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Mixing Algorithms in Urban Analysis and Transformation

In his research addressing tactics within architectural design studios, Donald Schön identified the possibility of "imposing an arbitrary discipline" as a means of reframing design problems. Schön noted that designers imposed arbitrary orders (such as grids) as a means of overcoming "stuck" design situations. Schön implied that these arbitrary impositions operated like design moves lacking normative justification. The fact that unintended consequences follow arbitrary impositions is not in itself remarkable. However, the possibility of arbitrary design moves which can result in positive value has important implications for both architectural design and analysis. For design, the possibility implies that successful designers are not necessarily obligated to justify design moves, provided that the designer is able to discern value in unintended consequences, and that the designer is able to act in response to identified value. For analysis, it implies that arbitrary impositions (of, for example, arbitrarily-sized grids onto maps) may be capable of provoking valuable insight, provided researchers remain sufficiently attentive to the accidental juxtapositions which can result.

This paper describes research into the possibility of mixing algorithms, i. e., programmable functions designed to apply arbitrary discipline to source materials or artifacts, resulting in new materials or artifacts characterized by accidental or unintentional relationships. Source materials may include contemporary or historical photographs or maps, urban plans and architectural drawings, as well as digital or physical models.
In this paper, I show that if source materials concerning an existing city are subjected to arbitrary impositions, the newly produced materials include accidental adjacencies which can form a basis for new assertions about the existing urban condition. Significantly, and distinct from operations such as the "indeterminate functions" proposed by Daniel Herbert in a 1997 paper, the imposition of arbitrary discipline does not require randomization. Algorithms are discussed, which while non-random, can result in the same kind of accidental relationships as would otherwise be produced by randomizing processes. Thus, programming of the algorithms into readily available software (e. g., Adobe Photoshop's Actions, or AutoLISP running within AutoCAD) is generally straightforward.

Discerning value within the found or arbitrary.

The value of serendipity in science is well-known (Foster and Ford, 2003; Roberts, 1989). The idea that explicitly stated hypotheses are unnecessary in order to analyze datasets for patterns, in turn informing knowledge, is also well-known and is increasingly common as a scientific practice (Halevy et al., 2009; Kell and Oliver, 2004). In design disciplines, including architecture and urban design, serendipity and accident are acknowledged as legitimate influences (Kolson, 2001; McLachlan and Coyne, 2001; Hayles and Mulder, 1998; Lynch, 1972). To successfully incorporate accident and serendipity into research and design, it seems necessary for researchers and designers to remain alert to inherently dynamic situations and ready to bring interpretive tools to bear on discoveries as they happen. Successful researchers and designers can recognize value in found situations, even (or perhaps especially) if those situations do not succumb to a priori explanations, and even in the absence of explicitly stated hypotheses, search criteria, or methodologies: they can discover value without necessarily knowing in advance what they were looking for (Rosenman, 1988).

Given this background, I make two primary assumptions concerning urban form and representation. First, I assume that urban form can be legitimately treated as a found condition which doesn't require the explicit formulation of hypotheses in order to be analyzed and transformed. This assumption is neither new nor controversial. The analysis and transformation of urban form constitutes a paradigmatic example of Rittel and Webber's "Wicked Problem," i. e., one which defies a consistent approach to problem-solving (Rittel and Webber, 1973). The world's cities are characterized by morphological relationships resulting from people of divergent opinions making decisions over time in pursuit of often conflicting priorities; that our largest cities should as a result appear accidental is not at all surprising. To restate, I assume that urban form can be productively analyzed as a collection of accidental relationships.
Second, I assume that conventional tools of urban representation often operate to actively obscure the apparently accidental nature of urban conditions. In particular, tools such as maps and photographs can tend to "tame" situations which are by nature disorganized, self-contradictory, and messy. For example, deciding to draw a figure-ground map of a city predisposes a researcher to ask certain kinds of questions and to exclude others. Photographs operate similarly insofar as they encapsulate discrete segments of the urban environment. This is not to suggest that maps and photographs should not be used in research, only to suggest that they are not neutral with respect to the kinds of questions they support.

