Light.Time.Space.Move

Humanizing the interaction with light

LEDMATRON

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INTRODUCTION

Nowadays most people are only using light switches or remote controls to control the lighting, but there are many other possibilities to do this. Just imagine changing the lighting in the room without even touching anything; Let us introduce you to the Ledmatron 2000. The Ledmatron 2000 is an interactive device that is used for changing the atmosphere in your living room.

In this report we will be giving you a description of our concept, and afterwards we will give you a couple of future developments that still have to be worked on.

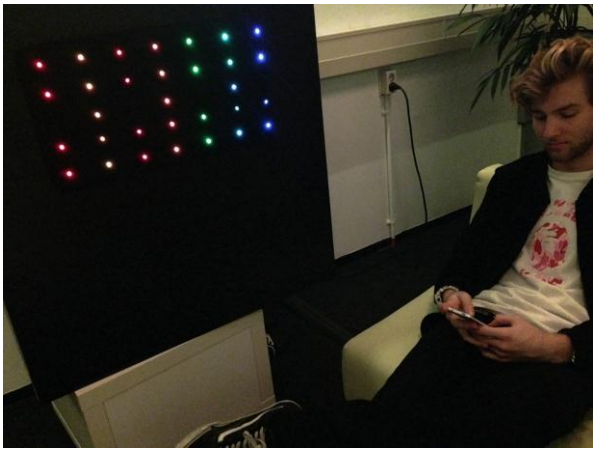
CONCEPT

Core: Changing the atmosphere in a room, using more natural movements than having to turn on several lamps with a simple on/off button.

LEDMATRON 2000

We wanted to create something to change the atmosphere in the living room in a more natural way. We thought that there should be a better way to change the atmosphere in a room. This would normally require dimming the main lights and manually switching on several little ambient lamps.

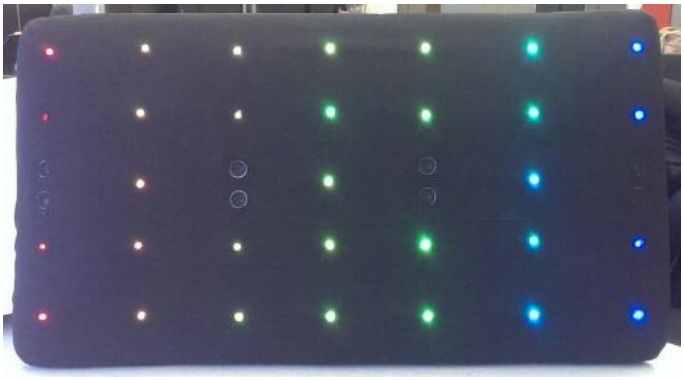
The Ledmatron 2000 does this in a more natural feeling way, and is definitely more fun. We envision our product to be used in the living room, but there are no limitations as to where you can use it.



The Ledmatron in the living room

Using ultrasonic sensors, the device registers the distance between your hand and the product. The closer your hand gets to the Ledmatron, the warmer the colour will get, fading from blue (a cold colour) to red, with all kinds of different colours in between.

The warm/cold principle is a very intuitive and natural principle, because it is displayed in many other things. When we are cold, we come closer to each other to get warm. When someone hides something for you and wants you to look for it, they will often say warm or cold depending on whether you come closer to it. Closer, is warmer.



In the future, there will be lights around the Ledmatron, which will light up the wall around it. This way, an entire wall will become a warmer colour, or a more refreshing colour. By giving the wall a colour, you can give the room a different feel to it, making it brighter or darker, warmer or colder, and thus changing the atmosphere in that room.

FUTURE DEVELOPMENTS

In the future, we would like to add several LED strips to the sides of the Ledmatron 2000, so we can get the desired effect of changing the atmosphere as explained in our concept. We also want to look for a way to cover up the sensors and LED's in the board. Our initial plan was to cover it with a diffused plastic, but the ultrasonic sensors do not work if there is anything in front of it. This would mean find different sensors, or finding a way to make the sensors less visible. We also want to make it easier to change the light from an angle, right now if you want to change it in a specific way you really have to stand in front of it.

We also want to make the LED's less bright to the eye, several visitors found the light too bright for them. The light should be less irritating for the eye. In future, we want our cover to diffuse the LED's (as explained before), this should solve this problem. We could also make a new interaction with which it is possible you can change the brightness.

We would like to do some more user testing and make several iterations of the product, especially for finding out what range the sensors should have in order to make the interaction more natural. We want to have a certain gesture with which you can turn off the Ledmatron. We would have to find out what that would be and how that would work.

We also want to user test whether it is desirable to place some LED's on gaps where the sensors are. Doing this would mean a more equal distribution of light sources, and this might look better. On the other hand, when you see the gap of the sensor, people will know where the sensor is, which makes it easier to interact with it, it gives away the place where you should keep your hand. If you take that away it might make it harder to interact.

