

Editorial Paper

**UNITING SENSORY DESIGN, COMPUTATION, AND CONSERVATION:
INTEGRATED TRENDS IN CONTEMPORARY ARCHITECTURE**

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Contemporary architectural research is converging along two mutually reinforcing axes: (1) human-centred adaptive environments that use sensors and real-time control to improve comfort and well-being, and (2) computational methods, parametric design, scripting, BIM, and machine learning, that reshape how buildings are conceived, tested, and maintained. The six articles under review exemplify fragments of this larger narrative: from Arduino-based biophilic prototypes [6] and Python parametric frameworks [7], to BIM adoption reviews [4] and YOLOv8-based façade inspection for heritage conservation [2].

Adaptive biophilic systems demonstrate concrete potential for coupling environmental control with physiological signals. Studies show that integrating natural elements, daylighting, and adaptive ventilation can reduce stress indicators and improve perceived comfort [5]; physiological metrics such as heart-rate or heart-rate variability (HRV) are now used as direct inputs for adaptive control logic in experimental prototypes [6]. Such evidence reinforces the premise that bodily signals can meaningfully drive space responsiveness when properly instrumented and interpreted.

Low-cost microcontroller platforms like Arduino Uno make prototyping these responsive systems accessible to researchers and practitioners. Multiple recent implementations use fingertip pulse or optical sensors connected to Arduino boards to capture BPM/HR signals [6], which then inform simple actuators (servo-driven vents, dimmable lighting) in pilot biophilic spaces. These prototypes are valuable: they expose practical issues, sensor placement, noise, user variability, that must be resolved before deployment at scale.

On the computational side, a clearer taxonomy of computational design—parametric, generative, and algorithmic methods—has helped shift design thinking from tool-use to tool-driven modes of problem framing [7]. Computational design pipelines enable rapid exploration, multi-criteria optimization, and coupling with performance simulation early in the design process. This changes the locus of decision-making: designers can test thermal, daylighting, and embodied-impact tradeoffs across hundreds of design permutations before committing to a single solution.

Bridging concept to practice is where BIM becomes essential. Parameterized design models can feed into BIM workflows to maintain semantic building information across disciplines, enabling downstream simulation, quantity takeoff, and facility management [4]. Recent work demonstrates parametric↔BIM integration for generating alternative structural options and assessing embodied environmental impacts at the conceptual stage [1], a model for sustainability-oriented decision making that keeps information continuity intact.

Machine learning and modern object detectors like YOLOv8 extend the computational turn into building maintenance and heritage conservation. YOLOv8 adaptations for façade inspection produce fast, accurate



detections of cracks, spalling, and staining on building exteriors [2], which helps prioritize interventions across urban inventories. For colonial-era façades, the promise is clear: automated, repeatable scans can reveal early deterioration patterns and support evidence-based conservation strategies. Still, heritage deployments require locally-representative datasets, rigorous field validation, and conservator oversight to avoid misleading false positives or missed detections.

Contextual, in-situ studies remain indispensable. Analyses of heat transfer and passive strategies in local cases — for example investigations on the thermal behavior of Semarang Cathedral — demonstrate how geometry, materials, and ventilation patterns produce unique internal climates [3]. Integrating those empirical findings into parametric/BIM models enables better simulation of intervention scenarios that honor both thermal performance and heritage value [1], [4].

Taken together, the six articles suggest four practical research agendas. First, build local datasets: physiological responses in tropical contexts [5], façade imagery under local lighting [2], and material thermal properties informed by in-situ studies [3]. Second, embed parametric and scripting competencies, including Python-based frameworks [7], into curricula so designers can link generative exploration to performance metrics. Third, develop interdisciplinary validation workflows that pair AI/sensor outputs with human expert review (engineers, conservators) [2], [4]. Fourth, treat BIM as a design competency rather than an intermediate software skill; integrate BIM earlier in studio workflows to preserve decision traceability through project lifecycles [4].

In closing, the reviewed works illustrate an architecture research ecosystem where sensors, computation, and conservation mutually amplify one another. Responsive biophilic prototypes show how buildings can attend to occupants' real bodies [5], [6]; parametric and BIM tools give designers the capacity to evaluate impacts holistically [1], [4], [7]; and AI-driven inspection methods promise new scales of stewardship for heritage assets [2]. The challenge ahead is craft: ensuring data quality, context sensitivity, pedagogical reform, and ethical validation so that technological promise becomes socially durable practice.

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