

Spring 2017

LED SCREEN RESOLUTION: A Lego Visualization

Andrew S. Trowbridge
University of Akron, at66@zips.uakron.edu

Please take a moment to share how this work helps you [through this survey](#). Your feedback will be important as we plan further development of our repository.

Follow this and additional works at: http://ideaexchange.uakron.edu/honors_research_projects

 Part of the [Graphic Design Commons](#), [Interactive Arts Commons](#), and the [Sculpture Commons](#)

Recommended Citation

Trowbridge, Andrew S., "LED SCREEN RESOLUTION: A Lego Visualization" (2017). *Honors Research Projects*. 417.

http://ideaexchange.uakron.edu/honors_research_projects/417

This Honors Research Project is brought to you for free and open access by The Dr. Gary B. and Pamela S. Williams Honors College at IdeaExchange@UAkron, the institutional repository of The University of Akron in Akron, Ohio, USA. It has been accepted for inclusion in Honors Research Projects by an authorized administrator of IdeaExchange@UAkron. For more information, please contact mjon@uakron.edu, uapress@uakron.edu.

LED SCREEN RESOLUTION: A LEGO® VISUALIZATION

Andrew Trowbridge
Honors Research Project
December 6, 2017

LED SCREEN RESOLUTION: A LEGO® VISUALIZATION

Andrew Stevenson Trowbridge

Department of Graphic Design

Honors Research Project


Submitted to

The Honors College


Approved:


 Date 12/2/16
Honors Project Sponsor (signed)

David Szalay
Honors Project Sponsor (printed)


 Date 12/7/2016
Reader (signed)

JOHN MORRISON
Reader (printed)

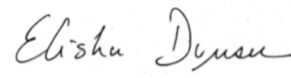
 Date 12/7/16
Reader (signed)


Reader (printed)

Accepted:

 Date 12-15-2016
Department Head (signed)

Janice Troutman
Department Head (printed)

 Date 12 Dec 2016
Honors Faculty Advisor (signed)

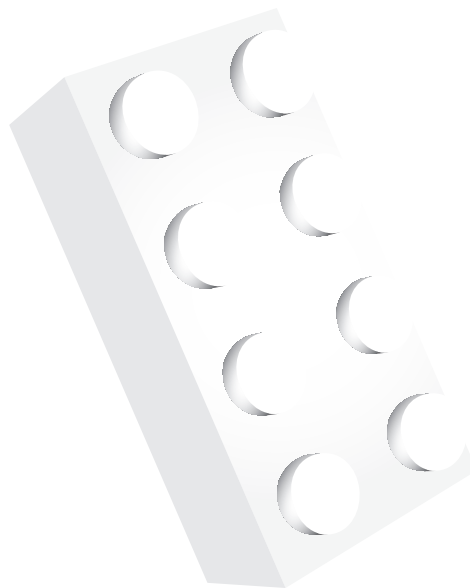
Elisha Dumser
Honors Faculty Advisor (printed)

Date _____
Dean, Honors College

ARTIST'S ABSTRACT

As a graphic designer, understanding the way a computer displays type and image is extremely beneficial. Before going into college, my knowledge of how a line of ones and zeros translates to a full color, high definition screen of pixels was abstract at best. This project serves to explore and demonstrate the meaning and process of LED screen resolution through a more playful and tangible lens of LEGO® bricks.

LEGO® encourage the creative, child-like side of us. The bricks become a doorway into another side of learning. It pushes us to not be afraid to explore and delve deeper into the framework of an idea. My hope is to clarify and explain the conflict that I wrestled with in attempting to understand LED screen resolution and unite science with art.



A WORK IN PROGRESS

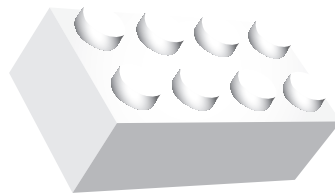
Understanding the concept of screen resolution does not come easily to the public. Many are not able to visualize how their computer or TV translates tiny LED lights into “full-color” pixels. I wanted my project to visually depict how RGB light conversion, various optical resolutions, and pixels in digital imaging work through LEGO® structures and murals to provide simplistic and tangible answers that anyone can understand.

