

ALLEYWAY POINTS; INTERWEAVING 'REAL' AND 'REPRESENTATIONAL' MATERIALITY

ANDERS KRUSE AAGAARD &
ESPEN LUNDE NIELSEN
PHD-FELLOWS,
AARHUS SCHOOL OF ARCHITECTURE



*Point cloud of Alleyway
in Aarhus.*

Point cloud as digital substance

Various forms of 3D capturing and scanning allows the physical world to enter the digital domain. In digitality, the representation is set free from physical solidity, gravity and materiality. Manipulations can happen on whatever condition allowed by software and hardware.

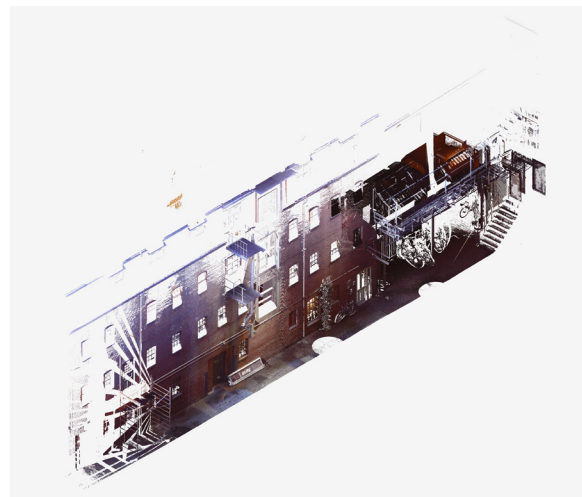
Often, workflows that connect the digital and the physical are seen in two versions. Either the physical is a realisation based on abstract, digital data. Or, reversely, the workflow is quantifying the physical matter into digital representation.

The digitisation of reality has proven useful in many ways. The ability to combine the possibilities of the computer with information from reality creates potentials for *interweaving* these two coexisting domains. 3D laser scanning is a technology that can establish a unique relationship between 'real' and digital environments through precise capturing of countless coordinates. The mass of measured coordinates, often combined with colours from photographs, are post-processed into a point cloud. The point cloud, thereby, provides both accurate and understandable representation of the reality. Unlike traditional surveying, the outcome is not notational based but is instead visually corresponding with the reality it depicts. Rather than the typical architectural drawing which consists of notational lines, the point cloud resembles more the condition inherited by still photography.

The capturing of reality into the digital realm seems straightforward at first, but eventually, the created representation holds a major paradox: While being an exact and high-resolution surveying tool and a digital depiction of reality, the data content of the point cloud is the ultimate digital reduction. The point cloud exists of millions of points that are individually placed in three-dimensional space. Each point has an exact position, but no relation to other points, the context or the material from where it originates. As such, the point cloud is a homogeneous assemblage, however without any true mass. The real world exists as a complex collage of mutually depending fragments, but the digitised version is more like a listing of separate individualities. The real world can be seen as a virtual composition whereas the point cloud is an actualised version of that reality. While initially sounding like



The point cloud is based on reality and has an immediate visual relationship with the reality. The behavior and nature of the point cloud are, however, far from its source. The point cloud is its own type of substance.



Axonometric section view through the point cloud representation of the scanned alley. The scanning is focused around a series of windows on the ground floor.

a delimiting affirmation, the nature of the point cloud instantaneously outlines, at least, two interesting consequences:

First, the point cloud and the creation of it represent a reversed situation in more than one way. The possibility of digitising reality is a highly potential strategy for working back and forth between physical and digital space. The technology can flip the physical-digital directionality but also changes the relationship between virtuality and actuality. The creation of the point cloud requires a physical context or subject, and someone (or somewhat) to handle the scanning of that context or subject. The kind of equipment, as well as the handling and operation of the equipment, will affect the output - as with any other photographic or notational device. Thus, the digitisation is a process involving decision-making, evaluation and judgement. The local concentration of point will, for instance, be affected by the placements and/or movement of the scanner. Since each point clouds consists of several scans over a duration of time, temporality is also a contributing factor. Thereby, the scanning itself becomes a process open for interaction, editing and manipulation. Going from the real world to digital representation means an instant suspension of material ability and alteration. While being highly descriptive by resolution, the point cloud also results in at high reduction of active information. The digitisation means a passivation of the context or subject. This is contrary to other types of digital data or drawings like NURBS curves, variable datasets or parametric geometry. The point cloud both flips the directionality of the creation of information and produces a descriptive, but actualised, type of digital data.

