Critical Computational Literacy

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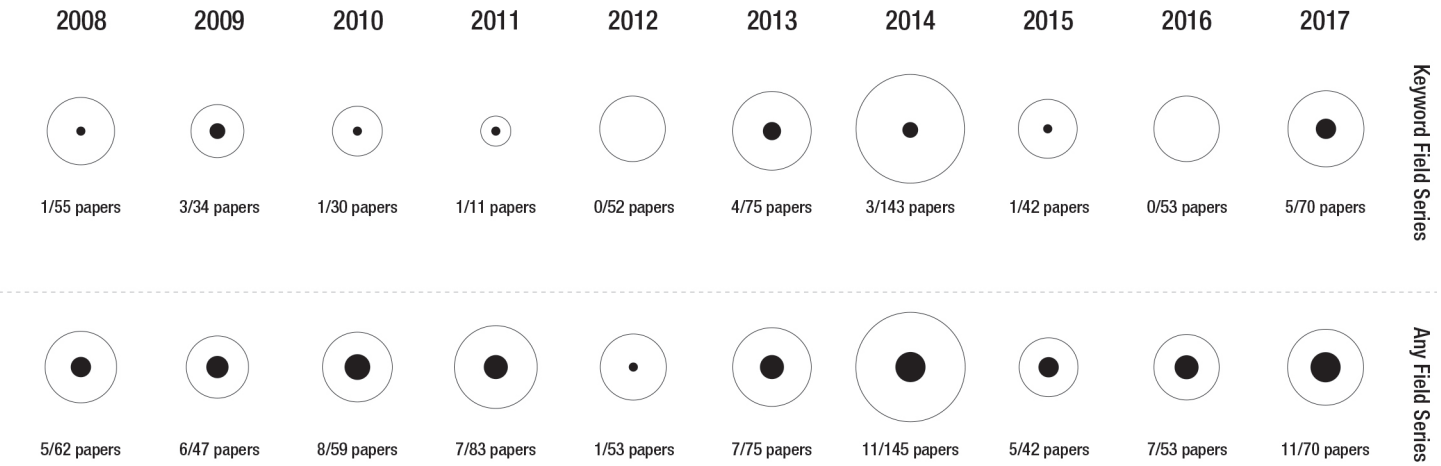
A Call for the Development of Socially Aware, Ethically Minded Research within ACADIA



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ABSTRACT

As computational design matures and strives to move out of the studio/lab and into the real world, multiple dimensions of literacy, valuing the social, the political, and the ethical as well as the technical and the creative, must be acknowledged and supported. This paper evaluates the presence of research advancing socially aware, ethically minded issues currently found in ACADIA's body of research and offers a strategy for shaping future work in this area. First, data from the CumInCAD index is used to provide a quantitative understanding of the degree to which these issues are represented in ACADIA's history, with particular focus on the last decade. The paper goes on to articulate key offerings from the field of Software Studies to motivate and identify possible entry points for computational designers to further engage the social and ethical agencies tied to their work. Within this context, the paper argues that the set of lenses used to understand a project's digital components expands to include social, cultural, political, and ethical effects in addition to the technical realities of implementation. The analytical methods presented are intended to support a preliminary survey of ACADIA's literature and serve as a first step in identifying avenues for pursuing socially aware, ethically minded computational design research.

1 A year-by-year summary of the proportional representation of thematic search terms, covering issues of ethics, society, politics, and critique, appearing in ACADIA papers in the past decade. The methodology used to construct this summary is described in the paper.

