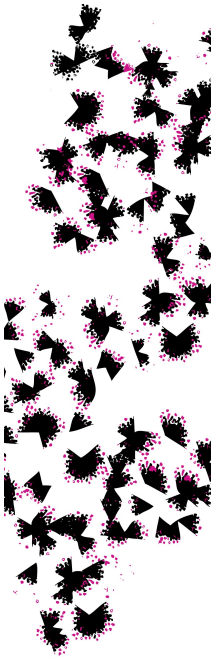

A desk light to improve working attitude

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BSc Report

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Abstract

The goal of this research is to find out if it is possible to create a robotic desk light that improves the working attitude of its user. This has been done by first of all exploring the current state of the art for human robot interaction and after that by building a desk light prototype that is able to react to different objects in a way that different colors generate different emotional states for the desk light which it then shows towards the user in order to interact with them. It has shown that it could be possible to design a robotic desk light in such a way that it can improve the working attitude of its user.

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Chapter 1

Introduction

Introduction

1.1 Context

Robots are becoming increasingly more relevant in our current society, where these robots in the recent history were mostly used as an assisting feature within for example hospitals or factories. Within these facilities these robots have a set function which they always perform in the same exact way, in this recent past this was enough to achieve satisfaction from the users. However, recently the focus of robots started to shift from being this assisting feature towards becoming a more autonomous entity. When robots start to become more autonomous, this means that interaction with other organisms also becomes increasingly important, the study relevant to this is called human robot interaction(HRI).

Human robot interaction is an essential topic when it comes to robots in general, because robots will always interact with humans in one way or another. Within the department of HRI three categories can be distinguished as stated by Dautenhahn[1]. The first category is robot-centered HRI, where robots are seen as a creature where the interaction with humans serves to fulfil the needs of the robot as it is designed for. The second category is human-centred HRI, where a robot has to fulfil its task in an acceptable and comfortable way to humans. The last category is robot cognition-centred HRI, which sees the robot as an intelligent system. These categories play a big role in the creation of robots, since people interact in different ways to these categories. Expectation plays a big part in this, because the way that people expect the robot to behave determines the way that these people interact with the robot. When a robot is designed for a specific goal, knowledge about this expectation becomes key in the creation of the robot.

Nowadays it is trending for people to change and also improve their lifestyle when it comes to general health, these people try to eat healthier and be more physically active. However, In practice these desirable lifestyle patterns may be challenging for individuals to realize. In these cases, technology can be applied indirectly as a tool to motivate behavioral change according to Nakajima, Lehdonvirta, Tokunaga and Kimura[2].

1.2 Research question

The idea is to design a desk light that is able to improve the lifestyle of its user, where the intended users are office workers, students and everyone else who spends a fair amount of time behind their computer or laptop and are who already have a desk light. These people are likely to life in an unhealthy or undesired manner, and the desk light will be there to improve this. The main research question regarding this project can be stated as follows; How can you design a desk light that improves the working attitude of its intended user? The two key functionalities that the desk light must have to achieve this are firstly to monitor and improve the break time schedule and secondly to monitor and balance the workload of its user.

Prolonged sitting time is a serious risk factor for various negative health outcomes, and in today's society many workers spend at least half of their work day seated. This means that

physical activity during the day is very minimal for a lot of workers. This is what the desk light aims to improve for these workers. The desk light should be monitoring the amount of time that the user is seated during the day and should then accordingly persuade the user to take a break from working and being seated while suggesting some kind of physical activity. The second key functionality is to improve the workload of the user, this functionality aims to find a balance between workaholics and lazy workers. Since workaholics are prone to burnout the desk light should slow the user down when he or she is doing too much work at once, and on the other side, the desk light should motivate the so called lazy workers to work harder.

Chapter 2

State of the art

State of the art

The work within this state of the art research is done following the main research area regarding this desk light project, which is robots that change human behavior. The ability for the desk light to change the behavior of its users is essential to fulfill its purpose.

2.1 Social robots

To increase human acceptance towards robots social skills should be added, since humans are very social creatures and use their social skill to communicate and interact with others. As stated by Duffy[3] the social robot can be perceived as the interface between man and technology. It is the use of socially acceptable functionality in a robotic system that helps break down the barrier between the digital information space and people.

