Responsive Daylight Register

International VELUX Award 2006 for Students of Architecture.

Arch 384

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The International VELUX Award is an annual competition seeking "exploration and discussion of the overall theme of 'Light of Tomorrow'"[1]. Implied in this statement of course is innovation in natural lighting techniques and/or the role of new and emerging technologies in improving the architectural quality of day-lit spaces and controlling the impact of the sun on the built environment.

This competition entry focuses on correlating current research on a number of different known material technologies into a new and dynamic solar-responsive architecture. Ultimately, the project looks to showcase a convergence of high-technology and architecture at a time when much of the architectural design community holds a phobic aversion to technologies that most other industries have been taking for granted since before the turn of the century.

The problem with most contemporary solar strategies is simply that nothing really works all of the time for most climates far enough north or south. There are hundreds of mechanical and orientation strategies which attempt to deal as best they can in their given situation, but very few projects take the next step and free elements of the design to change in direct response to the surrounding climatic conditions.

This project takes two different technological elements; one, a very practical extension of an existing material, the other a potential architectural application for a still developing technology; and combines them in a single gesture of architecture's dynamic capabilities in the face of increasingly less predictable climactic conditions the world over.

The first and most central element discussed in this paper is the LCD skin used in the project. Liquid Crystals are one of the top display technologies in the world because they are very flat and very light (unlike cathode ray tube televisions)[2]. This is evident simply by looking at a current LCD computer monitor (a common 17" monitor is often slimmer than an inch around the perimeter and weighs less than 10 pounds) in comparison to a CRT monitor (often thicker than it is wide and usually weighing in at a hefty 50 pounds)[3].

A liquid crystal is not exactly a crystal, nor is it exactly a liquid[4]. As such, one of its properties is that it is sensitive to heat and cold; a problem for use in architectural cladding. While exposure to extreme temperatures does not seem to be permanently damaging to the crystals themselves, it can render them unresponsive in conditions where their operation is most critical. To handle this, the LCD needs to be part of an insulated glazing system; likely at the center of a triple-glazing system equipped with low-e coating and argon filled cavity space to keep the crystals within a more consistent temperature range. Better yet, in architectural applications, it would be placed as the interior most layer to maximize effectiveness.

A second property of liquid crystals, and the real value of the material, is in their responsiveness to electric current. The type of crystal used in this application are known as 'twisted nematic' crystals[5]. This means that in their natural state, the crystals are 'twisted', but when a current is applied, they straighten[6]. The website referenced herein, "how stuff works", contains a very clear description of exactly how these crystals are produced between layers of polarized glass to allow light to transmit (or not), which will not be exhaustively reproduced here. Essentially, in their natural state, the layers of crystals twist to 90 degrees, which, in polarized glass allows light through, or in non-polarized glass blocks light transmission[7]. When a current is applied, the crystals straighten out, which blocks light through polarized glass, but would allow light to transmit through plain vision glass, as the crystals would now align. This allows a designer to choose which option is best; in a very cold climate in which solar gain is mostly a desirable thing; one would use polarized glass so that the default setting (which uses no electricity) allows sunlight to pass through. In a hot climate, one would do the opposite.

The technology is currently used as a commercial partition treatment, often on the wall of a board room, allowing varying degrees of privacy as the wall is rendered various transparencies as current is applied (controlled simply with a light switch)[8]. The material used in this project, however, is something of a cross between the board room application and that of a computer monitor. Whereas the partition treatment is one large array of crystals, the project separates crystals into ‘pockets’ of 10 cm by 10 cm, effectively pixelating the material more like a computer monitor, each pocket individually controlled.

To maintain a greater degree of simplicity, however, the pockets are strictly digital. That is, they are either ‘off’ or ‘on’. This means that each pocket is simply wired to either have a current applied or to not have a current applied, and as such, each pocket is either transparent or opaque, and varying levels of opacity are achieved by ratio of transparent to opaque pockets. The pockets themselves are plastic sheaths embedded with electric fibers that carry the current to each LCD ‘pixel’.

The effect of this material is clearly demonstrated in the project panels; most importantly, the LCD’s can be programmed to follow the path of the sun. This allows a maximization of atmospheric light allowed into a building while blocking 100% of the direct sunlight at all times of the day (or less, as desired). This efficiency and adaptability is where the ‘magic’ of the material really rests. Imagine, a building glazed on all four sides, no louvers, no blinds, no tint applied, no overhangs to control solar gain. And yet, morning, noon, and afternoon, there is consistent daylight in the building with no unwanted glare or solar gain.