INVOLVED PEOPLE

- Jonas Vorwerk, a designer in innovative concepts that lie between the autonomous and the applied arts. He helped us come to a clear concept, and gave us some extra input and information.
- Jan-Derk Bakker, he was our coach during the project at Light.Time.Space.Move, he was the weekly corrective pull on our steering wheel, helping us with going in the right direction, informing us of everything, and helping with issues in general.
- Serge Offermans, an expert/researcher in the yellow space. He helped us a lot with the programming of our final prototype.
- Several people at the E-lab, helping us with programming and the electronics.

Proces Report

INTRODUCTION

Hello, welcome to our process report. In this report we will tell you about the process we went through creating the Ledmatron 2000. We have done a lot this semester, we started off doing pressure cookers and after that we dived into our big project. The whole semester we have aimed at humanizing the interaction with light (which is part of the Light Time Space Move theme), and learned a lot in the process. We are going to give you insight in the choices we made during the project, the impact certain exercises had on our final concept and the various tasks we did individually and as a team.

METHOD

WEEK 36 (START PROJECT)

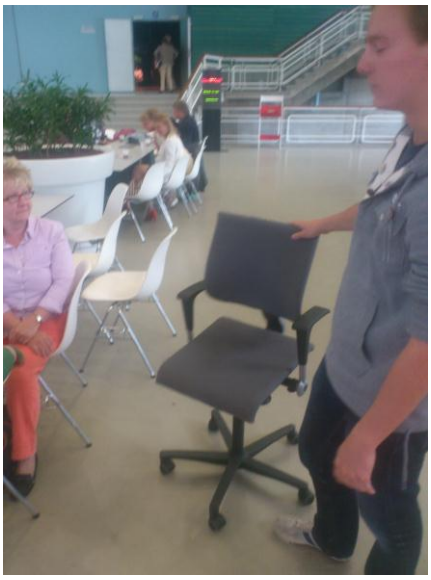
We started our project with a pressure cooker, the first concept was called EmotionLight. Our first iterations were about a system with which you can change the lighting of the whole room. The concept was that the lighting in the room reacted on how much activity there was in the room. The concept was a system that reacted to sound level, amount of people and amount of activity in a room. When we were going further into it we realized that these were far too many variables.

We made a small prototype for the presentation at the end of the week. We made a light in a room that changed based on the sound level in the room. When you there was a small amount of noise light turned on and when the noise got louder the light changed into a calming colour.

FEEDBACK SESSION

At the end of every week we had a feedback session with our coach and most of the time with the other team that he coaches also. The feedback we got the first week is that we should focus more on making an interface rather than making a system that adapts to you.

WEEK 37



The second week, our coach asked us to do another pressure cooker. Our concept was the light in the room adjust according to the way you position your chair. When you put the chair in the active working position the light would be bright and when you wanted to relax the lighting would become more calming and the accents on the surroundings would also become a more relaxed colour.

We did some user tests during this pressure cooker; we went to the auditorium with a chair during one of the breaks and asked people their opinion and how they would want to adjust the lighting. We took a chair from the yellow space with us to give the people an adjustable chair and let them experience it a little bit. The participants gave us lots of ideas to change the light and how they would like to adjust the lighting when in they are in their work space.

FEEDBACK SESSION

The feedback we received that week was that we focused too much on an application, we also (again) made too many assumptions. We already presented more of the application while we should have just presented the core of the concept. We shouldn't be interested in the position of the chair but how the person itself sits.

WEEK 38

Our coach asked us to do a third and final pressure cooker and try to present the real core of the concept and to first choose a setting before starting with brainstorming. We should also think more out of the box; He wanted us to come up with something totally different and crazy. After several iterations, we chose a Jacuzzi as the setting for our concept. Our concept was that everyone in the house had a personal rubber ducky which knows who you are, so whenever you put your ducky in the tub, the Jacuzzi knows who's in it. According to this, it would choose a colour setting, which you could adjust manually through the rubber duck. We also thought of all kinds of coloured duckies to let children learn how colours mixed.

FEEDBACK SESSION

At the end of the week we got the feedback that we did have less hidden assumptions in our concept (we still had several assumptions but a lot less). As long as we did them knowingly it wouldn't be a big problem, then they would be design choices. We should, in the future, think of making the duck the symbol, not the system. Store the information of preferred lights in the cloud, so you don't lose that when you lose your duck.

WEEK 39

After the third pressure cooker the coach asked us to come up with 3 concepts by the end of the week. We could be inspired by our own concepts of the pressure cookers or concepts from other people. We used some of the brainstorming techniques we learned from the assignment for DG000 and our experiences from the pressure cookers. We tried to root out as many assumptions from our concepts as possible.

