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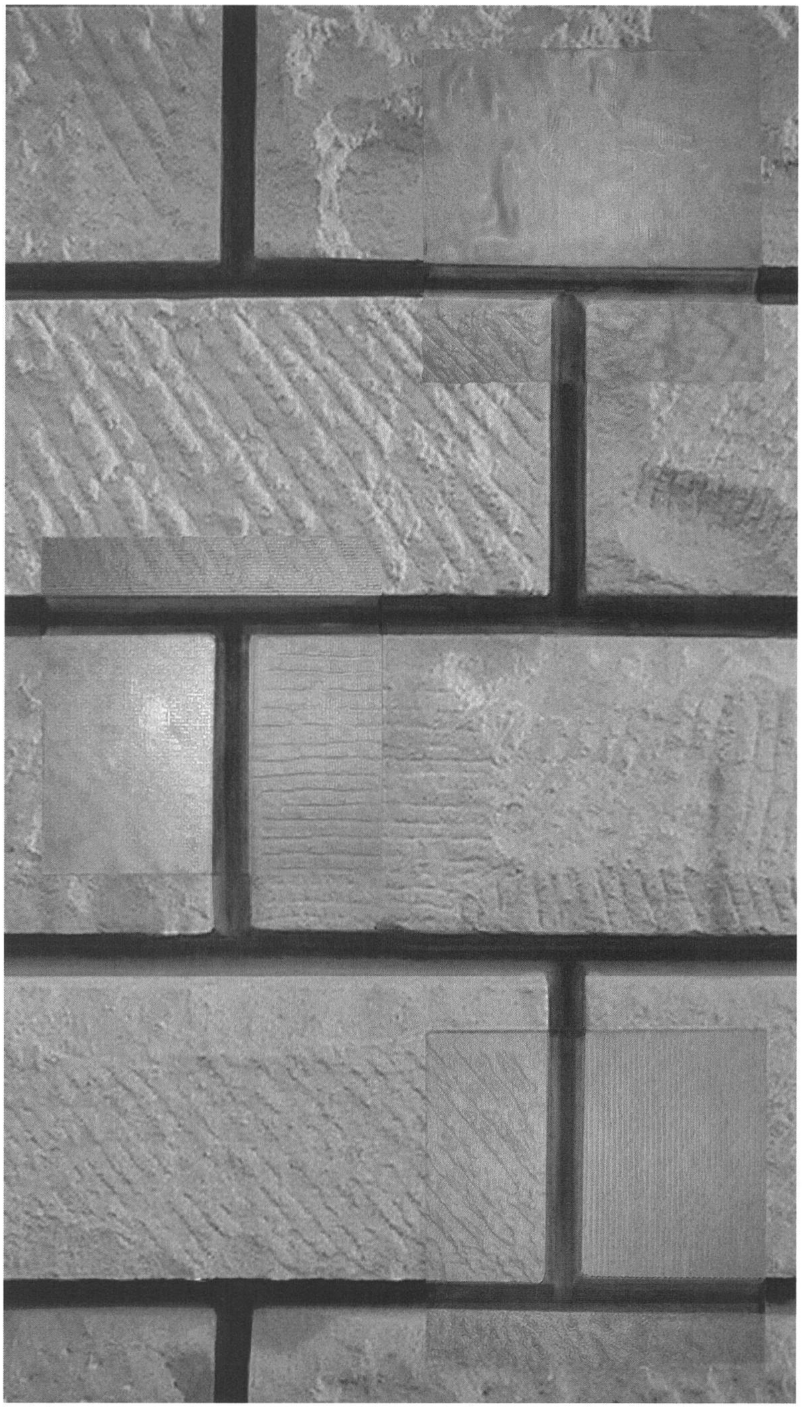


Image of the exhibition panel: the fabricated stones set into a 1:1 scale image of the original context

