EMPTY FIGURES: Observations on the Problem of Measurement

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Figure 1. Two views of the same body produced by a 3D optical scanner. Note the detail and resolution captured in these digital maps. 2004.

> "The more you look at something in detail…the less and less solid it begins to look."[1]
> - Dean Radin

In recent years new mapping technologies have seen widespread use in disciples as diverse as medicine, film and industrial design. As a result, the science of anthropometry has undergone a radical transformation. Not since the Monaco Agreement of 1906, one of the first international meetings on standardized body measurement, has there been such a dramatic change in the way we produce, deploy and evaluate ergonomic data.

3D scanners used in the automotive industry to generate computer models of clay mock-ups and full-scale prototypes typically consist of a manually operated sensor or haptic probe. These coordinate measuring machines (CMM's) create low-resolution maps that take hours to produce. Increasingly CMMs are being replaced by more efficient, automated techniques. Faster, high-resolution optical

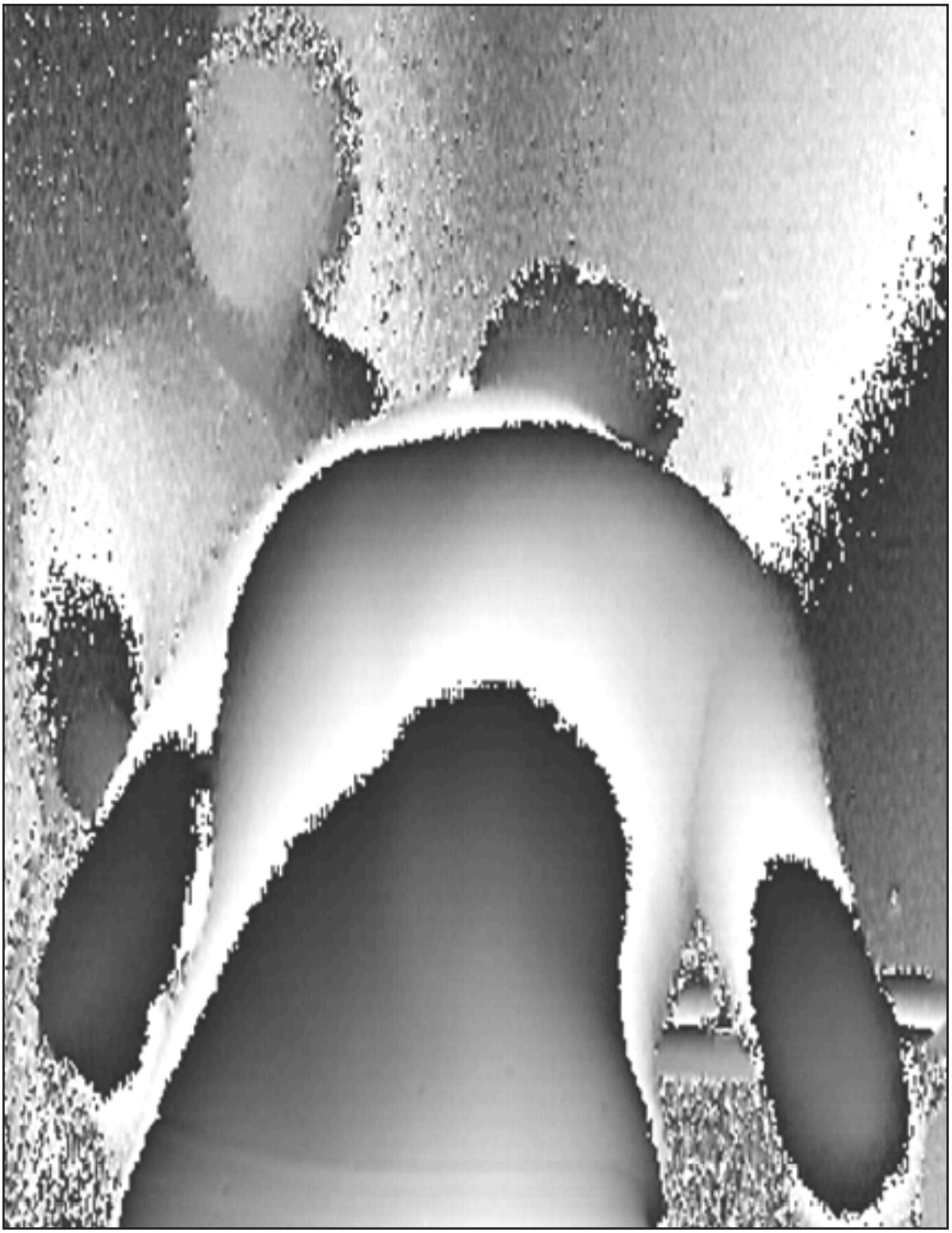

Figure 2. Image showing a 2D map with encoded depth information produced using a 3d optical digitizer.

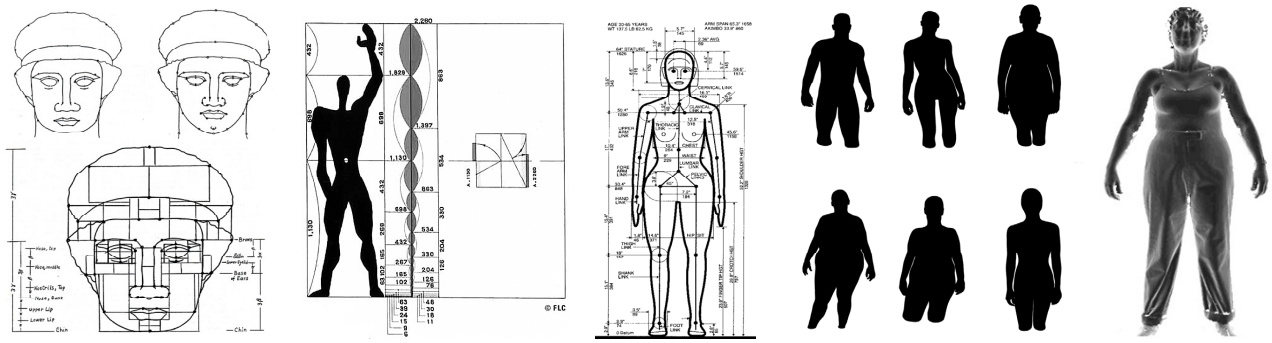

Figure 3. Over the centuries notions of physical rectitude have been determined by various geometric and statistical systems. Different body silhouettes illustrate the impossibility of reducing ergonomic distinctions to fixed or ideal types. Far right: digital body scans.

scanners record objects with lasers or by mathematically interpreting the distortion of flat lines, projected onto a three-dimensional surface. (Moiré Contour Mapping) Because these machines apply the instantaneous, non-invasive properties of light they are specifically employed by game designers to measure live bodies.

Given the power and speed of modern computers, an extremely dense collection of measurements can be stored, manipulated and reproduced. Digital scanners can be used to register complex shapes in a multi-perspectival data space that exceeds the functional constraints of conventional drawings and photographs. What's more their data can be robotically fabricated in a "mass customized" series of multiple scans taken from different individuals at different times. Through the use of digital mapping data building components, furnishings and household products assume an unprecedented degree of dimensional specificity. But this trend toward verisimilitude can also be employed critically as a way to overcome age-old biases especially those that tend to reify abstract notions of beauty based on pre-established orders.

By challenging the assumption that design proportions must follow standardized dimensions taken from surveys of a limited population,[2] new mapping techniques undermine the role conventional ergonomic surveys play in the measurement and accommodation of organic bodies. While late humanist writers like Rudolf Wittkower tried to loosen Modernism's ban on "anthropomorphic projection" his work mainly encouraged a return to the same static harmonies that governed Renaissance design. In classical architecture the "well shaped man" was less a product of statistical analysis and