This week we managed to work from the core of a concept. The first idea we came up with was a shadow guide, a shadow which could help you find your way through the hospital by walking with you along the walls. The second was the tunnel creature, a little 'animal' of light which you would place in a tunnel where people would interact and play a little with it. The third was a grid with cubes in it, which you would place in a house where people could play with it by taking the cubes out and changing the colour by tilting the cubes. When you would put the newly coloured cube back, the rest of the wall would adapt to that cube, so you could create colour patterns by changing the cubes.

FEEDBACK SESSION

After the presentation we chose to go for the cubes; we got the feedback to not do the shadow guide, because something similar was done before. After a short team discussion we chose to continue with the cubes, because that seemed the most interesting, feasible and original idea.

WEEK 40-42

We started with setting goals for the Demo Day and we made a plan to achieve those goals.

GOALS FOR MIDTERM DEMODAY

The goals we set for ourselves for the first demo day were to make a 2 dimensional model. We wanted a grid with cubes with fading colours. We want it to give an idea of how it would look like and light up the room. We wanted it to give an impression on how it would change the atmosphere.

We wanted to explore the materials that we could use for making the cubes. We wanted a material that was diffused and that was also strong enough to withstand some pressure.

Last we wanted to make at least one working cube which gives an idea of the interaction that you will have. We wanted it to change colour when you tilted the cube.

First our concept wasn't just the grid where you could put the cubes into, but also that you could take them out and build them into a structure you wanted. We chose to focus on the grid and the 2 dimensional part of the concept, because that was in our opinion the most important part. The 3 dimensional, the building with the cubes was in our opinion less important and not feasible in the time given.

WORK DONE

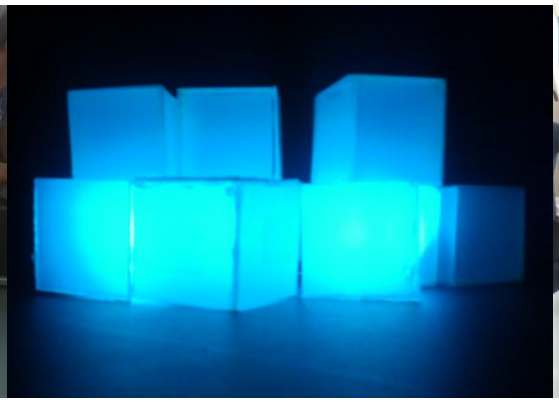
We started with making some cubes from foam, we made a lot of cubes to give a feeling how it looked like and how it would feel like. We also made several cubes with a bit more rounded corners, because the ones with sharp edges were not very pleasant in your hand. We went around with the cubes and asked people what they thought was better, sharp edges or rounded edges and it was quite equal which one the users thought was better. Since we were making the cubes from akyprop and we couldn't round off the edges easy we chose to make them with sharp edges.

We also did think about the size the cubes should have and made some cubes of different sizes. The first cubes were first 5x5cm and we tried making them 7,5x7,5cm and 10x10cm. In our opinion the smallest ones were the best, having thought about how big the grid or the building would be if you make the cubes for example 10x10cm. In our opinion the structures would get too big for most places where you would use them.

During these weeks we did several iterations on the materials for the cubes, we made first some with Perspex, but found that akyprop had almost the same characteristics as Perspex but was diffused so we chose to continue with that material.

We made one cube which would change colour when you would tilt it. We tried a lot of things to program and make it. We tried using tilt sensors for that, we tried using a tilt sensor with 4 directions and one with 2 directions to try give it all 6 directions. When we tried to program it we found that with our Arduino programming skills and the help from others in the space we could not achieve what we wanted. After a feedback session with the coach he advised us to use an accelerometer instead. We bought an accelerometer and after some programming we got it to work as we wanted. The cube where we put the system in was also bigger than it would be in future, because the electronics were too big to put it in a 5x5 cube. Instead they were put in a 10x10 cube.

We made a grid for the cubes as you can see in the left picture, we made the cubes light up with some Led pars. We made some cubes to show the 3 dimensional idea too. We made them light up with some led lights bought from Ikea. We made a promotion video to show the concept and give a general idea on how it would work. On the right you can see the poster we made for our project.



WEEK 46 (FIRST WEEKS AFTER SDL WEEKS)

We started after the SDL weeks with making a planning and setting goals again.

As a group we looked at the feedback we got from the Demo Day. The most important feedback was that we should talk to Jonas Vorwerk, a designer who has done something that was similar to our concept. We also should choose a clear context in where we wanted to put our product.

CHANGING CONCEPT

Pepijn and Jelle went to Jonas Vorwerk on Thursday to interview him on what he has done and how that worked.