The initial idea behind explaining this process involved a series of murals and sculptures utilizing design principles and my knowledge of LED display to walk the viewer through a basic understanding of this topic by translating 1x1 and 2x2 LEGO® bricks into pixelated images and type. I supposed the large number of bricks would require fundraising through grants, drives, or other means to acquire the necessary materials, possibly through a school searching for constructive building materials for classrooms or afterschool clubs.

The explanation of LED screen resolution must be distilled into logical, simple steps that can translate into individual pieces of work. This would involve working with software or algorithms that deciphered images into blocks of color in order to be constructed.

I expected to learn how to execute complex ideas, fundraise for an event, educate the public, and utilize design skills and creativity to contribute to society. Resolution was often described to students by professors with chalkboard illustrations lacking color and depth. As a pixel on a computer or TV is extremely small and hard to see, visualizing how three red, green, and blue dots comprise 256 hues of each color to the eye is a difficult task. With the completion of this project, I hoped to provide incoming students and the general public with a more in-depth, hands-on knowledge of resolution. Such knowledge would inform them on their purchases.

The concept of the final presentation for the project consisted of ten or more sculptures and murals that will explain LED screen resolution from pixels up to computer screens, as well as typography with LEGO® bricks. Descriptions would be underneath the structures to provide a reference for each piece. The bricks would provide a lighter, more comprehensive visual model. My goals for this project are to explain resolution in a simplistic manner, find software or an algorithm to translate image into buildable structure, acquire the LEGO® bricks and other necessary materials, and design the structures to be cohesive and tactile. The exhibit would be on display for the public to view and admire in the Myers School of Art gallery.



In the initial stages of the project, I mostly researched how others had communicated LED screen resolution or constructed LEGO® brick mosaics and murals with mild success. In order to properly show how a monitor works, I wanted to indicate how one pixel of color is comprised of three individual red, green and blue LED lights. This varied from others' designs with LEGO® bricks, as most did not sub-divide the pixel and treated the translation of an image as a mosaic, where one pixel corresponded with one 1x1 brick. One of the earliest discoveries of how this might work was of a designer's study, Monovektor, in Illustrator techniques. In his article "Experimenting With Lenna", Monovektor uses image processor functions to translate a pixel of color into an editable square with which various vector effects can be applied. One of these effects experimented in conducting color with only sub-divided

red, green and blue “cells” comprising the pixel square. Monovektor, in explaining a particular pixel color, remarks that “the color components are, [117, 99, 106], so dividing by 32 and rounding to its nearest integer on each channel, gives [6, 3, 3]. So, for the red channel, 6 out of 8 “cells” are filled.”

This created a substantial basis for building the project. If the replication of Monovektor’s process could be done to any image, then a corresponding brick size could be assigned to each “cell” group, leaving one pixel of color to be displayed as three 2x8 LEGO® bricks, one for each corresponding channel. This meant a completely filled pixel would represent white, while the complete color range with hues and shades could be represented with the addition of black LEGO® bricks.

Soon after this discovery, I realized how complex Monovektor’s image processor functions were. To edit an image in his particular fashion, an outside program must be used, such as JavaScript. As I have only a limited unstanding of JavaScript, I worked closely in collaboration with Seth Trowbridge, a well-versed programmer, designer and relative, as well as photography and digital imaging professors Neil Sapienza and Stan Kohn to possibly develop a Photoshop alternative. Mr. Sapienza and Mr. Kohn looked into utilizing Photoshop’s layer blending options and RGB channels to formulate a mask which isolates only the red, green and blue color of a chosen image. Mr. Trowbridge suggested an algorithm which analyzes a 20-pixel area in an image and converts it to one sub-divided pixel of red, green and blue.