Like any good technology, it is very theoretically simple and yet highly functional and efficient practically. Every computer science student has programmed LCDs and most agree that working the technology is very easy (or even that it is simply beneath their abilities in the same way architects look down on box stores and strip malls). The point is that the technology is accessible to a large number of professionals (and amateurs alike); the most advanced programmed requirements of this project could be comfortably accomplished by a computer science undergraduate and a local publication of solar data.

Just as importantly, there is incredible potential for the future for this material. Being a technology rather than a commodity[9], the cost of LCD's has been falling and will continue to drop as time passes and demand increases (the opposite of commodities like steel and concrete, in which cost increases at least coincidental to inflation and skyrockets at even the possibility of increased demand). While the economics of materials are not the focus of this project or this paper, it is worthwhile to note the incredible future cost benefits of investing in building technology over commodity.

Also, as other technologies improve and new technologies enter the marketplace, the potential for LCDs grows further. As photovoltaic arrays sit right at the tipping point[10] for mass consumption, future iterations of the technology could be easily integrated into LCD design, powering each 'pocket' individually (supplying more power to pockets needing it; that is, those most exposed to the sun). Likewise, even today it would be feasible to fix each pocket with a sensor that determines automatically when to apply current or not, eliminating the need for central computer control (and removing the fear of a computer crash turning a project into a greenhouse or black box instantaneously).

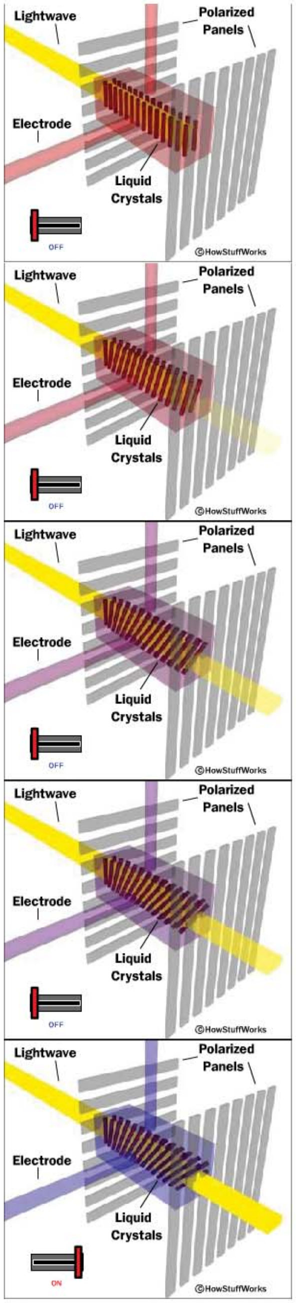
The second technology used is a somewhat less tangible emerging technology and one that is more open for future interpretation; the expanding structure. Inspired by the coil of a traditional thermometer, the expanding structure (as shown) grows and opens the project up as it gets hotter; this allows air to flow through freely and ventilate the space naturally. When it is cold, the structure shrinks, closing up tightly and providing shelter from the elements. How exactly this is achieved (to this degree) is more theoretical than practical, as the technology has not quite advanced far enough for this application. However, under the basic tenets of thermodynamics, a metal structure will expand and contract with temperature. Currently, there are very sensitive alloys that will liquefy even in hot air, thus expanding greatly with small temperature changes; however, making that structural is currently difficult to reconcile with the fact that these alloys are lead-based[11].

Another emerging technology in the medical field is that of metal replacement hearts. These hearts ‘beat’ (which is, expand and contract) when electrons are added or removed electrically[12]. Using solar power to move the electrons, this is another element that would aid expansion. While the real thesis of the project is the skin, this second element, despite being more abstract, solidifies the argument that architecture can be responsive to its environment in progressive ways.

In conclusion, the history of solar responsive building has largely been a static one. And while there is certainly a place for well planned and oriented ‘traditional’ buildings (it would be disastrous to see the architect outmoded by clever cut-and-paste technologies) even these buildings tend to end up very similar because they simply have to use similar strategies (LEED may have incredible merits, but discouraging ‘cookie-cutter’ green buildings isn’t particularly among them when a designer goes point hunting). And while a world of LCD screening wouldn’t be any better, (no one wants to feel as though they are walking through an Atari game when they go downtown) it does offer a new language for designing for daylight and if nothing else provides an architect one very precious thing; choice.

