Fragmented Innovation:
Anime and the Limits of Computer Science R&D

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ABSTRACT

This talk examines Japanese anime production as a case of *undone science* i.e., domains of potential knowledge left underexplored because of institutional, epistemic, and industrial misalignments. It aims to rethink how alternative, sustainable forms of academic-industrial collaboration might be imagined beyond dominant models in computer science.

1 INTRODUCTION

Computer science have advanced through close collaboration between research and industry. In particular, in Computer Graphics, Western studios such as Pixar and Disney are often cited as successful examples of such synergy, where creative production and computer science co-evolved through sustained institutional coupling. Importantly, this model is neither universal nor singular. Different creative industries have developed distinct production logics, infrastructures, and relationships to academic research.

Japan's animation (anime) industry presents a particularly instructive contrast. Despite its global cultural reach and economic visibility, the anime industry has historically developed with limited long-term integration with computer science research. Nevertheless, the absence of a strong academic-industrial feedback loop has not prevented anime from flourishing. Production has continued to scale through highly specialized labor, dense subcontracting networks, and practice-based forms of innovation that operate largely outside formal research frameworks.

At the same time, this apparent success masks a growing sense of structural fragility within contemporary anime production. From the perspective of a researcher embedded in the anime industry for some years, current pipelines seem increasingly strained by intensified output demands, limited opportunities for systematic professional training, and rising technical requirements imposed by global distribution platforms. While anime remains culturally and economically successful, its production infrastructure often relies on ad-hoc solutions and external technological dependencies, suggesting that its sustainability cannot be taken for granted.

Based on the author's expertise as a Human-Computer Interaction (HCI) researcher, this paper examines this tension through the lens of *undone science* [3]: domains of potential interaction knowledge left underdeveloped not because they lack importance, but because prevailing institutional and epistemic structures fail to recognize them as legitimate objects of inquiry. Through the case of anime production, the paper argues that undone science can persist within industrialized societies when specific sectors remain structurally decoupled from sustained computer science research. Crucially, however, whether and how technical intervention should follow is not assumed in advance. This paper offers anime production as a case study for discussing how alternative, sustainable forms of academic-industrial collaboration might be imagined. In doing so, it seeks to provide a groundwork for reflecting on how disciplinary assumptions and positional perspectives shape what is recognized, or overlooked, as a research opportunity.

2 INDUSTRIAL FRAGMENTATION AND THE LIMITS OF ACADEMIC INVOLVEMENT

Pixar's strength lies in an integrated structure that unites creative production, software engineering, and research. This institutional model enables production challenges to evolve into computer science research problems, while research outcomes feed directly into production pipelines. Former Disney and Pixar CEO Edwin Catmull explicitly described his intention to build such a structure: *How do you attract the best people? You do this by encouraging publishing and open communication within a community. I have lifelong friends in the SIGGRAPH community* [13].

In Japan, by contrast, anime production is distributed across numerous small and medium-sized studios, as well as freelance workers connected through subcontracting. This networked ecology sustains stylistic diversity but diffuses responsibility for technological innovation. Note that this does not imply that Japanese or small-scale studios are entirely absent from academic venues such as SIGGRAPH or SIGGRAPH Asia, where technical presentations on anime productions do occasionally appear. The undone science here lies not in the absence of creativity or technology but in the lack of a sustained, institutionalized R&D feedback loop that continuously translates production challenges into research agendas and reintegrates research outcomes into everyday production practices.

Importantly, the Pixar model is not presented here as a universal ideal to be replicated. Rather, it functions as a comparative reference that makes visible how different institutional configurations enable or constrain the coupling of creative practice and computer science research. The question is not why anime production should become Pixar-like, but why alternative configurations struggle to achieve comparable research continuity.

3 EPISTEMIC ASYMMETRY IN COMPUTER SCIENCE AND CREATIVE PRACTICE

Computer science tends to favor domains where problems can be explicitly formalized and systematically measured, such as geometry, lighting, rendering, and physics. While visual aspects of hand-drawn animation can be technically formalized, such as stylized rendering (e.g., cel-shading), the core practices of anime production rely heavily on tacit, situated, and affective judgments developed through repetitive and exploratory manual practices.