ID	AUTHOR	YEAR	TITLE	SOURCE	SUMMARY	KEYWORDS	TYPE
...	...	...	...	...	...	...	...
acadia16_362	Beesley, Philip; Ilgun,	2016	Hybrid Sentient Canopy: An im-	ACADIA // 2016:	This paper	intedisciplinary/collaborative	ACADIA
acadia16_164	Braumann, Johannes;	2016	Towards New Robotic Design Tools:	ACADIA // 2016:	This research docu-	material tolerances, individual-	ACADIA
acadia16_424	Twose, Simon; du Chat-	2016	Experimental Material Research -	ACADIA // 2016:	This research in-	object-oriented inquiry,	ACADIA
acadia16_72	Harrison, Paul	2016	What Bricks Want: Machine Learn-	ACADIA // 2016:	Ruin has a bad	rigid body analysis, machine	ACADIA
acadia16_196	Schwinn, Tobias; Krieg,	2016	Robotic Sewing: A Textile Approach	ACADIA // 2016:	Unlike any other	textile connection, robotic fab-	ACADIA
acadia17_18	Abdel-Rahman, Amira;	2017	Magnetic Morphing	ACADIA 2017: DIS-	In an attempt to de-	material and construction;	ACADIA
acadia17_28	Aguiar, Rita; Cardoso,	2017	Algorithmic Design and Analysis	ACADIA 2017: DIS-	In the past, there	design methods; information	ACADIA
acadia17_38	Ahlquist, Sean; McGee,	2017	PneumaKnit: Actuated Architectures	ACADIA 2017: DIS-	This research	material and construction; fab-	ACADIA
acadia17_52	Ajlouni, Rima	2017	Simulation of Sound Diffusion	ACADIA 2017: DIS-	Acoustical design	design methods; information	ACADIA
acadia17_72	Alfaiate, Pedro; Caetano,	2017	Luna Moth: Supporting Creativity	ACADIA 2017: DIS-	Algorithmic design	design methods; information	ACADIA
acadia17_82	Andreani, Stefano;	2017	Augmented Urban Experiences:	ACADIA 2017: DIS-	The built environ-	design methods; information	ACADIA
acadia17_102	Aparicio, German	2017	Data-Insight-Driven Project Delivery:	ACADIA 2017: DIS-	Today, 98% of	design methods; information	ACADIA
acadia17_110	Arnowitz, Ethan; Morse,	2017	vSpline: Physical Design and the	ACADIA 2017: DIS-	Virtual reality pro-	design methods; information	ACADIA
...	...	...	...	...	...	...	...

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2 ACADIA's Paper History, A snapshot of the database record structure with sample entries.

INTRODUCTION

This paper is prompted by ACADIA 2018's call for self-reflection and its promotion of critical thinking as a tool for computation. As evidenced by the various initiatives aiming to support building-sized fabrication and instrumented sensory environments, the discipline is pushing to move studio- and lab-scaled experiments out of test-bed environments towards real-world deployments.[1] As we prepare for this transition, we need to reflect on the dimensions and values we use to understand and evaluate project outcomes.

As projects move from test spaces with relatively minimal risks to real-world applications with potentially more serious outcomes, we need to incorporate a broader set of concerns, including social, political, and ethical awareness, to acknowledge the projects' increasingly complex context (Shepard 2011). Further, given the hybrid nature of some computational design practice, where physical artifacts and virtual components work together to mediate the environment, designers need to exercise the same criticality they have shown the physical project components towards the virtual project components operating inside the computer and the relationship between the two (De Monchaux 2016). In other words, a more robust notion of computational literacy is needed, wherein the data we integrate and the algorithms we code are understood and examined as designed project elements with agency over project outcomes—not only from a technical perspective, but also with respect to social and cultural impacts (Kitchin and Dodge 2011). This line of inquiry is particularly relevant for a design practice—labelled here as software-embedded-design (SED) and often associated with sentient and responsive projects—in which embedded computational processes contribute to project performance over time and space.

Anticipating this transition, we survey the body of work defining the Association for Computer Aided Design in Architecture (ACADIA) to verify efforts towards capacity building in this regard. Have we built up a body of research to support the development of these expanded forms of computationally literacy?

BLIND SPOT DETECTION

In order to examine the state of ACADIA from the perspective of critical, socially aware, and ethically minded research questions, we conducted an analysis of the ACADIA repository in the Cumulative Index about publications in Computer Aided Architectural Design (CumInCAD)[2]. Data mining software was used to extract all ACADIA paper records (1421 records dating from 1985 to 2017) into an external relational database that supports a wider range of search and sort functionalities. Each paper contained the following fields: ID, Author(s), Year, Title, Source, Summary, and Keywords (Figure 2).