1. Monovektor, "Experimenting With Lenna." Monovektor. March 15, 2012. Accessed May 04, 2016. <http://monovektor.com/>.

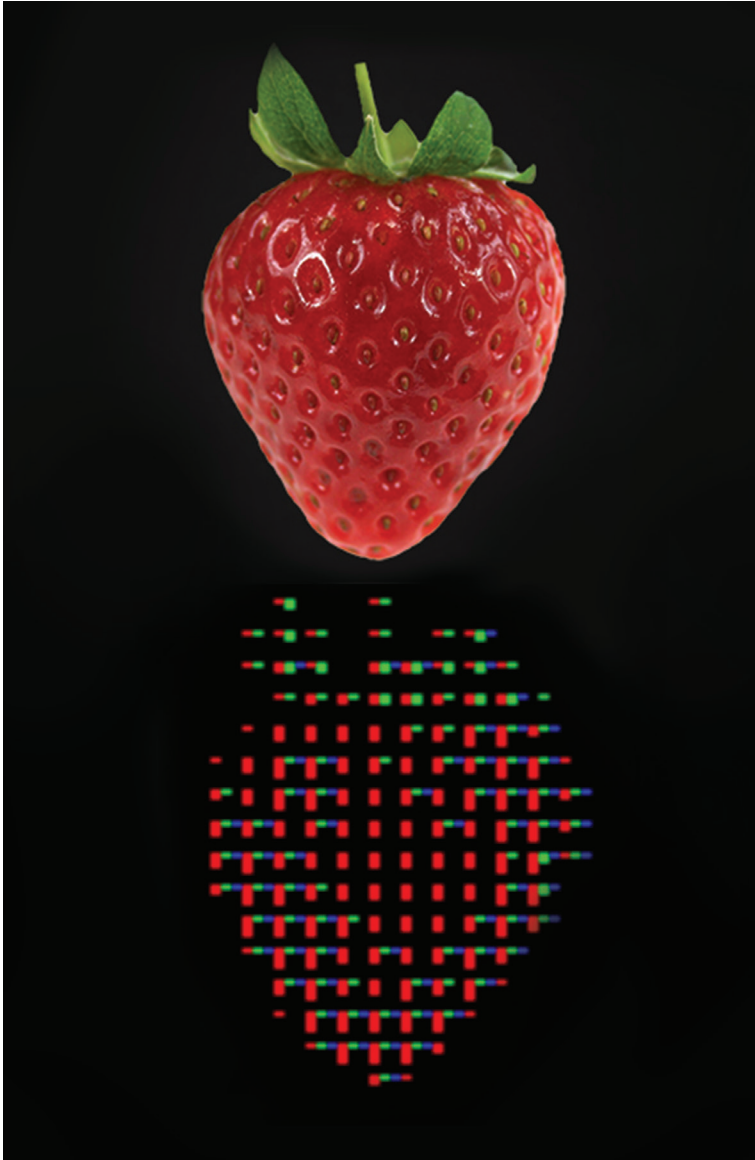
With slight adjustments, Mr. Trowbridge's JavaScript algorithm could analyze an image to allow LEGO® bricks to correspond with each pixel "cells", creating the desired effect. This seemed to generate the best results; Mr. Kohn advised a Photoshop algorithm to count the individual "cells" in the JavaScript algorithm image so that the proper amount of bricks could be ordered to construct the mosaic.

A few variables had to be taken into account to communicate the mosaic as simply as possible; the most crucial being image selection. Initially, I imagined depicting a famous person or painting. This would be easily recognizable and simple to construct since the mind automatically looks for the form of a face in shapes. However, as the project unfolded, a major flaw emerged that would reduce the usable images to a minimum.

A computer in its simplest form works off of only a few components. The outside shell, which holds all the parts in, a polarized lens on either side, a backlight, and the all-important LCDs (Liquid Crystal Display) in the middle. As the backlight hits the LCDs, each pixel is illuminated, and when each red, green and blue LED is fully lighted, the mind perceives white light. All this is possible through the additive color space. Without light, everything else utilizes the subtractive color space, where cyan, magenta and yellow form black when mixed together. Since typical LEGO® bricks are solids, and do not allow light to pass through them easily, many color combinations appear muddy instead of white or lightly-colored. Seth Trowbridge's JavaScript algorithm worked on the computer, but lost clarity when printed or built.

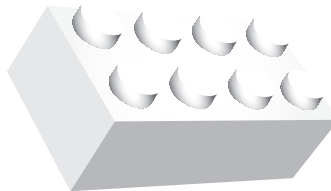
This realization brought on a careful selection of image choice. The image would have to be primarily red, green, or blue with slight color hues to showcase a vibrancy of color as

illustrating the computer screen. A black background would further aid the image by directing focus to a particular object. After much consideration, a picture of a strawberry sufficed. This allowed for color variance within the seeds of the strawberry, while maintaining a primarily red and green shape. I manipulated the photo to adjust color and change the background to black.



