Augmenting Creative Symbiosis Using a Cyber-Physical Aesthetic

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Abstract

Creative arts organizations are constituted by intricate symbiotic relationships between diverse stakeholders, including creatives, technicians, software programmers and producers. These thrive when facilitated by clear, seamless and swift communication. Cyber-physical systems can support such exchange yet require careful aesthetic design. Inspired by Manuel DeLanda's philosophical framework, the paper introduces *iModel*, a new networked modelling system that facilitates operatic rehearsal design via an interactive cyber-physical spatial aesthetic. After mapping its conceptual framework, we detail *iModel*'s architecture and functionalities that provide a shared workspace for distributed teams. *iModel* is capable of assimilating diverse data formats and enabling real-time manipulation and seamless previsualization of complex interactions between all components of operatic production, including orchestration of set ensembles, video content, cast movements and lighting design, all synchronized with the musical score. The paper reflects on *iModel*'s real-world application in 2022 in the design and technical production departments at Opera Australia, Australia's largest performing arts organization. We conclude with a reflection on the coalescence of philosophy, art and technology as a powerful conduit for catalyzing creative practice toward realizing new symbiotic imaginaries on and beyond the screen.

Keywords

Collaborative Design, Cyber-Physical Integration, Manuel DeLanda, Modelling System, Opera, Process Optimization, Real-Time Interaction, Rehearsal Design, Spatial Aesthetics, 3D Visualization.

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Introduction

Organizations in the creative arts are constituted by intricate symbiotic relationships between diverse stakeholders, including creatives, technicians, software programmers, producers and technology—who rely on each other's input to develop and realize cohesive creative endeavors. The Covid-19 pandemic has disrupted these relationships by inhibiting the sharing of physical space, traditionally central to artistic practice. This has challenged the sharing of ideas and creative visions through embodied exchange. Attempts to mitigate the impact of lockdowns and their mandate of social distancing, have driven the accelerated adoption of newly emergent digital technologies to facilitate collaboration across dispersed locations [1] . This embrace of cyber-physical engagement has induced a shift in the experience of space more broadly, initiating a new type of virtual yet visceral immediacy, where formerly the significance of geographical distance dominated [18]. However, the promise of approximating and expanding the utility of presence and seamless interaction in virtual space still remains an aspiration whose full productive capabilities are yet to be realized [16]. The forced rapid transition to digital collaborative tools and platforms among organizations from 2020 onward has painfully revealed the limitations that still exist in available hard- and software systems when it comes to facilitating and optimizing creative exchange across time and space as well as among diverse teams. This becomes obvious, for example, in lagging real-time collaboration features within networked environments, inability to preview diverse file formats in a unified visualization space, or lack of animation capabilities to orchestrate the intended interaction of separate design elements when coalesced into complex assemblages. Due to such limitations, established approaches are still unable to optimally support symbiotic relationships between technical and creative teams who rely on interdependent and reciprocal cross-pollination in ideation and prototyping processes. Consequently, teams struggle to unlock new horizons for collaboration and creative scope both in the virtual as well as in the—once again—accessible physical domain. At a time when the digital is shaping expectations for sophisticated visual content in all domains, creative sector organizations need to explore ways to enhance design ideation, production and evaluation using hybrid cyber-physical systems [17]. In a cyber-physical system, "computational elements heavily interact with physical entities, thus controlling individual, organizational or mechanical processes" [22] . To advance the dormant capabilities of digital technologies for expanding creative collaboration in art and design practice as a symbiotic partnership, we believe it is necessary to investigate interactive cyber-physical aesthetics as a conceptual foundation for new digital platforms. Such an aesthetic has to conceive humans and technologies as equally ranked symbionts in order to be able to address the current limitations in cyber-physically enabled creative collaboration. Approaches such as that developed by Manuel DeLanda (1998) open avenues to transcend human-centered concepts by reformulating the world as a field of informational and material processes from which an infinite number of entities may be formed. This philosophical framework enables investigation of the diverse relations between people and technologies as malleable and open to intervention in ways that enhance symbiotic exchange.

