the UNCRITICAL complexes of COMPUTING

This thesis begins and ends with a pressing question that has beleaguered me throughout much of my undergraduate education, as well as the summers and time I have spent abroad as a software developer: *why do so many of my peers not engage critically with the software and hardware that powers their everyday*?

This is a provocative question. It asserts the contestable hypothesis that there is a significant quota of students who do not participate in critical discourse with respect to their technological conditions. The veracity of this assertion relies heavily on how one defines 'critical discourse'—expository groundwork that constitutes the first part of this thesis' project. Once a clear definition of ‘critical discourse,’ I will argue that our digital infrastructure suffers from a general scarcity of it, specifically in two disciplinary sites that are currently considered responsible for computer and critical education in the United States; and therefore are also inadvertently responsible for fostering spaces for critical discourse on digital technology. The first is the department of Computer Science, and the second is the department of Media Studies (or Media Theory).

By tracing criticality's scarcity in these two departments, I outline the requirements of an alternative pedagogy in computer education, nominally 'critical computing,' and assert the urgent need for this pedagogy within tertiary instutional structures such as Princeton.

Note that I am using the term 'department' here to connote a disciplinary apparatus at large, rather than one that is specific to any particular institution. However, I admit in full disclosure that my conception of these disciplines as abstract entities is derived from the formations that I have experienced as a student at Princeton University. In point of fact, I refer to Princeton-specific incarnations of disciplinary abstractions as evidentiary material for the claim that neither Computer Science nor Media Studies adequately accomodates critical discourse in computing.

Though I am not aware of any tertiary institution, American or otherwise, that fully accommodates a notion of critical computing in the configuration I present in this thesis, I will eagerly concede ground on this claim. Notwithstanding the incarnation of critical computing's practice elsewhere, I intend this thesis to stand as a solicitous critique of computing education and pedagogy at Princeton, and a companion to the institutional and extra-institutional venues that may already practice a version of it. (I will review those of which I am aware in the final section of Part I.) My hope is that this thesis assists in further formalizing a pedagogy of computers and computing that continues to work towards a more societally constructive and conscientious practice of hardware and software.

By way of example, the second part of this thesis theorizes a methodology in critical computing through 3-D animation. I present a short film whose pedagogical intention is to engage students with the technical, cultural and political dimensions of Internet architecture to divluge a space for critical discourse that is not restricted to computer experts. To be clear: the intention of this space is not to amateurize the engineering science of the Internet's technicalities; but to enable and encourage critical discourse with respect to the Internet's socio-political emanations. The Internet is a technology, but it is also a cultural apparatus that operatively impacts our subjectivity as citizens and societal actors. Towards a notion of democracy, we must think about its processes critically.

PART I

*The Penguin Dictionary of Critical Theory* defines the goal of critical theory as follows: “to preclude the emergence of...an 'administered' modern industrial society which has such ideological control over the deepest desires and feelings of its subjects that they are quite literally unaware of their exploitation, frustration and unhappiness... by demonstrating that a transition to a freer and more fulfilling society is objectively or theoretically possible, and then by demonstrating that the existing state of society is so unsatisfatory and frustrating that it *ought* to be transformed.”[[1]](#footnote-1) The term was born with the Institute for Social Research at Frankfurt in the early 20th century, idiomatically 'the Frankfurt School,'[[2]](#footnote-2) but the terminology has since extended its significance, and now refers to a broader range of schools of thought.[[3]](#footnote-3)

What constitutes the 'critical' aspect of critical theory is contentiously debated by terminological fiendsters across various humanities departments. The definition of 'critical discourse' employed in this thesis references the 'critical' aspect of 'critical theory'. Critical discourse can be qualified by three distinct dimensions:

1. The discourse **details and reveals the technical operations of some socio-political apparatus** for a technically non-specialized, but otherwise interested and democratically consistent audience.[[4]](#footnote-4) These details would otherwise be opaque to all but a specialized constituency.
2. The discourse **further details and reveals what is at stake socio-politcally in these operations**. What impact do they bear on political subjectivity and agency? Which bodies are inflected, violated, and/or erased through them?
3. The discourse **generates a space for further examination and critique of the operations in question**. In other words, the discourse is a discourse: not a hermetically foreclosed matter-of-fact.

