported Manetti's model on all fronts: the calculated size of Lucifer, the steepness of the descents, and the direction of Virgil and Dante's journey. He even takes issue with Vellutello's charge against Manetti's model: that if the underworld was so wide, the dome of the surface of the earth (the ceiling of hell) would collapse into all of that hollow space. Using the new mathematics of scale, Galileo argues that like a dome on church, so the surface of the earth would similarly scale and hold up. It turns out that Galileo's arguments are wrong on many fronts, but the lecture entertained the home crowd, and Galileo won the professorship.[12]

Soon after Galileo's lectures, this literal mapping of hell fell out of fashion, and subsequent attempts to visualize the *Inferno* relegated themselves to more generalized illustrations and diagrams. So what made this practice a specifically Renaissance phenomenon that involved the some of the greatest intellects of the time? Kleiner and Peterson offer two perspectives. Kleiner suggests three possible factors: Florentine civic/intellectual pride, the rise of cartography in general, and, most central to his argument, the Renaissance idealization of mathematics as central to all knowledge. He writes, "This attachment to idealized geometry is a bridge between medieval and Renaissance culture."[13] But, Kleiner asks, "Is it actually the case that Dante

[10] Kleiner, 24
[11] Ibid, 25
[12] Peterson, 227
[13] Kleiner, 33

visualized the infernal terrain with geometrical precision?"[14] He argues that this literal cartographic vision of hell is a case of the Renaissance ideal of perfection imposing itself upon Dante. He goes on to demonstrate, via mathematical analysis, the geometric incongruities and impossibilities of all of Dante's hints at the exact dimensions. Pointing out that many of these clues are given in the circles of fraud, he suggests and that Dante's geometry is purposely and playfully riddled with error. He goes on to make the subtle point that Dante may be implicating himself is as an author in the circle of fraud.

The great value of Kleiner's approach is that he emphasizes the inherent ambiguity and erratic nature of the *Inferno*'s topography and geometry. Anyone who builds a map of Hell should certainly build that ambiguity—its essential unknown—into the model. But I would contend that there is too much at stake in the lowest ditches of Malebolge and the Ninth Circle—in the darkest and most despairing depths of the *Inferno*—for Dante to be playing around. More importantly, Kleiner's approach obscures how crucial mathematics is to Dante's initial attempt at world-building, while hyperbolically dismissing the value of the Renaissance mappers. As he colors it, the Renaissance cartographers are essentially falling for a purposeful trick on Dante's part. One of the primary goals of Kleiner's study is to demonstrate why mapping hell "should now be cast as a bizarre and extravagant enterprise."[15] Yes, claiming, in this day and age, to have the exact measurements of a fictional hell, would be bizarre. But ironically, by running the numbers on Dante, Kleiner indulges in the exact same activity as the Renaissance mathematicians. Writing in the early 1990s, Kleiner's literal analysis of the math seems much more bizarre, and entirely less productive. Finding error in the measurements of any fictional space is the stuff of fan fiction. He claims to be dispelling the notion of mathematical perfection in the *Comedy*, but this implies that proving perfection was the central goal of the Renaissance mathematicians. In the end, Kleiner's mockery of the entire practice of mapping hell belies a historical myopia that clouds the real and serious value of Dante's world to the Renaissance cartographers.

Peterson, offers a much more nuanced and convincing picture of both of Dante's mathematics and the Renaissance project of interpreting Dante's visual space. First, he makes clear that these Renaissance figures (Brunelleschi and Galileo among them) were no dupes.

> Manetti and his disciples are not describing a real Inferno and a real journey: they are all explicit about this. Rather they aim to reveal the poet's mind, his intention. Landino compares Dante's Inferno with the underworlds of the Odyssey and the Aeneid, and marvels at how, in contrast to those poetic predecessors, Dante "by his most subtle mind and by the discipline of mathematics" shows it to us almost as though it were there before our eyes.[16]

Rather than imposing a mathematical ideal on some fraudulent clues, they are responding to the explicit depth and mimetic dimensionality of Dante's world-building. Dante uses specific geometric language throughout the Comedy as a means of pushing his world-building capacities as far as possible. According to Peterson, Dante had read the new rediscovered works of Euclid

[14] Ibid, 34
[15] Ibid, 24
[16] Peterson, 235

and Archimedes—texts that fueled the rapid (three-century) advancement of mathematics that Galileo will bring to its height in his *Two New Sciences*. Seen in this light, the issue is certainly not perfection vs. error. Whether Dante's math adds up is irrelevant. What matters is that Dante may be the first writer to explicitly ground his poetic space (his fictional world) in the language of mathematics. At the very least, Dante used mathematics to build a level of imaginative dimensionality on a scale that had never before been achieved. (Borges might insist that no one has since.) The Renaissance craze of mapping, I would argue, was a prolonged fire lit by Dante's promethean imagination. These maps were speculations, translations and extensions of Dante's poetic space.