In the following, we briefly outline elements of DeLanda's philosophical framework that have informed the development of *iModel*, a networked modelling system that facilitates operatic rehearsal design via an interactive cyber-physical spatial aesthetic. After mapping its conceptual framework, we detail *iModel*'s architecture and functionalities that provide a shared workspace for distributed teams. *iModel* is capable of assimilating diverse data formats and enabling real-time manipulation and seamless previsualization of complex interactions between all components of operatic production including orchestration of set ensembles, video content, cast movements and lighting design, all synchronized with the musical score. This paper reflects on *iModel*'s real-world application in 2022 in the design and technical production departments at Opera Australia (OA), Australia's largest performing arts organization. The paper concludes with a reflection on the coalescence of philosophy, art and technology as a powerful conduit for catalyzing creative practice toward realizing new symbiotic imaginaries on and beyond the screen.

Conceptual Baseline: Manuel DeLanda

By drawing on Gilles Deleuze and Fe´lix Guattari's readings of the works of Baruch de Spinoza and Henri Bergson, Manuel DeLanda develops a philosophical framework centered on the argument of 'immanent morphogenesis' [9], roughly translated as the inherent ability of entities to self- organize their development. By probing the question of both how matter comes to be and to assemble into innovative complex forms (such as bodies and technologies), DeLanda develops a theory of

self-organization [13] that is premised on the existence of energetic flows, which are striving yet forever failing to reach an equilibrium state [5]. The inherent drivers, or aesthetic codes, underpinning these processes are 'virtual forms' that trigger and galvanize evolutions of matter into 'actual forms' that present as phenomena to the human senses. As codes rather than blueprints, virtual forms do not predetermine the specific articulations of phenomena but constitute an 'energetic possibility space' that is radically open to intervention and evolution [2]. With flows being subject to heterogenous and conflicting influences, they are compelled by imbalances that call for harmonizing. Citing Deleuze, DeLanda (1998) captures these imbalances as caused by "differences of level, temperature, pressure, tension, potential, difference of intensity", and increase energetic flow relative to their degree of disparity. Matter here exists in a "phase space, i.e., a space of possible states for each object" [3] —with a 'stable state' representing the preferred state in which an object is maximally harmonized. DeLanda argues that, in the chaotic swirling of energetic flows, approximation of stable states is achieved more readily (but never fully realized) through coupling of simple forms into higher entities. This is because coupling of forms can cater to a set of dispositions shared among these forms, and represent an energetically more resilient, hence favorable, state. DeLanda conceives states along a continuum from 'preferred stable states', which he refers to as "attractors", to least probable and volatile couplings, which he terms "repellors" [10]. Attractors are thereby capable of generating new dynamic structures in higher entities through interaction of constituent parts, refracting energetic flows onto new trajectories that open capabilities for novel constellations with new, and ever more complex, balancing requirements. DeLanda captures such branching and its dynamic mutational qualities in the term 'bifurcation' [4]. As Christian Hubert explains "bifurcations modify an entity's tendencies and represent a source of creativity and variability in nature" [14]. Once forms approach a stable state, they solidify into entities that "down-wardly select states of [their] component units that are [most] compatible with that global state" [11]. This embarking on an iterative design process reassembles and optimizes the cohesiveness of the higher entity [11]. DeLanda emphasizes that complex higher entities always unfold capabilities that exceed the limitations of their simple individual component parts [12]. He argues that these immanent aesthetic codes that govern the self-organizing production of matter (that is, its morphogenesis) underpin both organic and inorganic life [6]. Consequently, he deduces that on a formative level, humans and technologies must be conceived as morphologically alike because they are part of an integrated "machinic phylum" (lineage or body plan) that synthesizes elements according to "similar self-organizing and combinatorial processes" [4]. DeLanda here adopts terminology of Deleuze and Guattari who use the qualifier 'machinic' with the intent to highlight "the existence of processes [virtual forms] that act on an initial set of merely coexisting, heterogeneous elements, and cause them to come together and consolidate into a novel entity" [4]. DeLanda refers to this consolidation as bifurcation that happens at the point of 'singularity', that is a tipping point at which new characteristics emerge that "chang[e] the forms through which human bodies and materials are combined, organized, deployed, and made effective" [7]. He emphasizes that bifurcations are most productive if coupling occurs between forms that are heterogenous because this enables a diversity of possible trajectories into the future [4]. It can give rise to processes that act as catalysts, intervening into processes and facilitating encounters between components that would otherwise not have occurred, channeling energy onto unexpected trajectories.