Secondly, the behaviour of the point cloud produces a digital substance. The points are not relational, or specific, in any other sense than their position in space. The point cloud acts as a mass of *substance*. Substance is understood as *'a particular kind of matter with uniform properties.'* ("substance - definition of substance in English from the Oxford dictionary," n.d.). While this behaviour causes a dramatic reduction of the potentials of the information compared to the source, the nature of the substance opens up for considering the 3D scan as a pure, but susceptible, matter. This matter can, by utilising its material independence, be employed for either modelling or as a transitional medium. Both scenarios require

an involvement of external environments or setups.

Alleyway Points seeks to put the above understanding of 3D scanning and the point cloud forward as a motive force in the experimentation.

Scanning the alley

In the centre of Aarhus, an alley is squeezed in between an overlap of multiple functions connected by walkways and hanging cables. The architecture is a composition of a series of older factory buildings, now transformed into different purposes. The complex nature of the space makes it difficult to survey manually. 3D scanning can, however, capture the slightest details and deviations in the context.

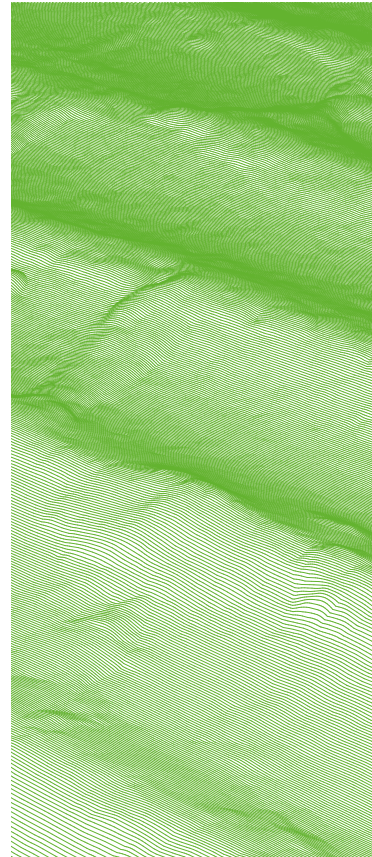
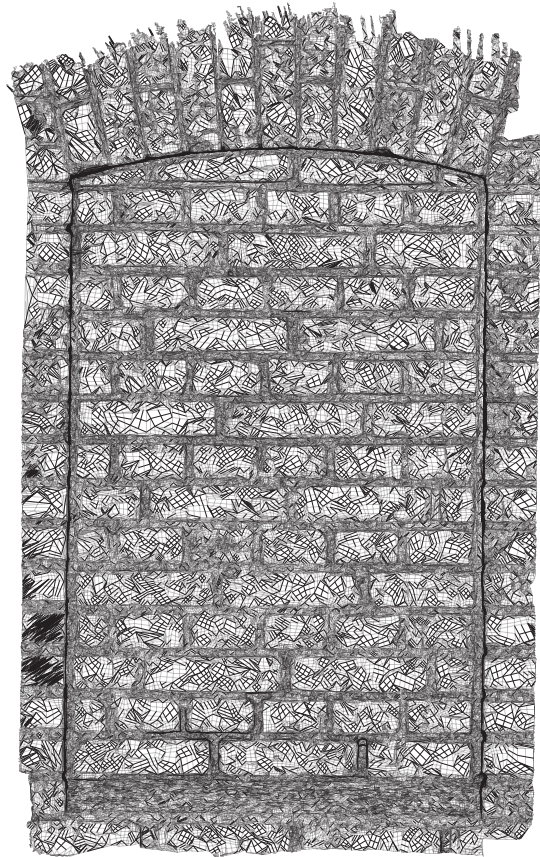
The alley was scanned using two different strategies. First, a Faro Focus 3D lidar scanner was used to establish an overall representation of the context. The Focus scans and photographs everything within line-of-sight. In this case, the point cloud was produced by a handful of scans captured down the alley. This strategy did not capture the alley in its entirety but established an excerpt with a high local resolution. Secondly, a few picked out locations were scanned using a Faro Edge Arm with a laser probe attached. The Edge is used by manually moving and orientating a gun-like laser probe. The movement of the probe defines not only the covered area but also the resolution in the direction of the motion. Compared to the Focus, the Edge creates a much more detailed and precise point cloud and enables the capturing of microscopic textures. The detailed scanning was carried out on a series of similar windows facing the alley. Some were still functioning as windows, others were broken, blocked or otherwise altered from their original form.