Moreover, Peterson argues that the fact that Dante's world was imaginary and based in mathematics, made it a better candidate for geometrical thought experiments. At this point in history, reality was not widely considered to adhere to mathematical laws. Those laws, Newton's, were still another two centuries away. Peterson even suggests that Galileo's eventual breakthrough in defining the physical laws of scaling were born from his Inferno Lectures. Galileo's argument that the dome of the earth's crust would hold up just as the dome of the church would was, of course, erroneous. Soon after the lecture, Galileo began to realize that the larger the volume, the greater the proportional weight of the dome. The ceiling of hell would certainly collapse. Fifty years later, he discretely included his new and correct theory of scaling in *Two New Sciences,* with no mention of the Inferno Lectures. Through Peterson's lens, we can see that Dante's poem became a site for mathematical knowledge building: a virtual reality for experimentation en route to the new discovery that mathematics did apply to physical reality.

Why then, did the mapping stop after 1600? This question is not part of Peterson's project. Kleiner, in his diminished view of the Renaissance mappers, asserts merely that "number, ratio, and proportion" were no longer "central aesthetic and philosophical concerns."[17] One can only speculate—but I would venture speculate quite a bit more specifically. The first factor I would consider is Galileo himself. In 1610, gazing through his technologically advanced telescope, he observed the phases of Venus. This act is considered the decisive affirmation of Copernican heliocentrism, and the final nail in the coffin of the Ptolemaic system. Dante's world in which the Earth was the center of the universe becomes patently false. His speculative world is officially dated. At this point, it would indeed seem foolish to argue for dimensional accuracy. Speculations are much less appealing when you are certain there is no chance they can be possible. While the Ptolemaic system still held some water, Dante's imaginary realms encompassed all of the known universe. Not anymore.

A second reason why mapping Dante's imaginary world likely continued to fall from the cultural imagination comes in the wake of Galileo and Newton—the rise and dominance of Western Materialism. As we saw in our examination of Dante's metaphysics: the materialist worldview denies even the imaginative possibility of metaphysical real. To the heliocentric materialist, Dante's world would seem quaint and misguided. With these two deep epistemological shifts in our models of the universe and of the self (not to mention the waning of Catholicism), the *Comedy* could no longer maintain the hold on the imagination that it once enjoyed. Perhaps with its new mathematics, its mimetic realism, and its anti-papal/pro-vernacular stance, the Comedy

[17] Kleiner, 41

helped set in motion the very epistemological shifts that would undo its own imaginative power. Does that mean that by the 21st century, the poetic space of Dante's Comedy has been utterly dissolved? Borges would certainly disagree. But what can be gained by mapping and visualizing the poem at this point? While math and physics have likely surpassed the the speculative possibilities built into Dante's world, his poetic space may still offer a great deal of room for continuing to build the human imagination.

PART TWO: READING AS VISUALIZATION / VISUALIZATION AS READING

2.1 *Purgatorio: Reading as Visualization*

The vivid, embodied mode of mimetic realism that Dante employs throughout the *Inferno* does not continue through the rest of the journey. Eventually Dante must shed the weight of the body and its senses in order to join his earthly love, Beatrice, at the top of the mountain of Purgatory—where Virgil disappears, and Beatrice guides Dante's through the planetary heavens. *Purgatorio* enacts this gradual shedding of material embodiment (recall the binary 0) as he climbs closer to metaphysical truth (the connected binary 1). A mirror image of Hell, the mountain of Purgatory consists of distinctly stratified levels assigned to various type of sin. But in Purgatory there is hope. Each soul that reaches the shores of Purgatory will, in good time, ascend to heaven. Thus, each soul will journey up through each terrace of Purgatory and remain there long enough to atone for each sin. While you may be stuck in the terrace of Lust for a millennium, you will eventually continue upwards.