Application: *iModel* System

DeLanda's philosophy commends itself as a conceptual framework for creative collaboration, and especially in the operatic sector, because it allows conceptualization of stake-holders, ideas, technologies and materials as an interdependent web of symbionts that coalesce into an ecology whose scope expands or contracts in line with the degree of flow. As a group-based aesthetic practice, opera involves a spectrum of digital and physical components and engages an ensemble of creatives at a larger scale than other art forms. For example, components flowing into a production may include choreography, costumes, lighting, music, props, scenography, robotic LED screens and revolves – all developed by domain-specific artists (graphics, modelling, photography, robotics, video), designers (costume, lighting, production, prop), directors (musical, stage, technical), and implemented by diverse technical crew, cast and orchestra. As such, operatic production constitutes a symbiotic ecology in which each craft depends on the communication with and input of others to realize its purpose and to thrive, through reciprocal loops of collaboration, into a new higher entity, in this case the stage production [21]. Conventional rehearsal design sees most creative team members develop their ideas in response to a production brief, mapping ideas in

isolation, using incompatible analogue/digital platforms [19]. The team then discusses concepts in development meetings, and makes amendments following these, again in relative seclusion. The combination of single ideas being transformed into complex assemblages that may yield a cohesive aesthetic for a production (approximating a Delandian stable state) hinges on the facilitation of productive communication among the diverse team. We argue that the more sensorily seamless this communication, the more readily attractors may emerge that enhance creative scope and complexity of design. The ability to combine heterogenous elements and design strands at various stages in the ideation, testing and evaluation phases can catalyze a process of cross-pollination and analysis that far exceeds capabilities of current stand-alone creative pipelines. If draft components can be assembled in fruitful, ongoing dialogue, bifurcations—resulting from conceptual and experimental tensions—can be identified and explored at length. Their resultant trajectories can feed into iterative design loops that may crystallize into more coherent and innovative operatic designs. Prerequisites for a system that can prompt creative singularities and act as a catalyst for the exploration of bifurcations, are:

– an interaction design that accommodates the diverse needs of the creative and technical teams;

– a visualization architecture that delivers a shared environment, in which the input by all user groups can be synched, reviewed and adapted in real time.

We believe that additional synergies may be unlocked if such a system can be articulated to the human body in ways that enable a visceral investigation of the modelling space because human sense-making capabilities would be activated that exceed a solely visual contemplation.

