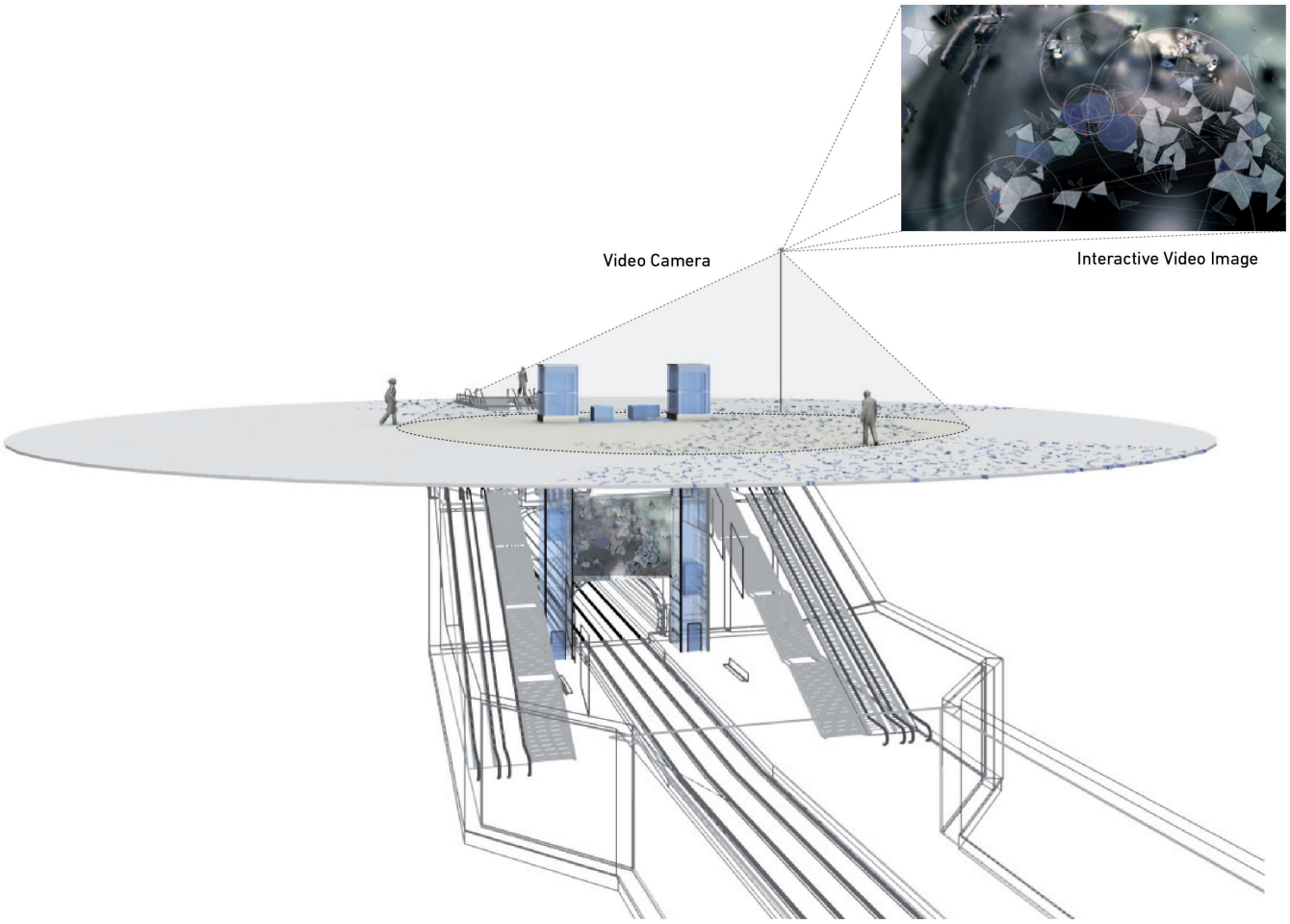
TURNSTILE – A Polygonal Canon



Schematic structure of the installation

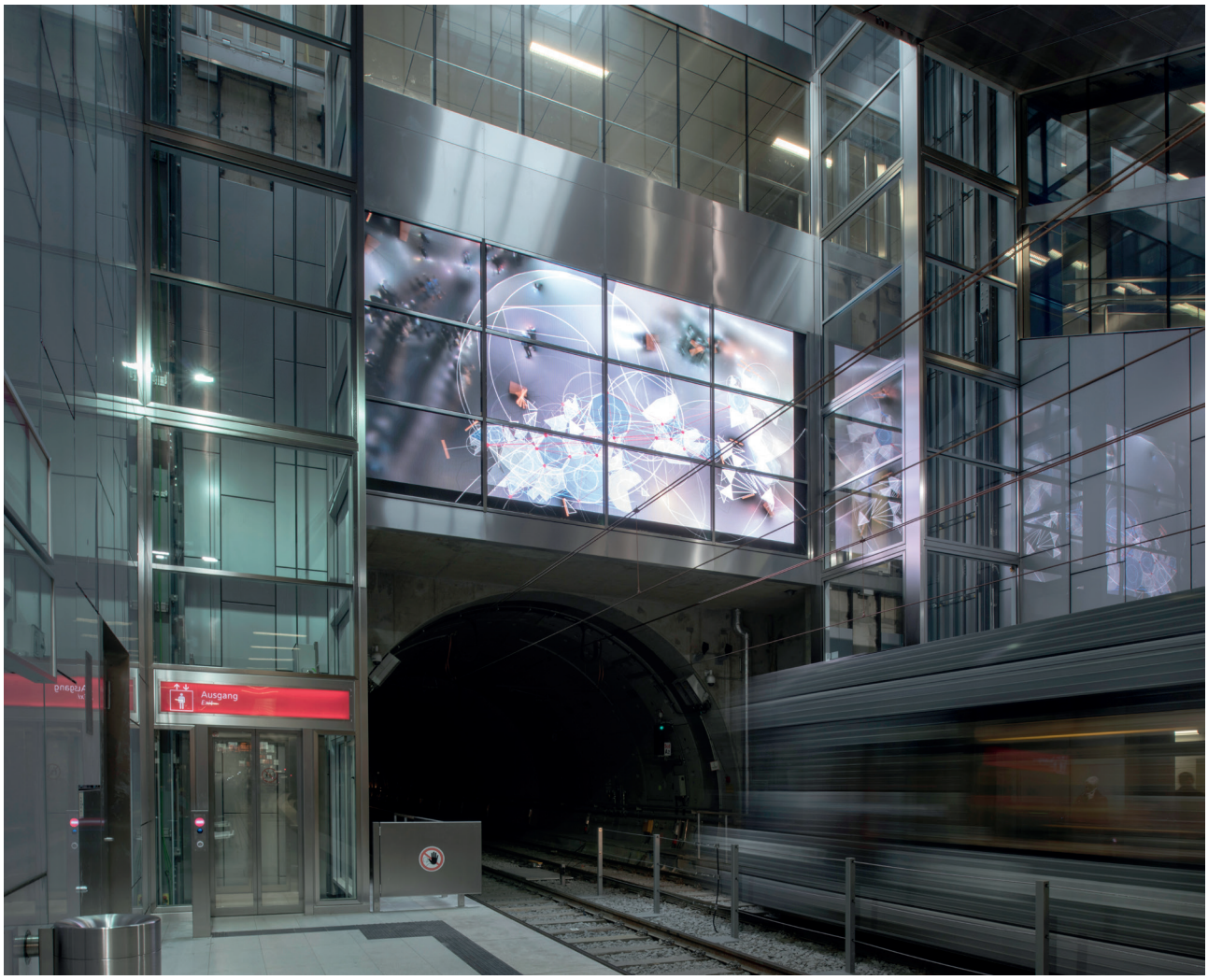
Summary

Turnstile is a digital artwork that translates the traces of pedestrians on a public square into a virtual geometric architecture. On the front wall of the Schadowstraße underground station in Düsseldorf, visitors can observe pedestrians within this generative architecture on an LED wall. The installation can be seen as the outcome of an artistic research process investigating swarm behaviour as a manifestation of collective togetherness.

I.) On Location

Turnstile, an artwork installed at Schadowstraße underground station in Düsseldorf, is one of six works selected in conjunction with a competition to artistically enhance the city's Werhhahn line.

The artwork is designed as a snapshot of a location comprising pedestrians crossing the square above the underground station, a video camera observing the pedestrians, lifts transporting passengers to their platform, an LED wall situated above the rail lines at the front of the station plus 23 screens showing a birds-eye view of Düsseldorf interpreted as generated patterns.



LED wall with generative video image as seen from the station platform. Photo: Thomas Mayer

The video images on the front wall of Schadowstraße underground station are generated in real time. The footage shifts our focus from the platform to the pedestrians passing by the station overhead. To achieve this, a camera captures the movements of pedestrians above ground and custom-made software interprets these movements as 'energy sources' or 'virtual fuel'; consequently the temporal-spatial accumulation of events unfolding above the underground station is manifest on the screens installed on the station's LED wall—ultimately becoming a virtual interpretation of the location's lively hustle and bustle, modelled with the help of artificial intelligence. Small, virtual beings use the motion-energies to build a temporary, fluctuating architecture that ebbs and flows in accordance with the stream of passers-by.