The purpose of each terrace is for the soul to shed each sin by through suffering and learning. At thresholds Dante encounters didactic examples of the sin and its opposing virtue—Pride vs. Humility, Envy vs Charity. These exemplars are represented in a gradual shift away from the senses. First comes Pride, with exemplars viewed on a carved marble wall. Then, for Envy, disembodied sounds fly across the air. At the third terrace of Wrath, we final shift away from the realistic, material language of the senses. Again we find ourselves at the exact center of a book of the *Comedy* (and the exact center of the *Comedy* itself). As the *Inferno*'s central episode of Geryon highlighted a shift in the mimetic stakes, so the beginning of Canto XVII of *Purgatorio* signals an explicit turn in the mode of representation. Dante is far enough up the mountain that the material language of the senses no longer applies. Instead, images rain down directly from heaven into his mind. He describes the process:

> O imagination, which at times so rob us
> of outward things we pay no heed,
> though a thousand trumpets sound around us,
>
> who sets you into motion if the senses offer
> nothing? A light, formed in the heavens, moves you
> either of itself or by a will that sends it down.
>
> Of the impious deed of her whose shape was changed
> into the bird that most delights to sing
> a picture formed in my imagination.
>
> At this my mind had so withdrawn into itself
> there was no impulse from outside
> that could impinge upon my senses.
>
> Then there rained down into my lofty phantasy
> one fastened to a cross, scornful
> and fierce in looks, and in his death.

Canto XVII, ll. 13-27

In this passage we find not just a description of the ecstatic vision, but Dante's definition of the imagination. For Dante, the imagination, the pictures that form in the mind, comes from lights that rain down from heaven. But was exactly is Dante representing here? The final three lines of the passage tell of two images—an impious women changed into a bird, and a man fastened to a cross—that appear directly in his head. These are exemplars of wrath. Interestingly, the beginning apostrophe on imagination, presents us with the image of someone so lost within the powerful images in his head that a thousand trumpets pass by without him noticing. What is he describing? Hollander's commentary explains the image nicely:

> This passage gave birth, in the early commentators, to the repetition of a charming story. Dante, having found a book he had never seen before in Siena, read it just where he found it, in a street stall, so that he might fix it in his mind, and did so for more than three hours one afternoon. When someone later asked him whether he ad been disturbed by the wedding festivities that had occurred during his reading, he expressed no awareness that any such things had occurred.[18]

Dante is describing the act of reading. As we have seen, Dante believed that poetic text had the power to represent metaphysical truth. Here he places the visual act of reading—the act of turning words in pictures in the mind—at the center of the entire poem. For Dante, this translation of words to images works via the light of heaven. Reading is the first step we can take to go beyond the realm of the senses.

In his essay on "Visibility," Calvino begins with these very same lines from *Purgatorio*. His essay is explicitly about the interchange of words and image at play in the reading and creation of literary texts. Calvino defines two types of imaginative processes: the first being the "mental cinema" of reading which "always has been" at work in the human mind, even before in the invention of cinema. The second imaginative process is that of creating words out of mental images—communicating the interior landscapes of the imagination via writing. Calvino examines the act of written creation from a contemporary vantage point. Whereas Dante may have believed his visions arrived straight from heaven, how do we create via more "earthly transmitters." For Calvino, the modern writer (and I would extend this to all creative thinkers) operates from an interior well of hyperlinked images:

> The poet's mind, and at a few decisive moments the mind of the scientist, works according to a process of association of images that is the quickest way to link and choose between the infinite forms of the possible and the impossible. The imagination is a kind of electronic machine that takes account of all possible combinations and chooses the ones that are appropriate to a particular purpose, or are simply the most interesting, pleasing, or amusing.[19]

For Calvino these double processes of the interpretive and creative imagination are the mechanisms that drive the expansion and expression of human knowledge. What then, he asks, "will be the future of the individual imagination in what is usually called the 'civilization of the

[18] Hollander, *Purgatorio,* 378
[19] Calvino, 91

image?'"[20] Writing his essay in 1984, Calvino understood that he was born only at the precipice of this shift in the nature of our visualizing capacities. His concern is that with each new generation the ancient process of visualizing text would become more imperiled. "Will the power of evoking images of things that are *not there* continue to develop in a human race increasingly inundated by a flood of prefabricated images?"[21]

