Abstract The research presented in this paper investigates the possible transfer of the concept of morphospaces from theoretical morphology in biology to the realm of robotic fabrication and design computation in architecture. This investigation is concerned with the search for suitable methods of differentiating between the geometrically possible and robotically fabricable in integrative computational design processes, a critical component for further developing a morphogenetic approach to design. In the first, second and third part of the paper, the relevant aspects of morphogenetic design in architecture, theoretical morphology in biology and the related distinction between empirical and theoretical morphospaces are introduced. In the fourth and fifth part, the transfer of the concept of theoretical morphospaces from biology to design computation and robotic fabrication is introduced and explained along with the research on constructing machinic morphospaces for robotic production for robotically fabricated plate structures with finger joint connections.

Keywords: robotic fabrication, machinic morphospaces, computational design, digital morphogenesis, theoretical morphology
Introduction

Over the last two decades the logics and economics of serial production in the industrial prefabrication of building elements has eroded rapidly in the face of an increasing availability of computer-aided manufacturing and digital fabrication processes in the building sector. Whereas in industrial prefabrication the product was the one and singular outcome of a specific automated machine, the first wave of digital fabrication in architecture based on the introduction of computer-numeric control of long-established analogue machines (CNC mills, CNC saws, CNC joinery machines, etc.) led to a first significant increase of variability in production processes.

The second wave of digital fabrication currently underway entails a transition from job-specific computer controlled machinery to more generic production robots. This generic character of the basic robotic hardware – that only becomes specific when equipped with a particular effector and tool – enables the design of new fabrication processes prior or in parallel to a specific project, and thus potentially challenges the conventional hierarchy and sequences still predominant in design and fabrication in today’s architectural practice. The research presented in this paper forms part of a larger research undertaking that investigates possible convergences of computational form generation and computer-aided materialisation in architecture through integrative design computation: an approach that has been termed morphogenetic design (Hensel, Menges et al. 2004 / Hensel, Menges et al 2006).

1 Morphogenetic Design

Contemporary architectural design is still characterised by a clear separation and hierarchical conception of the creation of form, space and structure and its subsequent preparation for materialisation. In contrast the approach presented here seeks to employ computational processes for a higher level of integration of form generation and materialisation (Menges 2011). Analogous to the processes of becoming that derive the complex organisation, versatile structure and articulated shape of natural systems, here the genesis of form is conceptualized as the interaction between system intrinsic materialisation capacities and constraints as well as system external influences and pressures. Exploring the space of the physically producible, this design process enables novel modes of architectural inquiry, functional integration, performative capacity and material resourcefulness.

A more detailed investigation of morphogenetic design computation has been discussed in various other contexts, including [i] the transfer of morphogenetic and evolutionary concepts by process biomimetics (Menges 2012), [ii] its relation to parametric design (Menges 2005), [iii] the relation between computational form and material gestalt (Menges 2008), [iv] the integration of material behavior (Fleischmann et al 2012), [v] the integrative characteristics of the developed design processes (Menges 2006), [vi] the underlying conception of performativity (Hensel and Menges 2008), [vii] the related multi-disciplinary design approach (Fleischmann and Menges 2011) and [viii] various specific