''Jonas Vorwerk designs innovative concepts that lie between the autonomous and the applied arts. These concepts are expressed in websites, installations and cross-media applications.''[1]

Friday after the interview we had a group discussion on how we could change our concept. After the interview we asked ourselves the question why people would want to take the cubes out and we let us inspire by some things Jonas Vorwerk said. We changed the cubes into LED's and we changed the interaction. Now we wanted to use distance sensors instead of tilting sensors. We wanted to make it more intuitive by making the colour range from warm to cold, the closer you got to the sensor, the warmer the colour would become.

CHOOSING CONTEXT

The other thing we had to decide was in which context we wanted to place it. We chose the living room, because we wanted a place where people could see and use it. We found the living room the best place for our product because it is a place where you spend a lot of time relaxing. We wanted it to change the atmosphere and the atmosphere is not important in for example the toilet or the hallway. Most people also spent a lot of money on furnishing the living room and not in (for example) your hallway.

FEEDBACK SESSION

At the end of this week we had talked about what our goals were and what we wanted to do. We didn't have a group meeting before the coach meeting to evaluate what he said. When we evaluated the interview we chose to change our concept. We went back to the coach and had a meeting about the changes we wanted to make, we found we made some big changes but he said that the core was still the same, only the implementation was different. We mainly changed the resolution, making the resolution higher by making the cubes disappear and making a lot more pixels in the form of LED's.

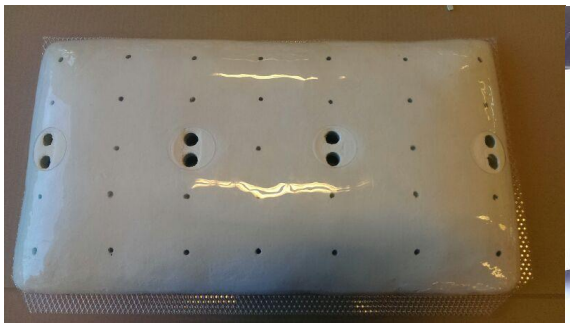
[1] Quote from http://www.jonasvorwerk.com/about/ - 10-01-2013

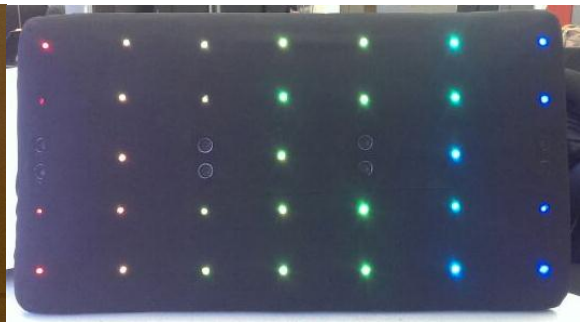
WEEK 47-50

After these decisions, we made a new planning and set new goals. We wanted to make a working prototype where you would have some sensors and LEDs to play with. We wanted people to get the feeling of how it worked, when we got further into it we decided to pick 4 ultrasonic sensors because they could exactly do what we wanted. We wanted the sensors to be able to read the distance from the frame to the hands. We also looked at IR sensors, but they were way more expensive without any real extra use compared to the ultrasonic sensors. The problem we encountered with these sensors was that we could not put a diffused cover over the sensors to keep them a bit out of sight and diffuse the light. Since we could not find a different kind of distance measuring sensor which worked through plastic, we cut some holes in the plastic.

FORMGIVING

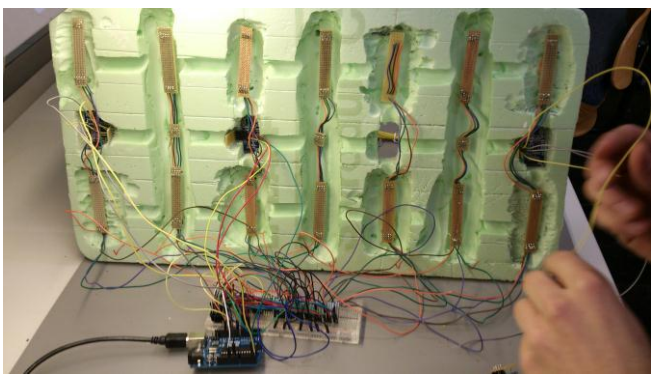
We made the grid with rounded corners, to give it (in our opinion) a nicer shape and feeling than a square one. We were thinking about 3 different forms but we chose for one which rounds off all the corners, like you can see in the figures. The left picture shows the initial prototype without the fabric around it, the right picture shows how we presented it at the Demo Day.