Nowadays technology is allowing us to create systems that are able to simulate human like activities better and better. This is called artificial intelligence(AI). Throughout the history of AI multiple viewpoints have been taking towards it, which mostly focussed on sensing and interpreting the surroundings. However, an alternative viewpoint towards AI, for which Dautenhahn has been arguing since 1994, is to propose that one particular aspect of human intelligence, namely social intelligence, might bring us closer to the goal of making robots smarter (in the sense of more human-like and believable in behavior)[1]. This view of AI is what social robots are based upon. Furthermore, according to Breazeal [4] it is important to recognize that humans are profoundly social species. She also states that our social-emotional intelligence is a useful and powerful mean for understanding behavior and the interaction with entities. According to Fong, Nourbakhsh and Dautenhahn[5] the area where social interaction between robots and humans is desirable is that where a the function of the robot is to change the behavior, feelings or attitudes of the human. They also state that the form and structure of a robot is important because it helps establish social expectation. Furthermore, they note that the choice of a given form may also constrain the human's ability to interact with the robot. They refer to Kismet, the robot from Breazeal[4], as an example, which has a highly expressive face. But because it is designed as a head, Kismet is unable to interact when touch or displacement is required. They continue to explain that according to DiSalvo, Gemperle, Forlizzi and Kiesler [6] a robot's morphology must match its intended function. And that if a robot is designed to perform tasks for the human, then its form must convey an amount of "product-ness" so that the user will feel comfortable using the robot.

DiSalvo et al. [6] refer to a theory developed by Mashiro Mori called the uncanny valley is very related to this topic, because this theory states that as a robot increases in humanness there is a point where the robot is not 100% similar to humans but the balance between humanness and machine-like is uncomfortable (figure 1). Duffy [3] also uses this theory where he states that this so called uncanny valley should be avoided when building a robot that uses social interaction. Furthermore, he states that Mori thinks that the robot form should be visibly artificial, but interesting and appealing in appearance and effectively aim for the highpoint of the first peak in figure 1.

Next to the shape of the robot, Fong et al.[5] also discuss how emotions can play a big role for robots in the interaction with humans. They state that primarily because of the recognition that people tend to treat computers as they treat other people. This idea can be used to generate acceptance for the robots.

It can be seen that the social aspect of a robot can be very significant when aiming for behavioral change, the idea is that humans are more likely to understand and accept certain behavior from robots when these robots make use of social skills. Emotions are a very powerful tool to generate acceptance for robots, since this social skill is one that is very commonly used by humans to express their feelings. However, to be able to make use of these skills the robot should have an appropriate form in which human recognize the behavior of the robot in the correct way. The theory of the uncanny valley also has to be taken into account here.

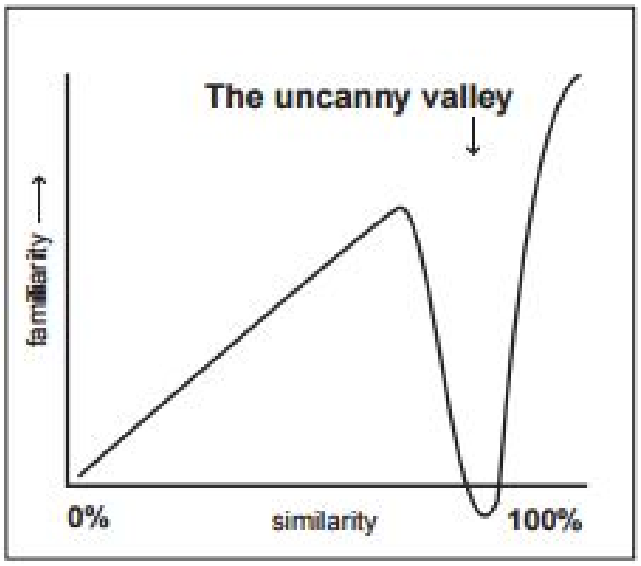


figure 1: Mori's "uncanny valley" (from DiSalvo et al. [6]).

2.2 Persuasion

For a robot to successfully change the behavior of a human a robot should be able to persuade its user, and to achieve this multiple motivational methods should be used while keeping psychological theories in mind.

In a research performed by Khalil and Abdallah[7] where they search for the best way to motivate people to become more physically active they state that multiple motivational methods are being used to achieve this. The method that is mostly used is called self monitoring which enables the users to follow their own behaviour. With self-monitoring the user is able to reflect on his own behaviour, which helps the user with his or her behavioural change. Furthermore, social motivational methods are also commonly used. This method is based on sharing information about your behaviour with others. Next to these methods goal-setting is a also a very successful way of motivating users to change their behaviour. A psychological theory called self-efficacy is also elaborated within this study, this theory refers to people's' sense of

confidence in their ability to perform a particular behavior. High self-efficacy is required to be able to sustain a certain behavior for a longer period of time. The technology should be assisting the user in the growth of their self-efficacy.