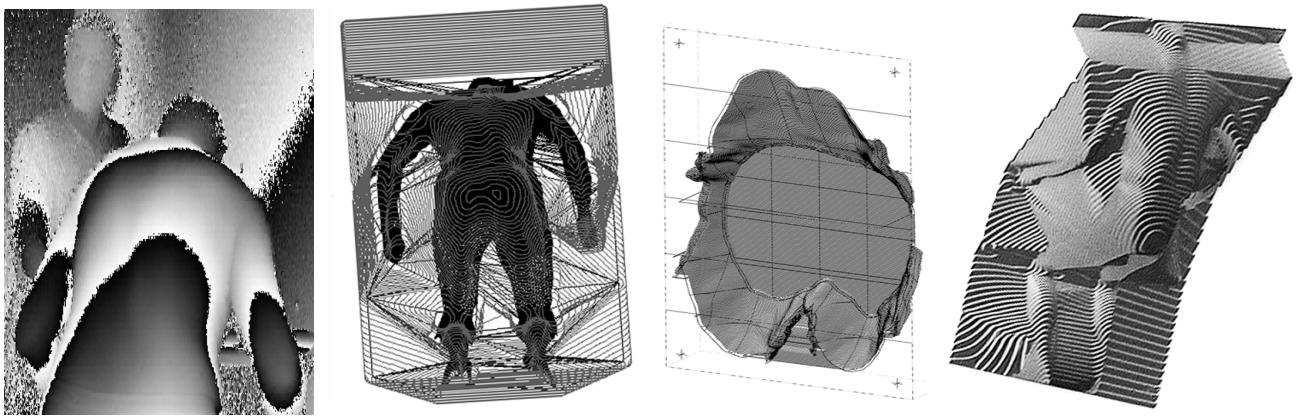

Figure 4. A 3D optical scanner was used to build uniquely tailored furniture suited to the body of a specific user. No standard, ergonomic data was used to produce the design. Left to right: Images showing a 2D map with encoded depth information, milling tool paths, sectional part and the final digitally fabricated 'Endless Chair'.

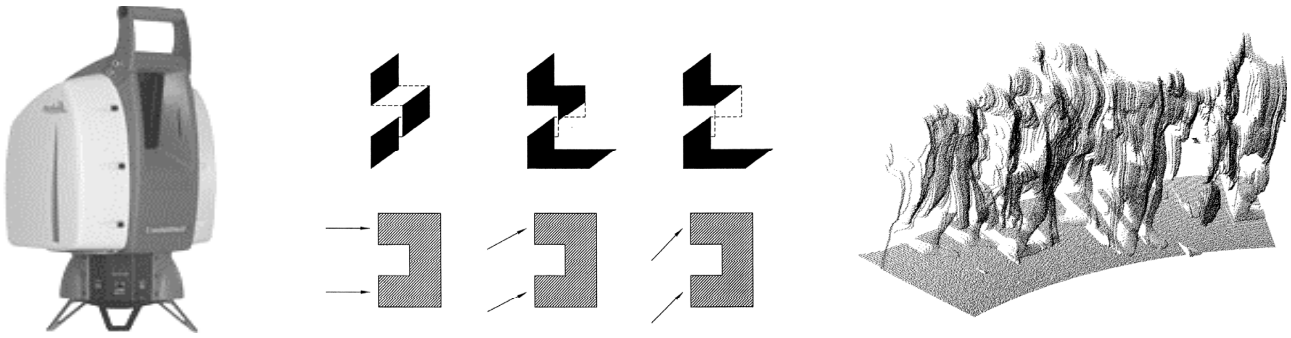

Figure 5. (left) Shadow diagram showing information lost by changes in the angle of a 3d laser scanner. (right) L.I.D.A.R. image of partial body maps. The scanner records only fragments of an object moving through its field of view.

more the representation of an ideal type subdivided and contained within a rigid geometrical framework. Le Corbuisier's attempt to establish the Modulor as the basis for measurement and proportion in the 20th century maintained a similar relationship between geometry and form by linking mathematical systems like the Golden Section with the agreed upon height of a person with arms upraised at 2.26 meters. The Modulor was therefore based on the assumption that architectural dimensions must conform to an abstract mathematical rigor laid over the trace of a so-called "normal figure". Thus, preserved intact, is the predominant concept of physical rectitude maintained in the West since Vitruvius.[3] But as Jacqueline Urla and Jenifer Terry have observed, "*bodies do not exist in terms of an a-priori essence, anterior to techniques and practices that are imposed upon them. They are neither transhistorical sets of needs and desires nor natural objects preexisting cultural (and scientific) representations.*"[4]