In other words, critical discourse makes visible, politicizes, and enables critique of the operations that simultaneously conceptualize and ratify the society in which we live. As can be seen in the increasingly evident muscle of computing systems in societal anatomy, computing substance in the world--algorithms, software, hardware, and so forth--is replete with operations that demand critical scrutiny.

One institutional reflex in response to the growing strength, impact, and tangible abuse of society's technological muscle is the genesis of (inter)disciplinary formations such as computer ethics and technology policy. Princeton's version of this is the Center for Information and Technology Policy (CITP), which sits at the intersection of Computer Science, Economics, Politics, Engineering, Sociology and the Woodrow Wilson School of Public and International Affairs.[[5]](#footnote-5) CITP houses important research and space for discussion, on topics such as national and subnational surveillance, the ethics of computer science research, and the policy and implementation of artificially intelligent systems.[[6]](#footnote-6) This is undoubtedly a space that fosters critical discourse on computing in society, and critical computing is conceptually aligned with CITP's ideological imperatives. Even with CITP, however, ethics in computer science pedagogy at Princeton is treated as an afterthought, rather than as a systemically incorporated aspect of teaching computer science. This is a pedagogical deficiency of which many CITP faculty and students are aware, and there is an active effort to incorporate ethics into course syllabi in the computer science department.[[7]](#footnote-7)

Critical computing is poised to work alongside CITP and like-minded intiatives. It looks to delimit the space of technical consideration by providing an interface between computer scientists and critical citizens and subjects of other denominations. This interface works both ways. On the one hand, it opens a space where non-specialists can understand, and thus more shrewdly critique, the computer-technical operations at work in societal infrastructure. On the other, it exposes computer scientists and other specialists to this critique: it opens a discursive space where constructive inter- and trans-disciplinary conversation can take place.[[8]](#footnote-8) I will more clearly articulate the advantage of such a poly-disciplinary discursive space by demonstration in Part II with respect to the architecture of the Internet.

The remainder of Part I entails a close reading of both Computer Science and Media Studies with respect to their potential for critical discourse, through the three dimensions outlined above. I draw on literature in computer science and computer education, as well as the course syllabi in Princeton computer science and elsewhere. I also occasionally draw anecdotally on my experience as a Computer Science major at Princeton, and as the authentic participant of five semester-length graduate seminars, and countless lectures in Princeton's ‘Media and Modernity’ program, which is affiliated with Architecture, Art and Archaeology, English, German and Spanish and Portugese at Princeton. I participated in these structures between September 2013 to January 2018, during most of which time I have also been a student at Princeton. (I spent a year under my own aegis in Europe from June 2015 to August 2016).

I then turn to various initatives in computing education and pedagogy with which critical computing is in conversation, and unpack their critical and pedagogical projects. These include the *Chaos Computer Club* in Berlin, Julian Oliver's *Critical Engineering Working Group* and \_\_\_. I also provide a brief commentary on what is at stake in disciplinary constructs such as the digital humanities, and initiatives such as MIT's ‘Critical Computing’ group. It is not, however, my intention to provide a thorough analysis of these initiatives. I mean only to put them in conversation with critical computing as it is conceieved in this thesis, as I see many of them as like-minded and mutually constructive initiatives.

In Part II, I formulate a practical methodology in critical computing that uses 3-D animation to make visible, politicize, and enable critique of the architecture of crucial digital and technological infrastructures that shape the modern world. This methodology uses Ivor Goodson's and Scherto Gill's theoretical framework in their 2014 book, *Critical Narrative as Pedagogy* to theorize narrative as a presentational mode that generates critical discourse with respect to technical operations in computing for a non-specialized audience. To demonstrate, I present a 3-minute film about the architecture of the Internet, the world's most ubiquitous and pre-eminent technological infrastructure.