Nakajima, Lehdonvirta, Tokunaga and Kimura[2] created the idea to reflect human behaviour in order to motivate a desirable lifestyle. They made two prototypes so far:Virtual Aquarium and Mona Lisa Bookshelf. Both of these prototypes used the self monitoring method to reflect on the user's lifestyle where the aquarium showed how well the user brushed his or her teeth by showing an aquarium where the fish living inside where affected by the users' toothbrushing activity. The Mona Lisa Bookshelf tracked how well the user organised his or her books by showing the mona lisa painting, which would be distorted when books are not placed back correctly or that are even missing. These prototypes both show different ways in providing feedback, where the aquarium uses positive reinforcement and the mona lisa bookshelf embraces negative reinforcement. The results of their tests showed that sometimes the users of the mona lisa bookshelf found it to be almost disturbing to behold, which is a success in a way but can negatively affect the overall experience in the end. Regarding the results of the aquarium they conclude that the repeated use of a stimulus can become boring for the users.

According to the research done by Ham, Cuijpers and Cabibihan [9] they conclude that it seems that gazing and gestures would significantly improve the persuasive power of a robot that delivers a persuasive message. However, after performing an experiment with a storytelling robot they conclude that only gazing is the determining factor. It can be seen from their research and experiment that a robot has an increased amount of persuasive power when the human feels like it is targeted by the robot.

A very related project is done by Jafarinaimi, Forlizzi, Hurst and Zimmerman[4] called "breakaway", where they created an ambient display that encourages people, whose job requires them to sit for long periods of time, to take breaks more frequently. They only tested their project with only one tester which is not sufficient to establish a constructed conclusion but the user was very pleased with the fact that she was able to ignore the breakaway when wanted, where the agenda on her computer or mobile would be intrusive. They conclude in their paper that ambient displays which are situated in office and domestic environments provide rich opportunities for information display.

From this research it can be concluded that self monitoring should be an essential feature when designing a robot that has to change someone's behavior. Furthermore, it can also be seen that positive and negative reinforcement should be implemented with care since when used in the wrong way it can have a very negative influence on the experience for the user. Gazing is also a very powerful tool when persuading the user, and it can be implemented with or without other features to increase the effect.

2.3 A robot as a team member

Required for a robot to help its user in the first place the user and the robot have to team up with each other. This means that the user has to trust the robot. As stated by Hancock, Billings and Schaefer[11] For a human-robot team to accomplish its goal, humans must trust that a robotic team-mate will protect the interests and welfare of every other individual on the team.

Furthermore, they state that trust directly affects the willingness of people to accept information produced by a robot.

An interesting experiment was executed by Nass, Fogg and Moon[12] where they investigated whether people will affiliate with computers in a team relationship, what role the two key factors, identity and interdependence, play in inducing a human to affiliate with a computer in a team relationship, and whether affiliation between computer and humans will lead to the same outcomes as human-human team affiliations. The results of this experiment showed that interdependence is the key to team affiliation, which means that for a human to successfully team up with a robot he or she needs to perceive themselves as a part of a team with the robot.

2.4 Related work

Before the state of the art section will be concluded, some related projects have to be discussed in scope of this desk light project to gain an understanding of what other people have already done regarding a robot desk light.

First of all, the AUR robotic desk light. This desk light, as can be seen in figure 2, was made by Guy Hoffman and had the functionality to follow the user around in a working space in order to enlighten the right area in which the user was working at that exact moment. Next to this function of enlightening the area the AUR was also able to find certain tools when these were needed by the user.

Figure 2: AUR robotic desk light

Another example of a robotic desk light is the Ergo jr, as shown in figure 3, made by the poppy project. The ergo jr is a cheap robotic arm which is intended to be used for educational purposes since it is easy to use and also very easily programmable with the use of “snap” which is a visual programming language.

Figure 3: Ergo jr

Next to these actual robotic desk lights there is of course the pixar desk light. This desk light is used in the logo of the company called pixar, as can be seen in figure 4. This little animated robot jumps on the “i” in pixar and replaces it. Pixar is a widely known company and many people are familiar with the desk light, as thus these people have already been in some sort of contact with a robot that shows personality.