Here, apprenticeship does not imply an absence of digital technology. Rather, it denotes a hybrid socio-technical mode of learning in which digital tools are widely used, yet key evaluative criteria and production heuristics remain embodied and experiential. Such forms of expertise resist simplistic mathematical representation, perhaps too complex to be captured by the mathematically elegant formulations favored in computer science, and thus remain underexplored in research that demands explicit models.

As Greenberg and Buxton [4] and Dourish and Mainwaring [2] observe, HCI's reliance on universal evaluative standards can obscure the social and cultural complexity of human practices. In this sense, the expressive core of anime production, namely the negotiation of line, timing, and emotion, constitutes a zone of undone science within computer science, not because it is unresearchable in principle, but because it is rendered difficult to study within disciplinary norms that privilege explicit formalization, generalizable metrics, and short-term experimental validation.

A recent effort to confront this asymmetry is *Griffith* [8], a storyboarding tool co-designed with Japanese animation professionals. Rather than replacing existing media, *Griffith* engages with the historical evolution of *E-conte* (translated as "storyboard" in English) as a cultural interface, revealing how inherited techniques can inspire new interaction designs. Another approach involves running experimental short anime production in parallel with the development of a practical style transfer pipeline [14], thereby situating technology development directly within ongoing production practices. Together, these efforts challenge the future-oriented bias of computer science by situating innovation within cultural continuity.

4 LINGUISTIC AND INSTITUTIONAL FILTERS IN COMPUTER SCIENCE

The global ecosystem of computer science is dominated by English-language publication and a preference for technical novelty. As noted in the *Special Interest Group on Creativity and Cultures in Computing (SIGCCC)* [7] and critiques of WEIRD biases [10], the academic center of gravity being situated in Western cultural contexts privileges seemingly universal abstractions that often embed implicit biases aligned with Western common sense. For instance, conducting research on YouTube rarely requires additional contextual explanation, whereas studies centered on platforms such as Niconico Douga or Bilibili typically demand extensive background description or, in some cases, explicit justification.

For researchers interested in anime production, this situation creates a double bind. Studies grounded in the wild often need to be conducted in Japanese, which raises the bar for non-Japanese researchers and consequently limits the size of the research community. Even when such studies are conducted, they are frequently criticized as parochial, overly descriptive, or "niche," while more abstract approaches tend to lose relevance to industry practices and local creative cultures. As a result, many potential research topics, such as workflows, conventions, and aesthetic logics specific to anime, remain systematically underrepresented in mainstream computer science discourse. Linguistic and institutional barriers thus contribute to undone science not by censoring research, but by shaping what counts as legitimate and researchable knowledge.

5 THE INDUSTRIAL-ACADEMIC DOUBLE BIND OF UNDONE SCIENCE

Taken together, the industrial fragmentation described in Section 2, the epistemic asymmetry examined in Section 3, and the linguistic and institutional filters discussed in Section 4 configure a structural double bind that helps explain why certain research problems in anime production remain undone.

Undone science in anime production does not result from a lack of technological sophistication or creative expertise. It does emerge from a persistent mismatch between the organization of production and the institutional logics of computer science research. On the industrial side, anime production is distributed across small studios and freelance networks that sustain rich creative practices but lack stable entities capable of translating situated production challenges into long-term research agendas. As a result, potential research questions remain embedded in practice without becoming legible as scientific problems.

On the academic side, computer science research is organized around evaluation regimes that privilege formalization, generalizability, and technical novelty. Research grounded in anime production, however, often requires long-term engagement, attention to culturally specific practices, and outcomes that resist standard experimental validation. Within prevailing disciplinary norms, such work is therefore difficult to justify, sustain, or reward, even when its relevance to practice is evident.

Neither side can independently resolve the gap: industry lacks the institutional capacity to host sustained research, and academia lacks evaluative frameworks that recognize practice-grounded experimental inquiry as legitimate computer science. The result is not merely an absence of collaboration, but the stabilization of undone science: domains of potential knowledge that remain systematically underexplored despite their significance.