On site: Preparing for digitisation. 3D scanners and computers are brought to the alley to capture space and texture.



High-resolution detail scanning using the handheld FARO Edge Arm. This type of scanning is a manual process that requires direct engagement with the material and continuous evaluation of the scanning result.



Left: 3D visualisation of a merge between NURBS geometry created in the computer and texture created using 3D scanning. The visualisation is based on triangulated mesh created from the merge.
 Right: Formwork milled with ball-end tool. Tool paths created by tracing the merged geometry.

Interpreting, manipulating and fabrication of new realities

The raw data requires an external involvement in order to utilise the 3D scans as a substance in the production of something new. This involvement often starts by the use of dedicated software and human assessment of the data. Every altering of the point cloud alters the representation at hand and can hence be perceived as a *redrawing* of the given material. The interpretation and involved decision-making become a transformation of the substance.

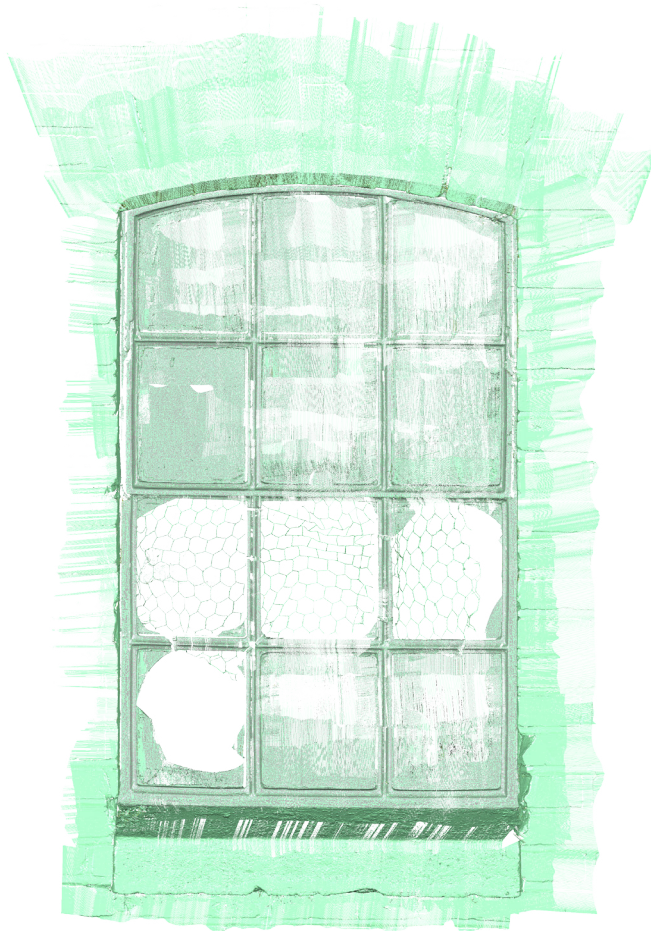
In *Alleyway Points* the point clouds were processed into triangular mesh geometry. The conversion from point to mesh relies on a process that establishes a relationship between points, thereby creating a surface. This conversion can be crucial in order create data that can inform digital fabrication tools but is also essential since it establishes a prior non-existent relationship between neighbouring points. While the mesh opens for new types of transformation and manipulation, it is, however, still limited in possibilities given that the geometry is locked by a dependency on the scale of the origin. For an ultimate manoeuvrable geometry, the mesh can be translated into NURBS surfaces or similar. The translation from point cloud to surfaces is neither non-destructive nor unbiased. Consequently, a shuttling between different translations and thereby different layers of potential and virtuality became essential throughout *Alleyway Points*.

Fabrication-wise, the materialisation in *Alleyway Points* started with concrete casting and CNC machining of formwork but expanded into other techniques, materials and explorations. During the curious-driven experimentation the three following 'works', among others, emerged:

Concrete Window. An initial and rather direct translation from point cloud to fabrication in the form of a concrete rendition of a broken window. The point cloud is translated into surfaces and tool paths and then milled in foam. A smooth vaseline coating is used for formwork. The process calls for an investigation of a non-material reproduction. The scanned window is composed of both steel and glass. Every point is, however, treated equal, and surface quality is judged upon its coherent uniformity, both in relation to digital and physical processing. The final concrete cast contains the traces of deviations, artefacts and distortions from the



A devastated window in the alley. Multiple materials and textures and the passage of time create a complex scenario.