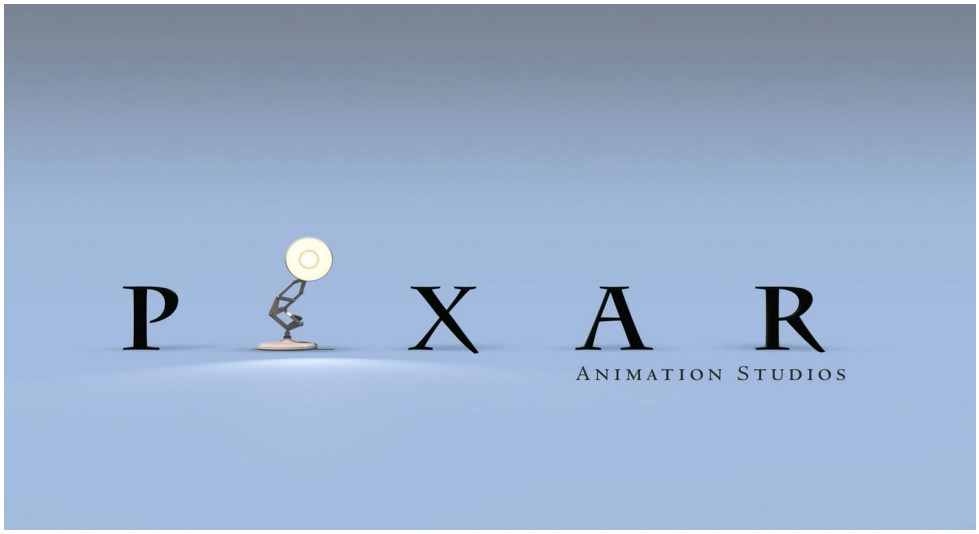


Figure 4: pixar’s logo

2.5 Concluding words

The state of the art research done in the previous paragraphs have given some clear insights into the creation of the desk light. Some clear guidelines can be made that will be very helpful. A social robot seems like the best platform to start with, this research has shown that a robot

which purpose is to change or improve the behavior or lifestyle of its user can best be designed with social-emotional skills. Next to these social skills the form of the robot has influence as well on the experience, this can become a difficult task as the desk light does not come with a lot of variety options. Furthermore, the uncanny valley theory has to be taken into account during the creation of the desk light, this is of great importance since the uncanny valley states that a robot can become completely unacceptable. To prevent the uncanny valley multiple testing phases during the project have to be implemented.

This state of the art research has also given insight into tools that generate persuasive power for the robot. Self monitoring can be seen as an essential feature for the desk light and should be implemented with possibly multiple additional motivational methods. This has to be tested carefully to find a perfect balance that works for the desk light, since it can easily generate unwanted and negative experiences. Next to this gazing looks like a powerful tool that can be implemented into the desk light. However, the problem with this is that people generally find it very intrusive if a light is shining directly into their eyes. There might be a way to implement gazing into the desk light but this should be tested very well.

This research has also shown that teaming up with robots can have a very positive influence on the experience. For a robot to actually team up with a human they both need to perceive themselves as a part of a team where input from both parties is required. It might be useful to implement this concept of teaming up with a robot within the desk light, but this should only be done if it is certain that this would increase the effectiveness of the robot significantly since it is not the actual purpose of the robot to team up with the human. It can be concluded that some guidelines have become clear that will help with the creation of the desk light. The next research question will be stated as follows: How can these guidelines be implemented to maximize the effectiveness of the desk light? This question can only be answered with multiple testing phases to be performed during the continues phases of this project.

Furthermore, the following sub questions can be stated to help answering the main question. How can the desk light be designed in a way that maximizes acceptance? How can the desk light become persuasive enough to fulfill its purpose? And how much does becoming a team increase the effectiveness of the desk light?

Chapter 3

Ideation

Ideation

In the ideation phase an idea had to be generated for the desk light. This was done by first exploring the possibilities of the desk light, since the desk light was already made by E. Dertien as can be seen in figure 5, the technology was already known. After exploring the possibilities that the desk light has, certain applications for it could be thought of. In the end of the ideation phase a clear picture of the desk light's function and target group had to be generated in order to proceed with the project.

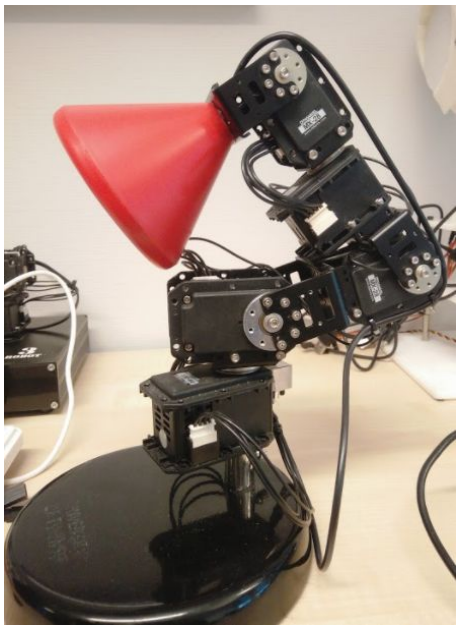


figure 5: E. Dertien's desk light

3.1 Desk light

Since the desk light already existed it was known that 5 dynamixel motors were used which would form the spine of the desk light. These motors give the desk light a certain freedom of movement which generates multiple movement options. However, the use of exactly 5 motors limits the freedom of movement as well. Furthermore, the desk light has a fixed position thus it is not able to move around in certain spaces.