On a deeper level, I made a third assumption, one which I call the assumption of tactical identity between analysis and design. This assumption holds that while architectural analysis and architectural design pursue different ends, their tactics are largely identical: they both involve the production of architectural drawings and models. On the basis of this assumption I allowed myself to project the demonstrated usefulness of representational tools from design situations to situations in analysis.
Following these assumptions, I set out to define a set of tools which deliberately introduce a level of disorder to the question of urban representation as a means of re-seeing the familiar.

Arbitrary discipline and imposed randomness.

The first question I considered was whether the tools were obligated to include a randomizing component. I chose to distinguish between the tactics of arbitrary discipline and imposed randomness in design. Both tactics assume the importance of serendipity, and both tactics attempt to produce "found situations" heightening the likelihood of accident.

Schön and the arbitrary.

In the 1970s, Donald Schön, then a professor at MIT's School of Architecture and Planning, participated in a study of architectural education (Balfour, 1981). Schön was interested in analyzing the pedagogical techniques of architecture studios. As a basis for his research, Schön relied on transcripts of conversations recorded by fellow researcher Roger Simmonds in a first-year MIT architecture studio. A significant portion of the recorded conversations took place between a first-year architecture student, who Simmonds pseudonymously called "Petra," and her instructor, "Quist." In one such conversation Schön identified the tactic of "imposing an arbitrary discipline" as a tactic for reframing a design problem (Schön 1981). A situation arose in which Petra encountered a problem which she was unable to resolve using known methods. Specifically, Petra found herself unable to fit discrete architectural volumes onto a sloped site. Quist's response, as recounted by Schön, was to impose an arbitrary discipline (a grid) over Petra's drawing, which transformed the original problem into a new problem capable of resolution with known techniques. Significantly, although the imposition was characterized as arbitrary, it was ordered rather than random. Except for the fact that Quist's imposition lacked normative justification, it functioned identically to a "design move," part of what Schön elsewhere called the "seeing-moving-seeing cycle" (Schön, 1992). The fact that normative justification was apparently not required implied that similar impositions could be made simply as tests, and could be expected to perform an important function in design processes.

Herbert and the imposition of randomness.

In a 1997 paper concerned with issues of metaphor and catachresis, Daniel Herbert, then on the faculty of the University of Oregon Department of Architecture, suggested the possibility of inviting randomness into architectural design processes (Herbert, 1997). In his paper, Herbert described the process of designing an addition to his own home in Eugene, Oregon. Herbert noted that computer-aided design (CAD) software included several basic operations such as grouping and scaling of components, which made it trivially easy to perform actions such as scaling architectural elements well outside of their conventional range. As an example, he described how he scaled a digital model of an existing roof dormer to 6.7 times its original size in order to fit the addition's desired width. Herbert observed that this kind of mis-scaling, while trivial from the point of view of software algorithms, necessarily resulted in unpredictable architectural relationships between form, proportion, structure, and material.

Although Herbert appreciated the value of accident in design ("its occurrence is unpredictable, its potential causes [the architect] to reinterpret current and future possibilities; its value is open yet subject to certain constraints"), he also recognized the paradoxical difficulty in introducing randomness or accident into design, which is, how can a designer cause accidents to happen? Herbert proposed that CAD software should include functions driven by random-number generators, functions "whose structure and parameters are themselves indeterminate up until the moment when they are invoked, so the designer cannot anticipate and thus influence the form of the intervention [emphasis in original]." Herbert went on to describe how such functions could be incorporated within CAD software applications then under development.

Herbert's 1997 paper defined how a randomizing intervention could take place within a process conventionally characterized by tools designed to "tame" dynamic situations. In an earlier paper (Herbert, 1995), Herbert had acknowledged the value of "media interactions" and particularly the significance of difficult-to-make translations between manual and digital media. In both cases, Herbert emphasized the hermetic nature of digital tools and the possibility of intervening with random numbers, mis-scaling, or problematic translation effects.

In the cases of both Schön and Herbert, the imposition of an external factor created unexpected collisions and conflicts which the designer was newly obligated to confront (or to choose to ignore). In Schön's case, the imposition was ordered (i. e., after the grid was imposed, it was possible to use it as an ordering device), while in Herbert's case, the imposition was random; it did not necessarily provide a new means of bringing order. Also, both cases emphasize that designers need to remain attentive to situations resulting from imposition. In Schön's scenario, the experienced studio critic orchestrated and navigated the process, while in Herbert's scenario, the computer was programmed to introduce randomness, yet the designer was obligated to remain alert to resultant collisions and overlaps, evaluating them against other possibilities. What isn't clear from either case is whether the kind of alertness required to navigate the arbitrary or accidental is necessarily different in kind, intensity, or quality than the alertness required in any other kind of design situation.