Responding to this brief, an interdisciplinary team of artists, computer scientists, architects, theatre and 3D modelling experts at The University of New South Wales, led by Laureate Professor Dennis Del Favero, has been developing the *iModel* prototyping system in collaboration with OA. Their objective has been to probe in how far interactive spatial aesthetics and associated new technologies may support the collaborative design process as a self-organizing, positive symbiotic exchange between institutional departments and across the human-machine interface. By seamlessly integrating creative ideation and production pipelines via cyber-physical architectures, the project seeks to provide solutions for unlocking the dormant potential of OA's strong investment into digital innovation—palpable, for example, in its pervasive use of large-scale modular LED screen assemblages. These require safe orchestration with physical props and cast as well as complex multi-screen mapping, which—in turn— intensifies the organization's need for a powerful integrative pipeline that can increase the rapport between their teams and the available technological platforms. To address these challenges, the team behind *iModel* has been developing a cyber-physical spatial aesthetic that facilitates the modelling of an operatic design within a shared 3D virtual environment by means of dynamic joint human-machine decision making. It provides a creative ensemble with the ability to develop and evaluate design components in real time prior to stage rehearsal across diverse platforms, ranging from desktop computers and tablets to 360° 3D cinematic CAVE theatres [15]. Using a dynamic visualization pipeline, team members can upload their domain-specific components into a shared modelling space where they can virtually validate designs before physically testing them on stage. This is facilitated through capabilities such as real-time collaborative composition and manipulation of components; playback of component operation, both individually and in combination, in time with the musical score; as well as AI-supported analysis of component composition and interaction, including collision, obstruction and line-of-sight detection. The categories of design information that can be included are: choreography, costumes, set designs (3D models and CAD files), directorial notes, lighting states and truss plans, musical score, stage robotics, props and screen content. To coalesce this information into a database from which unified visualization can be achieved, the team has scripted an asset conversion pipeline that uses the *Nginx* webserver in combination with the *Celery* queuing software to translate files on a static webserver from their native formats (for example, .json, .dwg or .fbx) into those readable by the *iModel* application. This is a prerequisite for visualizing the diverse data in a shared virtual space facilitated by the *Unity 3D* game engine. Once complete, asset bundles can be downloaded via the *Django* web app and imported into the *iModel* application onto a personal computer. This online pipeline leverages existing solutions and saves local computing power, enhancing the overall robustness and performance of the application. Drafting within *iModel* takes place within a 3D modelled theatre space, which can be either a generic venue or a digitally twinned real-world performance space. In the case of OA's 2022 use of *iModel* for their touring production of *The Barber of Seville*, the twinned space is a meticulous reconstruction of Sydney Opera House's Joan Sutherland Theatre and (separately) of the Drum Theatre in the city of

Dandenong. The detail-rich 3D models reflect their respective architectural specifications, available stage machinery as well as textures of walls, floors and auditorium—providing the team with an accurate rendition of the performance space within which the final staging of the opera took place. This allowed closely customizing ideation and prototyping to the available real-world conditions of the theatre space. If accessed via a cinematic-scale CAVE theatre, the 3D model can be explored at life-size and provide a sense of inhabitable space during the design process—adding a visceral dimension that conventional approaches, for example physical scale models, cannot offer in terms of atmospheric assessment [20]. The *iModel* interface features separate workspaces that can be customized to the needs of various user groups, such as directors, set and lighting designers, or stage managers. Each workspace comprises functionalities that are particularly useful to a user group, reflecting common tasks and information needs. For example, a set designer may introduce a setting, center or grid lines over the stage view, specify the speed and rotation of a revolve, and import, manipulate, rotate and scale objects, such as set pieces or props. Their placement can be specified on a timeline (the so-called 'sequencer') that is coupled to the musical score, allowing users to preview an animation of their movement at any time. They can record or screenshot for later reference if they want to compare different versions and their possible creative bifurcations. The sequencer is keyframed to allow for greater ease when editing, allowing to jump for example between scenes and acts, or from an overture into an aria or obbligato. Content added to workspaces is saved to the same project within the *iModel* application, which enables the combined review of all workspaces in a master window that layers all saved content onto the common timeline and thus enables a virtual stage rehearsal. For closer inspection, users can pause, forward, rewind or zoom in and out of the sequencer. Remote collaboration between geographically dispersed users will be streamlined through an annotation feature that allows input as text, drawing or audio commentary linked to customizable keyframes in the timeline. While this facilitates design engagement for the entire creative and technical team, *iModel* offers artificially intelligent features that support evaluation in terms of occlusions, potential hazards, path tracing and wayfinding for movable objects and cast members.