3.2 Applications

Now that it is known what the technical possibilities of the desk light are, different applications can be thought of for the desk light. To generate ideas for different sorts of application for the desk light a mind map was made which is shown in figure 6. This mind map mind first of all shows different sorts of spaces that the desk light can be found in, and after that it looks for possible functionalities for the desk light in these different spaces.

figure 6: Applications mind map

3.3 Results

The ideation phase has given insight into the multiple different possibilities for the functionality of the desk light and can be summarized into the selection of the application it will be used for and after that the selection of a target group.

3.3.1 Application

First of all, what sort of application will the desk light become. A lot of desk light usage goes together with working, or more specifically working behind a desk since there will always be a desk light involved. A normal desk light has the only functionality to light up the space, but nowadays technology allows us to combine certain functionalities successfully together. That means that there can be many more applications for such a desk light as is shown in figure 6. As said in the introduction of this report it is trending for people to change and also improve their lifestyle when it comes to general health, these people try to eat healthier and be more physically active. However, In practice these desirable lifestyle patterns may be challenging for individuals to realize. In these cases, technology can be applied indirectly as a tool to motivate behavioral change. The desk light will become such a tool that will motivate people to change their behavior.

3.3.2 Target group

For a desk light to motivate people to change their behavior, these people have to spend a significant amount of time with the desk light since the desk light would be less effective otherwise. So what is the biggest group of people that spend a significant amount of time behind their desks? That will be the people that work in an office and spend their whole day from nine

till five sitting behind their desk. Next to this, students are a big group as well as they spend a lot of time on studying which might involve sitting behind a desk for a prolonged period of time. This means that the main target group for the desk light will be office workers and students.

Chapter 4

Specification

Specification

A desk light that is able to change someone's behavior has to be created, but how is this concept achieved. First of all, the scope of this project is to see if there is a possibility that such a desk light can be made and not to create an actual desk light that changes behavior. To investigate if it is possible the desk light has to interact with the people and most important of all, the users have to interact with the desk light since this would be essential to fulfill the actual functionality of changing someone's behavior.

4.1 Emotional states

From the state of the art research it can be concluded that emotions play a big role in the interaction between robots and humans, since humans use emotions all the time. The desk light will need certain emotional states to interact more effectively with the user. These emotional states will be the key to change the behavior of the user. For the desk light that is made in this project five emotional states, neutral, bored, curious, scared and shy, were implemented to observe how they worked and how people interact with them. Next to this, these emotional states will have certain types of movements and also colored lighting connected to them that represent this emotional state. The emotional states and their associated movements and lighting can be seen in table 1. It should be noted that the three colors that represent the curious, scared and shy emotional state do not share this color which we would give to that emotion. The desk light is reflecting the color of the object it is most interested in, which in this way gives it some sort of personality.

Emotional state	Movement	Lighting
Neutral	none	White
Bored	Searching around	Rainbow
Curious	Lean in & nod yes	Red
Scared	Lean back & shake no	Green
Shy	Look away & look down	Yellow

Table 1: emotional states and their accompanied movements and lighting

4.2 Color recognition

To control the emotional states mentioned in the previous paragraph, a certain trigger has to be build into the system of the desk light that changes the states accordingly. The trigger for this desk light will be color, mainly because the camera that is used has build in color recognition but also because colors are easily recognized by humans as interesting. Because the emotional states neutral and bored do not require an interesting object, there are only three different colors that have to be implemented in the system. The colors for the curious, scared and shy states

will be the same as the lighting the desk light provides whilst in these states and can be seen in table 1.

4.3 Object tracking

The last feature that will be implemented in this desk light will be the ability to follow or track a certain object. This object that the desk light has to follow will be the most interesting one which influences the emotional state as well. The fact that the desk light is able to follow interesting objects give it a more humanlike behavior, since humans tend to look at interesting objects as well.

Chapter 5

Realisation

Realisation

Now that the specifications are set and clear it is time to actually build the system for the desk light. However, where the specifications have set a good starting point and guideline the actual creation of the desk light is a whole different process of continuously evaluating design choices and even changing them. This process of realising the desk light is described in this chapter.

5.1 Hardware

In this paragraph all of the components used in the desk light are described together with a brief explanation on how these components were used. Figure 7 shows the circuit diagram of the final version of the desk light, in this circuit it can be seen how every component is connected. Important to note are the pins used on the arduino micro which will come back in the software paragraph.