Characteristics and use of tools.

Software imposes arbitrary conditions on the work of designers and researchers. For example, to encode, process, and display a digital image requires the imposition of a pixel grid of fixed though arbitrary size. Building information modeling (BIM) software imposes an arbitrary discipline of categories and relationships, as for example when the software prohibits actions such as placing objects of type "window" in a manner that they are not hosted by objects of type "wall." In the following sections of the paper, I consider how these arbitrary conditions within software can be capitalized upon as a means of re-seeing the familiar.

Images.

Even if we allow that only a small portion of the billions of images available online directly addresses urban environments, when we consider in addition the millions of historical photographs and maps of cities, as well as the explosively expanding number of online photographs taken with cell phones and consumer cameras (Crandall et al., 2009), it's obvious that images concerning cities constitute an immense and expanding resource for researchers and designers interested in urban environments. Given as input an image of any size, it is a simple technical matter to write an image-processing script in Adobe Photoshop which systematically rearranges the image content following a simple set of rules. Figure 1 illustrates conceptually how such a script can function. The figure shows, from top to bottom: an original image, cut in regular, vertical slices; every other slice shifted vertically; slices re-inserted at a horizontally shifted position.
An image resulting from the application of this script (which I term a regular mixing algorithm or RMA), bears a degree of visual similarity to both the original image and a third image generated by randomly rearranging pixel blocks. Figure 2 shows, from left to right: an original image taken from a moving vehicle in Jaipur, India; a randomized rearrangement of pixel blocks within the image; the result of running an RMA with vertical slices; and the result of running an RMA with horizontal slices. Similarly, the script can run on maps, as shown in Figure 3, which illustrates a map of Jersey City (USA), randomized and mixed.

The act of comparing mixed images to original images, or of comparing vertically sliced to horizontally sliced images, emerges as an important step in the process of interpreting the results. Initial visual recognitions are often followed by insight concerning the original image and its subject matter. For example, relative to original images, randomly mixed images may prompt visual recognition of an overall balance of color and tone, followed by insight concerning the overall balance of (for example) solids and voids within an elevation of an urban street, or of water and land within a topographical map. Images rearranged according to a vertically-sliced RMA may, as in the case of the image of Jaipur, prompt a visual recognition concerning the prominence of horizontal bands, followed by a recognition of commonalities and differences between first- and second-floor cornices. Or, as in the case of the map of Jersey City, the vertically sliced image may prompt a visual recognition of the tendency of red and black lines to run at 45-degree angles to the image edges, followed by insight concerning the connectivity of freeways and railways within the city. The horizontally sliced image of Jaipur may prompt a visual recognition of white and black blocks of color, followed by insight concerning the disposition of "jalis" (latticed screens) within the building elevations. Certainly, it would be possible to reach any of the insights described here by other means, but the fact that mixed images are capable of prompting these kinds of insights is significant.

Digital models.

Like photographs, digital models constitute a growing documentary source for researchers, available through online resources such as Google Earth and the Google 3D Warehouse. In my research, I considered a digital model of suburban Moorhead, Minnesota (USA) as a test case. As with the question of image-processing in Photoshop, it is relatively simple to construct an AutoLISP routine which systematically slices and rearranges a solid model according to several predefined parameters. Figure 4 illustrates, from left to right: an original digital model; the model sliced and systematically rearranged according to an RMA similar to that described above; and the same model rotated by 45 degrees and then systematically rearranged. Figure 5 shows details of the models in Figure 4.