This question is one of the main driving forces behind my project. In the 30 years since Calvino wrote his "Visibility" essay, the migration of text to the screen has transformed the basic visual quality of the text we read, while simultaneously forcing text to complete directly with a constant flood of images. How does this shift affect the reader? In her book *My Mother Was a Computer,* N. Katherine Hayles frames this transformation of reading media from two perspectives: first, how the shift in medium affects meaning; and second, how the experience of reading on screen transforms subjectivity. She cites Fredrick Kittler who, like Calvino, characterized traditional print reading as "hallucinating a meaning between letters and lines."[22] In Kittler's view, the medium defines the meaning: the shift toward networked, screen-based media is a move away from subjective meaning-creation. The technological apparatus constitutes the discourse and irretrievably jettisons past forms of meaning creation. In contrast, Hayles offers Mark Hanson's argument that the shift in the locus of reading from print to the interactive screen empowers the embodied subject. The hyperlinked, site-specific, contingent and alinear make up of the interface allows the reader to frame and constitute meaning in singular ways. These two interpretations of reading in new media stand at dialectical ends: Kittler privileges the medium, Hanson the subject.

For Hayles, the subject and the medium transform, build and rebuild each other in a recursive feedback loop. Print is not supplanted by the screen, and interior imagining of text is not stripped away into blank information consumption. Instead, screen media is deeply informed by print media, which is then transformed by screen media, which is then re-transformed by print media, and so on. Similarly, the reading subject can no longer be expected to only read like Dante, standing in a public square for three hours, oblivious to the world around him. The subjectivities produced by computational media will evolve along much more varied lines of imaginative and meaning-making processes than those of readers in the 13th, 16th and 19th centuries (all whose subjective reading practices certainly differed as well). The 21st century act of reading will become a more heterogeneous soup of focused/non-focused, linear/alinear, empowered/passive, collaged/fragmented activities. Still, the radical changes to the medium of reading assure us that the "mental cinema" of interior, subjective visualization of text will be much harder to sustain.

Do we need to sustain this imaginative faculty? If we agree with Calvino that this interior visual capacity is not only the site of seeing invisible worlds, but of creating them—then the answer is yes. But it is more complicated than clinging to a print-based visual interiority. Calvino himself discusses the primacy of the image in the imaginary life of his childhood via American comic books from the 1930s. His initial childhood "schooling in fable-making" came out of inventing pastiche narratives from the multi-framed drawings of comic strips whose words he didn't understand. Perhaps the genius of Calvino stems from an early version of the empowered

[20] Ibid, 91
[21] Ibid, 92
[22] Hayles, *My Mother was a Computer,* 4

subjectivity of the multi-frame interface reader. And maybe his example serves as a promising hint at the kinds of literature that may potentially arise from 21st century interface-bread subjectivities. But Calvino admits, "this habit undeniably caused a delay in my ability to concentrate on the written word, and I acquired the attention needed for reading only at a later stage and with effort."[23] Thankfully, Calvino found some incentive to develop the necessary reading capacity to not just imagine his worlds, but build them as well.

One of the goals my project is to investigate how we can create new avenues for developing the basic imaginative faculty of visualizing the imaginary worlds of text. This skill of meaning creation, while it will certainly be maintained by some outliers, has been increasingly eroded by the media/subject feedback loop of our interface economy. In her more recent book, *How We Think,* Hayles' chapter on "How We Read," charts the diminishing reach of the academic textual practice of "close-reading" along with the rise "hyper-reading."[24] Close-reading is, of course, academia's word for Dante and Calvino's conception of text-to-"mental-cinema." Hyper-reading, on the other hand, is the screen-based, computer assisted practice of searching, querying, jumping, and skimming text. Hayles addresses the increasing dominance of hyper-reading among college students, and academia's struggles to contend with the shift. She cites cognitive studies that demonstrate both a diminished level of attention and comprehension among hyper-readers. On the other hand, she cites cognitive studies that link increased literary and close-reading skills to a greater capacity in the working memory. Meaning, those who build their close-reading the skills do seem to have a greater imaginative capacity. It seems that today's science corroborates Calvino's intuitions. In light of these findings and intuitions both Hayles and Calvino call for a pedagogical approach to building the imagination. Hayles quotes Maryanne Wolfe's *Proust and the Squid*:

> We must teach our children to be bitextual or multitextual, able to read and analyze texts flexibly in different ways, with more deliberate instruction at every stage of development on the inferential, demanding aspects of any text. Teaching children to uncover the invisible world that resides in written words needs to be both explicit and part of a dialogue between learner and teacher, if we are to promote the processes that lead to fully formed expert reading in our citizenry.[25]

30 years earlier Calvino writes:

> If I have included visibility in my list of values to be saved, it is to give warning of the danger we run in losing a basic human faculty: the power of bringing visions into focus with our eyes shut, of bringing forth forms and colors from the lines of black letters on a white page, and in fact of thinking in terms of images. I have in mind some possible pedagogy of the imagination that would accustom us to control our own inner vision without suffocating it or letting it fall, on the other hand, into confused, ephemeral daydreams, but would enable the images to crystallize into a well-defined, memorable, and self-sufficient form, the icastic form.[26]

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[23] Calvino, 94
[24] Hayles, *How We Think,* 60
[25] Ibid, 75
[26] Calvino, 92

With both Hayles and Calvino in mind, I built my interface to attempt a synergy between the activities of close-reading and hyper-reading. The initial reading mode is modeled on hyper-reading, but the hyper-reading within this interface emphasizes the exploratory, subject-empowering aspects of active queries, roving across the screen, and producing meaning via construction and pastiche. This exploratory hyper-reading mode is built with the intent to increase interest and attentiveness. There are over 2000 activated hyperlinks on the screen, but the navigation and reading space remain stable. The 3-D model is organized by Dante's geometry, the text is clearly set apart, and it consists of one three-line stanza. Hyper-readers can draw their mouse across the screen in order to navigate the dimensions and populations of hell, much like Dante, the pilgrim, but in alinear fashion.

Much of the success of this reading component depends on the power of the stanza as an entryway into the poem. The stanza (Italian for "room") is a discrete unit of poetic language, usually with a set number of lines, that is repeated throughout a poem. Dante's three-line stanzas operate as part of his overall metrical pattern of terza rima—in which the first and last line rhyme with each other, while middle line rhymes with the first and last lines of following stanza. This creates concatenated and overlapping sets of threes—the three lines of one stanza, and the set of three rhyming lines that loops across two stanzas. In the exploratory mode, the linguistic power, dramatic force and imagistic density particular to Dante's stanzas will function as the site for taking the first imaginative step into the poem. In this way, the stanza itself becomes a bridge between hyper-reading and close-reading. Three lines are not too much to read, but three poetically dense lines demand a level of attention beyond mere roving. The singularity of stanza gives the reader time and space to let the image crystalize in his or her mind.

If the reader is drawn more deeply into the episode, he or she can enter a close-reading mode, in which the entire canto can be scrolled through, and the whole poem continuously read. This close-reading mode offers its own rewards, including episodic highlighting and guides, and responsive mapping (the map will light your way through Dante's poetic space). In all, I have designed the reading components of my visualization to balance the poetic reward of both getting lost and finding yourself again. Once the fully functional interface is deployed—with a MongoDB database for managing user-features such as bookmarking and tracing reading paths—I plan to study the use-cases. I will be curious to see whether different users favor different modes of reading: if reading begins with exploring and then moves on to close-reading, or if there is a continuous jump between the two. I also plan to work closely with test users from a variety of academic backgrounds to continue to refine the reading modes. My hope is that the poetic structure of the *Comedy*— the tension between strength of the single stanza and propulsive narrative force of the full cantos—will foster a wide range of linear and alinear reading.

2.2 *Paradiso:* Visualization as Reading

The last lines of *Paradiso* recount Dante's final vision at the highest point of the universe, the Empyrean, which lies outside of time, outside of the motion of the planets and stars, and encircles all of space and matter. Dante gazes at its height and sees the three and one of trinity, together spinning in a perfect circle.

> That circling which, thus conceived,
> appeared in you as light's reflection,
> once my eyes had gazed on it a while, seemed,
>
> within itself and in its very color,
> to be painted with our likeness,
> so that my sight was all absorbed in it.
>
> Like the geometer who fully applies himself
> to square the circle and, for all his thought,
> cannot discover the principle he lacks,
>
> such was I at that strange new sight.
> I tried to see how the image fit the circle
> and how it found its where in it.
>
> But my wings had not sufficed for that
> had not my mind been struck by a bolt
> of lightning that granted what I asked.
>
> Here my exalted vision lost its power.
> But now my will and my desire, like wheels revolving
> with an even motion, were turning with
> the Love that moves the sun and all the other stars.
>
> Canto XXXIII, ll. 127-145

