The Singularity of Design Creativity

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Singularity is the moment when an arithmetic progression converts into a geometric and acceleration takes off. Artificially creative design, as is manifested through the use of contemporary digital tools, is at such a moment in time and its impact on our cultural evolution is undeniable.
A few decades ago, in the earlier days of computer aided design, we were asking whether CAD really had any effect on the quality of design and on our physical environment. We now know it does and the examples of a new architecture are plentiful. We shall look at some examples as more appear daily.

Keywords: *CAD, singularity, artificial creativity, design.*

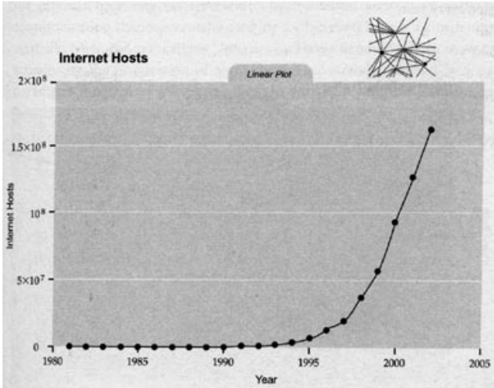
The future ain't what it used to be (Yogi Berra)

If you do not mind starting with a cliche, the progress that the computers have made since their arrival in the 50s is truly impressive. This is true for the machines themselves, but also for specific areas of application, including computer aided design, our area of interest. While what happened in the recent past is very impressive, what lies ahead is even more impressive, in spite of the fact that we are not sure exactly what it will be and how it will manifest itself.

It is always an interesting exercise to look back and review the problems we were trying to solve in, say, the late 60s and also review what we were thinking and what we were predicting. We were able to forecast quite a few developments, but also missed quite a few others. For example, it is questionable how well we predicted the arrival of the PCs and their impact. I have no doubt that a variety of science fiction stories included descriptions of devices that were very similar to our PCs, including the laptops of today, but it was hard to take them seriously at the time when computers occupied complete rooms. And, of course, the saga of the PC evolution continues. At the same time, we continue to have difficulty imagining how far their miniaturization will go, how soon they will be completely liberated from electrical plugs, when they will converge with the cell phones, TVs, CD players, when access to e-mail and the Internet will be trivialized, and when will their cost shrink to the level of a textbook (Figure 1).

Figure 1
From MIT's Media Lab "100 Dollar Computer for Every Kid" project: "The winning design is roughly ¾ the size and half the weight of a typical laptop. It will sell for about $140.00" (McGray, 2006).

Figure 2
The "explosion" of the Internet the last 10 years (Kurzweil, 2005)



The Internet is possibly the most dramatic example of something whose rapid growth we failed to predict (Figure 2). Neither did we predict the impact of the Internet on our lives. Even now, we still have difficulty anticipating and imagining its next stages of evolution. Yet we know that they will happen, they will happen fast, and they will have some additional dramatic implications for our lives. How capable and how fast we shall manage to adjust to these technological breakthroughs remains to be seen.

All this may sound peripheral but in fact is very central to the future of computer aided design. While I am willing to express some thoughts about how the practice of architecture may be in the near or distant future, I know that nobody can be sure and there will definitely be more surprises we are in no position to anticipate. I also expect that the evolution will happen fast and that the period of suspense will be short.

First we build the tools, then they build us (Marshal Mcluhan)

Those of us that have been involved with computer aided design since the 60s, recall that in the earlier days, we have spent a lot of time trying to persuade the professionals about the virtues of the new digital tools. In these days our arguments were admittedly not very strong. Not only the cost of a CAD workstation was prohibitively high, the CAD capabilities were also limited. Yes, even then computers were quite successful as production machines, but they were intellectually quite restrictive when it came to facilitating design. They were also quite effective as marketing devices. In larger offices, they were typically enclosed within glass walls and were shown off to all potential clients that were visiting the office. Soon we also experienced the trend to make even drawings that were done by hand look like they were done with the computer.

Luckily, many of these practices did not last long, even though marketing remains marketing and production needs continue to be real. Without going into too many details, let me review where the state of the art stands today.

Without question today we have software that is miraculously mature when compared to that of only 15 years ago. At the same time it has to be considered primitive when compared to what should be in the future. In addition, we are still lacking software that was promised over 30 years ago but never materialized.