The film narrates the journey of a data packet sent from a cellphone in Madrid, Spain to a Facebook server in North Carolina, United States from the 'first-person' perspective of the data packet. The film's critical intention is to detail that the Internet, though often thought as 'the cloud' through Mircosoft's commercial rhetoric in the early 2000s that gave rise to that conception, is actually enabled by a global, physical infrastructure of cables, routers, and other hardware that are subject to material and geopolitical exigencies. The film represents a concrete step towards a pedagogy of critical computing, and intends to foster discourse regarding what is at stake in the Internet's socio-political operations—for us as political subjects, as agents, and as bodies.

PART II

STORYBOARDING

Why narrative? – *Critical Narrative as Pedagogy*. Why 3D? – more room for complex representation, *Forensic Architecture*. Why film, rather than VR or video game? – formalized medium, we are familiar enough with it so as not to deride it as kitsch; concrete distillation of complex layers. Then: spell out how it carries the potential for ‘critical discourse’ as a methodology in critical computing.

**WHY NARRATIVE**

Storytelling is acknowledged as an effective methodology in computing culture.

* Storytelling through Agile development, ‘user stories’.
* Increasing call for ‘narrative’ pedagogies in teaching software. Gamified resources for learning how to code, etc. CS literature here, could review more.
* *Critical Narrative as Pedagogy*,
* Documentary film-making, the cultural history that looks to animate data through narrative frameworks.
  + Edward Said, *Culture and Imperialism* 1994: “stories are the heart of what explorers and novelists say about strange regions of the world; they also become the method colonized people use to assert their own identity and the existence of their own history. The main battle in imperialism is over land, of course; but when it came to who owned the land, who had the right to settle and work on it, who kept it going, who won it back, and now who plans its future—these issues were reflected, contested and even for a time decided in narrative.” pp.xiii
  + In fact, they are still decided by narrative: c.f. legal narrativity. The construction of the national subject in a court of law is still formed and defended around narratives qualitatively comparable to those persuasionist tactics used in Greek courts to appeal to the sympathies of the democratic ballots (c.f. high school Classics texts). The narrative status of the legal subject is highlighted in Forensic Architecture’s work: c.f. Keenan’s essay, and the role that racialized narratives play in the performance of legal persecution, white supremacist shooting. *Narrative’s legal legibility in democratic governmentality*.
* Which leads us (ish) to Pixar’s and Disney’s prerogative: to literally animate data through narrative frameworks.
  + Pixar literature, aesthetics of this work.

**WHY FILM**

Many experimental interactive teaching resources fall through, as they ride a wave of kitsch that permeates all new forms of technology.

* There is a media-cultural legitimization that takes place with new technologies
  + Theatre: still very little legibility (through Plato’s anti-theatrical bias)
  + Film is an established form of representation, particularly pertinent to documentary.
* *Documentary*: this genre contains a media-specificity that we often don’t admit; it is filmic. When thinking about making a documentary of the Internet, the question becomes: how to legitimately portray the Internet when its fundamental concepts have no materiality; at least, not in the same way that we can show the materiality of a phenomenon (c.f. *Fuoco Ammare*).
* Animation: through Lamarre, an emerging legitimacy.
  + Allows us to look at the architecture (and consequently politics) of something that is not actually visible.
  + Particularly relevant to software complexes, as software architecture is *spatial*.
  + Is particularly punctual in keeping from code’s frightening syntax.
    - In CS classes, you are taught architectural paradigms, not code. The code is the implementation of the architectural paradigms (and utterly important; the building processes)—but as an intellectually engaged observer, you don’t need to know everything about the building to appreciate the political figurations in which the architecture is implicated, or implicates its residents.
    - In this sense too, can be both a tool for young viewers, but also theoretically interesting and engaging across many generations and areas of expertise.

**WHY 3D**

More room for complex representation. Reusable and open source models, iterative corrections, re-animations possible.

* *Forensic Architecture*, shows the critical potential of 3D? (maybe unnecessary)

**ANIMATED DOCUMENTARY OF COMPUTING INFRASTRUCTURE**

A dialect of critical computing: making complex infrastructural(ist, c.f. Durham Peters) concepts available to an audience that is not code nor algorithmically literate.

