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GENERATIONS OF COMPUTATIONAL DESIGN

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ABSTRACT

Since computers have been introduced to the world, they have been applied in the Architecture, Engineering and Construction (AEC) industry to attempt to take over and automate tasks of the human designer or engineer to obtain time savings or increase quality by reducing errors. Initially, on the one hand manual drafting on paper and large drawing tables was replaced by Computer-Aided Design (CAD) applications to digitize the drafting activities of designers and engineers. On the other hand, manual (structural) engineering calculations were replaced by Finite Element Analysis (FEA/FEM) software. In other fields than structural engineering other simulation and analysis applications emerged. The author proposes that this signified the first generation of computational design. It needs to be mentioned that the earliest developments usually meant that the designer or engineer was also the software developer. Originally this meant that the developing designer or engineer needed to write source code to build his or her application, but special mention needs to be made for spreadsheets which requires less programming skills and a less steep learning curve. In a second stage off-the-shelve software became available so that the designer or engineer did not need to author the application.

From this first generation the developments moved into different directions. The author would like to propose that Building Information Modelling (BIM) [1] can be seen as a second generation of computational design which followed CAD software. Although some CAD applications already incorporated three-dimensional modelling abilities, BIM applications such as Tekla, Revit and Allplan natively adopted 3D modelling. Also, these applications shifted the paradigm from drawing geometrical objects (while leaving the interpretation of these geometrical objects to the user) to object-orientation (where the computer has a named

object from which the geometry is derived as a property). This means that BIM applications have rich information on what the object is and what its characteristics and behavior are.

A second variant of a second generation of computational design which can be observed is that some designers and engineers started programming buildings using scripting and programming languages to drive the CAD, BIM and/or FEA applications to automate the generation of the object to be constructed from which drawings and models could be derived. This can be seen as the earliest form of parametric design. Downside to this approach however was that this approach still required a lot of skill and programming knowledge. Often only large firms which special groups could afford to work in this manner.

The author would like to propose that a third paradigm shift which can be observed is the emergence of parametric design through visual programming languages, such as GenerativeComponents [2], Grasshopper [3] and Dynamo [4]. It can be observed that designers and engineers experience a less steep learning curve to automate their work through visual programming than its predecessor of textual or scripted programming. The learning curve is comparable to that of the popular use of spreadsheets in engineering. The trial-and-error or direct feedback nature of both visual programming and spreadsheets is very comparable and adoption seems to be a lot easier by designers and engineers.

Within this third paradigm shift distinction can be made between the first generation of (visual) parametric design through GenerativeComponents which only attracted a small group of power-users, mainly large architecture and engineering firms with special modelling and technology groups, and the second generation of Grasshopper and Dynamo which attracted a large community of users, but also developers which helped to turn these applications into rich and growing ecosystems of functionality through plugins.

These plugins extend the original abilities of the applications with many new abilities but also connections to other applications, amongst others to BIM and FEA applications. It can be argued that through these developments a third generation of parametric design is emerging where the information richness of BIM is combined with the rich expression and automation abilities of visual programming. Another shift which can be observed is the connection of parametric design applications and FEA applications towards more interactive modelling and analysis [5]. Both plugins as an extension in the parametric software as well as integrations through newly added APIs (Application Programming Interfaces) on FEA software can be observed.

The author would like to propose that a new paradigm shift is currently emerging: the shift to the cloud. There are quite a few reasons which can be mentioned for this shift, but this abstract will focus mainly on the ability to expose the (use of the) logic in the parametric model to others in a controlled manner. Very quickly after the emergence of parametric design in the experience of the author designers and engineers already felt the need to share models with their colleagues or expose them to clients. However, barriers exist which prevented this. Barriers which can be mentioned are: 1. The reliance on (particular versions of) the parametric software, in combination 2. with the reliance of models on a particular set of plugins, as well as 3. the 'Spaghetti'-like nature of the visual models which prevented others than the original developer of the model to simply control the model.

Cloud-native parametric modelling can help to overcome these hurdles. The author is involved in the development of Packhunt.io (http://www.packhunt.io) which is an example of such a platform which runs Grasshopper models on cloud-based services and exposes the controls through a configurable web-based user interface.

The web-based user interface removes the reliance on the parametric software itself: only a modern web browser is required. Because the parametric solvers are hosted on the cloud services as long as the platform has the appropriate plugins available models which rely on these plugins always work.

This has major advanced when sharing the use of logic embedded in parametric models with others. It needs to be noted however that the logic itself is not shared which perhaps is a disadvantage to those who would like to expose this logic but a huge advance when you would like others to use your model but not walk away with the knowledge you have put in. The disadvantage can be overcome by separate sharing the logic graph as a separate entity.

Cloud-based parametric modelling is used in many use cases but at the moment is applied in web-based configurators which allow the user to share parametric models or sell customizable products online.

A live example has been shown in Fig. 1 of a configurator which demonstrates steel joint logic.

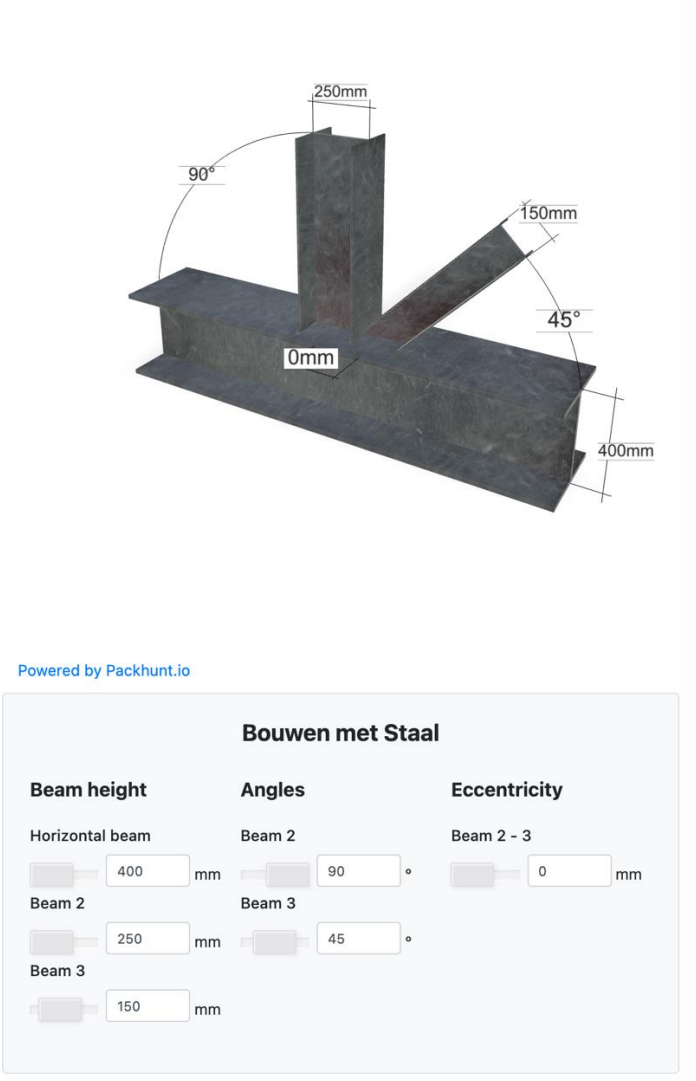

Fig. 1. Steel joint configurator built with Packhunt.io

The configurator can be tried on this public available web address: https://kpcv.nl/borgingsacties/ontwerp/parametrisch-ontwerpen/

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