A 'non-standard ergonomics' employing new cartographic technologies does not underwrite statistically determined or ideal forms. The normal body is not an average or perfect body. *The normal body is everybody*. Contemporary systems of computer-aided mapping allow us to reconsider the long-standing practice of organizing the world following samples of low-resolution data. The so-called imperfections, that distinguish good forms from bad, and the differences that exceed pre-established models, can be imaged and materialized in ways that were unthinkable in the past. For these 'post-proportional'[5] bodies no absolute framework or conventional idea of beauty can be used to determine their aesthetic value. In other words the scanned figure is empty of any mathematically established or pre-determined essence. (New imaging machines liberate the body from fixed images.) Here, standards of physical health (properly the concern of medicine) are detached from body images circulated in the media and supported by historically narrow aesthetic criteria. A person can be overweight and in risk of a heart attack while in the same turn perceived as physically desirable just as runway models are considered attractive even when they suffer from serious eating disorders.

Figure 6. A computer controlled hot-wire foam cutter (left), a robotically controlled stone saw (middle) and a metal forming Wire-EDM machine (right) can generate ruled surfaces with strait cutting tools. In this way foam cast concrete, stone and metal details all share a similar formal logic.

Casting Shadows: From L.I.D.A.R to Robotics

A L.I.D.A.R. scanner (Light Detection and Ranging) works by reflecting laser pulses off an object or body. Like RADAR (Radio Detection and Ranging) L.I.D.A.R machines generate three-dimensional maps by measuring the time signals take to travel between a transmitter and a receiver. Undercuts and surfaces running parallel to the scanner's beam evade detection while creating a series of irregular gaps or shadows. These effects are produced in the co-dependent exchange between object and observer. Considering this fact is important for two reasons: first, shadows record the context of their formation creating data that is instrument specific. Second, through a process of mediation, shadows change what is being mapped into something new. A complete capture without gaps can be obtained through multiple scans pieced together from separate files but this procedure deliberately masks the limits of the technology and how it works. An incomplete scan records the process of its making in the same way that a 3d fabrication machine imposes limits on the kinds of forms that can be expressed during construction.

The Berkeley Collage Reading Room at Yale (unbuilt, 2003) was designed using high-resolution L.I.D.A.R scans of classical ornament from the surrounding campus. Unable to capture the undercuts and crevices of these complex forms, the scanner instead generated a series of incomplete traces. With a simple algorithm, points selected from the scan were projected into a sphere, stretched and rescaled. This was done to accentuate the loss of information produced during the mapping process and to prepare it for fabrication by a hot wire, CNC foam cutter. The manipulated scans created both a compressed, 2d elevation of the original as well as a complex, ruled surface that functions as a desk/shelving wall cast in concrete using EPS foam molds. (Smaller details for the project were designed for production by a computer controlled stone saw and a metal forming wire EDM machine.) Through a simple process of distortion and noise amplification small details became the seeds for a new architecture. Here neither the scenographic nor the tectonic can be considered in isolation. Rather than privileging "image over process and form"[6] the reading room uses classical iconography as source material to be actively reconfigured by the instruments of building measurement and construction.

So far, in the examples provided, we have moved through at least three distinct phases in the measurement process 1. *abstraction*, where objects are viewed through reductive filters, 2. *explication*, the moment when details proliferate making the differences between bodies more important than their similarities and 3. *mediation*, where an original, not directly changed by the process of representation, has almost no resemblance to its copy. Following