6 EMERGING SIGNS OF CULTURAL-TECHNICAL MEDIATION

Despite these constraints, several recent developments hint ways to engage with this undone science. On the industry side, the organizational conditions of anime production are also beginning to shift. Recent years have seen ongoing consolidation through acquisitions by larger companies, as well as efforts to stabilize labor by transitioning some freelance roles into salaried positions. At the same time, a younger generation of creators is emerging whose familiarity with digital tools and workflows has reduced resistance to technological intervention, potentially lowering the barriers for sustained engagement with research-oriented practices.

The ongoing digitization of anime production pipelines enables forms of data collection and tool experimentation that were previously infeasible. Data-driven methods can now model certain aspects of creative work without requiring explicit formalization; however, critiques of technosolutionism [9] caution that such approaches must remain grounded in cultural practice rather than framed as standalone solutions. Additionally, growing awareness of cultural asymmetry within the HCI community [10] has created space for alternative epistemologies.

Among emerging initiatives, *Animāre* [6] seeks to build an R&D network linking anime studios and researchers through co-located

fieldwork and prototype tool development. As opposed to typical data-centric AI innovations that treat datasets as primary assets, this project centers tools for artistic creation. Rather than merely collecting datasets that may become obsolete as creators adapt their workflows, it focuses on documenting and archiving the tools in use, along with representative sample data, to support a community-oriented and sustainable ecosystem of tool development and practice.

Feedback loops within such a community may enable, for example, the co-design of tools that externalize otherwise tacit production criteria, the development of evaluation methods grounded in professional judgment rather than abstract benchmarks, and new forms of data stewardship that respect the distributed authorship characteristic of anime production. Rather than centralizing resources as Pixar does, *Animāre* adopts a distributed model suited to Japan's multi-studio ecology, proposing a cultural-technical infrastructure through which computer science can engage production contexts in the wild [12] as part of longitudinal inquiry [11].

7 PROGRESS, LEGACY, AND THE UNDONE SCIENCE OF COMPUTER SCIENCE

While anime production serves as a particularly revealing case, the argument developed here is not confined to this industry alone. Similar patterns of institutional persistence and epistemic neglect can be observed across many domains where legacy practices coexist with rapidly advancing computational technologies.

Disciplines such as HCI have long been driven by the technological paradigms, from command lines to graphical user interfaces, from the web to mobile, and more recently to AI and mixed reality. Each paradigm shift opens new research opportunities yet often leaves earlier ones conceptually and institutionally unfinished. Forty years after the rise of the GUI, the field has accumulated its own legacies, including systems, interaction styles, and cultural practices that persist but remain under-theorized. Addressing such legacies requires theoretical frameworks beyond specific technologies, such as generative theories of interaction [1]. These legacies are themselves undone sciences, areas where knowledge has not kept pace with the technologies once created.

In this sense, the challenges faced by anime production mirror those within HCI. Both fields struggle to balance technological novelty with the maintenance and reinterpretation of accumulated practices. *Griffith* [8] exemplifies how revisiting a historical artifact, the storyboard (*E-conte*), can generate new design insights. It demonstrates that innovation can emerge from re-engaging with the material and cultural residues of earlier practices.

For computer science, acknowledging such residues is not nostalgia but a form of critical maintenance. Recognizing undone science in our own past as well as in emerging technologies broadens the scope of what counts as scientific progress. To move forward, we must develop research frameworks that treat legacy systems, practices, and cultural techniques not as outdated detours but as active sites of inquiry where new paradigms might again be born.

8 AUTHOR BIOGRAPHY

Dr. Jun Kato is a senior researcher at AIST and a technical advisor at Arch Inc. He was a visiting scientist at Université Paris-Saclay in 2024 and is currently there for a one-month stay in March 2026. His research in HCI focuses on studying creative practices and on building and deploying creativity support tools in the wild as a "toolsmith researcher" [5]. He is the principal investigator of the *Animāre* project [6], which sets anime creation as a key application domain to develop foundational techniques for malleable tools and realize an environment where anime creators and tool developers can form reciprocal relationships.

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