1.1 The Spatial Situation

Schadowstraße underground station is architecturally characterised by a steep entrance, high ceiling and two distinctive elevators situated on either side of the expansive video image above the train lines. In front of the LED wall a light shaft leads to the square above the station where

The underground as seen from the platform.

a camera has been installed.
The video image and the underlying concept constitute the core of this artistic intervention. The concept further expands to the design on the walls: the underground station's blue glass hosts a scattering of single panels showing geometric representations of Düsseldorf neighbourhoods.

Situated on the eastern walkway is an aerial view of the city of Düsseldorf interpreted according to its geometric concept. 16 Düsseldorf neighbourhoods extracted from the aerial view have been interpreted as local aerial shots: urban spaces are represented through regular polygons as energy centres that form correlations due to the city's architecture (ref.: Das Konzept der Mustergenerierung,Engl: The Concept of Pattern Generation).
The patterns' delicate structures juxtapose the station's solid architec-

Aerial image of Düsseldorf with pattern drawings; panel explaining the concept of the pattern generation

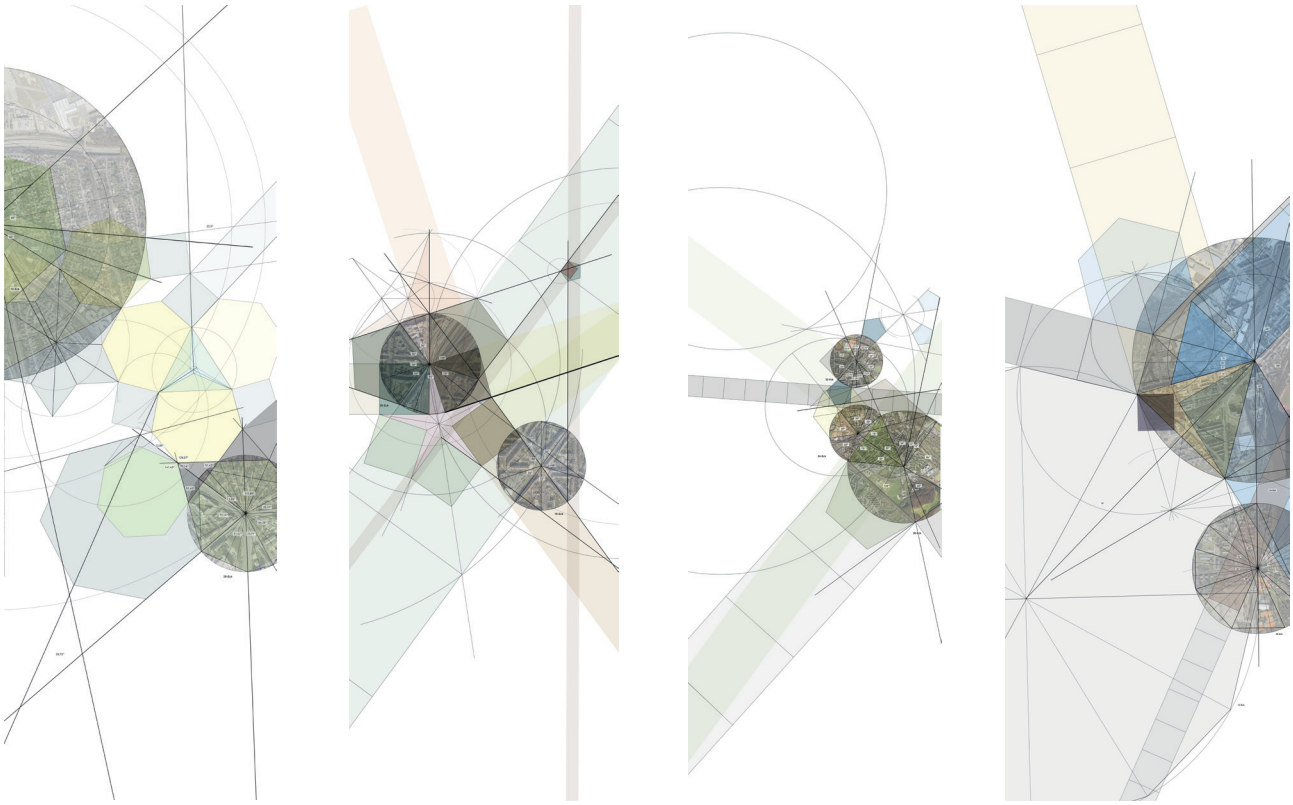
ture, gesturing towards the sensitivity of nature and of man and also alluding to a design approach based on forming large-scale connections through the symbiotic arrangement of a multitude of individual elements. Thus the design fulfils the social principle in which the individual has an effect on the whole.