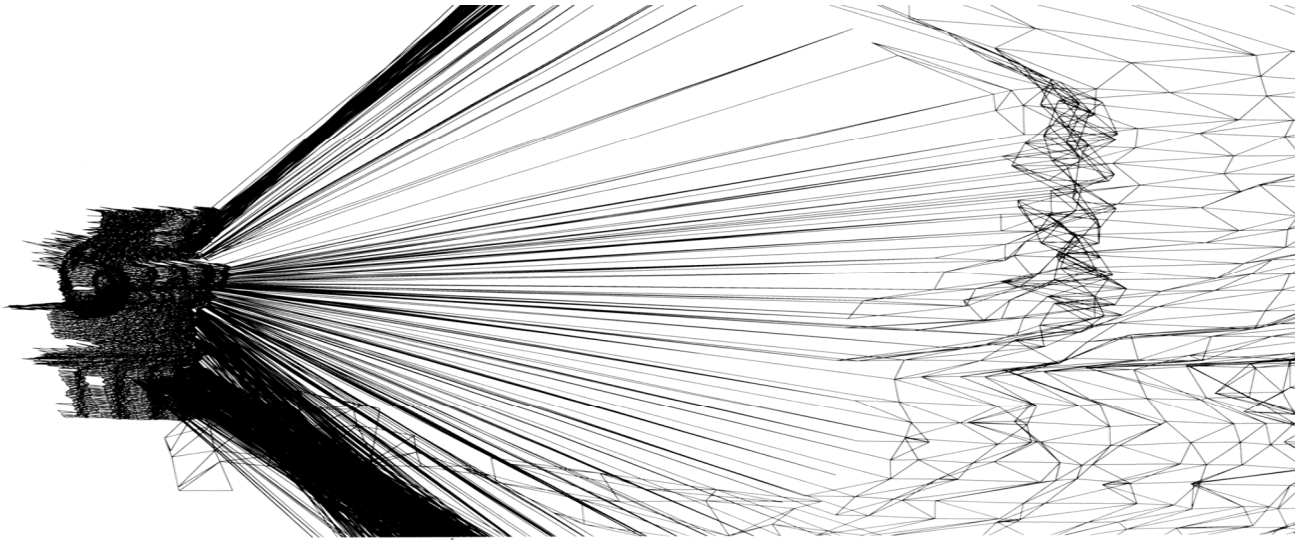

Figure 7. LIDAR scan of an ionic capital with amplified shadows. The scan was exploded into a ruled surface to be cast in concrete using wire cut foam molds. Berkeley Collage Reading Room, Yale University, 2002.

these logics there is a forth, *co-creation*, and it suggests an even more profound truth about reality and our role as observers.

Beyond the New Materialism

Quantum mechanics describes two paradoxical facts about the sub atomic world. When observed matter consist of discrete particles with a specific location or momentum. When unobserved matter behalves more like a wave of probabilities existing indefinitely in space like ripples on the surface of a lake. Eugene Wigner's still unproven interpretation of Quantum Mechanics states that only a measuring devise operated by a conscious observer is capable of effecting matter's condensation from wave to particle. In other words objects in the physical world are inseparably bound to the perceptions of a living subject. But even if Wigner is wrong and consciousness does not "collapse the wave function" the Kantian "thing-in-itself" will still remain forever unknowable outside the act of perception. There is no comprehensible universe existing in perfect isolation from the subject. "*What we observe is not nature itself but nature exposed to our method of questioning.*"[7] Realism, the belief in a world that exists independent of an observer no longer holds.

In the "Pin Scanner Experiment" a small 3D digitizer was used to record the flat surface contained in a one-inch square box of dust. With each touch of the machines automated probe small particles in the sample were either consolidated or displaced. The resulting scan produced a series of "pits and trenches" (*empty figures*) that were re-materialized as physical objects using different printing techniques. While this experiment is not a scientifically rigorous demonstration of "observer created reality" conducted on a quantum scale, it does illustrate the co-creative relationship between the act of observation and the thing observed. (The way we take our measurements determines what we see in the world.) A 'New Materialism' in architecture is likely to ignore this calculus preferring instead to focus design discourse on biases (process over product, transformation over permanence) that bracket the subject in favor of a world made from intrinsically real stuff[8] existing outside the "measurement situation". Despite its apparent distance from older beliefs in a static, indivisible and ideal reality underlying physical change the "becoming of matter" or form theorized as "a snapshot view of a transition",[9] still employs dualistic metaphors based on the limiting, conceptual distinction between things and means, objects and observers. These oppositions cannot even begin to grasp the experience of actual perception because the mind neither moves nor remains at rest. 'Being' and 'becoming' are terms that simply do not apply to consciousness.[10] *So if architecture relies for its meaning and significance on the narrow expression of material techniques, functions and methods of production, digital or otherwise, it will be by definition incomplete.* A similar point can be made about the self. As the philosopher David Loy points out, *"It is [just] as wrong to say that the object is in the mind as it is to say that consciousness resides in physical objects. So subjective idealism is no better a label than realism."*[11] *It seems that when applied to mental phenomena the terms inside and outside have very little meaning indeed.*[12]