THE TECHNICAL SYSTEM

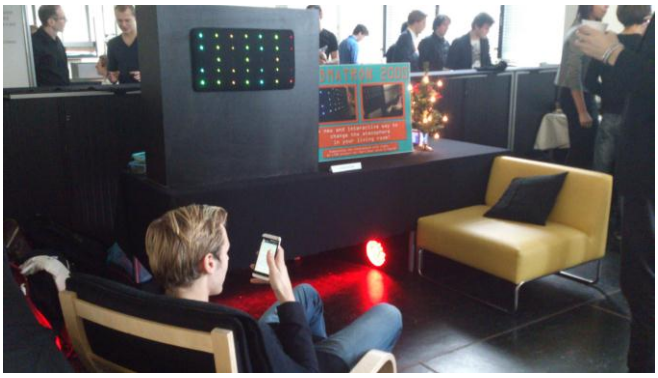
First we thought we would have to use several Arduinos for the amount of sensors and RGB LEDs. After some advice from our coach, we asked Serge Offermans about shiftPWM. With shiftPWM we were able to control a lot of PWM out's with just 1 Arduino. Serge advised us to look at the site of Elco Jacobs (http://www.elcojacobs.com/shiftpwm/). We learned a lot from this site. We started out with re-making the example on the website and then adapting it in a way that we could control our LEDs with 4 distance sensors. We had 7 (vertical) columns of LEDs, 4 of them were in the same column as the sensors. Those columns were directly linked to the value from the sensors. The columns between the sensors were linked to the average value of the sensors left and right of that column. In this way the colours would fade over into each other.



The backside of our prototype, with all the electronics wired up.

WEEK 51 (FINAL DEMO DAY)

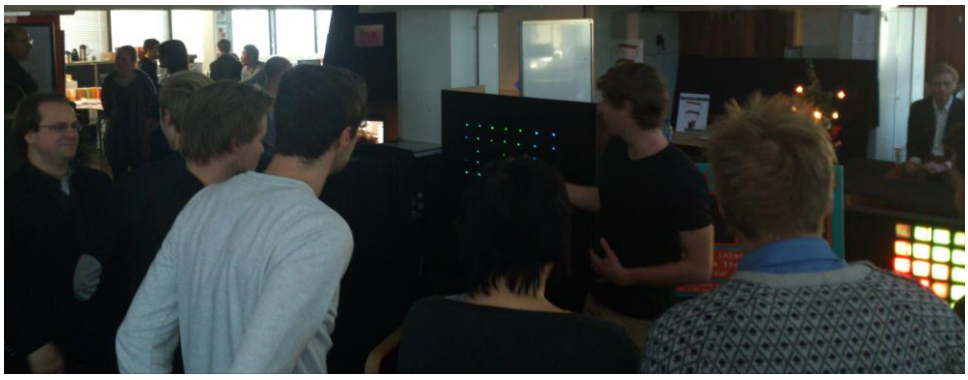
In the week of the final demo days we finished our prototype. We showed the prototype on the last coach meeting the week before and got the comment that it didn't look pretty. After that we started to brainstorm for ways to make a different cover. The sandblasted cover wasn't as diffused as we wanted it to be. We got the tip that the ultrasonic distance sensors might still work with a fabric cover. We tried that and it worked and looked a lot better (as shown earlier in this report). We made a wooden frame to hide the wires and give it a nice touch.



EVALUATION

The demo day was a great success! People who walked by immediately started experimenting with our model, this was exactly what we had hoped. We got some very nice reactions and we also got a lot of useful feedback.

People told us our model didn't show very well how it could create an atmosphere in an entire room. To be able to do this, there would have to be a bigger model and there would have to be ambient lighting around it so it would light up the whole wall behind it. The LED's were also too clearly visible and weren't very pleasant to look at. It would be better if there would be more LED's and that the light should be more diffused so it would create a more diffused lighting with smoothly fading colours. The colours should also be more saturated, people probably don't want a bright green colour on their wall, but the colour green should be the accent colour of the light. Some people also suggested that we should look how it worked if we placed it in another context. We didn't think of how we could shut the Ledmatron down. Some people suggested that we could shut it down in the same way as you close a book.



When we would have the time to work further on this concept we surely would have spent time on the saturation, something which could be done easily. We would also try to make the ambient lighting around it. Our current model didn't show the atmosphere we wanted to create, it did however show the interface pretty well. In our next model we would have improved this, so we could show the users what kind of atmosphere our product could create. After that we would have done some user test by placing it in a real living room so we could see how people interacted with it. Besides that we would have improved the business model. Changing the name is one of the things we would need to do. Also looking for parties, calculating the production costs and making a marketing plan.

TEAM REFLECTION ON PROJECT B1.1

Like every team we had our share of bumps in the road, there were team members struck with illness, ones that were chronically late and of course the occasional endless discussions. However we always made our decisions based on what was best for our project, and acceptable for everyone. Despite some discussions we made most decisions quick and decisive.