The design of the 'pattern drawings' (German: Musterzeichnungen) developed gradually. The first step was to create a pattern drawing of the city that enhanced relevant movement axes for vehicle and pedestrian traffic; areas enclosed by the axes formed polygons. The lines and axes were then scanned for integer fractions within the polygons.

The smallest polygon—that which integrates all symmetries in the relevant location (e.g. fractions of pentagons and squares would be icosagons)—is used to describe the intersection.

The next step is to identify connections (networks) between large neighbouring polygons.

Analysis of the aerial images revealed that polygonal spaces within the city centre are very small, whereas the suburban areas are clearly more generously structured. Often the transition from non-squares to squares relates to historic interruptions within the cityscape. Thus the pattern drawings link the local spatial situation to Düsseldorf's peripheral urban landscape and thereby present a view that seems to strive towards forming large scale connections.



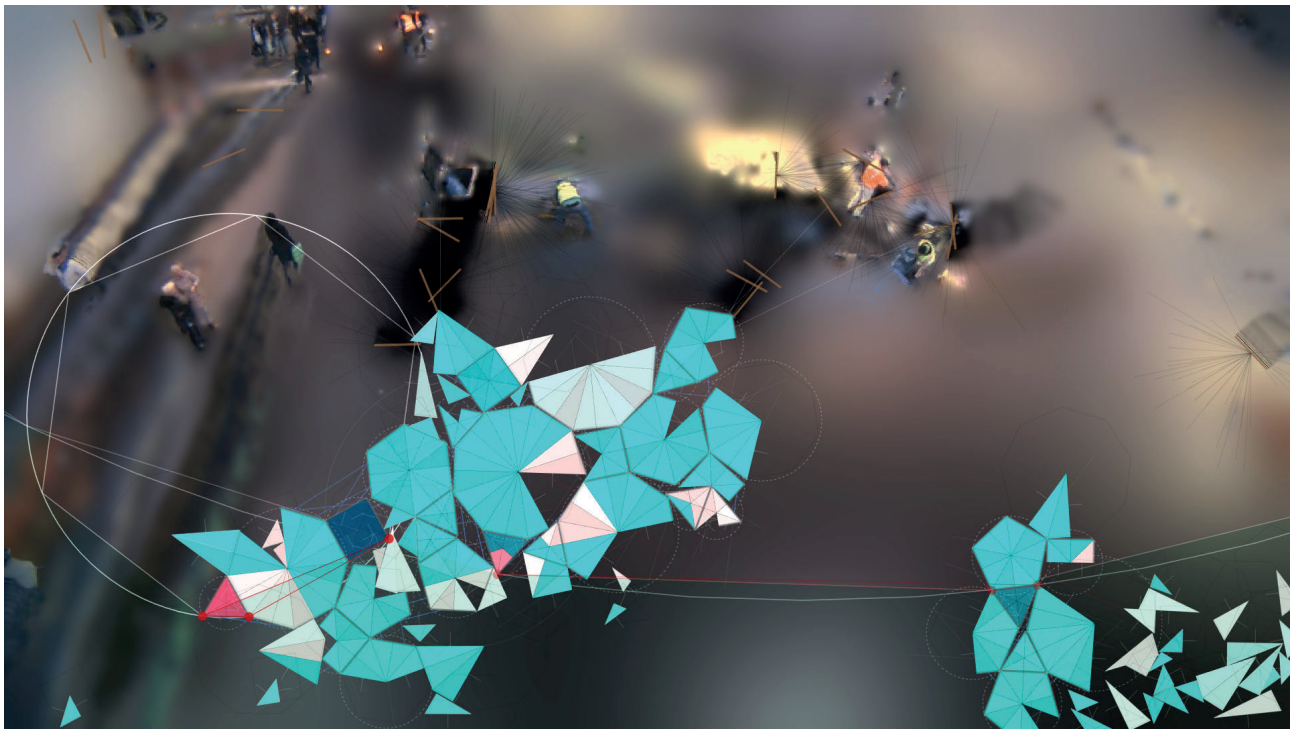
Pattern drawings as overlay on aerial view

1.2 Elements of the Virtual Image

The events unfolding on the station's LED wall show a complex, lively, virtual system composed of digital picture elements that follow the paragon of nature. In keeping with these metaphors the software develops a strategy with which to interpret the events filmed above the square. Small geometric agents—brown lines with black 'feelers'—termed 'brown brooms' 'sweep' the pedestrians' motion trails into areas with a lower frequency. Here, an architectural hybrid lattice of geometric shapes forms a virtual habitat (out of the energy of the motion trails) consisting of pattern formations.

The system is able to sustain itself by accessing a global energy reservoir—the environment—comprising (simulated) physical parameters that perpetuate the animation through the artificial metabolism of motion data (information processing). The ebb and flow of geometric forms depends upon the movements of the pedestrians crossing the square above the station; their traces determine the positioning and lifespan of the geometric shapes.