Next, we defined four sets of theme-based terms (Figure 3) designed to capture the issues addressed above, and evaluated the frequency with which the case-insensitive terms

Theme Set 1	Theme Set 2	Theme Set 3	Theme Set 4
Social	Critique	Ethics	Politics
Societal	Critical	Ethical	Political

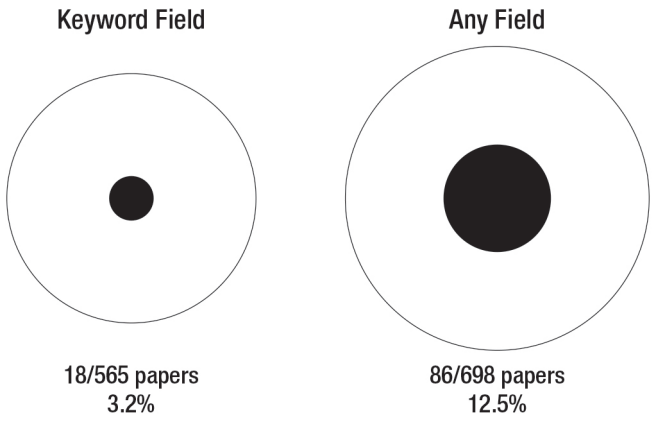
3 Themed search terms used in the ACADIA index scans.

Two types of scans were conducted: in one series, labelled *Keyword Field*, we searched only the Keyword field of each record, and in the second scan, labelled *Any Field*, we looked across all fields within each record. We report on the proportion of papers that contain search terms in either the Keyword field explicitly or more generally, anywhere in the record. Only records from 2008 to 2017

were included, since this the period of time where the inclusion of keyword descriptors as part of paper submissions became standard practice, with 82% (565 out of 689) of papers including keyword entries. Prior to this only 18.9% (90 out of 477) of papers included values in this field.

The presented series of figures captures the results of these searches. Figure 4 presents an overall summary where we grouped all of the search terms into a single scan and counted the number of papers that contain any of the terms in either the Keyword field (left) or, more generally, in any field of the record (right). Figure 5 isolates each of the thematic sets and presents the count and proportional representation of each theme. Figure 1 (presented on the previous spread) uses the same data as Figure 4 but isolates results by publication year.

This quantitative study sheds light on the underrepresentation of critical, socially aware, and ethically minded research within ACADIA over the past decade. The Keyword Field approach produced hits on 3.2% of all papers and the broader Any-Field approach resulted in hits on 12.5%[3] of papers. Notably, the ethics-based word set resulted in zero hits when searching the keywords of 565 ACADIA papers and only 3 hits when scanning all fields of 698 entries. With these results it is clear that blind spots exist around these thematic issues. While excusable, and perhaps even necessary during a period of skill- and technical-focused developments, it is essential that these blind spots are noted and their pursuit is supported and promoted by ACADIA—especially as the community moves its work into more complex contexts with a broader set of stakeholders and possible impacts.[4]



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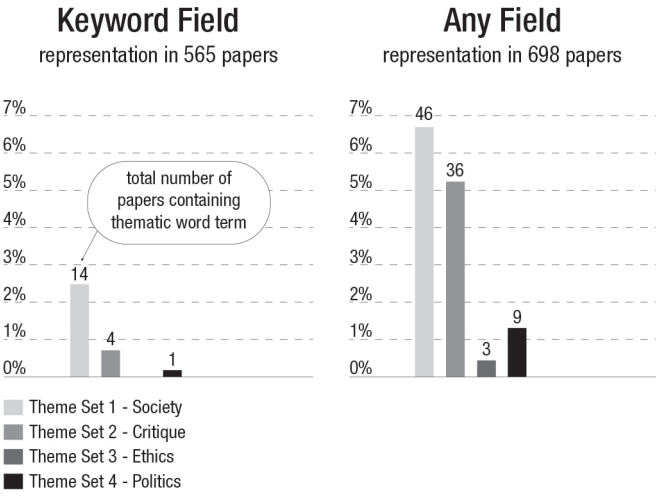

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4 Representation of search terms in ACADIA papers from 2008 to 2017.