Today we seem to have an interesting split in software personalities. On the one hand is the BIM type of software with all its implications, which the schools continue to dislike, while the professionals tend to view as a savior and are anxiously awaiting its maturity. On the other hand is the interest in software that enhances design explorations and facilitates the discovery of new forms that some believe are manifestations of a maturing artificial design creativity. The paradox about this latter trend is that it is largely exploiting software whose creators did not even suspect the uses their software would be put in. In other words, there is hardly any software yet that was written specifically to support design explorations that go beyond what is possible with conventional means. This would be software intended to explicitly support artificial design creativity.

In some ways BIM has become the drafting of earlier days. Drafting can only be applied to draw a known design solution, something that does not need any more intellectual searching and exploring (which would be design). So does BIM, which is based on parametrics, which can only be applied to known entities and solutions. In other words, the current manifestation of BIM leads to "franchise" architecture and restricts design innovation. Yet, it is valuable to the professionals, since it saves them a lot of effort and improves the construction, even the whole lifecycle of (more or less conventional) buildings. But it can not support the kind of architecture that invents new forms and aims at enriching our culture, in addition to offering shelter. This paradox is then the next challenge that CAD has to address: How the BIM techniques and philosophy can merge and support the design exploration and solutions that enrich our environment, lives, and culture.

From artificial intelligence to artificial creativity

Since the early days of computing, artificial intelligence (AI) has been defined as the activity produced by a machine that would have been considered intelligent if produced by a human being (Minsky 1968). Note that this rather circular definition makes no attempt to refer to neurons or the brain and does not even care to understand those human organs. It is only interested in the outcome having certain characteristics, be it an outcome produced by a human or a machine. Neither does it make any reference to any particular techniques that may produce a desirable outcome. These are left to be addressed per individual task or group of tasks.

Many will argue that artificial intelligence has been slow to develop. Certainly much slower than its initial promises. Yet, it has made some impressive progress. We have programs today that can beat Chess Masters. We may not yet have little human looking robots running around and performing all kinds of chores, but we have robots that are employed heavily in our factories. Intelligent programs are discovering oil reserves for us, are predicting our weather, and are finding the targets for our missiles, to mention just a few examples.

In architectural design, AI has made some progress, but it is still far from fulfilling the promises for automated design or any of the broader promises for equal partnerships between human designers and machines projected by the Architecture Machine (Negroponte, 1970). At the same time, we are seeing the so called "intelligent buildings" performing at variable levels of sophistication, through the implementation of sensing and robotic techniques. This being the status of AI in architecture, artificial creativity, a close cousin to AI has also manifested itself and is evolving impressively.

Borrowing from AI, artificial creativity (AC) is defined as the activity that is produced by a machine that would be considered creative if it were produced by a human being. Again, we are not interested in the ingredients that produce creativity. Neither are we interested in borrowing techniques from AI. We are interested in what techniques we may be able to employ that would produce design results that go beyond what is possible by traditional human methods. To the extend innovation and discovery are ingredients of creativity, we are especially assured that our methods are creative when the results are forms that significantly deviate from the already known and conventional.

It is safe to say that today's digital tools, and the cultural revolution they are provoking, are leading us to a new era of architectural design, which is not expected to result in another "style", if style means the production of homomorphic forms. It will probably be a "movement" that ties together all those designers that are willing to partner with computer programs that are capable of extrapolating a user's commands to levels beyond what the human brain can anticipate. This movement is still in search for a name that has yet to be coined.

Needless to remind us that, before we get there, there are many open questions that will have to be addressed first. Most of them are about constructability. We either need to evolve our computer generated forms to a state that can make them constructable with materials available today, or we need to develop materials capable of supporting the frequently fluent essence of computer generated shapes. In other words, we may either have to continue "freezing the music" when we produce architecture or may be, through virtuality, architecture may manage to come closer to the materiality of unfrozen music and its rhythmic freedoms. No wonder there is today renewed interest in, even a doctoral program dedicated to "adjustable architecture" or what used to be referred to as "self-regulatory architecture" in the days when cybernetic theory was popular in architectural cycles.