1.3 The Conception of the Software



The video panel. Photo: Thomas Mayer

The installation's geometries are created in a construction process deploying the smallest geometric elements. Regular polygons (polygons with homogenous outer edges and various rotation symmetries) are self-organising. These elements can be understood as the building blocks of a universal, urban architecture.
These building blocks do incorporate the square—a shape that dominates our cities—but regard it only as a special variant in the context of a diverse canon of rotation symmetries. This way the software is proposing an urban architectural concept that liberates the spatial order from the dominance of the right angle.
The basic geometric building blocks are given agency algorithmically and thus appear as living beings moving across the image independently.
Though the impact of a single polygon may not make much of an impression, in a cluster they have great performance-capacity. This phenomenon of the whole achieving more than the sum of its parts can be found in nature time and again, e.g. in swarm behaviour of fish and birds.

The software is based on algorithms I've been developing in my pattern drawings since 1989; as shown in the 1993 Neuer Aachener Kunstverein exhibition entitled Raum Muster (Spatial Patterns) [1].

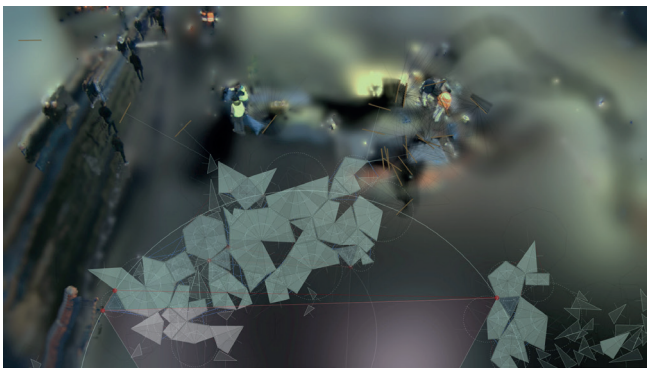
The software automatically adopts these manually developed tessellations (mosaic patterns). In earlier geometry-based software experiments (Trace Pattern I [2] and Trace Pattern II [3], Double Helix Swing) [4] generating purely geometric patterns proved to be aesthetically uninteresting. In Trace Patterns I and II the artefacts of the pedestrians' motion traces break up the hermetic geometric world. Double Helix Swing introduces random processes into the generation of geometric agglomerations. In Turnstile three principles come together (geometric tessellation, video-image data analysis and swarm behaviour) and assume creative power alternatively and responsively in accordance to temporal rhythms.

The setup of the geometric architecture is established by joining regular polygons with varying rotation symmetries. If tessellation occurs they can form patterns with an inherent grammar defined by geometric qualities. However, for the most the pattern is made up of a more or less chaotic assemblage of parts of regular polygons (triangles) with varying symmetries. The software represents an attempt at automatically establishing pattern constructs based on the smallest, self-organizing geometric building blocks; in this case a right-angle triangle that can by rotation become a regular polygon. These elements create ever-changing fluid formations in the 'environment' of a live-camera-image of architectures based on the movements of people.

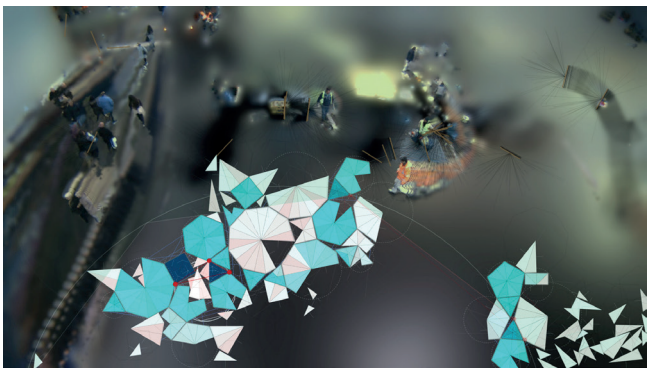
It was important to us to let the viewer see the algorithmic processes running in the background. For this reason we try to avoid using explicitly implemented visual effects in our graphics; rather in many instances the graphics are based on modified debug output, which builds a bridge between form and calculation.

The environment for all agents within the system is provided by the live footage recorded by the camera installed on a mast above the area where the images are captured. In order to separate traces from static image components, each new frame is measured against a median estimate of a pedestrian free space.

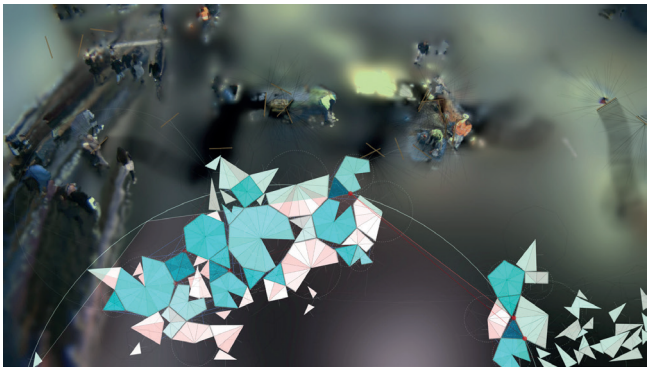
Image components that significantly stand out against the background, such as moving pedestrians, are added to the environment of the agent, whereby colour as well as quantity of the movement is recorded. All elements within the agents' environment are subject to a continuing diffusion that transmits motion and colour information from its source out into the rest of the picture where it begins and continues to blur sat a set pace. The colours of the pedestrians (i.e. their clothes) spreading across the image are detected by linear agents —'brown brooms'— through sampling coordinates marked by black lines; these are then gathered, whereby they form a black trace and are guided to the triangular agents which evade the motion within the image.