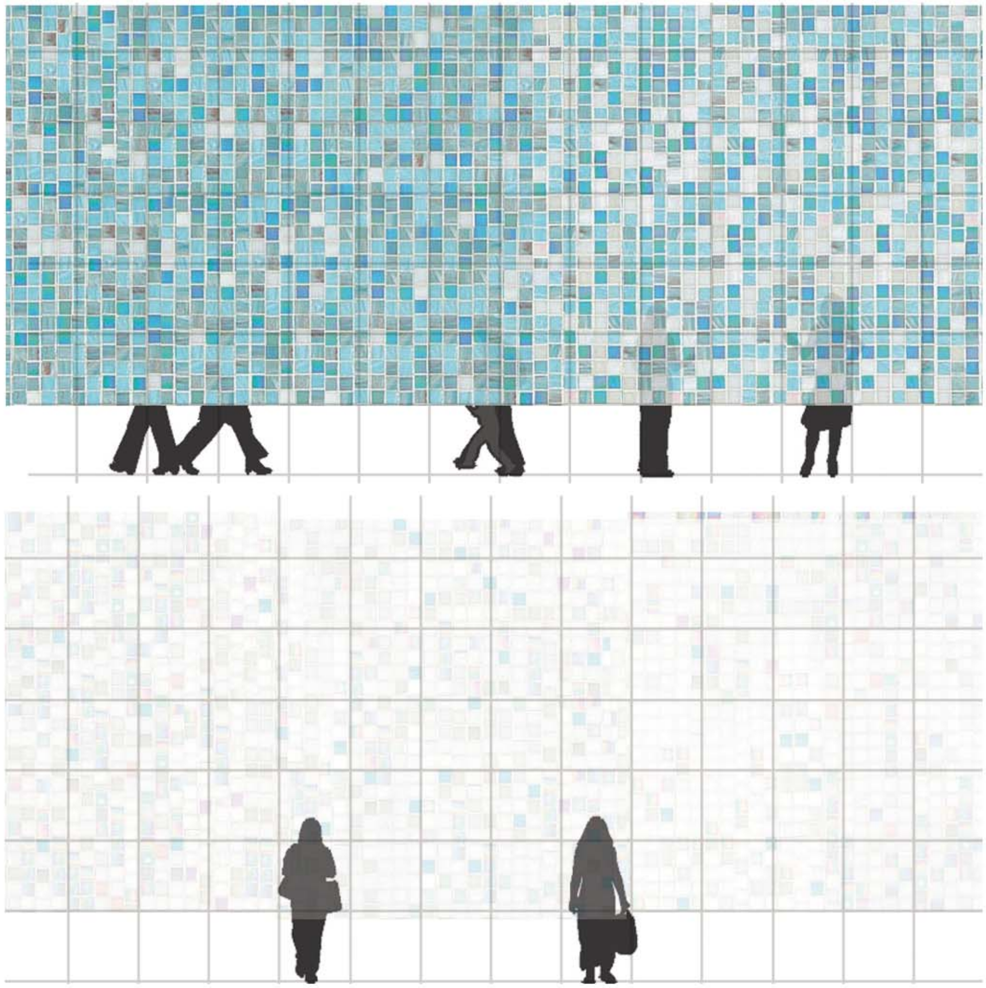
1. International Velux Award 2006 Website**, http://193.163.166.98/com/a/**
2. Tyson, Jeff, How LCDs Work http://electronics.howstuffworks.com/lcd1.htm
3. Dell Canada, UltraSharp 1707FP Plat Panel LCD Monitor Product Page http://accessories.dell.com/sna/productdetail.aspx?c=ca&l=en&cs=CADHS1&sku=320-4567
4. Tyson, Jeff, How LCDs Work http://electronics.howstuffworks.com/lcd1.htm
5. Tyson, Jeff, How LCDs Work http://electronics.howstuffworks.com/lcd1.htm
6. Tyson, Jeff, How LCDs Work http://electronics.howstuffworks.com/lcd1.htm
7. Tyson, Jeff, How LCDs Work http://electronics.howstuffworks.com/lcd1.htm
8. Armor USA inc. Privacy Glass Product Page http://www.armorusa.com/Privacy%20Glass.htm
9. Mankiw, Kneebone et al, Principles of Macroeconomics Thompson Nelson, Toronto 2006
10. Gladwell, Malcolm, The Tipping Point: How Little Things Can Make a Big Difference Time Warner Book Group, NY 2002.
11. Metal Phone, We Make Money Not Art, http://www.we-make-money-not-art.com/archives/008729.php
12. Msn.com; this article is no longer actively linked from the site.