The possibility of subjecting digital models to regular mixing algorithms opens up a realm of new possibilities because of the multitude of ways in which digital models can be made visible to researchers. Digital modeling software affords a virtually unlimited space of manipulation in which views can be compared, allowing for a process of visual recognition and conceptual insight similar to that described above for photographic images.
Questions which emerge from this kind of manipulation for digital models center around whether regularly mixed models embody observable or otherwise measurable characteristics similar to their unmixed sources. For example, does a mixed model embody a disposition of built and open territory similar to the unmixed model? Certainly, the total open area remains constant, but the configurations of open space necessarily change. Similarly, one could ask whether the amount of ground area exposed to direct sunlight at a given time is the same for a mixed model as for an unmixed one. Questions like these could lead to the determination of characteristic slicing intervals, or characteristic slicing angles, for which the original and mixed models achieve maximum correspondence. Should this be possible, cities themselves could be compared according to their related characteristic intervals.

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Discussion.

The value of mixing algorithms to urban analysis does not derive from hypothesis verification, but instead from how the algorithms enable researchers and designers to re-see the familiar, thereby expanding the range of possible observations; this appears true whether a photograph or a digital model is used as a source. The work described here, though initial in scope, demonstrates that designers, analysts, and researchers concerned with urban morphology and transformation can benefit from the ways in which mixing algorithms operate to make information visible, prompting new insight capable of provoking action and transformation of found conditions.

The first question to arise from my initial attempt to define this toolset was whether the desirable characteristics of mixing algorithms could be identified. Are there certain kinds of mixing algorithms which can be applied successfully to multiple kinds of source material? What qualities characterize a good algorithm? First of all, a mixing algorithm in order to be successful should be simple to apply, that is, it should not involve a tactical move any more complicated than Quist's imposition of an arbitrary grid by means of tracing paper placed over a drawing. Second, it should be scalable; like Herbert's work with CAD software, it should capitalize on the inherent functions of the software without being limited by the material relationships it is attempting to represent. And third, a successful mixing algorithm should be capable of accepting multiple forms of input (for example, JPEG images and DWG files).

The second question concerned quality assessment. Are some source materials inherently more amenable to the use of mixing algorithms than others? Can the latent potential of source materials be identified prior to the application of algorithms? For example, do panoramic images have more potential than singular, small-scope images? Are high-contrast images more interesting than low-contrast ones? Does an image which contains a variety of textures contain more potential than a singular-textured image? Do digital models of free-standing buildings have more potential than models of joined buildings? How do we determine in advance whether it's worth the time to execute a mixing algorithm on given source material?

Finally, I question the role of interpretive tactics. As mixing algorithms are applied to source materials, and new materials result, is it necessary for researchers to develop new interpretive tactics, or do pre-existing techniques remain viable? Pre-existing techniques for interpretation include asking questions about observable physical characteristics of a zone or neighborhood or city. It isn't clear whether such questions are necessarily precluded through the use of a mixing algorithm, because mixed images and models share some of the characteristics of the source material (e. g., average color, in the case of images, or average building height, in the case of models). It is clear at this stage of the research that the act of comparing mixed material to original material is essential, for without comparison, there is a risk that the mixed artifact remains uninformative of anything beyond itself.
In future work, I hope to extend these tactics, first into the analysis of historic photographs, which as mentioned above constitute an immense resource – one which I believe to be amenable to the methodology described here. Second, into the analysis of digital models of urban form constructed by multiple designers, e. g., cities modeled in Google Earth. Like cities themselves, digital environments such as these register conflicting priorities about how the environment should be organized. These digital resources continue to expand, and it's imperative that our toolsets keep pace.

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FIGURE 1.