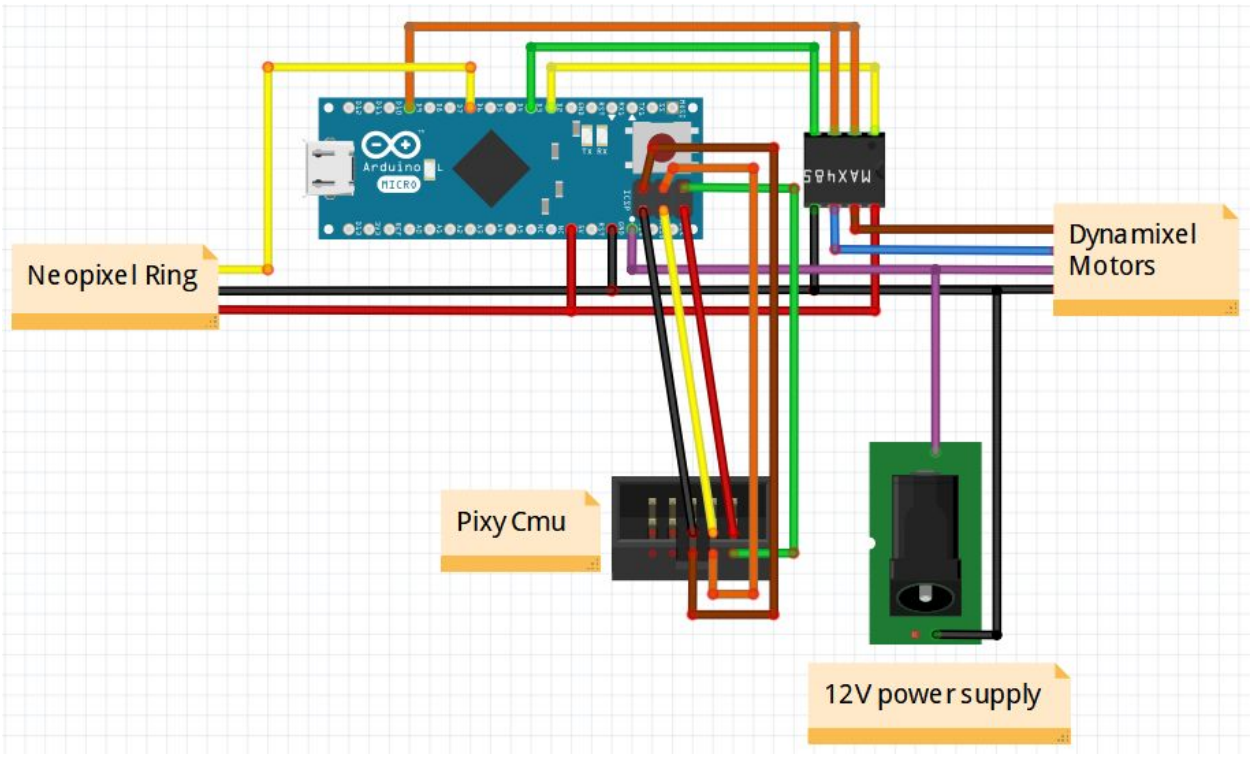
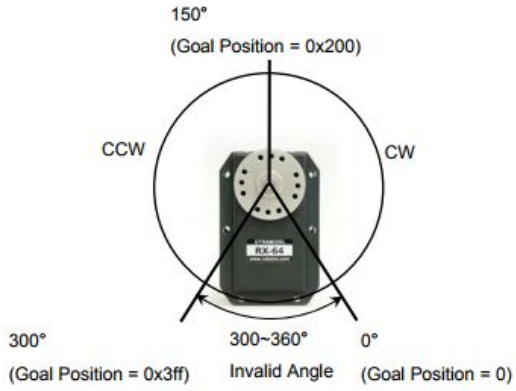


Figure 7 Wiring circuit of the desk light

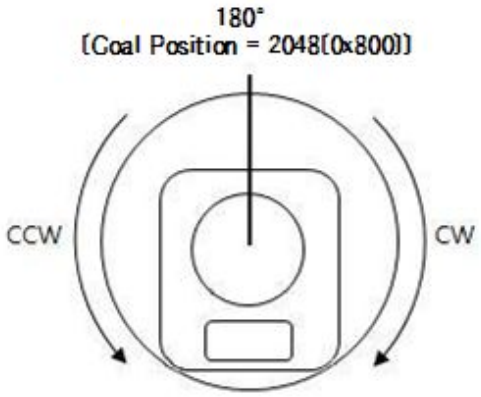
5.1.1 Dynamixel motors

The dynamixel motors are the spine of the desk light, these motors allow the desk light to move in multiple directions. Within the desk light there are 2 different kinds of dynamixel motors implemented which are the RX-64 and the MX-28. These dynamixel motors have the advantage

that they are rather compact and generate relatively big torque. The RX-64 version of the motor has a freedom of movement of 300 degrees as shown in figure(8.1), the MX-28 on the other hand has a freedom of movement of the full 360 degrees as shown in figure(8.2) and can also be configured as a rotating wheel.
First, these motors had to be configured before they could be used for the desk light. For communication purposes the baud rate of every dynamixel had to be the same, next to this every dynamixel had to be given an unique ID number in order to address them individually. To configure the dynamixels a “USB2Dynamixel” had to be used to connect the dynamixels to the pc where a program called “RoboPlus” was used to set an unique ID and a constant baud rate for every dynamixel.