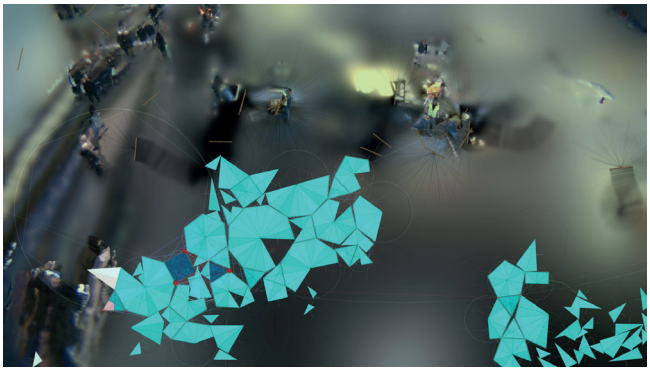
Screenshot of a pattern generation



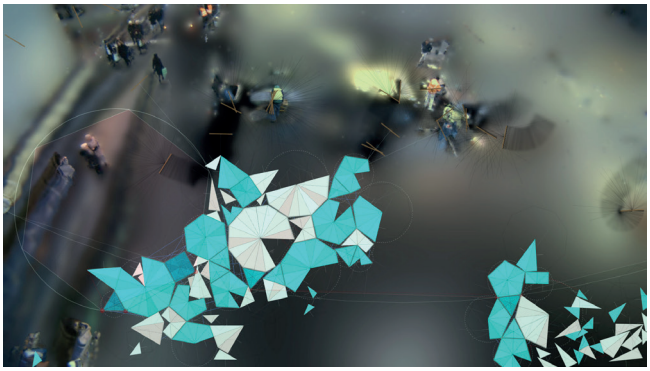
Attraction of a polygon graded in colour: high=dark turquoise; middle= turquoise; none=grey



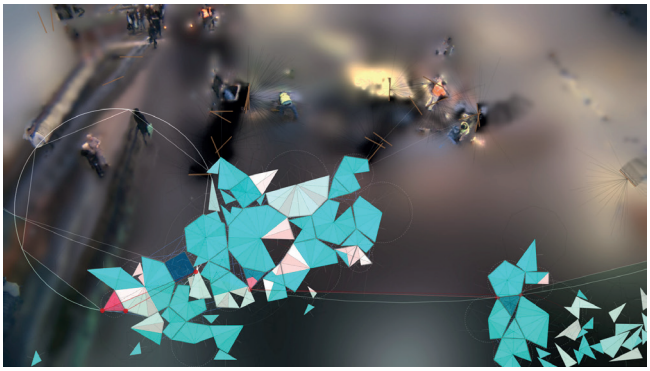
Complete polygon = dark turquoise; almost complete=turquoise; incomplete (splinters) = grey



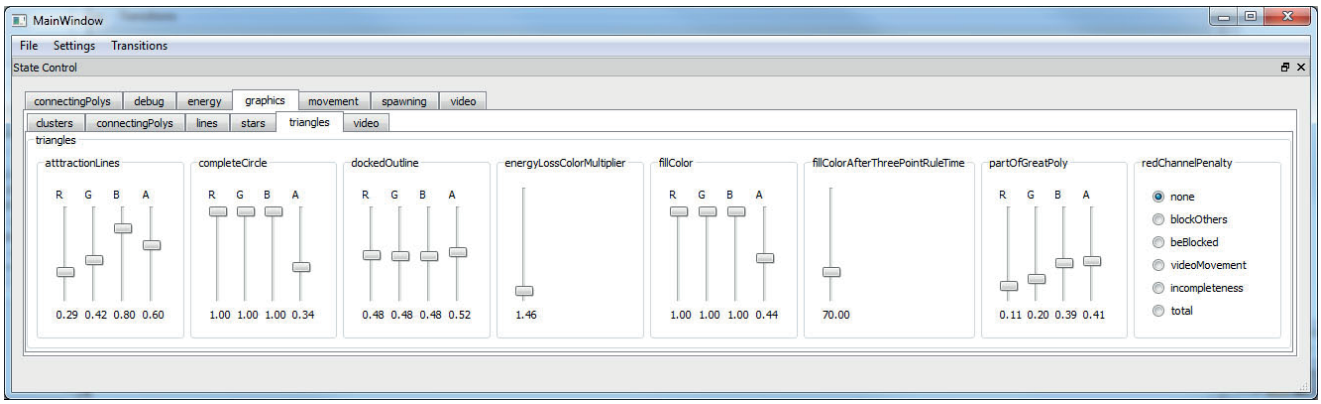
Completeness obstructed slightly by other polygons = turquoise
Completeness not obstructed by other polygons = dark turquoise
Completeness obstructed by other triangles = light grey



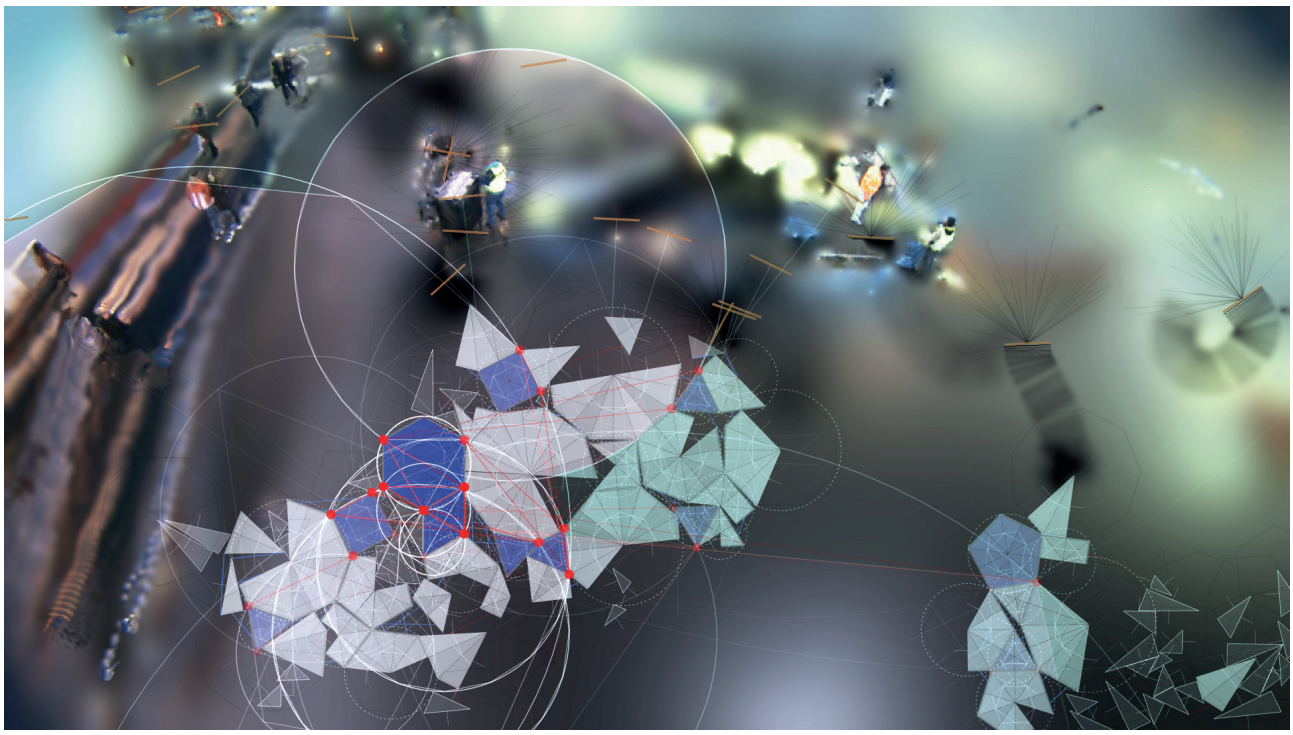
Geometry disturbed by pedestrian movement = light grey
Geometry slightly disturbed by pedestrian movement = turquoise
Geometry not disturbed by pedestrian movement = dark turquoise