Dividing the tasks in the second quartile worked very well, the first quartile we waited a lot on other team members to finish something or to arrive and dividing the tasks solved this problem. We were very dependent on the whole team being present to make decisions. The dividing of the tasks made the people responsible for what they did, and also allowed us to work separate from each other. We were very proud of our final model that we showed on the demo day. We grew a lot in our overall designing competency but we also developed as a team and worked rather smoothly throughout the second quartile.

APPENDIX

A. PEOPLE WHO WERE INVOLVED

Our coach for this semester is Jan-Derk Bakker

Jonas Vorwerk, we interviewed him (we have a record of the interview)

Serge Offermans, gave a lot of help and advice on how to make and program our concept.

People who came by at the Demo Days, fellow students, other coaches/experts.

B. TASK DIVISION

Task	Competency	Team Member
Programming the arduino and soldering everything together	Integrating Technology, and DMM	Daan Matthijsse Jelle Wories
Creating the model (excluding technology) and making the poster	Form and Senses	Pepijn Temming
Doing user tests	User Focus and Perspective	We did this as a team
We made various models to map our concept	DMM	We did this as a team
Make a business canvas	DBP	Bart Bierling
Make product and process report		Bart Bierling did the most work in this area; However the whole team contributed to the reports.
Idea Generation	IT	Bart Bierling
DG000 Assignment:	DBP	Pepijn Temming
DG000 Assignment:	DMM, DRP, SCA, IC, FS, UFP.	As a team

Humanizing the Interaction with Light

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DPM84

Coaches

Harm van Essen
JanDerk Bakker
Frans Parthesius
Katrien Ploegmakers

Clients

Serge Offermans
Smart Contextual Spaces project
Intelligent Lighting Institute

Philip Ross
Fonckel B.V.
www.fonckel.com

Abstract

In this project you will explore the interaction with future lighting systems. You will search for ways to allow people to benefit from the opportunities that modern light sources have to offer. You will design interfaces that open up these opportunities to people in a way that suits their needs and capabilities. While technology allows for virtually unlimited lighting possibilities, we need to humanize the interaction.

Main competency development targeted in:

IC; IT; UFP; FS

Targeted blocks

B1; B2; B3.2; M1.1; M1.2.

Introduction

In the near future, we will have highly dynamic light sources embedded throughout our environments. Lights will be able to communicate to each other and together form a lighting platform. This platform in turn allows us to create light settings that are more in tune with our activities and benefit us in terms of visibility as well as psychological, physiological and emotional effects.

From a technological viewpoint, we have a high degree of control over the lights in such platforms as we are able to adjust the lights' intensity, color, color temperature, position, direction and possibly even more parameters. How to make this control available to people in an appropriate way, however remains unknown.

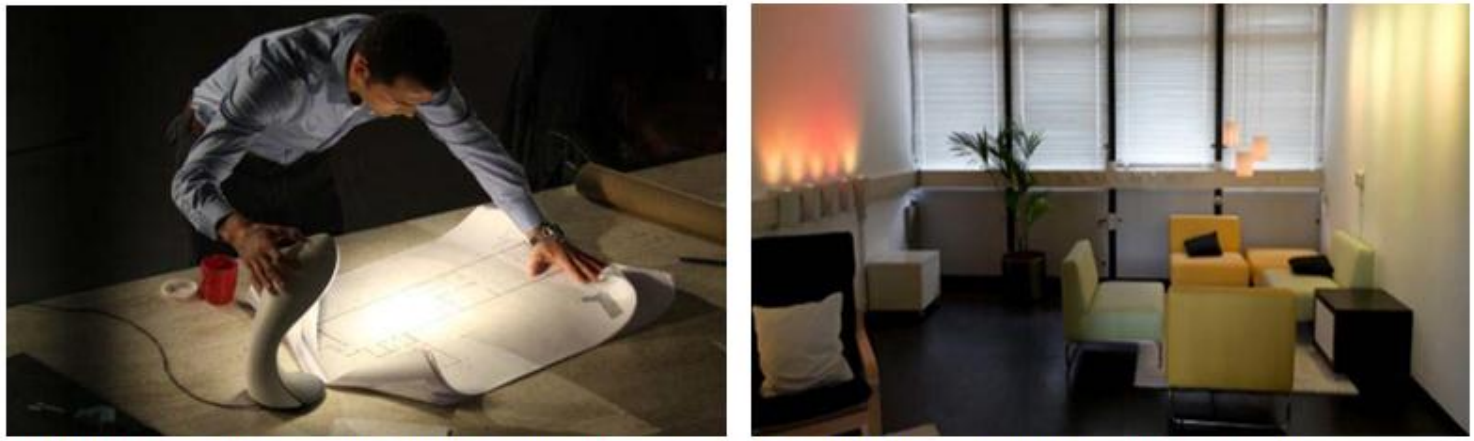

figure 1. left Fonckel's Touch Light concept and right Breakout 404; the lighting platform in a living-lab in the Yellow space.

figure 2. Three existing Interfaces for Breakout404; with varying levels of control; expressive atmosphere setting with the LightPad, calling presets with the LightCube, and detailed control with a tablet interface.