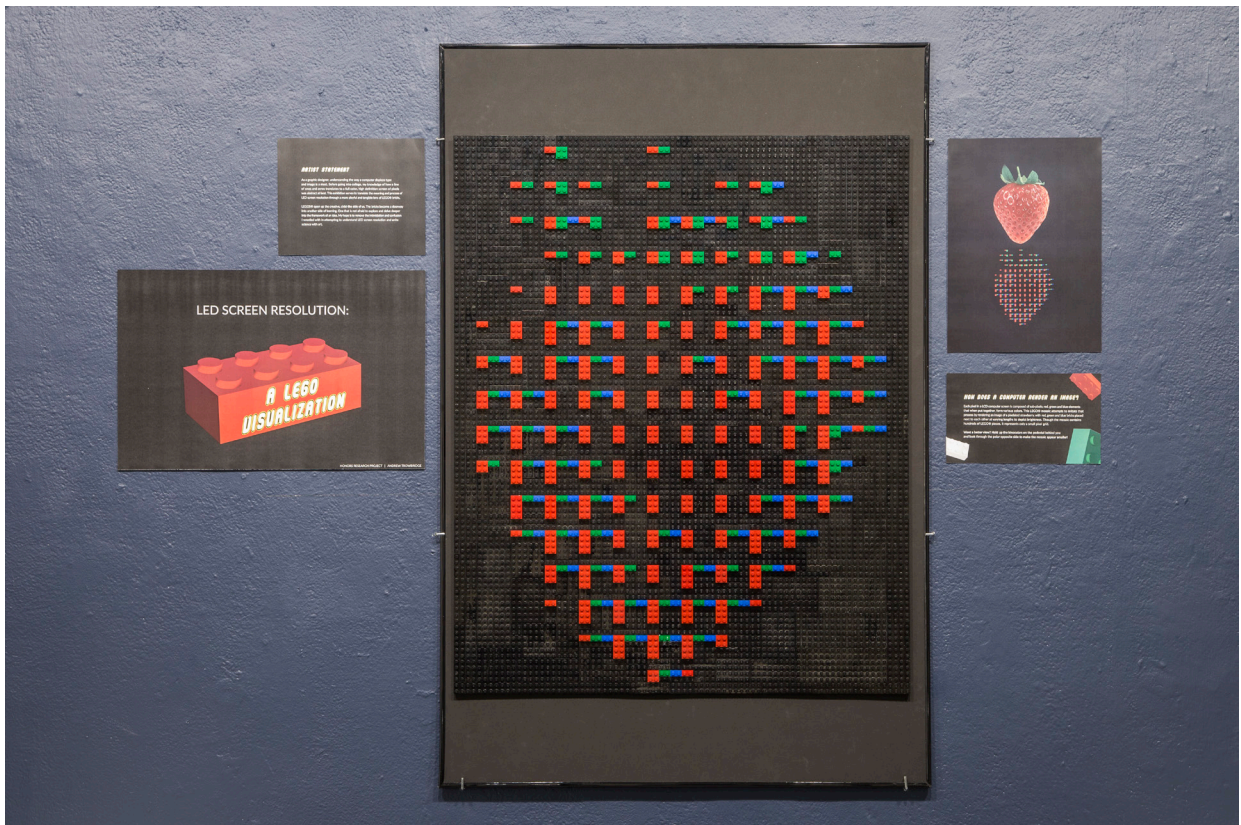
The next challenge consisted of determining appropriate size. With the current translation from the JavaScript algorithm, one pixel would account to a 1.5"x1.5" square. This would quickly accumulate to filling vast amounts of area, for example, a square image 300 pixels wide would take up almost 40 feet on either side. By adjusting the resolution of the strawberry image before translating it through the JavaScript algorithm, I found a suitable size for the space allotted for the exhibition.

The final obstacle in constructing the mosaic consisted of finding the least expensive way to acquire the LEGO® bricks. As I investigated grants available for LEGO®, none offered money for individuals seeking to educate the general public. Most were offered to teachers seeking to use LEGO®s in the classroom. With further investigation, no grant would support personal use of the bricks.