What exactly does Dante describe here in the closing lines of the *Comedy*? As we have seen, the poem progresses from the darkly modeled intimate realism of the *Inferno*, to the didactic meta-representation and meta-materials of the *Purgatorio*. In *Paradiso*, the language moves further and further away from the material—into pure idea, pure song, and pure mathematics. The planets of Paradise are populated by divine souls who exist both in the specific planetary spheres and collectively in the light of the Empyrean. Most of *Paradiso* consists of long sermons on virtue by divine figures of the church, and sublime and beautiful songs sung by angels and the saved. The structure of Paradise is dominated by a complex and ethereal language of geometry.

In *Galeleo's Muse*, Peterson interprets this final vision as Dante's greatest and deepest speculation to geometric potentiality. While the passage is hard to parse, most commentaries recognize the metaphor of the geometer attempting to circle the square, and interpret this final vision as the one that finally extends beyond Dante's limits. Peterson pushes further, interpreting the bolt of lightning as granting Dante's final imaginative insight into mathematics. While the

intricate details of Peterson's argument are beyond the scope of this paper, Peterson speculates that Dante is referencing a proof by Archimedes, in which he proposed calculating the area of a circle by building polygons within the circle from an infinite set of triangles. Archimedes goes on to prove that, in fact, a finite the set of triangles will reach a limit at which the area of the polygon and the circle are the same. This is the concept of the limit, developed by Archimedes, that was later employed by Newton and Leibniz in the invention of Calculus.[27] While Dante's vision is most literally, that of the cross, of Christ crucified moving within a circle, Peterson contends that Dante final metaphysical flourish penetrates, at least metaphorically, a mathematical insight that would come centuries later.

It is certainly possible that Peterson is pushing the math within the metaphor too far. But that is the great beauty of Dante grounding his poetic space within the language of geometry. Whether or not Peterson's speculation is convincing, it is grounded in the historical fact that Dante had read classical mathematics and attempted to apply their theorems and laws to his imagined worlds. In Dante's poetic space, geometry is cast in the language of metaphor—making the space itself contingent, open, and imaginatively malleable. As we have seen, this was the main appeal of the *Comedy* to Renaissance cartographers: that Dante had built an invisible, mathematical world in which they could readily conduct spatial thought experiments. For three centuries, the *Comedy* functioned as an imaginative sandbox for mathematical speculation. The fact that Brunelleschi, credited with inventing linear perspective, and Galileo, the father of modern science, were at the forefront of these speculations attests to the imaginative and spatial potentialities embedded in the metaphors of Dante's poetic space. It is telling that even today, Galileo's Inferno Lectures are almost universally considered an embarrassment to scientists and scholars. Scientists, valuing truth over speculation, can lose sight of the necessary processes of speculation and error that paves the way to truth.

This is an important lesson to be applied to the emerging field of Data Visualization. The inherently speculative nature of visually representing data often gets lost or clouded by truth claims. Our culture's habit of equating data with truth certainly drives this impulse; so do the economic stakes of the field, and the desire to cast professionally designed visual work as authoritative. But for Data Visualization, the truth is more in the medium than in the data. The truth is that when we are reading a visualization on screen, the geometrical primitives and text that we see are defined more by the limits of the screen display and the current coding languages than by the data. If we probed a little deeper into the metaphysical truth of a visual display of quantitative data, we would see a layer of visual metaphors constructed from a human (and/or machine) interpretation of digitized information. To repurpose Singleton's statement about Dante, I would say: "The fiction of Data Visualization is that it is not fiction."

At best, a Data Visualization is a metaphorical visual representation of facts whose visual arrangement provides new routes for understanding and gaining insight into those facts. Johanna Drucker, whose *Graphesis* examines the history of "visual forms of knowledge production," would call such a visualization a "knowledge generator." For Drucker, however, "the real challenge is in conceptualizing the spaces of the interface in a way that engages humanistic theory."[28] What she is calling for is not just generating knowledge about the data, but

[27] Peterson, 92
[28] Drucker, 130

interrogating the nature of the interface itself as the site of knowledge production. In order to address the human subject for whom a visualization is (presumably) designed, the designer must understand and expose the ways in which the interface shapes the human subject.