PREPRODUCTION

Creating a 3-D animated short is, it turns out, no trivial project. There are multiple steep learning curves to scramble up. To name a few: 3-D animation suites, story construction, animation technique, character realism, 3-D lighting theory, rendering softwares and techniques, 2-D post-production, other contingencies of film production such as audio—and on top of this, practicing and refining a data-intensive workflow and pipeline that requires a close attention to folder organization, file types, storage capacity, version control, and keeping backups in case of computer meltdown. The process of learning how to make a 3-D animated film is comparable to learning all the technologies in a full stack web application architecture—front end, back end, devops—that are all in unfamiliar programming languages.

In order to make progress on the task at hand, it is imperative to schedule, prioritize the task at hand, and take shortcuts wherever they are available. It is all too easy to get lost down a rabbit hole reading about technical domains that are not at all relevant to the short one is trying to make. The world of 3-D animation, like so many other software parishes, is vast and pregnant with marvelous fissures of techno-religious reverie that self-implode a project’s progress.

At places like Pixar and Disney, 3-D animated films and shorts are produced by a creative-industrial pipeline.

To come:

* The remainder or Part I, as proposed in the first four pages above.
* The detailed and theorized outline of 3-D animation as critical computing pedagogy. This will discuss why animation is compelling pedagogically, why narrative is the preferred methodology, and why 3-D space is a fertile medium for representing complex technological architectures that has not yet been adequately practiced or explored.
* A once-over on 3-D animation in industry structures such as Pixar and Disney, and a comparative framing of my approach.
* A reading of my own short with respect to its critical potential (as located in the three dimensions outlined in the first section of this draft).
* A ‘further work’ section that explains what the specific fruits of this thesis’ labour are, how they can be extended and/or reworked, and what other forms of critical computing might arise.

BACKGROND

It has been my intention to construct a project that investigates computing infrastructure with a critical interface since at least January 2017. While taking pause from school back home in New Zealand, I started collecting notes towards a critical history of the web browser: starting with Tim Berners Lee’s inaugural *WorldWideWeb* in 1989, the browser that was coevally released with the Internet itself, through the browser’s commercialization by Netscape in the early 90s, the browser wars at the turn of the century, and the highly corporatized ‘free’ nature of the web browser today.

After some research, it was somewhat astonshing to me that, though there exist many histories of the Internet,[[9]](#footnote-9) there seems to be no book-length history of the web browser available. The history exists only as a Wikipedia page, and is also collected in part as chapters of these histories of the Internet, between software development manuals, corporate retrospectives and other technical documentation such as Internet RFCs; but has not yet been readily collected in one text for the critically engaged reader who is not necessarily a computer scientist.[[10]](#footnote-10)

During a PIIRS Research Fellowship in Berlin in the summer later that same year, I worked to design a project for my thesis that would present Internet architecture in a form that might prove interpretable to my peers and colleagues in humanities departments, and to a more general public. It was clear from conversations that there was a general desire to learn more about how the Internet worked; but, not knowing how to code, they considered much of the widely available technical documentation (such as Stanford’s whitepaper[[11]](#footnote-11)) somewhat inaccessible (see pp.xxx in Part I regarding the hyper-disciplinary gap to Computer Science.)

I iteratively researched (and in some cases began implementing) a range of different projects with this in mind. Some of these false starts are outlined here:

* A ‘wayback’ browser emulator through which to explore the development of Internet aesthetics from the 90s to the present.
* A stand-alone browser that would explain parts of the Internet as it happened, instead of displaying HTML and CSS in their conventional attire.
* A proxy web application that uses a headless browser under the hood to retrieve websites and ‘annotate’ them to explain how parts of them work.

While these projects remain interesting to me, I came to realize that their ability to reach a non-technical audience might be limited. More likely, I would create another poorly maintained web application that doesn’t do quite do what it promises, and is of dubious use to anyone.

