Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: Building Technology

Personal information	
Name	Cedric Spijksma
Student number	5481627

Studio		
Name / Theme	Building Technology: Informatics & Product design (urbanism, geomatics)	
Main mentor	Serdar Asut	Informatics, Collaborative Robots in Architecture, Flexible Molds for Computer Assisted Making, Robotic Weaving with Bio-composites
Second mentor	Marcel Bilow	Product design, specialized in prototyping of building construction and product development related projects with a special interest in production technologies, including, additive but also subtractive technologies.
Argumentation of choice of the studio	The model will be a computer and robotics driven giving the main topic being Design informatics. Product design can be found in the creation of a product/model. The graduation is bound to building technology by the use of model making and the data required to generate these models.	

Graduation project	
Title graduation project	Pin model as a base for a design tool
Goal	
Location:	The model could be used on all kinds of sites/locations, 3 cases have been chosen for testing: Case 1: dike house, Oudebilddijk, Ouwe Syl, Friesland, Netherlands (53.300303, 5.712277) Case 2: parking lot city, P Acht Zaligheden, Dokkum, Friesland, Netherlands (53.323790, 5.998741) Case 3: Farming land transformation, Aalsumerweg, Dokkum, Friesland, Netherlands (53.334170, 6.003683)
The posed problem,	Physical Architectural and urban/rural models are still important in the early design stage. These models have several functions, as they can be used for mass studies, solar studies or just as part of a design process. Current modeling techniques can be expensive, take up from several hours up to days and require some skill. (Gibson, Kvan, & Ming, 2002). Currently, hard labor, 3d printing and CNC milling are used to create (large) scale models of areas and building sites. Some research shows the potential of pin-type

	models to replace the need for such models. (Follmer, Leithinger, Olwal, Hogge, & Ishii, 2013) Pin-type models are a versatile way to show a model physically, but the current technology does not reach the required pin density, and it does not focus on the use in model making or architecture in general.
research questions	How can pin models be used in the concept/design phase of mass modeling and analysis in urban, rural and complex building sites? 1. What is the current technology available in pin-type modeling? 2. How can pin-type modeling be used for designing (architectural and urban purposes)? 3. How can these models be scaled up and made affordably? 4. What (matrix) size should be used for the physical model? 5. What (digital) data inputs can be used for architecture and urbanism?
Design assignment in which these results.	Design a new type of pin-type design tool that can transform digital data of urban and complex building sites into a physical model.

Process

Method description

The project started with a literature search on the topics of pin-type tooling and the use of models in architecture and urbanism. Scientific papers from the last 20 years were used to find these papers. Keywords like: pin type, Pin mold, flexible molds, reconfigurable models and adjustable models have been used to find the references in this paper. From these keywords, Universities had their project describing the code and making of these molds. (TU/d, TU/e, MIT and Stanford).

The second part of the research is based on experiments in a design process. Choosing and altering options and choosing the best solution based on results/data. In this stage, the mechanical model and the code to drive this mechanical machine will be created. A schedule of requirements has been written based on the findings in the Literature search. The decisions were made based on values mentioned in the schedule of requirements and key values from the literature search.

To test the viability of the project, 3 case studies have been chosen. These cases can be seen in the location topic above.

Literature and general practical preference

The literature can be divided into e different categories, General papers, University repositories and patents.

General papers:

The research started with a general search on the topic of flexible molds/pin-type tooling, giving the following interesting articles/papers:

Reconfigurable Pin-Type Tooling: A Survey of Prior Art and Reduction to Practice (2007)
DOI: 10.1115/1.2714577
The evolution of molds in manufacturing: from rigid to flexible (2019)
DOI: 10.1016/j.promfg.2019.04.039
Evaluation of reconfigurable pin-type tooling patents listed chronologically according to tool taxonomy and ideal tool (Munro & Walczyk, 2007)

Besides all the literature about pin-type molds/tools, literature is needed about the use of models in architecture and urbanism. Giving the following results:

Panero, J., & Zelnik, M. (1979). Human Dimension and Interior Space
Cannaerts, C. (2019). Models of / Models for Architecture - Physical and Digital Modeling in Early Design Stages. Schaarbeek.
Gibson, I., Kvan, T., & Ming, L. W. (2002). Rapid prototyping for architectural models. Emerald.
Global, A., Donn, M., & Twose, S. (2012). Digital To Physical: Comparative Evaluation Of Three Main CNC Fabrication Technologies Adopted For Physical Modelling In Architecture. international journal of architectural computing, pp. 461-480
Pommer, R. (1981). Ideas as Model. New York: Rizzoli

University repositories:
Many universities have done some great research on this topic. From the literature search to university of Massachusetts Institute of Technology (MIT) has the most papers and a comprehensive repository regarding the coding and construction of pin-type models. Some examples:
Inform:
DOI: https://doi.org/10.1145/3294109.3295621 (2019)
DOI: https://doi.org/10.1145/2851581.2892414 (2016)
DOI: http://dx.doi.org/10.1145/2858036.2858104 (2016)
DOI: http://dx.doi.org/10.1109/MCG.2015.111 (2015)
DOI: http://dx.doi.org/10.1145/2702613.2732494 (2015)
DOI: http://doi.acm.org/10.1145/2642918.2647377 (2014)
DOI: http://doi.acm.org/10.1145/2501988.2502032 (2013)
DOI: http://dx.doi.org/10.1145/2470654.2466191 (2013)

DOI: http://doi.acm.org/10.1145/2047196.2047268 (2012)
DOI: http://dx.doi.org/10.1145/1979742.1979754 (2011)

Stanford University has a model called shapeshift. This model can move and is used for tactile feeling and object representation.
shapeShift: 2D Spatial Manipulation and Self-Actuation of
Tabletop Shape Displays for Tangible and Haptic Interaction (2018)
DOI: https://doi.org/10.1145/3173574.3173865

From the Technical University of Eindhoven, a professor has done his PhD about flexible molds and done a great description of all the different needs for the molds/pin type tools.