How can we visually produce knowledge about both the information and medium of delivery? How can we situate Data Visualization as a field for the investigating both knowledge (epistemology) and the subjective human reader of the interface (ontology)? My answer would be to frame the entire field of Data Visualization as speculative. Drucker writes, "We are in the incunabula period of information design."[29] In that respect, we find ourselves in the same place within the new paradigms of visual language and the n-dimensional space of the interface, that the Renaissance mappers did with classical mathematics. We have the potential to shape knowledge and the human subject in new ways. Our goal as designers and coders should be to investigate the formal, metaphorical, and fictive dimensions and potentialities of the screen and the data transit. We should seek out data sets that will allow the greatest potential for experiments in constructing new epistemologies and ontologies.

While Drucker points to the 7000-year history of the book as a model for interface design, my interest lies in the much longer history of poetry as a model for shaping the n-dimensional space of the imagination. Poetry has been the site for building metaphysical formal structures for containing and shaping human knowledge since the advent of song and the oral tradition. The components of poetic space—letter, word, line, stanza, rhyme, meter, sentence—create formal linguistic structures that the imagination may inhabit (through sound, vision, meaning, sensation) in contingent and shifting way. Similarly, the formal components of the interface—code, queries, links, color, text, shape, image, motion—create a primarily visual linguistic structure that the viewer may inhabit and explore. Poetry and the code that drives the interface share a level of formal, metaphysical structure that works to contain and produce knowledge and experience.

In drawing the geometric primitives of Dante's invisible would, my primary interest is to translate the metaphysical space of his poem into the metaphysical field of the activated and internet-connected screen. It is a speculation on the *Comedy*: on the shape of Dante's universe and on the state of souls within his design. It is also a speculation on the poetics of digital space: on the ability of the interface to expressively contain and tell Dante's story. The recent emergence of standardized browser-based 3-D graphics via WebGL, made the interface particularly suited to Dante's explicitly 3-D dimensional world. In fact, WebGL and the Threejs library that I employed to build the visualization, draws all of its geometric shapes in the way described in the final lines of *Paradiso*. It builds polygons and circles from the basic unit of the triangle. Moreover, Dante's invented poetic form of terza rima—three line stanzas with circularly overlapping rhymes—mirrors this process of building a metaphysical circular shape from a triangular unit.

These concordances, whether they are pleasing or forced, exist only on a metaphorical level. That level, however, may be the most important one. While all of the world is quite familiar with the concept of metaphor in language, how can we as culture begin to parse and understand the concept of visual metaphor? Images are usually understood as either representations or symbols.

[29] Ibid, 176

I would propose that if we can begin to understand the visible graphics of the screen as metaphor, both our critical understanding and the depth of our experience of the interface would grow immensely. This point is purely speculative, but I would argue that until we do begin to see (that is, visually interpret) in terms metaphor, the true power of visual storytelling will never be realized. In the end, interactive networked screen-based visualization is a new form of reading. We will gain much more from its potential if we jettison the desire to make truth claims about the form. By grounding the practice of Data Visualization as fictional and speculative, and by experimenting with its formal components as poets do, we may eventually begin to construct visual fables on the scale that Dante achieved with the *Comedy*.

CONCLUSION: THE LIMITS OF DANTE

Does Dante's poem, as Borges suggests, enclose the universe? In the 21st century, of course not. Its Ptolemaic model with the earth at its center is the least of the problems. The poem's basis in medieval Christianity which, despite all of Dante's science and humanism, remains an impediment to a vast number of readers. Possibly the greatest challenge to the *Comedy*'s potential universality is the fact that it is a poem. Despite (or maybe because of) the deep complexities and vast metaphysical and contingent potentialities that reside in the fabric of poetic space, the human mind will continue to drift away from the densely wrought imaginative text-based visions of the poets. While it is my utopian wish that visual language and poetic language, the metaphysical substrates of poetic form and networked interface, may join each other in a constructive feedback loop—the delayed immediacy of poetry will always resist and fade behind the swift temporal eye blink of the visual. But I would argue that this is one of the strengths of poetry: its capacity to delay time, to slow down the imagination, pause the elements in motion, and bring us back to the time out of which it was born. Poetry is by nature dated. It is an artifact of its time. The limits of Dante's *Comedy* are built into the form of its own making. My visualization is not an attempt to update Dante. It is an attempt to work within the vast and rich imaginative limits of Dante's 700-year-old speculation on the invisible, so we may begin to speculate on the state of human souls today.

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