Seeing the problem from another angle David Chalmers has warned that even "*quantum theories of consciousness suffer from the same …explanatory gap as classical theories"*[13]. This is to a great extent true because no mechanical description of the world can account for the "feel" and "texture" of first-person experience. Scientific studies of mental processes necessarily ignore the irreducibility of the subject favoring instead explanations based on objectively verifiable processes in the brain (neural correlates). But how can anyone explain to you "what it is like"[14] for them to experience the color red? Future accounts of these issues in architecture will be complicated, on the one hand by the fact that buildings seem so convincingly solid, so 'out there' as absolute forms of exteriority, on the other hand we have the ineffable fact of consciousness itself, a truly astonishing phenomena, one that evades description, but one that must be explored through design as an antidote to the now ascendant views of a naïve realism in contemporary culture. To remain relevant architecture must be critical. To realize this goal it is enough for a building to expose the limits of dualistic thinking and the monopolies it hold over our imagination. The rest is up to the individual.

SUMMARY

Materialism is false. In order for it to seem true we must deny certain facts about perception, and subjectivity. Both an 'old materialism' and 'new materialism' impose unnecessary limits on the expressive

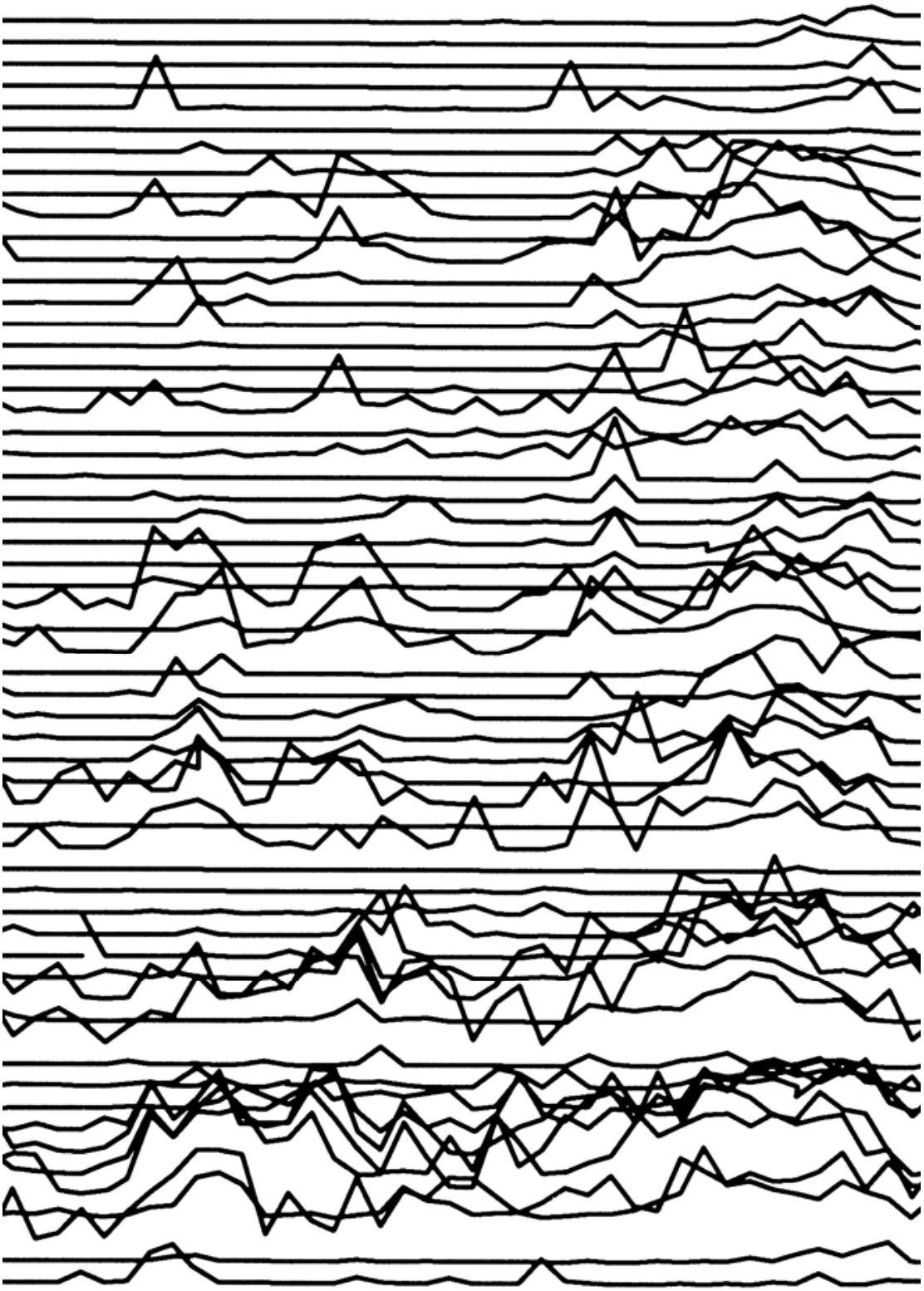

Figure 8. Roland DGA's 3D digitizer uses a haptic sensor to map the surfaces of small objects. The above image was generated by scanning a box filled with dust. Particles in the sample were disturbed by the machine's probe. The scanner writes as it reads.

power of architecture and its potential as an elucidating medium. Since buildings have a capacity to question the terms that underwrite their production a critique of matter becomes possible by design. In this essay I try to show how new mapping technologies bring to the fore problems similar to those quantum mechanics encounters in the process of studying subatomic phenomena. (The more closely an object is looked at the less solid it appears.) Any work that confronts the problem of measurement and asks questions about reality, change and the role design can play in the world must in some deal way with the fact of consciousness.

ENDNOTES

1 Dean Radin, "A Quantum View of the World," http://www.youtube.com/watch?v=ssO3uhvF73o.

2 "Commonly accepted anthropometrics tables are based on samples of military personnel which (due to entry and retention criteria for size, age and physical condition tend to exclude very large or very small persons…" Bill Stumpf, Don Chadwick and Bill Dowell from "Aeron The Anthropometrics of Fit" see: www.hermanmiller.com/CDA/SSA/Product/0,a10-c44o-p8.htm.