In the course of keeping up with web development while working on these projects, I was reading Lin Clark’s ‘code cartoons’ on WebAssembly and Mozilla’s new *Quantum* browser engine.[[12]](#footnote-12) Clark’s blog posts deep-dive into technical intricacies of parts of the Firefox browser, illustratively using cartoons to clearly demonstrate what is happening in an algorithm, or some other programming construct. As concepts in computer science tend to be spatial (there is a reason we talk about computer and software *architecture* rather than computer *literature*), cartoons and diagrams are a principal pedagogical tool.[[13]](#footnote-13) Even if one doesn’t understand the semantic convolutions of a given language, it is almost always possible to understand what is happening conceptually by looking at a diagrammatic representation of the algorithm. Thinking these false starts and code cartoon as pedagogy together led me to thinking that the best way to detail the architecture of the Internet was not necessarily through an interactive structure, but rather first and foremost through an analogue of this diagrammatic pedagogical paradigm.

1. David Macey, *The Penguin Dictionary of Critical Theory.* Penguin Books, 2002. pp.75-76. [↑](#footnote-ref-1)
2. See—Jay, Martin. *The dialectical imagination: a history of the Frankfurt School and the Institute of Social Research 1923-1950*. Berkeley: University of California Press, 2008—for a sound intellectual history. [↑](#footnote-ref-2)
3. "critical, adj.". Definition 3c. OED Online. January 2018. Oxford University Press. http://www.oed.com/view/Entry/44592?redirectedFrom=critical (accessed March 02, 2018). [↑](#footnote-ref-3)
4. 'Democratically consistent' here indicates that there should be no anti-egalitarian qualifications for this audience; economic, racial, gendered, or otherwise. The Brazilian theorist Paulo Freire articulates the egalitarian labour that is contingent to critical thinking in his eminent 1970 work, *The Pedagogy of the Oppressed* (Freire, Paulo. *Pedagogy of the oppressed*. Penguin Group, 1996). As Scherto Gill notes in his 2014 essay *Reframing the Critical*: Friere's conception of the critical investigation "in turn helps men and women develop a critical form of thinking about their world, through dialgoue. The dialogic approach to education is not to impose or convey any existing views, but rather to explore shared understanding about the world. Part of the dialogue is to enable the oppressed to identify that the oppressor has been 'housed' in the oppressed; consequently, the oppressed is a dual being, as he/she continues to carry the oppressor within himself/herself." (Goodson, Ivor, and Scherto Gill. *Critical Narrative as Pedagogy*. “Reframing the Critical.” New York, NY: Bloomsbury Academic, 2014.) [↑](#footnote-ref-4)
5. <https://citp.princeton.edu/about/>, accessed 3/2/18.. [↑](#footnote-ref-5)
6. <https://citp.princeton.edu/events>, accessed 3/2/18. [↑](#footnote-ref-6)
7. c.f. Jasmine Peled's thesis workshop on ethics, Jonathan Lu's seminar last semester, *Society and Ethics of Computer Science*, Princeton AI4ALL, <http://ai4all.princeton.edu>. [↑](#footnote-ref-7)
8. need citation? surely interdisciplinarity is established enough now... [↑](#footnote-ref-8)
9. For a good example, see Johnny Ryan, *A History of the Internet and the Digital Future*. London: Reaktion Books, 2013. For many others, just type ‘history of internet’ into Google. [↑](#footnote-ref-9)
10. This paper is currently incomplete, titled at present *Towards a Critical History of the Web Browser*. I am meaning to re-write and eventually publish it somewhere. [↑](#footnote-ref-10)
11. <https://web.stanford.edu/class/msande91si/www-spr04/readings/week1/InternetWhitepaper.htm>, accessed 2/3/18. [↑](#footnote-ref-11)
12. <https://hacks.mozilla.org/author/lclarkmozilla-com/>, accessed 3/2/18. [↑](#footnote-ref-12)
13. Another notable pedagogue who is known for her code cartoons is Julia Evans. See <https://jvns.ca/teach-tech-with-cartoons/>, accessed 2/3/18. [↑](#footnote-ref-13)