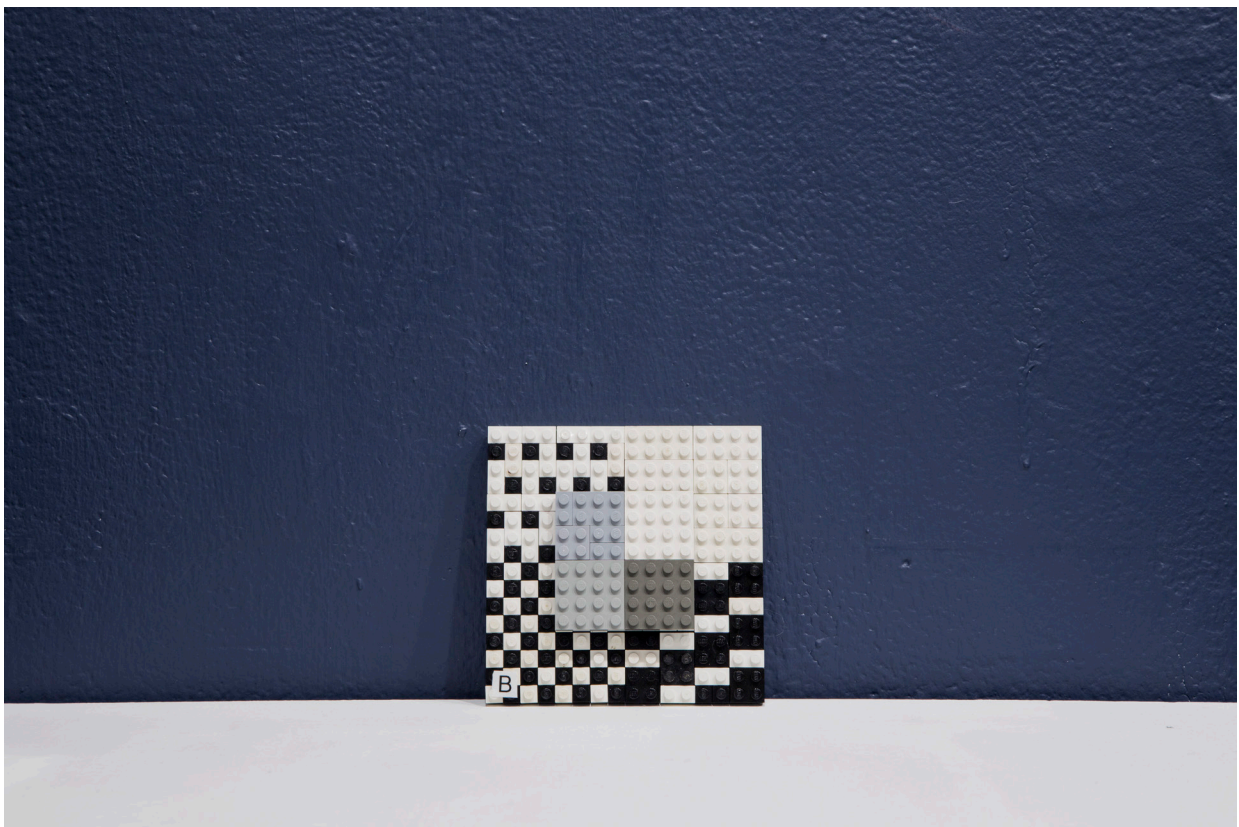


I decided to extend my search into online sites where bulk LEGO® bricks could be purchased. One particular site offered an inexpensive option to purchasing bricks. The site consisted of LEGO® builders from around the world seeking to sell unused bulk bricks. This option would allow me to acquire a massive amount of bricks for a few dollars; eliminating the need for a grant. Utilizing the site, I purchased all the materials needed to build the LEGO® mosaic for a reasonable price

With these variables resolved, construction on the mosaic could begin. A myriad of baseplates were connected together to form the base structure. Using a simple grid, red, green and blue bricks were systematically placed in rows and columns where the algorithm designated them to be positioned. The remaining space was comprised of mostly 1x6, 2x4 and 2x2 black LEGO® bricks to ensure complete coverage. Once the mosaic was assembled, it required a frame to hang on the wall for viewing. This posed a problem, as any sturdy solution that would hold the bricks in place would compromise using them ever again. To solve this, I removed the plexiglass from a simple poster frame and replaced it with a solid black matte of identical size. The LEGO® bricks then could be secured with picture mounting tape to the poster frame to allow viewers to engage the mosaic without it falling.