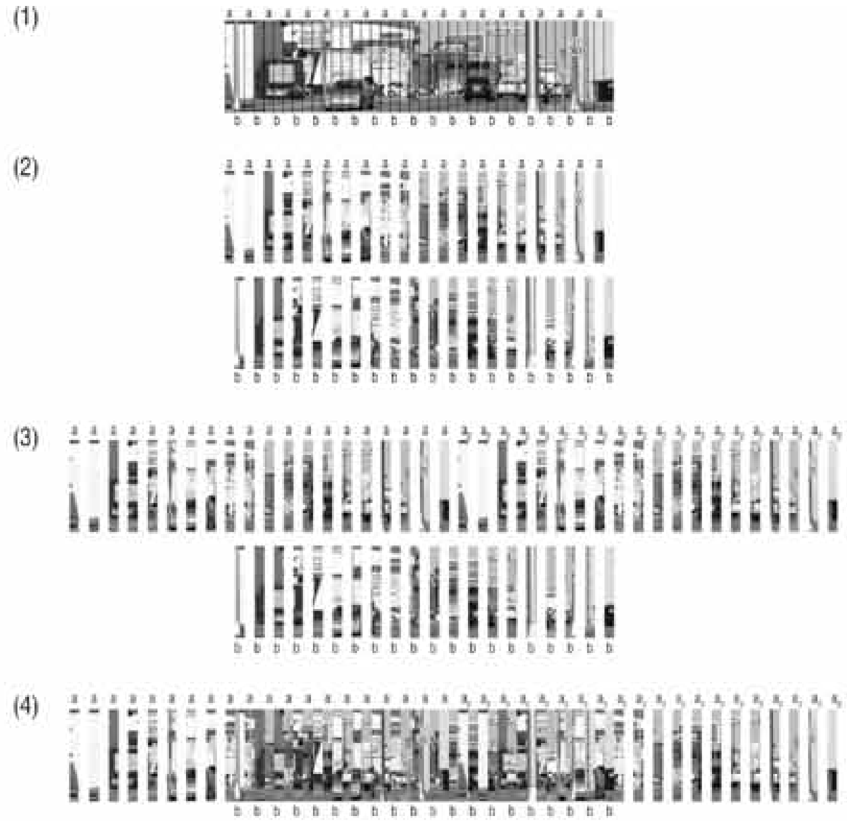

FIGURE 2.

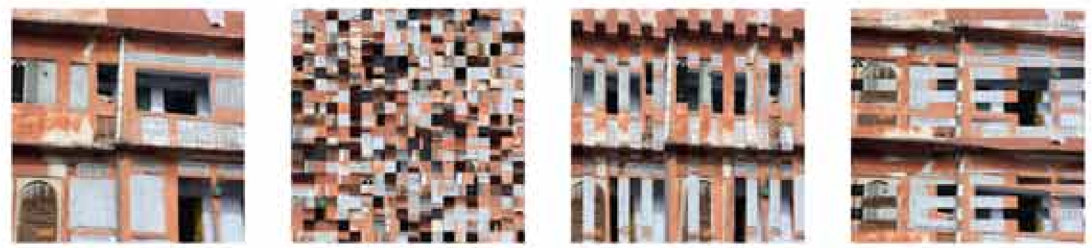

FIGURE 3.

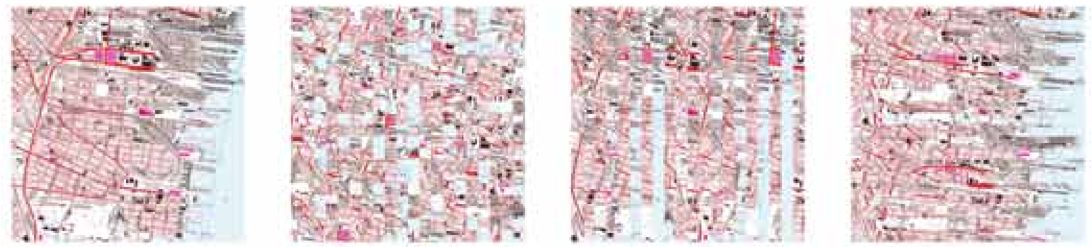

FIGURE 4.

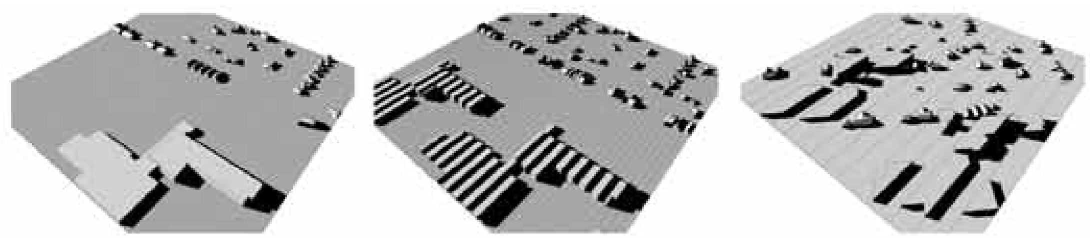

FIGURE 5.