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Architecture
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Opponent review of the doctoral dissertation 'Building Robotic Systems – design of a self-reconfigurable system with sharable actuators' by Jan Petrš

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To whom it may concern

General Summary

This thesis set out three hypotheses related to the design and development of a novel self-reconfigurable modular robotic system that employs a shared actuator(s), and the claim of its potential to contribute concepts and technologies for addressing broader architectural issues of sustainable adaptability.

The three hypotheses revolve around concerns of:

1. Maintaining functionality of modular robotic systems but reducing their cost through the use of shared actuators
2. Improving construction efficiencies through the use of modular and reconfigurable systems
3. Reducing demand for living space through the ability to reconfigure

The dissertation is a hard-bound, 200 page volume, written in clear and precise English, organised across 8 chapters, with 286 references and well supported with colour images, photographs, drawings, diagrams and tables.

Chapters 1 sets the terms of the thesis. It states the overarching research goals, the nature of the technologies investigated as part of the state-of-the-art review, outlining of the technological challenges, statement of methodology employed and outline of the dissertation structure.

Chapters 2 to 5 aim to establish the theoretical ground, ranging from positioning within a lineage of architectural ideas developed through reference to specific projects and architects across the 20th and 21st centuries, to underpinning concepts and state-of-the-art in robotic systems pertinent to the trajectory of the synthetic work. This includes emergent systems (chapter 3), distributed robotic systems (chapter 4) and soft robotics (chapter 5).

Chapters 6 and 7 focus directly on the prototyping work. Chapter 6 outlines key considerations for the development of the modular robotic system, including an abstracted appraisal of cost, weight, charging and task implications. Chapter 7 covers the experimental development through iterative prototyping of passive and active robotic constituents, simulation work to explore assembly planning strategies and testing in use-case scenarios.

Chapter 8 provides a summary of the work and reflects upon the outcomes in relation to the hypotheses stated at the outset.

It is imperative to note that this review does not consider the written dissertation alone to constitute the body of the doctoral work. Rather, this review considers the extensive synthetic work, which has led to six iterations of functioning robotic systems, and the dissemination activities via peer-reviewed (5 papers/articles) and non-peer-reviewed (2 papers/articles) publication, as central and essential constituents of the doctoral work.

Critique

Figure 1, provides a visual overview of defining research goals and structure of the thesis as presented in the dissertation. The author presents this as a linear progression commencing within the theoretical realm where challenges are defined and technologies selected before transitioning into experimental work where prototypes are synthesised and results obtained. The immediate question that arises here is, how does the iterative development of the synthetic work feedback into questioning, critiquing,

developing and evaluating concepts, assumptions and methods – across both the experimental and theoretical aspects of the work?

There is an overriding sense that many of the technological concepts and objectives for the robotic system have been defined in advance and that precedent, especially in reference to the architectural positioning in chapter 2, has been selected to support these aims rather than being more open, critical, challenging, generative and nuanced in the development of ideas regarding architectural objectives and applications. This aspect of the theoretical positioning adopts a mode of 'presenting' rather than 'discussing' and, in my reading, represents the weakest part of the work.

The documentation of the synthetic prototyping work – which contributes to the 'experimental part' of the dissertation – provides a rich and engaging account of an iterative development process that incorporates multiple modes of testing and evaluation. It is here the reader really senses the drive, curiosity, rigour and passion for the subject matter – in the technical and engineering issues related to reconfigurability and adaptation. The production of multiple functioning systems represents a significant body of work and is to be congratulated. However, this work opens broader questions within an architectural frame.
Here, I draw a distinction between the logics of spatial assembly, which is explored and covered in the chapter 7 through evaluations of lattice and chain strategies, and the logics of broader spatial design – for example the morphologies of the architectural propositions shown in fig. 88 (p. 170), fig. 94 (p. 175) and fig. 97 (p. 179). The dissertation does not adequately offer resolution to the question of how these spatial designs are generated and compiled into the lower-level assembly logics that are well investigated through modelling and simulation. Are spatial designs emergent, pre-determined, or a hybrid between the strategic (designed) and the tactical (self-organising)? How are existing spatial organisations evaluated whilst 'online'? What/who determines when they should be changed? What/who determines the new spatial organisation, and how is this compiled and communicated to the system? How does the modular nature of the system interface and negotiate with complex site conditions?

These are critical questions required for the reader to be able to assess the degree of autonomy anticipated for the system and defining the roles and agencies of both designers and occupants. Some answers are hinted at through the

interior use-case scenarios – which in many ways suggest more plausible applications than a 'complete' architecture (and seems to have been reflected upon in the afterword) - but would benefit from further elaboration. It is also likely that answers relate less to properties of the system and more to specific contexts of design, architectural objectives and use-cases.

It is strongly suggested that the candidate offers reflections upon these open questions within the examination context.

In summary, the dissertation represents a significant body of work that offers insights and contributions to the field of architectural robotics and the emerging field of self-organized construction in architecture. These reside more in the technical and engineering aspects related to the development of a novel modular robotic morphology the exploits the principle of a shared actuator to manipulate passive units, rather than the broader architectural positioning. Nevertheless, it is felt that the dissertation satisfies the test of identifying a systematic enquiry leading to insight and contributions shared with the community.

With kind regards

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