The Rustizierer

A dimensional translation of antiquity into technology

Russell Loveridge
Kai Strehlke

The Rustizierer is the first project to formalize ongoing research work aimed at translating two dimensional images into three dimensional forms. This research was first undertaken in the ETH winter semester course of 2002/03, to provide examples and tools for student use in the milling course SURFACE:LIGHT. The resulting software code was developed to translate two dimensional pixel data into three dimensional digital forms that could then be manufactured on the 3 axis computer numerically controlled (CNC) milling machine. *The Rustizierer* was developed from this initial research, to take part in a larger experimental contribution of the Chair of CAAD and the Department of Architecture to the exhibition *G. Semper 1803 – 1879, Architektur und Wissenschaft.*

Gottfried Semper came to Zurich in 1853 on his appointment as professor of architecture with a commission to build the polytechnic school building. He was eventually also commissioned to design the university observatory, Haus Fierz and the Stadthaus in Winterthur. In his designs for these public buildings Semper employed his architectural philosophy of facades to project both a sense of significance and an ornamental narrative.[1] In *Die vier Elemente der Baukunst*, Semper depicts four basic parts of the building: the plinth, the walls, the roof, and the hearth. His approach to the facade was inspired by these principal components and manifested itself as a differentiated treatment of the facade.

The rustication of stone is very important in the plinth, as it was used to create a sense of strength and boldness for the base of the building. Despite its rough appearance, the workmanship of these stones is very intentional and controlled. The different techniques of stone-working are balanced to produce an overall rusticated texture for the facade, yet each stone has different intensities of tool markings and different levels of coarseness. Semper's writings of this time include specific writings on the practical artistic working of metals and hard materials such as stone.[2] This fact is most fitting as the rusticated stonework at the base is not structural, and acts specifically as a cladding; the stones having been placed *in situ*, with the masonry joints, block spacing, and rustications carved into the facade after mounting. Semper's architecture was itself a translation of antiquity to the purpose, scale, materials, and working methods of 1850's European architecture. *The Rustizierer* takes a specific part of this work, and further translates it into the contemporary architectural language of digital design and fabrication.

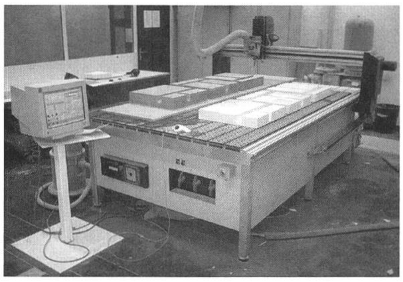
The 'old' flatness

Current forms being generated by computer in contemporary design often strive for an aesthetic of geometric purity. Recent architectural discourse in this area has focused on issues of topological surfaces, and is most commonly associated with non-Euclidean (*blob*) architecture, where surface is seen as slippery, fluid, formable and flexible.

1 *The Rustizierer* project was a collaboration between the Chair of Machinic Process in Architecture and the chair of CAAD. The project was part of the exhibition *Semper+*, an exhibition of projects that reinterpreted some of Semper's works and theories in architecture using contemporary technologies and techniques. The project was included with the exhibition *Gottfried Semper 1803 – 1879, Architektur und Wissenschaft*, and was on display at the Museum für Gestaltung from October 2003 to January 2004.

2 Gottfried Semper, *The Style in the Technical and Tectonic Arts,* Zürich, 1863, as referred to in: Nold Egenter, *The Metabolism of Form In Antique Architecture*, presentation paper – International Seminar, Architettura in: Pietra a Secco, 27.-30. Sept. 1987

This aesthetic is a natural evolution from the modernist doctrine of transparency and immateriality. Flatness and standardization prevailed in modernism, due to the direct influence of industrial manufacturing and mass production of building components. The modernists emphasized the efficiency of standardization through the use of regular geometry and component assemblies in construction. The introduction of the computer and its ability to calculate "freeform" surfaces has mutated the geometry of this doctrine, but has had less impact in the areas of materiality, texture, and ornament.