From a different perspective, today's digital tools are offering us a new world, the virtual world, that exists in parallel with the real world and is sometimes very different and other times quite similar to the real world. This terminology presents us with a paradox, because the virtual world is also real in its own right. Simply think of the Internet (or world wide web), which provides us a new type of space that demands its own architecture and does it in a very democratic fashion. "Although the web may be intangible and seemingly non-existent in our world of sensory perception, it has done what no other physical space on the globe could previously do; fit every one in." Subsequently, it does not require licensed architects to produce its architecture, but any body can. Will this lead to some sort of vernacular or will the web culture raise itself to levels of taste and technical competence that make professional licensing obsolete and unnecessary.

When it comes to virtuality that is intended to become physical reality, as I already mentioned earlier, we need to figure out the means by which it can happen. We have made some major progress to this end, partly thanks to the automatic fabrication techniques and devices that are already available and are becoming very popular. They help us show that what was considered utopian just a few years ago is proving to be constructable and also affordable, which raises promises that the brave new world made possible by the new digital tools will be afforded by many rather than being exclusive to few.

The Singularity Is Near (Ray Kurzweil)

This is actually the title of a book published last year (Kurzweil, 2005), where the author discusses rather persuasively that we are at the forefront of an era of accelerated artificial intelligence and projects a specter of "machine intelligence becoming indistinguishable from that of its human progenitors within the first half of the 21st century." This acceleration the author calls "singularity" and uses it to express the transition from linear to an exponential growth and progression (Figure 3). This then will be the brave new world of this century and beyond.

"Singularity" is an English word, derived from Latin, and means a unique event. It was adopted by mathematicians to mean a value that transcends any finite limitation, such as the value that approaches but never reaches infinity, as a constant is divided by a number that approaches (but never reaches) zero. The result is an explosion of magnitude whose graph corresponds to that of an exponential growth.

In the 50s, the legendary information theorist John von Neuman was the first to observe "acceleration" and "singularity" in the progress of our technology. Much of it is based on the evolution of the computer power, which according to Moore's Law of the mid-1960s, doubles every 12 months. This was revised to every 24 months in the mid-1970s. The real number is some-

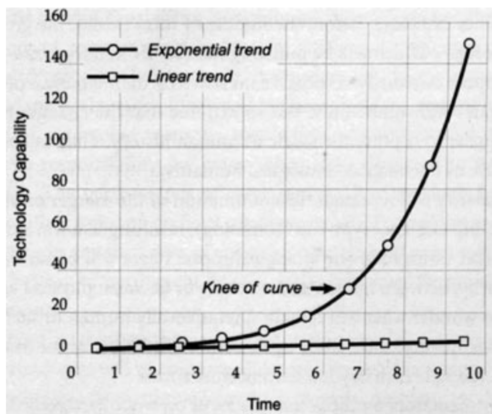


Figure 3
Linear versus exponential: linear is steady, exponential becomes explosive.

where between these two, which is approaching the exponential growth that signifies Singularity.
According to Kurzweil, the key idea underlying the impeding Singularity is that the pace of change of our human-created technology is accelerating and its powers are expanding at an exponential pace (Figure 4). His further predictions are almost scurry: "There will be no distinction, post-Singularity, between human and machine or between physical and virtual reality." This definitely goes significantly beyond what Negroponte (1970) perceived, but offers a nice justification to my previous observation that artificially creative architectural design is already manifesting itself through the use of digital tools we already have. The Singularity theory further more tells us that the design activities affected by the digital tools must be expected to move faster.

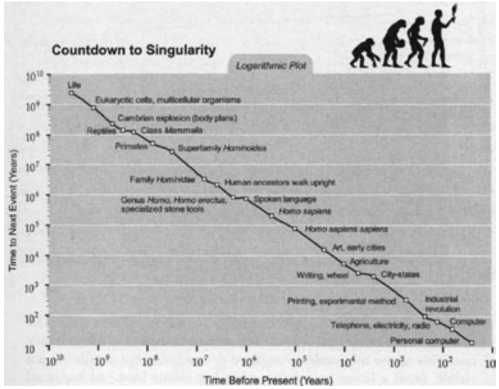


Figure 4
Countdown to Singularity (Kurzweil, 2005)

Partial conclusion

Let us at this point summarize some partial conclusions and then proceed with trying to illustrate some of the trends that can be observed today.