To support the main LEGO® structure, six other stand-alone pieces were designed, each explaining more in-depth the LED screen resolution concept. The first explained how a screen displays full color. Computers use thousands of pixels to make up a screen. Each pixel begins as a bit of information between 0 (being black), and 1 (being white); acting as a switch between ‘on’ and ‘off’. This would represent 1 bit, or two colors. Martin Splitt elaborates further in his article “Life of a Pixel” that “each pixel needs to be expressed in three different colors: red, green and blue – each color has 256 shades (or 8 bits), so our memory looks like this: [255, 255, 255] . . . for a white . . . pixel.”² From this point, the red, green, and blue LCDs can be blended together, a vast 16.7 million color possibilities.



2. Splitt, Martin. "Life of a Pixel: A Primer on Computer Graphics Part 1." Archilogic. May 09, 2016. Accessed November 06, 2016. [http:// about.archilogic.com/](http://about.archilogic.com/).

The second structure applies a technique using the additive light space. By representing the LCDs (Liquid Crystal Display) with transparent LEGO® bricks, a backlight can illuminate them, giving a more accurate depiction of the inner workings of the computer screen. Had I discovered this prior to the construction of the main mosaic, and utilized this technique, the end result would prove much more convincing.

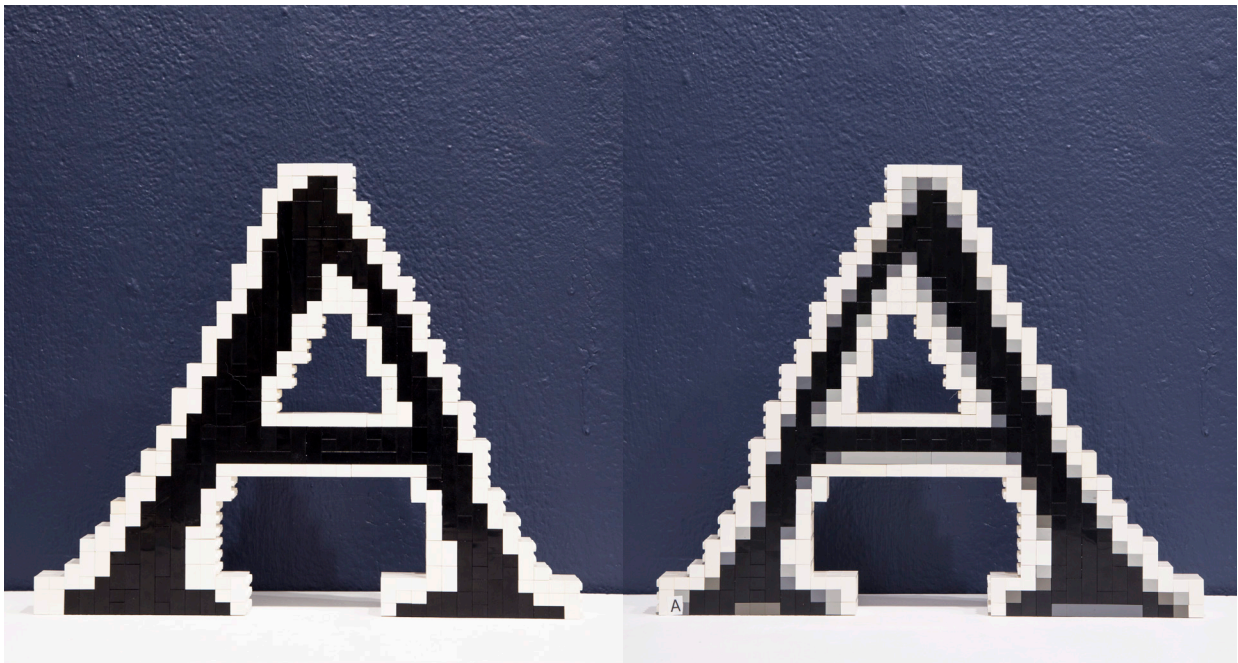


The third structure displays the arrangement of LCDs inside a computer screen.

These are evenly spaced in rows to create pixels, or minute areas of illumination, that make up an image. When light is placed behind the pixels at full brightness, the color white is created thanks to the additive color space.