Red: obstructing the completeness of other polygons



Behaviour control settings, interface parameters (screen-print)



Screen-print on the display

Following an intensive debate about different forms of growth and the accumulation of structures we opted for a system in which triangles successively self-assemble into complete, regular polygons, which in turn form larger agglomerations of tessellating polygons. The regulative principle is twofold: restricting the attractive forces of compatible triangle sides and determining the connection affinity of the motion-triggered 'temperature'; the latter running analogue to crystallisations-, or sublimation processes that break up the connection of structures in unattractive locations, thus allowing the building blocks to move freely across the image and settle in a 'cooler' spot.

If this process—propelled by the movements of pedestrians across the image, the completeness of polygons and overlaps with further polygons—were left undirected as in Brownian motion, it would result in jerky dynamics. For this reason we decided upon an 'intentional approach'. Hereby the sides of the triangles virtually scan the various spatial directions within the geometric scene, until a more attractive location is identified. Once it has assessed its surroundings through 'ray casting' (as visualised by the blue lines) and determined that the path leading to its goal is obstacle free, it accelerates towards it in a fluid motion at a speed that is proportionate to the remaining distance.
These construction parameters cause tessellations to form in zones with low pedestrian traffic leaving high pedestrian zones more or less void of geometric artefacts.

Once all the elements in the system, the forces and collisions affecting them, have been programmed to simulate physical processes [5], the results show natural looking movements—and some fascinating effects—with agents colliding en route or using their remaining momentum to assemble. With the support of methods for the speedy recogni-

tion of elements within a particular zone our programme continuously searches for accumulations of tessellated triangles and special constellations of complete polygons. These influence the appeal of their surroundings and—should the relevant rules apply—cause polygon chains to form that span the space and create the rhombic fragments of a star mosaic.
All the data on the interplay, the ebb and flow of agents and polygon chains is transmitted via a network protocol (OSC) to software for sound production (composed by Yunchul Kim).

1.4 The Sound Installation

The generative video installation interprets motion traces that consequently create their own 'agents'. The activity of these geometric agents is translated into sound: large polygons connecting small polygon islands are translated into tones according to their symmetries. Thus the tones represent those sounds the virtual agents are creating in their synthetic world.

II.) The Artistic Concept: Differentiation and Reference

What underlying ideas form the genesis of this work? And what argumentation does the work use within its own context? The artwork encompasses urban space and its geometries. Geometries define the earth up to a point; when humans settled, geometries were also used to map the near and far, the inside and outside, the you and I. In short: geometries map the physical coexistence of human beings.
Geometry orders habitats. It interprets, structures and alters movement within a space; it is a component of the 'language' of habitats. It records the flow of movement, the swarm behaviour of humans (and animals) within urban environments and the surrounding areas.

2.1 Geometry as an Alphabet of Space

The aim of the geometric tessellations is not the measurement of a space. Geometry is used to record the motion or inertia of people within a space and thereby identify basic characteristics of the terrain: spacious or restrictive? Open and with perspective? Attractive to people? Who or what is dominating it: nature or architecture? Animals or creatures? Can one sense neighbouring architectures from the given space? Is the structure of the (urban) landscape recognisable?
The geometric pattern drawings at hand use geometric primitives to visualise the axes of the architecture and the neighbourhood. These identified structures form the basis of geometric calculuses that offer suggestions for further design and building plans.

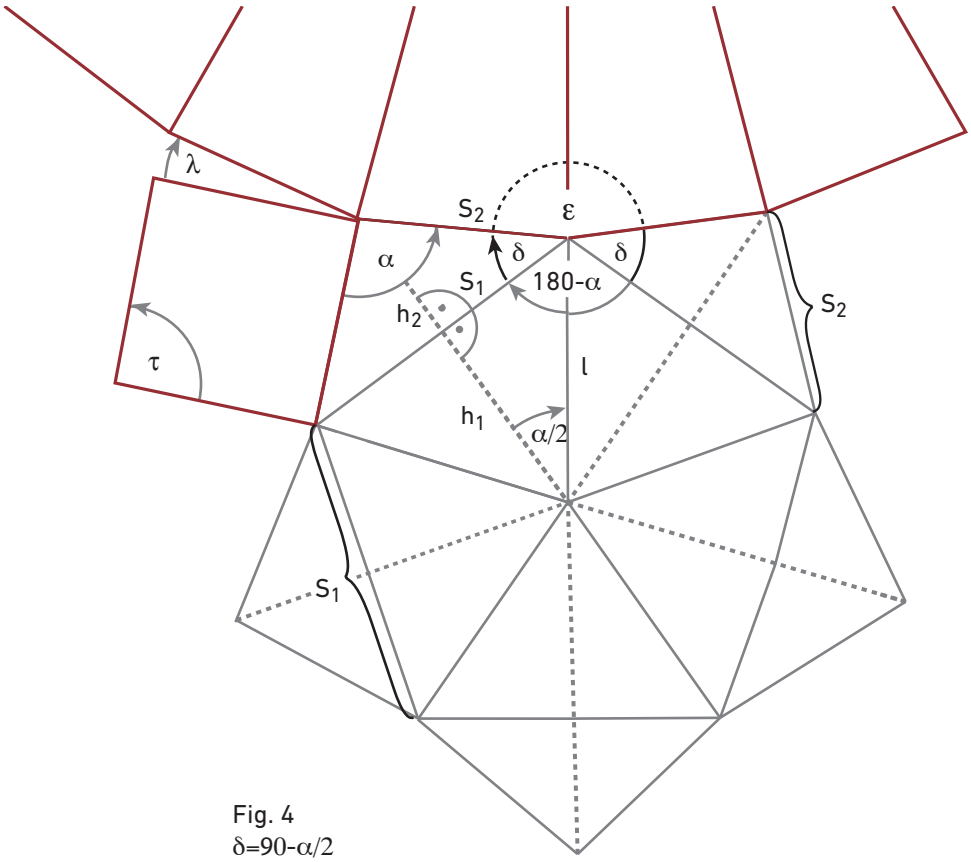


Fig. 4
δ=90-α/2
ε=360-(180-β)-2x(90-α/2)