- There has been a tremendous progress over the past 50 years, mostly ignited by the exponential increases in computer power we have experienced.
- These increases are expected to continue at the same exponential rate and are manifestations of the phenomenon of Singularity, which is leading us to unprecedented levels of intelligence to occur in the current century.
- Design is already influenced by artificial creativity, a manifestation of the broader spectrum of artificial intelligence.
- The usage of artificial creativity will accelerate in the coming years and, by mid-21st century, will drastically affect the aesthetics and culture of the environment we live and work in.
- Our task as designers should be to lead these exploding trends to directions that are compatible and respectful of humanity (discussing the "how' would of course be another full length lecture).
- The task of software developers should be to make tools that inspire, invoke, and maximize the application of artificial creativity, then discover the BIM techniques that are able to serve whatever unprecedented shapes the collaborations between human designers and machines may unravel.

Next, I shall be looking at some examples of contemporary design work and try to understand some of the directions in which CAD tools should evolve.

What tools do we need

Skipping examples of more or less conventional buildings that can be handled by BIM tools available today, let me start pointing out a few that cannot (Figure 5). The random slants applied to the walls of this design render the orthogonality requiring parametrics of current BIM procedures unusable. What will then be the tools that will allow designs to "play" with form as in this example?

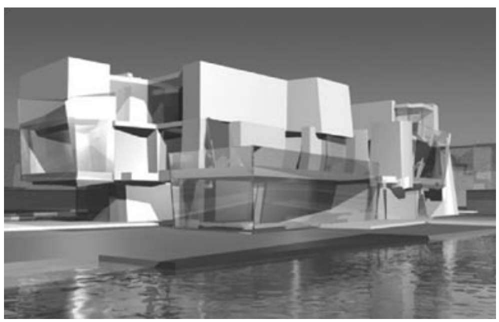


Figure 5
Dream House by L. J. Porter of Resolution: 4 Architecture, New York, New York. "A house with no style." (in•form•Z, June 2005)

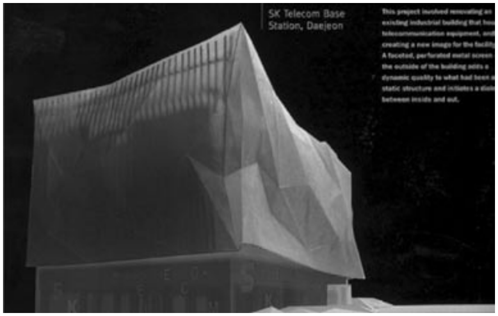


Figure 6
SK Telecom Base Station, Daejeon, by Architecture studio himma: Creating a new image for an existing industrial building (Pearson 2005).

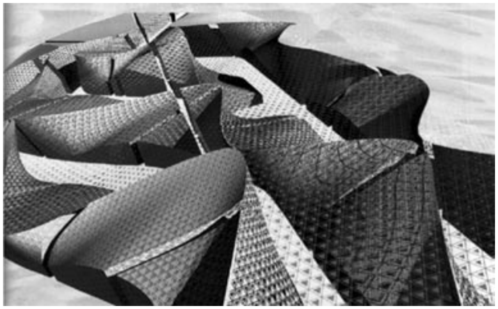


Figure 7
Quarters in Doha, Qatar, by Chris Lee Architecure & Urbanism, London and Contemporary Urban India Pte, Mumbai: "The spatial system alludes to the surrounding sand dunes in a series of undulating voids and masses." (Siessor, 2005)

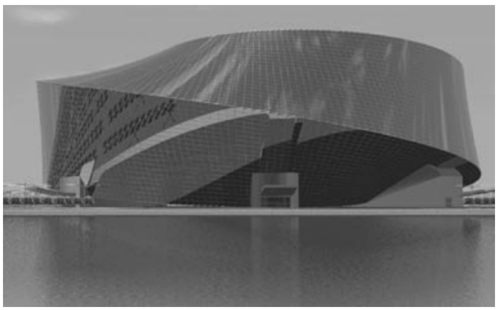


Figure 8
Mobius Building by Anwar Al-Mallah, Visual Reality International (VRI Design), Beltsville, Maryland: "The design was inspired by the curious surface known as a Mobius band or a non-orientable surface." (in•form•Z, June 2005)

