



## Conceptual structural design of shell structures in virtual reality

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### Abstract

The paper explains a prototyped workflow for conceptual structural design of gridshells using Virtual Reality (VR). Based on 3D-doodles made by the user, a gridshell is automatically generated, analysed and materialized. Unlike hand-drawing and conventional computer modelling, the workflow seems to be both well informed and efficient as an early-phase design tool.

**Keywords:** Shell structures, parametric modelling, Virtual reality, AEC collaboration

## 1 Introduction

Different types of shell structures has been widely used for many centuries. Examples are gothic vaults, timber gridshells to recent free form structures. Mutual for these shell structures is the challenge of finding their forms. That is, a form that both suits its program and structurally perform as a shell. To succeed requires a well-established collaboration between architect and engineer. Traditionally, physical models such as hanging chain networks have been used to determine suitable forms. Lately, digital software, especially parametric software, have simplified the process of making models that helps finding structurally sound forms. However, there is a great potential in making digital conceptual design more intuitive.

Virtual Reality (VR) [1] have emerged recent years. By wearing a head-mounted display (HMD) and hand-controllers, the users are able to view, draw and navigate in virtual 3D-space.

The primary objective of this study have been to elaborate on the potential of applying VR as a sketch tool in the conceptual structural design process of shell structures. Different from drawing in a birds-view perspective, VR enables the user to more intuitively define a design space while virtually walking around in a given site.

## 2 From sketch to gridshell

Choosing methods of early sketch development is often a compromise between efficiency and level of informed feedback. Pencil doodling is extremely efficient, but are demanding for drawing irregular spatial forms. Opposite, computer and physical modelling is more informed and detailed, but often too slow for sketching. The following method automatically generates a gridshell based on VR-doodles and results in both an efficient and detailed iterative design-process.

### 2.1.1 Sketch: VR doodling

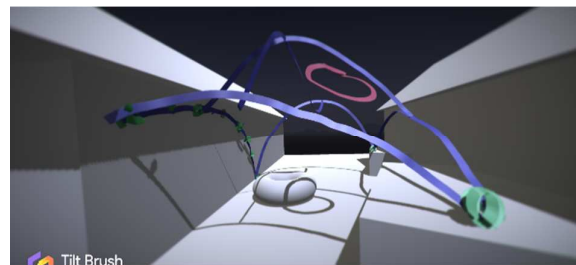


Figure 1. Shell doodling. Blue is shell curves, green is foundation, red is openings.

Using VR and Google Tilt Brush[1], the designer navigates in a virtual site model. Sketching is done by drawing virtually in three dimensions. To make the parametric model understand what the doodle-curves represents, openings, guide-curves