Example of tessellation

In *Laws of Form* George Spencer Brown develops a system of graphic calculus in which the distinction between elements is considered the basis for the recognition and description of a situation. Brown states: *We may know nothing at all through narrations* [6]. According to Brown's observation and formalisation, knowledge derives from experience and practical action.
By referencing Brown I hope to position the manifestation of urban architecture beyond the current narrative. A system of symmetry operations (translations, rotations, reflections) serves as a regulatory system for deciphering the urban environment and developing its future.

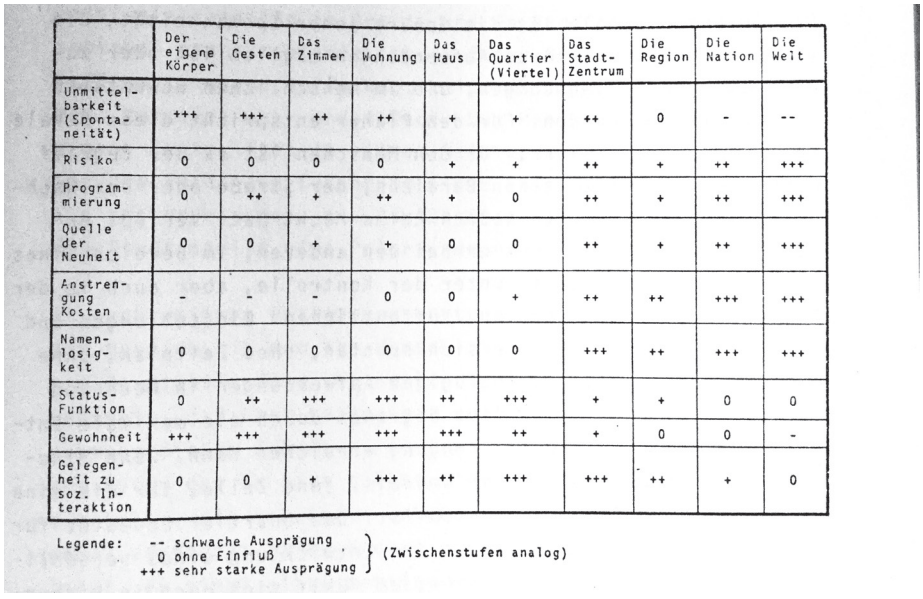
2.2 Polygons as Models in Urban Planning

Within the regulatory system of my constructions polygons constitute the smallest components. To explain their roll within urban planning I quote Abraham Moles and his shell model, which schematically describes man's activity and influence radius. Regular polygons are an attempt at depicting these circular shells within an environment by means of classic symmetry operations.

„The only psychological certainty the individual can experience in his or her perception of space is the awareness of him-, or herself as the centre of the universe. Only from the standpoint of the philosophers' 'the self and the here and now' can the individual experience the 'outside' i.e. the en-

vironment as a spatial extension of the self or alternatively as an obstacle; equally the expansion of space is experienced to the extent to which it relates to the self. One experiences the world from one's home outwards, and not the other way around; not from the universe to the home. Hence every phenomenology of space and every psychology of a town or an environment should begin with the 'self' as the centre of the universe; this universe unfolds as a series of subjective shells nested within one another with the immediate universe at its core, that is, the body of the individual. The psychologist will not be able to avoid taking the elementary certainty of the individual into account when studying the individual's relation to the town and his or her attitudes, perceptions and reactions." [7]

In his writings Abraham Moles formally depicted the 'interaction space of the individual' (1977) and thereby paved the way for processing respective objectives in medial systems. Moles' shell model shows how urban planners can read and utilize the circles in my pattern drawings and the software as (semantic) metaphors. Moles' approach postulates a psychological perspective beyond the individual view in order to overcome the artist's or architect's conflict of interest, i.e. remaining true to themselves whilst planning for the community: „*In this regard, the psychologist challenges the creator of the space—be it the architect, the planner, the interior designer or engineer—whose starting point is the space itself in its entirety and not the individual. There can be no centre of the universe for those who by definition are situated on the 'outside'.*" [7] Moles requests an ...interplay that aims to guarantee the optimisation between interaction and privacy according to the temporal and spatial budgets specific to each socio-professional group.