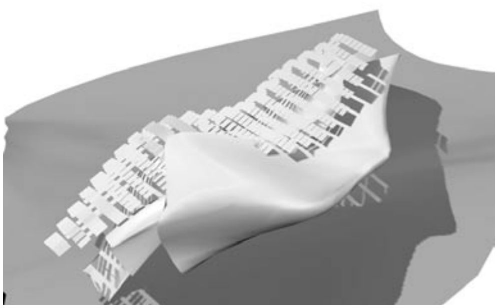


Figure 9
Interstitial Space by James Cornetet, University of Cincinnati: "This is a project that seeks to examine the relatrionship between public and private spaces within a house." (Partnerships in Learning, 2005)

A "faceted perforated metal screen" is added to an otherwise square static structure to remodel it and add a dynamic quality (Figure 6). One initially has the impression that some sort of a NURBS operation would be the proper tool to use here. However, a closer observation shows that it is not. This is an unevenly faceted surface that transforms to a constructable wall in the place of what would otherwise have been a series of glass walls. Again, what would be the tool to model such a form?

In this design (Figure 7), the "perforations in the structural system are abstractions of traditional Islamic architectural elements." Certainly no known BIM tool can parameterize these shapes, but new tools are needed that may be able to derive "abstractions" from traditional cultures and architectures.

For the remaining of the examples I shall stop asking the rhetorical question "what tool is needed," but such a question will be implied. I'll just point out the transformations, or deformations, or morphing, or some other yet to be named operation designers are looking for.

There are a number of known mathematical formulas that can generate exiting forms. More can be invented by mathematically inclined designers. The building design in Figure 8 is inspired by one of the better known but also more challenging surfaces: the Mobius band. This is a surface where one side flows into the other, which can lead into what otherwise might be an architectural paradox, the continuity of the inside with the outside, which may imply a relationship between private and public spaces.

The design in Figure 9 also deals with "the relationship between public and private spaces" but in a different way. Two cylinders are used to represent these spaces and are transformed and deformed until they derive what the designer calls an "interstitial" space.

The set design in Figure 10, which was actually built as a special effect for the "Cat in the Hat" movie applied deformations to an otherwise straight forward model of a house. These are definitely forms that would be nearly impossible to generate without the assistance of a digital tool.

The design in Figure 11 is a new type of building, according to its designers. It is a tall building and its el-

Figure 10
Transformed House, a set for The Cat in the Hat by Victor Martinez, Santa Monica, California: "The challenge of this film was to create a visual language that alluded to the whimsical, surreal world that Dr. Seuss has created in his stories and artwork, without literally copying the art." (in•form•Z, June 2005)

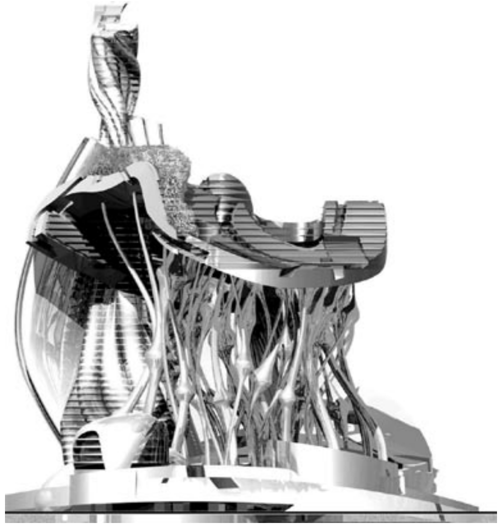


Figure 11
Peristal City (Winning Design for the eVolo 2006 Skyscraper Competition) by Neri Oxman and Mitchell Joachim OJ Studio, Cambridge, Massachusetts: "A cluster of soft elevators comprise a space for a new tall building type. Our intentions combined fluidic muscle technology with the elevator to mimic a peristaltic circulatory effect." (in•form•Z, June 2005)

evators "mimic a peristaltic circulatory effect." This is an automatic movement of the muscles, which has a number of implications for the shown design. Of course, constructability of this design remains a dream, which did not deter the jury from granting an award to this design.

I am not quite sure what were the challenges for the design in Figure 12, but one has to be intrigued by the goal of the designer: to "create an object that you almost could not craft." Needless to say that the object was crafted using a 3D printer. This, of course is another huge area that the digital tools are asked to support with fluency.

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Figure 12
Change or Visualizing Knowledge by Michael Meier, vasp datatecture, GmbH, Zurich, Switzerland: "Our ambition was to create an object that you almost could not craft." (in•form•Z, June 2005)