With the topic of LCDs aptly covered, the fourth structure demonstrates legibility of type through a technique called anti-aliasing. While the computer may display type as strictly black and white with jagged edges, minute shades of grey fill in the gaps of the line to make an image appear smoother. The piece demonstrates this difference with one side built with only black and white LEGO® bricks; the other composed of a mixture of black, white and greys on the edge. Viewers can interact with the piece by studying the difference between both sides.



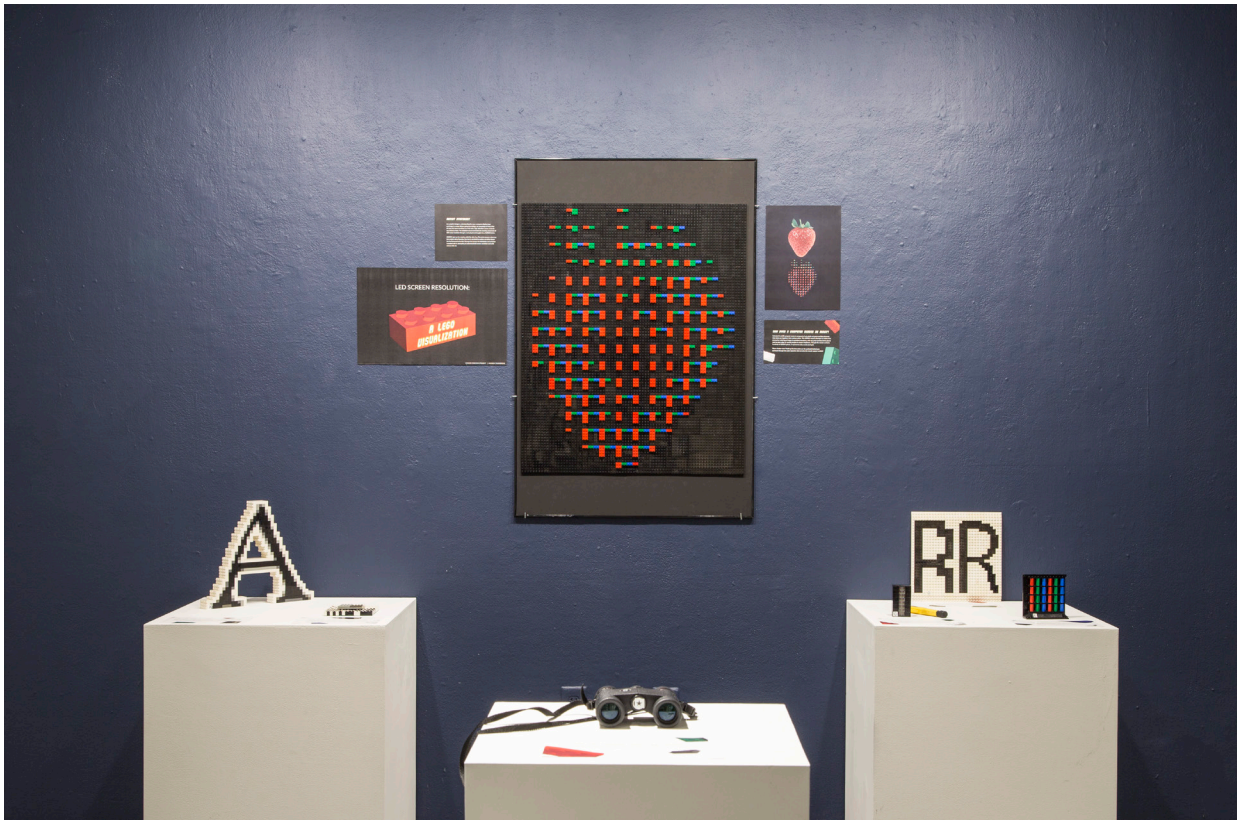
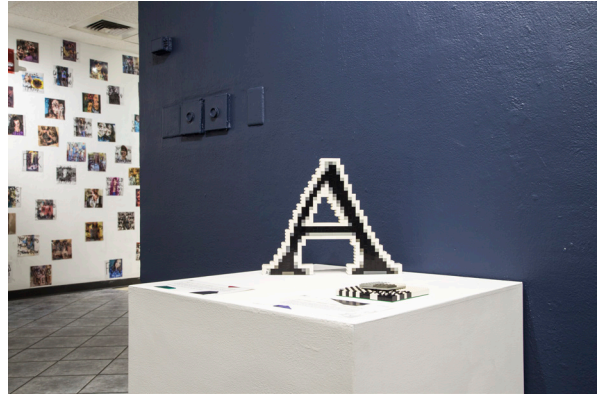
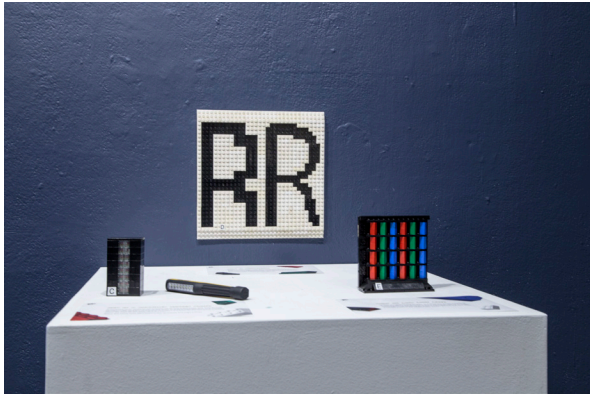
The fifth structure explains the fundamental idea of resolution as the detail an image holds, measured in ppi (pixels per inch). A higher resolution depicted using a 1x1 LEGO® brick as its resolution size, represents a higher pixel count. A lower resolution, with a 3x3 LEGO® brick as its resolution size, represents three times less pixel information as the right image. This shows why a 300ppi image is more defined than a 72ppi image, even if they are the same size. The final structure compares screen resolution sizes from 720 pixels to 4K pixels by displaying each subsequent size on a LEGO® model of a computer screen.