5 Proportional breakdown of search results of ACADIA papers from 2008 to 2017 according to thematic groups.

TOWARDS BLIND SPOT CORRECTION

Since little work exists in ACADIA's archive to build upon, we look to external understandings and frameworks to identify possible entry points for guiding the next wave of research exploring the relationship between computationally oriented design practice and social/ethical concerns.

Computational Design as a Social-Spatial-Material Practice

The increasing interconnections between computational elements, material elements, and project outcomes add complexity to how we assess project impacts. Architects are responsible for creating a built environment capable of enhancing certain values while downplaying or rejecting others (Taylor and Levine 2012). Traditionally, these responsibilities manifest themselves in decisions around things like spatial effects, programmatic support, technical performance and, to an increasing extent in recent years, ecological and ethical considerations. With the addition of custom computational procedures as active mediators of project outcomes, architects have essentially added elements such as data and algorithms into the conception of a project's material assembly.

This addition should not be seen as a purely technical challenge, as these computational components have their own capacity to support, enhance, and undermine values and outcomes. This argument is articulated in key offerings from the field of Software Studies that position software—in its actual lines of code, not just its effects—as a material practice with both social and spatial outcomes (Fuller 2008, 87–91; Fuller 2003; Mattern 2016, 49–60). Software Studies positions the design and implementation of both software and the built environment, and the people that populate it, as constituting mediating and shaping forces of everyday life.

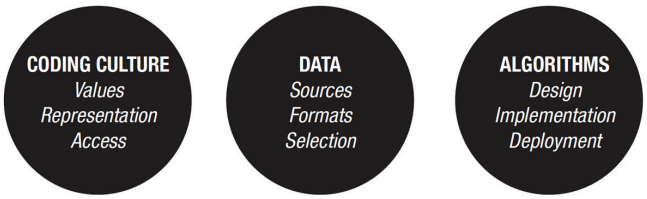
Rob Kitchin and Martin Dodge's concept of *code/space* is particularly useful in trying to understand how architects can establish relationships between immaterial project components, such as data and algorithms, and real-world project outcomes—be they material, formal, or socio-cultural. *Code/space* captures the idea that "spatialities and governance of everyday life unfold in diverse ways through the mutual constitution of software and geo-spatial practices" (Kitchin and Dodge 2011, 16). Through code/space, which the authors define as space dependent on software-driven technologies to function,[5] they position software as a spatial agent by foregrounding the work that software does as a product of people and things in time and space. Using this definition, SED environments clearly qualify as code/spaces, and while many of the technical challenges of SED are being addressed, it is mostly unrecognized that the software/code/data bundles driving such projects have, in and of themselves, direct sociocultural agency; an agency that, if neglected, could be operating independently from, or even counteracting, the effects planned for in the design of the physical project components (Przybylski 2018).

All this points to the need for new analytical frameworks and related tools directed at enabling architects to better understand and more effectively work with computational elements to achieve greater levels of synchronicity between the physical and digital components, ensuring that they are working towards the same set of values, objectives, and outcomes. This is particularly true when the technology is embedded with a goal of supporting, responding to, and mediating the built environment. The set of lenses through which the projects' digital components need to be understood expands to include social, cultural, political, and ethical effects in addition to the technical realities of implementation.

Advancing Critical Computational Literacy

In setting a course for future work in response to these findings, we feel that working to correct this blind spot through a line of inquiry that blends together ACADIA's technically focused approach with the socially minded frameworks emerging from Software Studies is a meaningful pursuit. How we can achieve greater degrees of literacy with the computational elements in our design work—where we begin to read these components not as means to an end but as social and ethical agents in and of themselves?

In synthesizing Software Studies' offerings, we suggest three areas in which these expanded forms of critical literacy should be developed: (1) data (sources, format, and selection), (2) algorithms (design, implementation, and deployment), and (3) coding culture (values, representation, access, and diversity) (Figure 6). Each of these areas demand their own conceptual and methodological frameworks in order to unpack their relationships to project outcomes. We have started to examine data in this context and found that the concept of data quality can be used to achieve more complete engagement with the computational components embedded within SED (Przybylski 2018). The third component, dealing with coding culture, is being tackled across numerous disciplines and has recently been identified as an issue within computational design (Doyle, Forehand, and Senske 2017).



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6 Areas for the advancement of critical computational literacy.