ETH CNC milling lab

Most surfaces and materials employed in the architecture of the present day are flat, un-textured, and show little trace of their manufacturing process. Items that do show their fabrication history are most often regarded as handicrafts, and are used to signify value and importance, or more importantly - cost and reduced fabrication efficiency. But to a CNC fabrication machine, a smooth surface or a formed surface are topologically identical. The complexity of texture and pattern is a product of the surface's mathematical code, and independent of the topological level of a basic surface. The production costs then simply become an equation based on the quantity of raw material and processing time, however at an industrial scale the processing time becomes less and less of a factor, and the positive economics of *mass customization* become possible.

Versioning and *Mass Customization*

Architects seeking to be on the cutting edge freely appropriate technologies from other disciplines. To realize this successfully they must work at translating the theories, concepts, designs, and technologies into an appropriate architectural context. This translation is often problematic due to the different knowledge, traditions, and methodology between disciplines and their supporting trades. An effective translation requires a common language that can be used to express ideas, explain methodology, provide support for analysis and experimentation, and effectively communicate the results. A common language between all contemporary technologies actually exists, however architects are typically untrained and unfamiliar with its syntax. The language is digital binary code, and it is only now that architects are expanding the definition of their discipline, architecture, to include an understanding of this language within their palate of design tools.

The concept of a programmed and adaptive response to a specific design problem is still in its infancy. The computer has typically been perceived as a tool, used for CAD drawings, visualizations, and in some cases "virtual" analysis. However, with ongoing advances in both the power of the technology (and its declining cost), and in the arrival of a new generation of architects who have grown up being educated with computers, the full potential of a computer as a procedural machine is slowly being realized. The ability to analyse, manage, and manipulate vast amounts of data can be used to drive both working efficiency, and generate a final design.

"Quickly and continuously converting new product ideas into crude mock-ups and working models turns traditional perceptions of the innovation cycle inside out: instead of using the innovation process to come up with finished prototypes, the prototypes themselves drive the innovation process."[3]

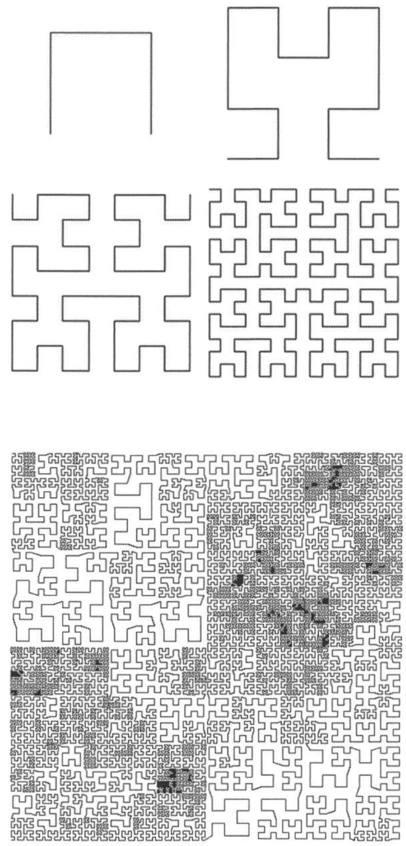
The declining cost (and increasing availability, as the technology trickles down from the auto manufacturing, aerospace, and shipbuilding industries) of CNC fabrication technologies, is driving this process further. The first examples of "flagship" buildings were conceived and built with these methods in the late 1990's, and the technology is now filtering down towards the common practice of architecture. This transformation of the design process is what SHoP Architects calls *Versioning*[4] – a focus on process rather than on form. *Versioning*, as the name implies, promotes a continual evolution of a design using both parametric based generative software, and CNC manufacturing. The end goal of the process is to create a broader understanding of the design problem and then be able to customize the final response from the infinite possibility of solutions. The end product is not so much a single prototype as it is the innovations that occur as a result of thinking and working the problem. Through the working of the methodology and understanding and codifying the parameters of the problem, the architect achieves increased control relative to the production of their idea.