Figure 1: *iModel* Software Interface ©iCinema Centre

During the development of OA's *Barber* production, the *iModel* system enabled the creative and technical teams to achieve significant synergies and efficiencies across the entire design pipeline, enabling seamless visual communication especially in relation to the complex stage movements of props, set pieces and cast members. As *Barber* was conceived as a touring production for over 20 locations across Australia—ranging from expansive, formidably equipped to very minimalist venues-, a design had to be delivered that would aesthetically resonate across locales as well as pragmatically pack down for quick venue changeover—all to be achieved within tight budgetary constraints in the aftermath of the Covid-19 lockdowns. The solution to these challenges was found in an intricate modular set design, whose elements cast members would deconstruct and maneuver across the stage in choreographed sequences, aided by locally recruited choruses that had to be inducted on the fly once the crew arrived at a new location. The set elements required custom-built travelling cases, which were also designed using the *iModel* application as it allowed precise articulation of dimensions and formats. The *iModel* system provided the much-needed capability to virtually trial and evaluate different draft designs across three destination theatres whose spatial and technical resources required strongly divergent design provisions. Through visceral exploration of the 3D-rendered architectural spaces as well as visual manifestion of designs at 1:1 scale, the teams were able to rapidly achieve a shared understanding of possibilities and constraints and to direct their mental resources more readily onto feasible design trajectories. Rather than getting caught up in lengthy verbal or textual explanations of spatial concepts, team members used the *iModel* system to rapidly block out space and to trace movements of set pieces and bodies across the stage. This allowed identifying bottlenecks and preempting collision pathways, as well as adding playful complexity to the orchestration of the swiveling stage action that closely integrated with the musical score—

amplifying its tumultuous and joyous pace. With costume designs ingested into a workspace, each character could be displayed in at least one attire. The designs were ingested as .png files (i.e. 2D images) attached to 3D boxes that would provide them with depth in the 3D space. Raytracing allows light to bounce off them and cast shadows, which aides in integrating the avatars more fully into the visual concept.

Figure 2: *iModel* Sightline View ©iCinema Centre

Grouping the characters together on stage, and animating their movements synched to the orchestration of set pieces, enabled assessment of their aesthetic effect. In response, textures were refined and details added that enhanced the overall composition and which imbued characters with idiosyncratic flair. Most importantly, the *iModel* system facilitated maximally clear communication of ideas and enabled rapid evaluation and iteration of concepts. The team thereby made full use of the range of visualization platforms, starting out on desktop computers connected to large wall-screens for initial prototyping, importing designs into a 360-degree cinematic CAVE theatre for 1:1-scale team review, and lastly using the system on laptops in the rehearsal room to annotate and refine design aspects that could be shared with cast and crew. With pandemic disruptions continuing to affect the availability of personnel and resources, *iModel* provided capability to convey complex design ideas across time and space, allowing remotely located team members to review and annotate files on their personal devices, which helped to stay on schedule for delivery.

Conclusion

Through its provision of a shared environment, visual integration of design streams and real-time interaction, *iModel* has proven its capability to productively intervene into design processes at OA, streamlining—while at the same time—enhancing complexity and creative scope of output. It does so by supplying a catalyst that enables creative bifurcations through the coupling of human creativity and cyber-physical computational capabilities. It supports the ideation and analysis in ways that do not prescribe form but enable self-organization of processes with open outcomes. In doing so, it facilitates a redrawing of the relationship between makers and technologies, opening pathways for conjunctive symbiotic exchange not just between creatives but also between humans and machines. With ubiquitous digital technologies increasingly reassembling workflows and imaginations, such a partnership—if facilitated in the right ways—can yield a creative force that deeply fuses human, computational and mechanical systems [8]. The crosspollination between the arts and technology can thereby furnace new modes of engaging the machinic phylum that open up multiple bifurcations for imagining and shaping our planetary futures as collective and symbiotic rather than individual and isolated entities.

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