figure(8.1)



figure(8.2)

5.1.2 Arduino

Now that the dynamixel motors had been configured properly the next step was to hook them up to an arduino. However, to communicate with the motors with an arduino the signal from the arduino has to be converted to RS-485. First a RS485 shield was used together with an arduino uno, this shield could be mounted directly on top of the arduino uno, which was very convenient for testing purposed in the early stages of the realisation, the schematic of the RS485 shield can be found in appendix B. However, the RS485 shield together with the arduino uno are a relatively big component for the lamp as the idea was to put the whole circuit inside of the lampshade. To decrease the size of this component an arduino micro together with a LTC485, shown in figure 9, was used. There was only one big difference between these components and that was an extra inverter implemented in the RS485 shield to invert the signal towards the !RE and DE, which meant that to activate the LTC485 for sending commands a high signal had to be send instead of a low signal.

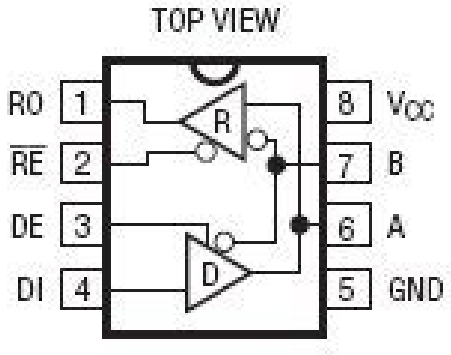


Figure 9: pinout of the LTC485

5.1.3 Pixy Cmu

The pixy cmu module, as shown in figure 10, is the only sensor implemented in the desk light, it is a camera that has color recognition software built into it. To recognise certain colors there is a possibility to manually “teach” the pixy cmu by holding a certain color in front of the camera and pressing the white button, pixy will set the shown color to a signature which it will recognise afterwards. To configure the pixy cmu module for the desk light 3 different colors where used, red, green and yellow, set to their own signatures respectively, 1, 2 and 3.

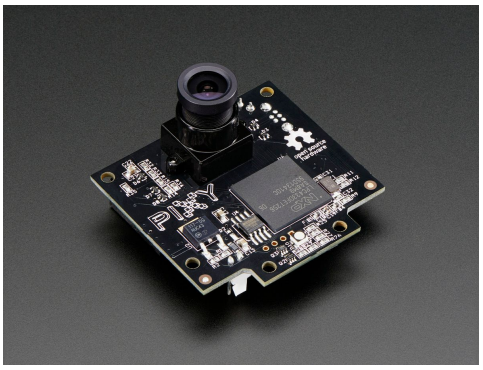


Figure 10: pixycmucam

5.1.4 Neopixel Ring

The Neopixel ring, shown in figure 11, provides our desk light with the lighting function a normal desk light has as well. The ring form of the neopixel ring allows the desk light to have the camera from the pixy cmu to be built within. Next to this the LEDs embedded in the neopixel ring can be controlled separately which opens up a wide variety of lighting options for the desk light.

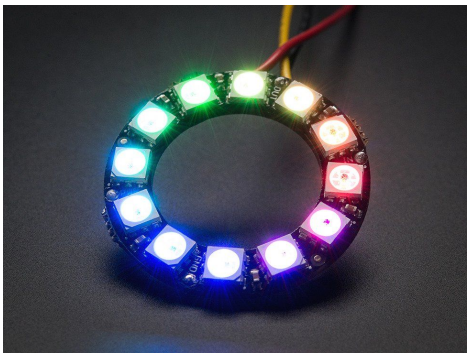


figure 11: adafruit neopixel ring

5.2 Software

In this paragraph the process behind the making of the code for pixy is elaborated. First of all the code that had to be made for pixy was split into different sections, the communication with the dynamixel motors, the camera, the movements and the lighting. For every section the code was constructed separately to be able to easily test and improve this code. When these loose section where all completed they would be combined together one by one, these different section will be elaborated in this paragraph. The complete and final version of the code is delivered with this report.

5.2.1 Controlling the dynamixel motors

The communication between the main controller, which is the arduino, and the dynamixels is done by sending and receiving packets. These packets can either be instruction packets which are send by the main controller to the dynamixels or they can be status packets which the dynamixels use to respond to the main controller as is shown in figure (12.1) and figure (12.2).

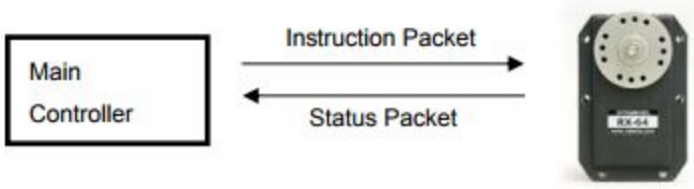


figure (12.1): communication with the dynamixels[12].