"This is not a call to replace the human act of design with algorithms, but is a critical search for a common language between design and execution. The resulting control of these processes empowers the architect to take on the role as the translator of unforeseen relationships existing simultaneously in imagined and real space."[4]

This combination of parametric design and CNC manufacturing forces a reevaluation of the modernist machine paradigm, from standardized mass production, to *mass customization.* Mass customization allows for the possibility of adjusting each manufactured piece to the specific requirements of its eventual owner. This concept of customization is most often applied to industries where there is a direct interface between the body and product, such as tailoring, or furniture, however, mass customization can equally be applied to concepts of structure and aesthetics, and specifically to architectural construction. *The Rustizierer* demonstrates how procedural design codes and production techniques can be used to expand the architectural material palate, to reintroduce the issues of texture, ornament, and the working narrative, and to develop items that express their individual characteristics.

A return to the narrative surface

In parallel to the creation of topology with computers, a different, yet related, trend is reemerging, the return to the narrative surface. The use of building facades as symbol, depiction, or billboard, is occurring through the application of digital presentation technologies and modern material technologies. The development of digital projection facades has evolved dramatically over the last decade. Beginning with the Blinklights projects in Berlin and Paris, and Toyo Ito's Tower of Winds, and evolving to the complexity of the NASDAQ-Times Square media surface. These facades act as urban transmitters, bringing architecture into the realm of projection media such as television and film. The envelopes of buildings become programmable surfaces that can project their contents outwards translating a traditionally interior narrative to the exterior.

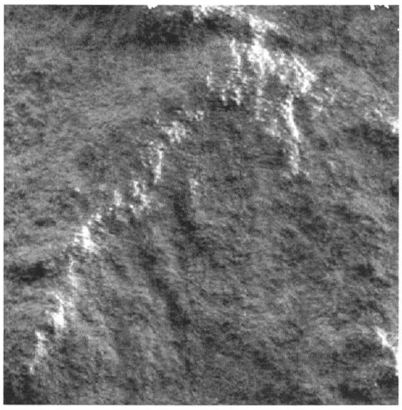


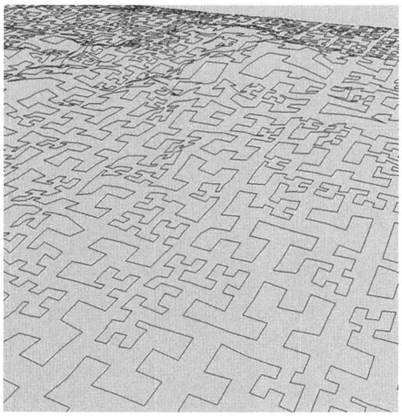
The Hilbert curve: a mathematic algorithm whose recursive formula allows one continuous line to create different densities of texture

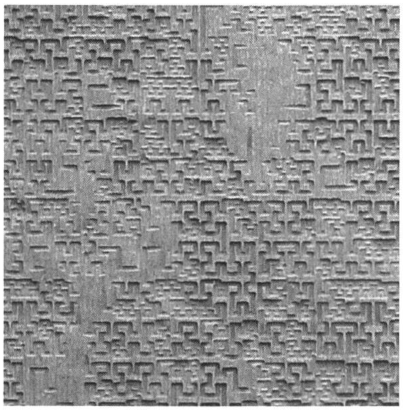
3 Micheal Schrage, *Serious Play: How the Worlds Best Companies Simulate to Innovate*, Harvard Business School Press, Boston, 2000

4 Holden, Sharples, Pasquarelli (SHoP), *Versioning: Evolutionary Techniques in Architecture*, in: *Architectural Design* vol. 72, no. 5, Wiley Academy, London

Narrative surface is also evolving independently from digital technologies, and is being employed in new passive and material ways. Herzog & de Meuron's Technical School Library in Eberswalde, Germany uses images directly screened into the buildings concrete surface, and printed on the window glass. Architect Francis Soler directly screens images of the gods of antiquity onto the full height windows of the Rue E. Durkheim Apartments in Paris. The images remain static, but they act similarly to Semper's rustication and ornamentation, to enliven, communicate, and differentiate the facade. The narrative facade is again being used to augment the architecture and communicate with the viewer. The relationship between the possibilities of mass customization of pictorial or aesthetic elements and the use of narration across a building facade should be obvious. A series of customized surface panels could adopt attributes from both passive and active narrative surfaces, allowing for direct communication with the viewer in a highly specialized and controlled manner.