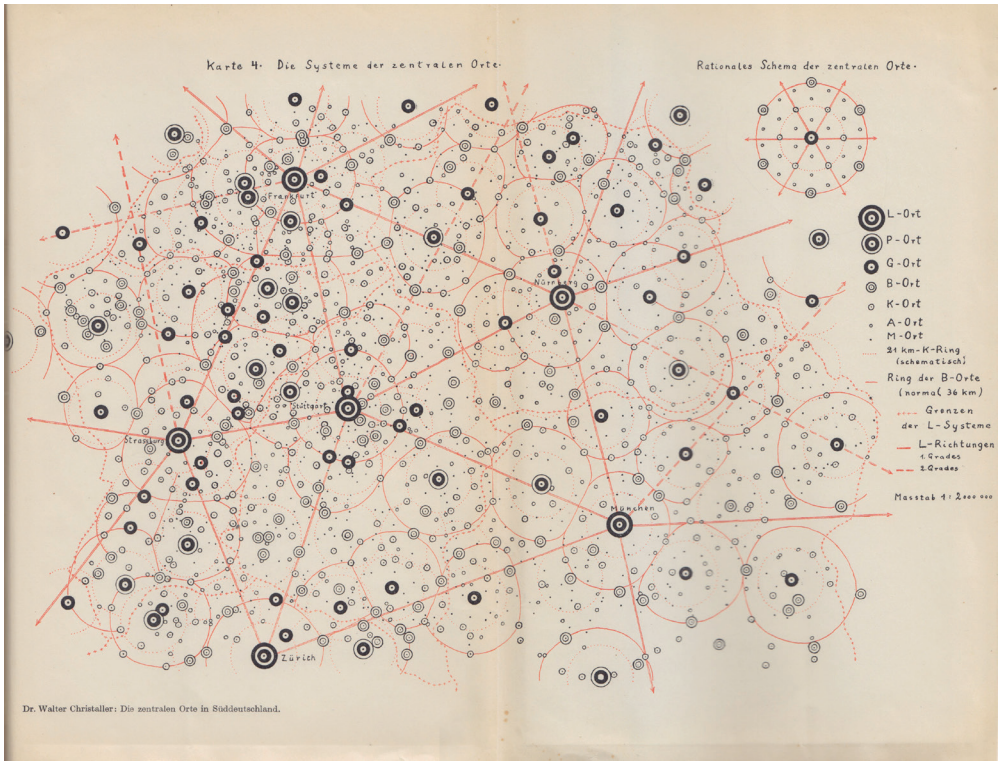


	Der eigene Körper	Die Gesten	Das Zimmer	Die Wohnung	Das Haus	Das Quartier (Viertel)	Das Stadt-Zentrum	Die Region	Die Nation	Die Welt
Unmittelbarkeit (Spontaneität)	+++	+++	++	++	+	+	++	0	-	--
Risiko	0	0	0	0	+	+	++	+	++	+++
Programmierung	0	++	+	++	+	0	++	+	++	+++
Quelle der Neuheit	0	0	+	+	0	0	++	+	++	+++
Anstrengung Kosten	-	-	-	0	0	+	++	++	+++	+++
Namenlosigkeit	0	0	0	0	0	0	+++	++	+++	+++
Status-Funktion	0	++	+++	+++	++	+++	+	+	0	0
Gewohnheit	+++	+++	+++	+++	+++	++	+	0	0	-
Gelegenheit zu soz. Interaktion	0	0	+	+++	++	+++	+++	++	+	0

Legende: -- schwache Ausprägung
0 ohne Einfluß
+++ sehr starke Ausprägung
} (Zwischenstufen analog)

Abraham Moles shell model

Abraham Moles makes it clear that the algorithmisation of a space results from a change in perspective. A secondary observer becomes the formal framework within a formal system, which is interpreting reality. In order to achieve this, Moles applies the same geometries Walter Christaller used in his urban planning paper (1933) [8], Die zentralen



Map illustrating the frequency of telephone connections as a key to describe the centrality of locations according to Walter Christaller

Orte in Süddeutschland, (Central Locations in Southern Germany), and expands them to include the subjective evaluation of the individual, thereby making them accessible in a planning context.

2.3 Intersubjective Space

However, as a framework for the power of the imagination, geometry has its limitations. How then can we manifest visions of a communal space? For this is the very social space we are debating in our search for a design process that is not dominated by the designer's personality (with participation depending upon cultural agreement) but rather one that supports creating structures as spaces of opportunity.

Whilst working on my initial pattern drawing, I made the acquaintance of Vilém Flusser in Southern France. The connection he draws between Western tradition and media euphoria steered me towards conceptual art and computer programming. But how to translate those values that resonate in art into the framework of geometry or software? What can geometric networks offer?

In contrast to Christaller, in his essay *From Subject to Project* [10] Flusser doesn't regard topology as a description of supply nodes. Like Moles he emphasizes the network of communications and identifies a virtual space that allows visions and cultural activity to unfold—encouraged through the immateriality of these networks.

...as soon as geometry is practiced, villages become cities.[...] The cultiva-

ted and cultivating life is a connection plan. Intrahuman relationships are so tangled thanks to this plan that the knots behind the mask of vegetarian wolves can be identified.
In order to conceive of this new city model, one must surrender the intellectual categories of geography in favor of topology. This task is not to be underestimated. One should not conceive of the city to be designed as a geographical place (such as a hill near a river), but rather as a fold in the intersubjective relational field. [11]

Vilém Flusser diverts from the perspective of the individual as portrayed by Abraham Moles. The layout or 'circuit board' of a town or city should serve relationships and communication. Like Spencer Brown, Flusser requests not a description of the urban space, but rather a design offering the 'hardware' to develop what he terms 'theoretic spaces'. *The theoretical space to be designed in this manner is a school (a place of leisure), because all work (all transformation of relational fields) is mechanized and relegated to the subhuman.* [12] *It is [...]a laboratory for formal experiments, for sperimentazione mentale; for it is a space for the processing of intrahuman relationships...* [13]

Since Flusser wrote his book life has been transformed by the digital age. Flusser's anticipation of the creative power of a theoretic laboratory was visionary and opened up new spheres for artists to explore. Today's technology presents us with a number of possibilities to create self-learning, flexible programmes, to establish intersections and to predict influences in real time—be it in the public sphere or on social media. It is hereby evident that the agency of the algorithm has more and more influence on our everyday lives. Turnstile opens up architectures digitally, operating playfully and ephemerally, suggesting and discarding designs as it goes. Flusser warns us that this technical space is a philosophical one and its influence must be regarded as culture. In his essay *Protokoll einer Ausfahrt (Protocol of a Drive)* [14] Georg Trogemann describes how the various formal systems and different levels at Schadowstraße underground station influence pedestrians and points out how the installation succeeds in bringing this effect into the public consciousness.

2.4 A Digital Installation for the City

Turnstile is an interactive installation and thus in essence ephemeral. It was not designed to alter the city's structures, but to influence our perception thereof. Turnstile exists in a temporal dimension defined by algorithms; it develops relationships and discards them; it plays with various agents to create an image composed of pedestrians, plaza, light and geometry.

Ultimately the geometrics are based on a planning vision with a pragmatic focus: to challenge the ridged framework of the right angle, which has infiltrated the modern city, and extend it into a canon of varying angles and geometric primitives. This way, urban planning can

tackle the complexities of a real situation—without diggers or demolition balls—by incorporating axes and alignments near and far into the design process.

The geometry of motion (i.e. the movements of pedestrians across the square above the underground station) in the interactive installation Turnstile follows a particular grammar: the interplay of local events, pedestrian activity and social interaction becomes its architecture. The diverse possibilities of the algorithmic performance soften the radical position geometry naturally holds and instead pose a hypotheses and make an offer to the citizen; an architecture that is formed from the actions of the passer-by.

Ursula Damm, Berlin 2018

Sources:

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