Design challenges or research questions

The current interaction paradigm of a switch or dimmer for each lamp or group of lamps will no longer suffice if we wish to exploit the opportunities of modern lighting technologies. In this project you will design interfaces that open up these opportunities to people in a way that suits their needs and capabilities. Several contexts are interesting and relevant to design for.

You will be able to use newly emerging frameworks for interactive lighting platforms as well as the accompanying design tools. These frameworks support design and analysis processes by connecting context, interaction, and light issues. Vice versa, through design and evaluations you will contribute to the refinement and development of the frameworks and handles for design.

For this project it is important that numerous iterations of design and evaluation take place, working towards an interface, or set of interfaces, that supports people in the interaction with light, and allow them to benefit from the opportunities that lighting platforms have to offer.

Stakeholders

The project is part of ongoing research in the Intelligent Lighting Institute that focuses on novel interfaces for lighting control. In the project we join forces with Fonckel, an ID spin-off company (www.fonckel.com) who offers its Touch Light concept and challenges you to make it your own and create a new generation of luminaires. The rich theme facilities, equipment, and expertise are available offering a technical infrastructure and living lab for implementations and evaluations.

References / information sources

Research papers, documentation, previous reports as well as introductions to available hardware and lighting resources will be made available at the start of the project

D. ARDUINO PROGRAM

```
/*
 * ShiftPWM non-blocking RGB fades example, (c) Elco Jacobs, updated August 2012.
 *
 * This example for ShiftPWM shows how to control your LED's in a non-
blocking way: no delay loops.
 * This example receives a number from the serial port to set the fading mode. Inst
ead you can also read buttons or sensors.
 * It uses the millis() function to create fades. The block fades example might be
easier to understand, so start there.
 *
 * Please go to www.elcojacobs.com/shiftpwm for documentation, fuction reference an
d schematics.
 * If you want to use ShiftPWM with LED strips or high power LED's, visit the shop
for boards.
 */

// ShiftPWM uses timer1 by default. To use a different timer, before '#include <Shi
ftPWM.h>', add
// #define SHIFTPWM_USE_TIMER2  // for Arduino Uno and earlier (Atmega328)
// #define SHIFTPWM_USE_TIMER3  // for Arduino Micro/Leonardo (Atmega32u4)

// Clock and data pins are pins from the hardware SPI, you cannot choose them yours
elf.
// Data pin is MOSI (Uno and earlier: 11, Leonardo: ICSP 4, Mega: 51, Teensy 2.0: 2
, Teensy 2.0++: 22)
// Clock pin is SCK (Uno and earlier: 13, Leonardo: ICSP 3, Mega: 52, Teensy 2.0: 1
, Teensy 2.0++: 21)

// You can choose the latch pin yourself.
const int ShiftPWM_latchPin=8;

// ** uncomment this part to NOT use the SPI port and change the pin numbers. This
is 2.5x slower **
// #define SHIFTPWM_NOSPI
// const int ShiftPWM_dataPin = 11;
// const int ShiftPWM_clockPin = 13;


// If your LED's turn on if the pin is low, set this to true, otherwise set it to f
alse.
const bool ShiftPWM_invertOutputs = false;

// You can enable the option below to shift the PWM phase of each shift register by
 8 compared to the previous.
// This will slightly increase the interrupt load, but will prevent all PWM signals
 from becoming high at the same time.
// This will be a bit easier on your power supply, because the current peaks are di
stributed.
const bool ShiftPWM_balanceLoad = false;

#include <ShiftPWM.h>   // include ShiftPWM.h after setting the pins!


int trigPin1 = 5;
int echoPin1 = A5;
int trigPin3 = 4;
int echoPin3 = A4;
int trigPin5 = 3;
int echoPin5 = A3;
int trigPin7 = 2;
int echoPin7 = A2;


long duration1, distance1;
long duration3, distance3;
```

```
long duration5, distance5;
long duration7, distance7;

// Here you set the number of brightness levels, the update frequency and the numbe