Material Research Images

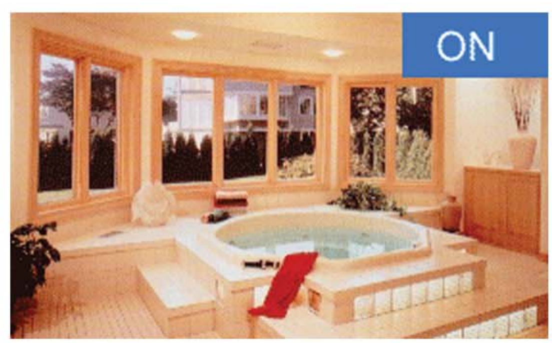


The effect of LCD's sandwiched between polarized glass.

image source: http://electronics.howstuffworks.com/lcd1.htm



This skin detail shows the huge difference between the 'on' and 'off' settings and the dynamics of the skin.



Typical residential application of the LCD technology. When current is applied, the glass is transparent, allowing views. When current is turned 'off' the crystals scatter and the glass is rendered tanslucent.

image source: http://www.armorusa.com/Privacy%20Glass.htm

Simplified, everyday LCD application; opaque crystals are rendered opaque a to form the numbers shown on a calculator screen.

Project Precedents

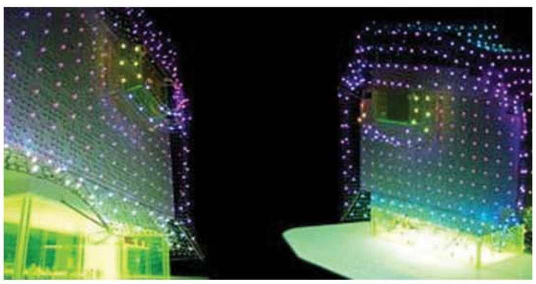
Kubik night club - Berlin - Modulorbeat

This night club project consists of stacked 1000 litre water tanks filled with individually controlled luminous bulbs that can be used by the VJ for visual effects.

4D Pixel - Daan Roosegaarde - Installation

This wall is an example of greater interactivity between a person and his/her environment. The wall responds to the voice and touch of the occupant, opening and closing the individual ‘pixels’ as shown. There are many examples of new installations responding to human interactivity; environmental interactivity is a logical place to take a similar ambition.

source: www.we-make-money-not-art.com



Habitat Hotel - Cloud 9 Architecture

Wrapped in an ‘energy mesh’ of light emitting diodes that will individually record exposure to the sun during the day and at night be lit up as a representation of that day’s solar intensity, this project is essentially a solar register.

Party Wall - nArchitects

This interactive wall moves up and down in ‘waves’ in response to any number of potential stimuli, touch, voice, etc, and is a rudimentary example of a structure forming itself around the influences of those occupying the space.

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A@VELUX.com February 11, 2006 2:33:44 AM

To: acrclark@hotmail.com

Subject: Registration closed - International VELUX Award 2006 for Students of Architecture

INTERNATIONAL
VELUX AWARD 2006
FOR STUDENTS OF ARCHITECTURE

VELUX

LIGHT OF TOMORROW

Dear participant in the International VELUX Award 2006,

Registration closed yesterday and you are one of the 2037 students registered for participation. The students that have registered represent 92 countries, which means that you are part of a truly global competition among students from all parts of the world.

The submission deadline - **5 May** - is the next cornerstone, and we hope that you will take the opportunity to explore daylight in architecture and complete your project for submission. You will find guidelines for submission here. We will send you the submission form to follow the project later this spring, after deadline for questions.

As inspiration to your work we would like to draw your attention to the newly launched site - thedaylightsite.com, where you will find research and literature on the topic of daylight and architecture. You might also visit architectstudent.net, a forum for knowledge sharing and discussion among students of architecture.

Until **10 March** you may ask questions to the award by mail to A@velux.com. After this deadline we will not answer further questions according to the award rules agreed with UIA. You may also consult the FAQ on velux.com/A