The raw 3D scan made on site. Millions of points describe the window and its associated textures.



The window cast in concrete. Going from points to concrete requires several steps and translations. Eventually, the casting becomes a representation of the digital point cloud.



Topographical Montage. Textures and ephemeral elements of the alley juxtaposed into the existing window frame.



Brick Transition. The concrete casting of merged computer-made geometry and texture from the digitisation of reality.

scanning and steps of the fabrication process. The concrete window is much more a physical representation of a point cloud, than a pantographic reproduction of the physical window.

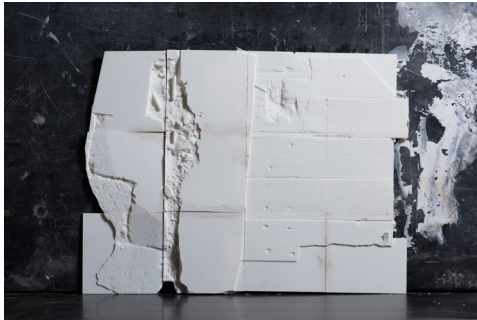
Topographical Montage. A series of point clouds, representing particular contextual textures or ephemeral elements of the alley, were montaged together, meshed, and 3D printed. This topographical montage was an attempt to use the points literally as building materials: a sculptural juxtaposition of 'substance'. The emerging large-scale 3D prints, initially intended for latex-form making, were made using SLS technology featuring a fine nylon powder. The result is a homogeneous and consistent material result with a complicated and wondering mode of expression - and appear as a material prolongation of the homogeneous reality of the point cloud.

Brick Transition. With the intention of bringing a form editing process into the workflow before materialisation, a point cloud representing a piece of a brick wall was combined with a rippled NURBS curve. The curve was used to digitally bend and warp the point cloud data and create a gradient shape and texture from the point cloud brick representation toward the curve. The warped point cloud was applied with parallel toolpath for milling. The high-resolution tool path became the primary drawing set for both visual representation and fabrication instructions. The conclusive concrete cast both solidifies the textural gradient and underlying processes into a solid object and exposes its materiality in the piece.

Scanning as architectural tool

Alleyway Points uses 3D scanning as the basis for fabrication of architectural elements, somehow related to building design. The experiments embrace that the transition from scanning to materialisation is not a direct and impartial path but a series of transformations, translations and decision-making processes.

In the experiments, a rather open handling of the point clouds is introduced and establishes an articulation of the points as a type of digital substance. While only just establishing this as an initial discussion, the intention is to contribute to an emerging field of digital fabrication in architecture. The development around



Different fabrications made from scannings of the alley: CNC-milled foam, beeswax casting, SLS 3D print of texture collage and latex casting hereof.

digital fabrication is often seen a way of pushing materials toward new functions or geometries (Gramazio and Kohler, 2008, pp. 7–11; Schröpfer and Carpenter, 2011, pp. 23–25) by technological improvement. In the experiment *Alleyway Points*, the workflow and hierarchy are, conversely, shifted, and the outcome is different of what is usually favoured within the field. The production mixes textures and materiality in an unorthodox way, with the intention of looking for relations between the real world and the digital from another perspective.

Simultaneously, 3D scanning evokes similar discussions to what appeared with the emergence of the still camera, which was at first, by many, believed to be a technical device to create objective documents and *transcribe* reality, rather than an artistic tool in its own right (Rosenblum, 1997, pp. 208-215). Likewise, 3D scanning needs to be understood not only as a transcriber and beyond surveying purposes, but, potentially, as an architectural tool and alternative mode for travelling between representation and realisation. *Alleyway Points* suggests how 3D scanning can be perceived and utilised for mediating existing and becoming spatial realities, interweaving and shuttling between real and representational materialities.

Rosenblum, Naomi. *A World History of Photography*, third edition (New York: Abbeville Press, 1997).

Gramazio, F., Kohler, M., 2008. *Digital Materiality in Architecture*, first edition. ed. Lars Muller, Baden; London.

Schröpfer, T., Carpenter, J., 2011. *Material Design: Informing Architecture by Materiality*. DE GRUYTER, Berlin; Boston.

Substance - definition of substance in English from the Oxford dictionary [WWW Document], n.d. URL <http://www.oxforddictionaries.com/definition/english/substance> (accessed 9.13.16).