Stone sample 1:
- original image
- Hilbert curve interpretation
- milled result

Contemporary translation

The depiction of digital images is controlled by variations in the degree of intensity of red, green and blue pixels. This technology is consistent for all digitally rendered images. In the printing processes there are, however, many different styles of halftone patterns, screens and, offset printing rasters used to reproduce an image. In each style the overall image remains clear and the content remains the same, however each style also imparts a unique visual character, and only upon close scrutiny can the eye distinguish the variations in texture which are inherent to the reproduction process.[5]

The Rustizierer, in its abstract way, is also an image reproduction process. This differentiation of textural characteristics was adopted as a guideline for the project. The surfaces, seen from a distance, should be perceived as "real" or an exact duplication. At closer observation the viewer should be able to determine that the surfaces have different qualities to the original stone-masonry work. Under scrutiny there should be no question as to the role of the computer in generating the final product. These three levels of representation set the benchmark to asses the different algorithms and their resulting surfaces and textures.

Perception

This research was initiated as a method for producing three dimensional forms from two dimensional images. Existing technologies to capture 3d surface data, such as laser scanning, and photogrametry, give precise surveys of existing forms and topologies, however these proesses are computationally intensive, require time and precession in their set up, and require skilled operators to execute and process the resulting data. The objective of our research was to simplify the acquiring of a surface topology that conforms to the visual character of the existing condition.

The localized topography of a surface is acquired by our eyes based on the interplay of colour, and on the contrast of light and shadow. To decipher any given view we rely on both physiological input, and cognitive process. Physiologically the stereoscopic nature of human sight allows for a sense of three-dimensional vision in the form of bifocal depth of field. In addition to this, the sensitivity of human visual acuity gives us the ability to perceive small differences in gradient and reflection, which in turn allows for the perception of even minute texturing.

The cognitive interpretation of visual input cross references the current view with known conditions from experience. The brain uses pattern matching to create a logical interpretation of what is being seen. This use of visual memory allows individuals to train their visual acuity and improve their ability to perceive and interpret a scene.[6]

Process of translations

The Rustizierer's software code mirrored these processes of visual interpretation. The resulting methodology for the re-interpretation of the rusticated stonework is a multi-part process. The development of the project first relies on the capture of an ultra-high resolution image of the test section of the rusticated stone wall (taken from the north facade of the ETH main building).[7] The image is then digitally analyzed using several specifically written software programs, extracting the pixel values, and using different algorithms to reinterpret the surface topology, texture, and also map consistent repeating patterns (the tool traces).

For the texturing of the surface, the project goal of working at different visual scales presented the opportunity to reinterpret the original textural qualities using different analytic and conceptual techniques. The Hilbert Curve was one of several mathematical algorithms that was evaluated, in an attempt to exploit its recursive (fractal) nature to establish different degrees of density and gradient. Other textures were created using algorithms that "twisted, bounced, spiraled, or modulated" the cutting paths in the manufacturing process to create texture and topology that at close inspection was obviously digitally created, yet from the intermediate and distant views accurately resembled the original chiseled surface. The output from the software code was visualized in the CAD and animation software MAYA, and the CNC cutting code (*G-code*) was generated either by the initial *Rustizierer* software, or through the software SurfCAM.