Optimum forming strategies with a 3D reconfigurable die (TU/e) (2006)
DOI: https://doi.org/10.6100/IR615797

For more information about model making, the repository of the technical university of delft has been used.

Stellingwerff, M., & Koorstra, P. (2013). Model & scale as conceptual devices in architecture. EAEA-11 conference, pp. 491-498.
Vink, M. G., & Koorstra, P. A. (2020). Beeldend onderzoek: Tekening en model (dutch). Inzicht, pp. 155-168

Patents:

(U.S. Patentnr. 3,559,450, 1971) (U.S. Patentnr. 5,846,464, 1998)
(U.S. Patentnr. 5,192,560, 1993) (U.S. Patentnr. 5,253,176, 1993)
(U.S. Patentnr. 5,330,343, 1994) (U.S. Patentnr. 5,738,345, 1998)
(U.S. Patentnr. 5,796,620, 1998) (U.S. Patentnr. 5,546,784, 1996)
(U.S. Patentnr. 6,012,314, 2000) (U.S. Patentnr. 6,089,061, 2000)
(U.S. Patentnr. 6,209,380, 2001) (U.S. Patentnr. 6,363,767, 2002)
(U.S. Patentnr. 6,578,399, 2003)

Products

Besides the papers and research, there are currently some products on the market that use pin beds. However, these products do not have a design function and are very expansive due to the nature of having to deal with much force.
Dynapixel(https://thecognitivecondition.com/?p=237)

Other general practical experience/precedent:

Besides the products about pin type tooling/molds, other manufacturing techniques could also be embedded into the project, like 3d printers, gantry systems, CNC machines and dies

Reflection

How does it compare to the study?

The topic would be bound to building technology by design informatics and product design, designing a design tool that could be used by architects or other engineers in the field of design, massing, or urban analysis. Especially the coding part would be close to the informatics part of the study. This project also relates to the study based on manufacturing. Many of the programming and designing is closely related to manufacturing methods used in the build environment.

What are the challenges?

Within the found research, a small number of pins were used. Also, using motors/actuators for all pins would make scaling the system really expansive. The addition of this research is to scale up the number of pins, reduce the cost, and implement architectural/urban use cases.

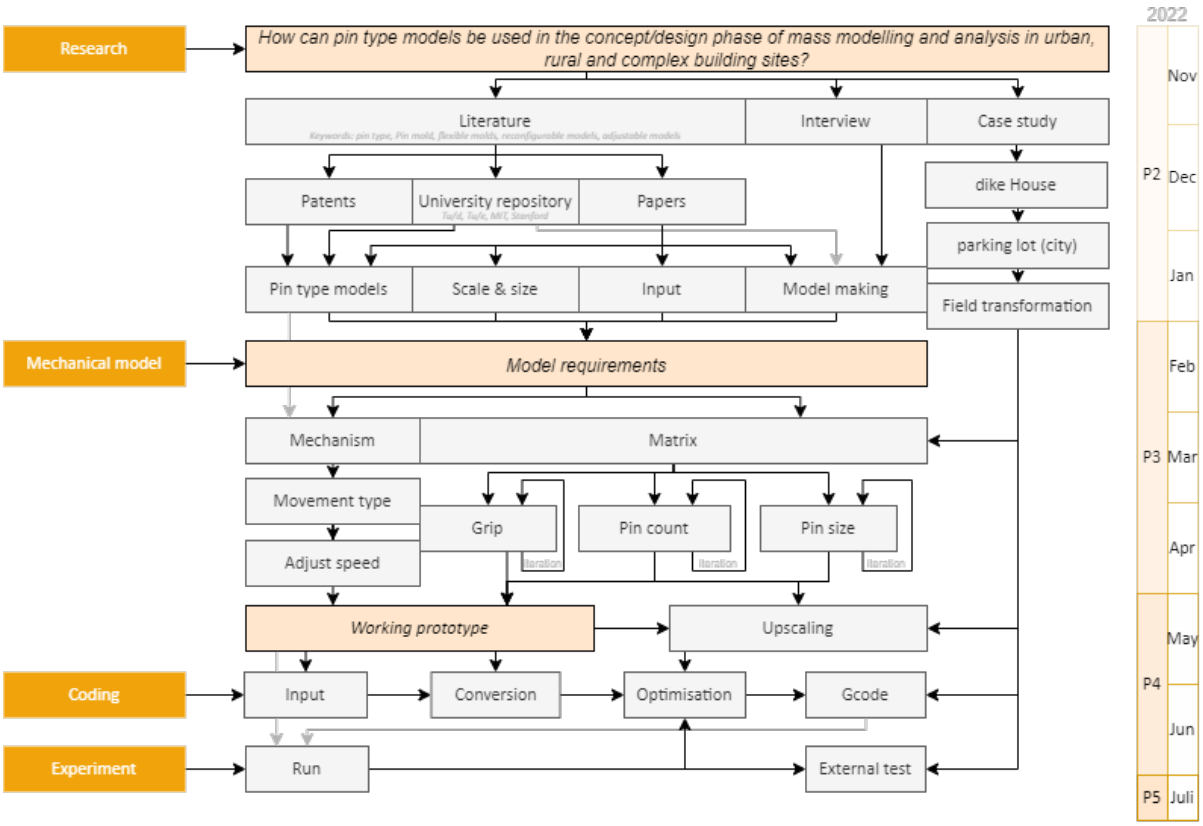

Figure 1 - research framework within the time plan