r of shift registers.
// These values affect the load of ShiftPWM.
// Choose them wisely and use the PrintInterruptLoad() function to verify your load
.
unsigned char maxBrightness = 255;
unsigned char pwmFrequency = 75;
unsigned int numRegisters = 3;
unsigned int numOutputs = numRegisters*8;
unsigned int numRGBLeds = numRegisters*8/3;

unsigned int hue1;
unsigned int hue1Final;
unsigned int hue3;
unsigned int hue3Final;
unsigned int hue5;
unsigned int hue5Final;
unsigned int hue7;
unsigned int hue7Final;
unsigned int saturation;
unsigned int brightness;

void setup()
{
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin3, OUTPUT);
  pinMode(echoPin3, INPUT);
  pinMode(trigPin5, OUTPUT);
  pinMode(echoPin5, INPUT);
   pinMode(trigPin7, OUTPUT);
   pinMode(echoPin7, INPUT);

  Serial.begin(115200);

  // Sets the number of 8-bit registers that are used.
  ShiftPWM.SetAmountOfRegisters(numRegisters);

  // SetPinGrouping allows flexibility in LED setup.
  // If your LED's are connected like this: RRRRGGGGBBBBRRRRGGGGBBBB, use
SetPinGrouping(4).
  ShiftPWM.SetPinGrouping(1); //This is the default, but I added here to
demonstrate how to use the funtion

  ShiftPWM.Start(pwmFrequency,maxBrightness);

  saturation = 255;
  brightness = 255;
}
void loop()
{
  distance1 = duration1/58.2;
  distance1 = constrain(distance1, 5, 30);
  distance3 = duration3/58.2;
  distance3 = constrain(distance3, 5, 30);
  distance5 = duration5/58.2;
  distance5 = constrain(distance5, 5, 30);
  distance7 = duration7/58.2;
  distance7 = constrain(distance7, 5, 30);

  //sensor 1 = line 1
  digitalWrite(trigPin1, LOW);
  delayMicroseconds(2);
```

```
  digitalWrite(trigPin1, HIGH);
  delayMicroseconds(10);

  digitalWrite(trigPin1, LOW);
  duration1 = pulseIn(echoPin1, HIGH);
//  Serial.println("one");
//  Serial.println(distance1);

  hue1 = map(distance1, 5, 30, 20, 280);

  if (distance1 < 30)
  {
    hue1Final =  (hue1+340)%360;
    ShiftPWM.SetHSV (0, hue1Final, saturation, brightness);
  }
  else {
  }

  //Sensor 2 = line 3
  digitalWrite(trigPin3, LOW);
  delayMicroseconds(2);

  digitalWrite(trigPin3, HIGH);
  delayMicroseconds(10);

  digitalWrite(trigPin3, LOW);
  duration3 = pulseIn(echoPin3, HIGH);
//  Serial.println("three");
//  Serial.println(distance3);
//
  hue3 = map(distance3, 5, 30, 20, 280);

  if (distance3 < 30)
  {
    hue3Final = (hue3+340)%360;
    ShiftPWM.SetHSV (2, hue3Final, saturation, brightness);
  }
  else {
  }

  //line 2, between sensor 1 and 2
  int hue2Final = ((hue1Final + hue3Final)/2);
  ShiftPWM.SetHSV (1, hue2Final, saturation, brightness);

  //sensor 3 = line 5
  digitalWrite(trigPin5, LOW);
  delayMicroseconds (2);

  digitalWrite(trigPin5, HIGH);
  delayMicroseconds (10);
                                                          //Sensor
3
  digitalWrite(trigPin5, LOW);
  duration5 = pulseIn(echoPin5, HIGH);

  hue5 = map(distance5, 5, 30, 20, 280);

    if (distance5 < 30)
  {
    hue5Final = (hue5+340)%360;
    ShiftPWM.SetHSV (4, hue5Final, saturation, brightness);
  }
  else {
  }
```

```
  //line 4, between sensor 2 and 3                                        line 4,
between 2 and 3
  int hue4Final = ((hue3Final + hue5Final)/2);
  ShiftPWM.SetHSV (3, hue4Final, saturation, brightness);

  //sensor 4, line 7
  digitalWrite(trigPin7, LOW);
  delayMicroseconds (2);

  digitalWrite(trigPin7, HIGH);
  delayMicroseconds (10);
                                                                          //Sensor
4
  digitalWrite(trigPin7, LOW);
  duration7 = pulseIn(echoPin7, HIGH);

  hue7 = map(distance7, 5, 30, 20, 280);

    if (distance7 < 30)
  {
    hue7Final = (hue7+340)%360;
    ShiftPWM.SetHSV (6, hue7Final, saturation, brightness);
  }
  else {}

//  //line 6, between sensor 3 and 4                                        line
6, between 3 and 4
  int hue6Final = ((hue5Final + hue7Final)/2);
  ShiftPWM.SetHSV (5, hue6Final, saturation, brightness);

//  Serial.print ("/");
//  Serial.print (hue1Final);
//  Serial.print ("/");
//  Serial.print (hue2Final);
//  Serial.print ("/");
//  Serial.print (hue3Final);

  delay(20);

}
```