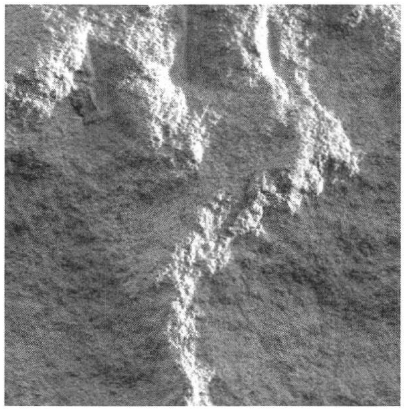
Because the rusticated stones used on the ETH facade had no bearing function, but were essentially only used as a cladding, a contemporary cladding material was sought as a basis for manufacturing. *Eternit* cement plates, a contemporary cladding material, were bonded together to create a monolithic block, providing an excellent ideological, material, and structural relationships to the goals of the project. The use of a manufactured material, that has both a significant local history, and is rooted in technological development, was seen as an excellent choice for this translation of stone.

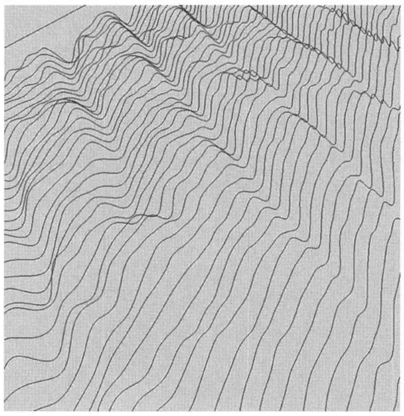
The different G-code files, corresponding to each of the test rustica, were then executed with the CNC mill. Surface qualities and cutting patterns were further modulated by using different tools and grinders attached to the CNC machine, and by adjusting the machine settings during the fabrication.

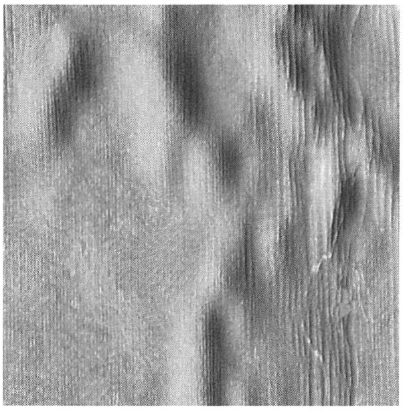
Results

For the *Semper+* Exhibition the final milled blocks were mounted within a 1:1 photograph of the rusticated facade from the ETH main building. The position of the blocks was exactly matched with the photographic data that had been extracted for the surfaces and textures. This mounting provided visual continuity between the image of the original context and fabricated blocks.

The results were very successful in appearance both at the distant and close visual scale. At the end of the digital and manufacturing process the original







Stone sample 2:
- original image
- undulating line interpretation
- milled result

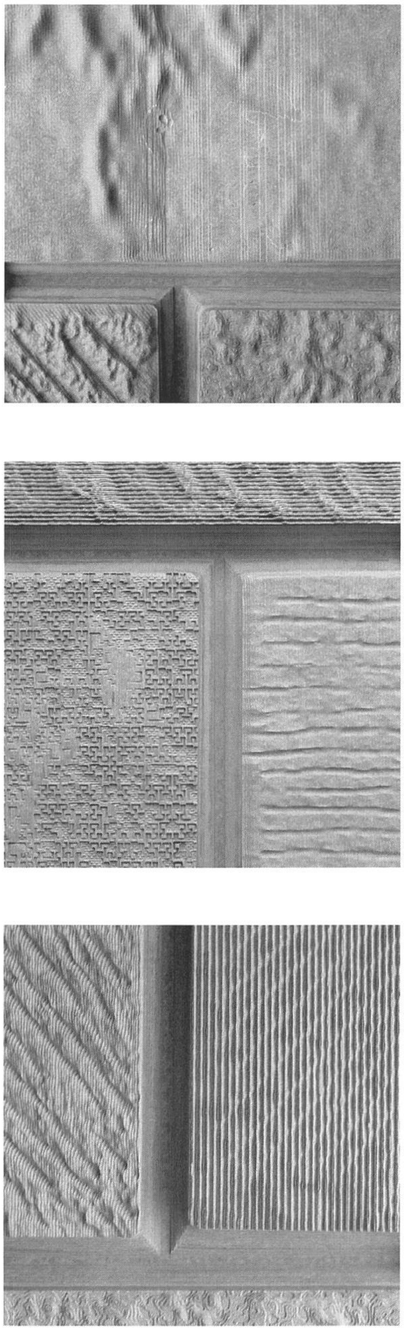
5 Holden Strothotte, *Seeing Between the Pixels: Pictures in Interactive Systems*, chapters 2.1, 9, & 13.1. Springer, Berlin, 1997