This set's deliberate overlaps with actively explored topics, at least from technical and material perspectives, provide a common ground on which to build richer understanding of computational elements' agencies. The goal should not be to remove computational design discourse from the technically rich context in which it currently resides, but instead to use that context to inform and shape a next generation of methods.

The white-box/black-box model of understanding is useful here. In the black-box model, the lenses through which we examine the outputs and outcomes from SED work need to be expanded to include critical readings in terms of socio-political and ethical impacts. A corresponding white-box model demands that we build capacity in examining the internal structures and workings of embedded computational elements to better understand the relationship between a project's computational components and its real-world, physical outcomes–valuing the social, the political, and the ethical, as well as the technical and the creative.

These preoccupations should not be seen as undervaluing current research efforts but instead as opportunities for advancing new lines of inquiry to complement those already underway and for supporting the inclusion of a more diverse set of voices in computational design research.

REFLECTIONS ON METHODOLOGY

This research is very much a work-in-progress, and its methodology was designed to support a rapid, preliminary survey of ACADIA's literature. While instructive and motivating as a first step, future work is planned to build confidence in the extracted insights. One component of future work is to create a stronger dataset by, first, expanding the current methodology to include the other collections indexed by CumInCAD, and second, combining a broader range of sources related to design computation. Another improvement includes consideration for qualitative measures of the literature, such as papers' impact scores by citations, to establish a measure of quality and influence. As this methodology becomes more robust, it should also undergo a formal review.

CONCLUSION

As we enter new frontiers in computational design, it is no longer enough to only have methods that integrate computation and data in design projects; new methods are needed to engage with it critically throughout the design process and beyond. In shaping potentials for this criticality, we recognize that computational components embedded in design work, such as data, algorithms, and code, have, in and of themselves, direct sociopolitical and ethical agencies; agencies that, if neglected, could be operating independently from or even counteracting the effects intended in the design of the physical project components. Presently, these issues are minimally represented in ACADIA and little is offered to guide its future expansion. Recognition of this disciplinary blind spot is a first step, and the development of new analytical frameworks and related tools to support richer degrees of computational literacy should follow. Without these efforts, the ambitions for much of this work—to seize a capacity afforded through a pairing of computational design and information communication technologies, and to create new inclusive ways to organize, use, and shape the built environment—are undermined and threatened.

NOTES

1. Princeton University's Embodied Computation Lab is an example of such a facility. [https://soa.princeton.edu/global-tags/embodied-computation-lab#2046]
2. CumInCAD is a cumulative index of publications about computer aided architectural design. It includes bibliographic information about over 12,300 records from journals and conferences such as ACADIA, ASCAAD, CAADRIA, eCAADe, SIGraDi, ASCAAD and CAAD futures.
3. This number should be viewed as an upper-limit since the test to be included in the count was easy to meet and when identified records were reviewed manually we found many didn't actually align with the considered themes.
4. In order to better understand such broader implications we can consider the StreetBump smartphone app, designed for the city of Boston, which automatically records and reports pothole locations that need filling to municipal services. The app works well technically and is well-reviewed by its users yet is problematic. Entire groups, perhaps those most in need of new services, either don't have smartphones or the disposable bandwidth needed to participate, and as a result are not only excluded from the process, but are at risk of having their services diverted elsewhere. The software's failing is due not to a coding error, but to a misalignment between the values embedded in the code/data bundles defining the software and its broader goals to improve access to municipal services.
5. For Kitchin and Dodge a modern supermarket is an example code/space: without a functioning check-out system, a supermarket ceases to have the ability to make transactions and it is therefore transformed into a warehouse until the check-out functionality goes back online.

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IMAGE CREDITS

All drawings and images by the author.

Maya Przybylski is an Assistant Professor at the School of Architecture at the University of Waterloo where she runs the DATAlab research group [www.datalab.uwaterloo.ca]. Through her research, she combines her backgrounds in computer science and architecture to position and develop methods for achieving more complete engagement with both the sociocultural agency and technical capacity of the computational components embedded within data-driven design work. She is an editor of [Bracket], a publication series that, since 2010, has documented the intersection of architecture, environment and digital culture. [www.brkt.org]