3 Digital mapping technologies in many ways recapture the intimacy and scale found in folk architecture, native building types and the loosely styled vernacular of American colonial settlements from the 17th century. Through observations of specific sites one is sometimes lead to conclude that its builders possessed a physical stature much smaller than contemporary humans. But this is probably not the case. Rather the unusual proportions of these do-it-yourself structures most likely resulted from a hands on approach to construction. In the absence of classical codes or standardized materials early American architecture developed a more intimate connection between the body and space.

4 Jacqueline Urla and Jenifer Terry, *Deviant Bodies*, (Bloomington and Indianapolis: Indiana University Press, 1995), 4.

5 The term 'Post-proportional' was first used by Prof. Keller Easterling to describe the "Endless Chair" project.

6 Robert Venturi, *Learning from Las Vegas*, (Cambridge Mass.: MIT Press, 1972), 87.

7 Werner Heisenberg, *Physics and Philosophy: The Revolution in Modern Science*, (New York: Prometheus Books, 1999), 78.

8 The infinite divisibility of sub atomic particles cannot be experimentally refuted. A proof to the contrary would require an endless series of experiments and endless amounts of energy.

9 Henri Bergson, *Creative Evolution*, (Mineola, New York: Dover Publications, Inc., 1998), 302.

10 Time is conceptual not physical. We have no evidence of matter existing independent of an observer. Minds have thoughts. Thoughts do not produce awareness because thoughts appear and disappear without destroying the subject. Consciousness must therefore be in some way atemporal. In this context 'Being' in the now or 'becoming' the present from the past through the future does not apply.

11 David Loy, *Nonduality: A Study in Comparative Philosophy*, (Amherst, New York: Prometheus Books, 1988), 87.

12 Idealism is as misleading as materialism because it presupposes the existence of an intrinsically real entity that perceives the world from some eternally established perspective. But if there are only nonduel relationships between observers and things i.e., objects without essences and thoughts without thinkers, then there is no 'self' that can used to make ideas ultimately real.

13 David Chalmers, *The Conscious Mind: In Search of a Fundamental Theory*, (New York: Oxford University Press, 1996), 333.

14 See Thomas Nagel, "What Is It Like to Be a Bat," *Mortal Questions*, (Cambridge: C.U.P., 1979), 165-180.