6 ebd, chapter 4.5

7 It should be noted that the rusticated stonework photographed for the project is actually a restoration of the original stonework. The renovation and expansion to the ETH main building, conducted between 1915-24, replaced and repaired much of the original stonework that had degraded over time.

rustica patterns are still easily recognizable within the blocks. Each of the nine different surface conditions "blended" with the image at distance, however the algorithmic abstraction of some textures, particularly the Hilbert Curve texture, was more contrasting at the medium visual scale than desired.

The choice of *Eternit* as the material for the stones proved excellent as its durability held the minute detailing of the smaller generated textures. The *Eternit* also provided an excellent continuity in the physical impression of the samples, allowing the viewers to touch and appreciate the tactile qualities of the work, while imparting a strong material relationship to the reinterpreted stonework.



The three final stones displaying their different textural qualities

Conclusion

Semper's work was a sophisticated reinterpretation of antiquity which defined his approach to renaissance architecture. *The Rustizierer* is a further translation of this architectural language into the technology of contemporary practice. Semper's rusticated wall was an ideal testing ground for the application of this technology. The uniform materiality, regular and decipherable patterning of stone working, and consistent colour, all presented a controlled condition where the analysis could more easily focus on the three chosen surface variables: surface topography, grain texture, and tool traces.

The final result is a product of the entire methodology of the project. The project was designed specifically to be flexible and parametric, allowing for a great degree of control over the process. The variables used in the final procedure to define the qualities of each surface, were decided upon based on an understanding of their effect on the program, and on the resulting fabricated surface. The ability to alter the program code and choose the parameters for each of the different rustica, became the design decisions for the researchers.

The inclusion of parametric design in architecture will continue to grow as the architectural role of the computer evolves. Digital design that takes advantage of computationally driven analysis, interpretation and invention, reveals new procedures for solving a task, and new parametrically based solutions. CNC fabrication is already being popularized in both architecture and construction. These technologies will continue to challenge the traditions of architecture, and liberate the architects that employ them.

The Rustizierer project is a multi-layered approach to translation in architecture. It translates physical into digital and back to a reinterpreted physical, it translates two dimensional data into three-dimensional form, historical technique into contemporary technology, and it is in itself a product of other disciplines of technology translated to an architectural context.

The software developed for *the Rustizierer* is continuously evolving. In its most recent version, it has been used in experimentation with ornamented surfaces, and the translation and fabrication of structured and ordered patterns. The results thus far continue to be positive, and future projects to push this research further are in the proposal stage.

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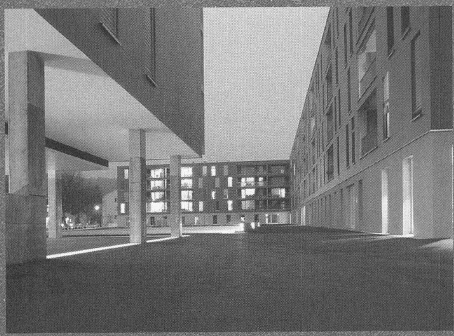
Architektur
Bysäth + Linke, Luzern
Foto: E. Küenzi, Langnau a. A.



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Eternit

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