Once all of these pieces were assembled, I conducted a group critique with the readers, advisor, and sponsor before its debut in the exhibition to fine-tune any issues. Upon the completion of the critique, a slight problem arose. Unless a viewer observed the main mosaic of the strawberry from 30 feet away, its form did not hold as a strawberry. This particular problem could not be solved by the placement of the mosaic, as the exhibition space only allowed for a 15-foot viewing distance at most. During the critique, my sponsor, Dave Szalay, suggested a pair of binoculars be placed on a pedestal and instruct viewers to reverse the magnification by observe the mosaic through the opposite end of the binoculars, which forced the viewing distance of the mosaic away in minimal space restrictions. This technique worked surprisingly well, and did not require the viewer to stand more than 10 feet away from the mosaic. With the problem of distance resolved, minor changes were made to distill and clarify, such as the removal of the sixth structure for redundancy purposes, and the addition of descriptions under each structure. Triumphantlly, the installation of the exhibit began and each piece fell into proper place.



DOCUMENTATION OF WORK

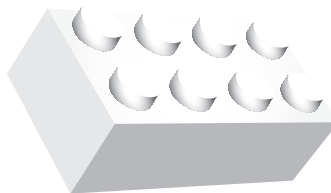




Upon the completion of the Honors Research Project, I have learned a great deal on the subject of LED screen resolution. I feel confident that the concept was conveyed to viewers concisely and in a more practical and interesting manner than I had previously thought possible. In addition, the logistic process of sorting through the organization of an exhibition became more apparent as I worked in collaboration with professors and colleagues in the discovery and advancement of the project's design.

As a rule of thumb, I have found the greater and more exciting the discovery, the more involved onlookers will be. This project, though somewhat abstract and lofty, allowed for collaboration to spark in inviting others into the process of seeking the new and untouched.

Perhaps the most influential takeaway from the project would be that scientific discovery, as well as design work, is never finite. Rather, each is transformed into a piece of a puzzle or a stepping stone for the next entrepreneur to build upon. The discoveries and exploration underwent through my project will hopefully serve as a basis for a future learner's project, much as the data I gleaned from my sources has aided in the production of the LEGO® mosaic; its failures a side note and its successes a bedrock for later challenges.



BIBLIOGRAPHY

Monovektor, "Experimenting With Lenna." Monovektor. March 15, 2012. Accessed May 04, 2016. <http://monovektor.com/>.

Splitt, Martin. "Life of a Pixel: A Primer on Computer Graphics Part 1." Archilogic. May 09, 2016. Accessed November 06, 2016. <http://about.archilogic.com/>.

"How Does a Computer's Screen Work?" UCSB Science Line. Accessed December 07, 2017. <http://scienceline.ucsb.edu/>.