OXFF	0XFF	ID	LENGTH	INSTRUCTION	PARAMETER1	...	PARAMETER N	CHECK SUM

figure (12.2): instruction packet[12].

To test if the communication between the arduino and the dynamixels was working properly the instruction packet to turn on the LEDs on the dynamixels was constructed and send, since this is an easy packet to construct. First the connection between the main controller and the dynamixels had to be setup properly within the code which is done with the use of the library for arduino called “SoftwareSerial”. To set up this serial connection the following code has to be implemented.

```
#include <SoftwareSerial.h>

const byte rxPin = 2;
const byte txPin = 3;

SoftwareSerial mySerial(rxPin, txPin);
```

Next to this the serial connection must be set to the same baud rate in which the dynamixels are operating, The pin that is connected to the enable pins on the 485 chips in this case pin 9 has to be defined as an output.
The function that was used to turn on the LED was based on the code used by Edwin Dertien for his dmxmirror[13] and can be found in Appendix A.
After the connection was set properly, the function for the control of the position and velocity could be constructed based upon the function for the LED control and can be found within the whole code. However, some important notes have to be made regarding this function. First of all the difference between using the RS485 shield and the LTC485 is how the chip is enabled to accept a transmission from the arduino. With the LTC485 this is done by sending a HIGH to open the connection before sending the data and a LOW to close the connection when all of the data has been send. However, to do this with the RS485 shield the “”HIGH” and the “LOW” have to be swapped around since there is an inverter before the enable pin in the RS485 shield as can be seen in Appendix B.

5.2.2 Pixy CMU

To be able to make use of the information that the pixy camera provides a library for arduino has to be implemented. The latest version of the library can be found and downloaded from the

cmucam website; http://cmucam.org/projects/cmucam5/wiki/Latest_release. On this webpage it is also possible to download the program called pixymon which allows you to configure the camera with more advanced options. After the library is downloaded and installed it has to be initialized in the arduino code as shown in the examples that come with the library. When the library is initialized the data from the camera can be stored in a variable, the pixy library works with blocks which means that every object in the line of sight of the camera that is connected to a signature will be seen as a block as can be seen in figure 13. These blocks will then be stored in a variable where they can be accessed from.

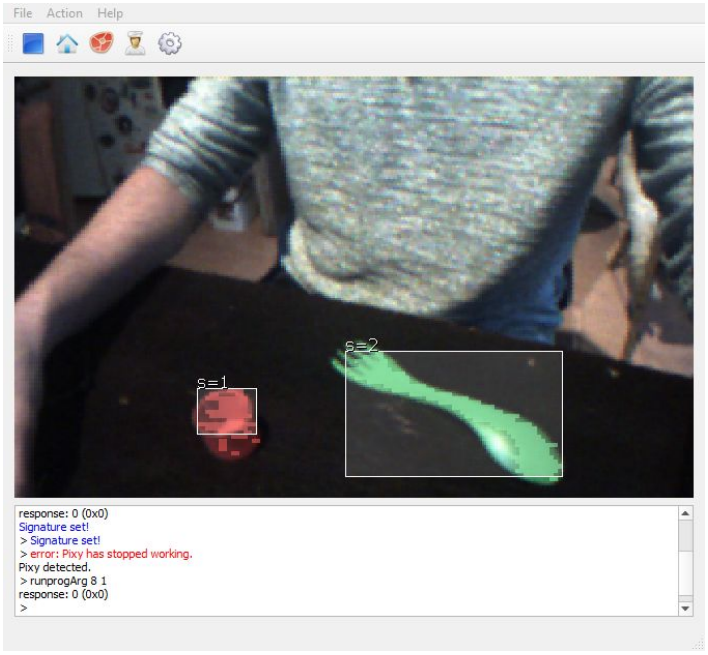


Figure 13: view of the camera as can be seen in PixyMon

The desk light reacts to the most interesting object which in this case is simply the biggest object as seen by the camera. It is noticed that just by just using the pixy.getBlocks() function the camera is often not accurate or completely misses an object. To prevent this from happening a for loop is used to create an interval in which the camera is searching before it continues with any other code, this improved the accuracy of the system significantly. Following this, when the system recognizes an interesting object it has to act accordingly to the signature of this interesting object.

5.2.3 Movement

The movement of the desk light is very important, since movement is a very powerful tool within the world of communication. For the desk light to interact with humans it has to be able to use movements to communicate. Most of the robots use a concept called inverse kinematics for their movements. The definition for inverse kinematics states that ‘in robotics, inverse kinematics makes use of the kinematics equations to determine the joint parameters that

provide a desired position for each of the robot's end-effectors. Specification of the movement of a robot so that its end-effectors achieve the desired tasks is known as motion planning[14].’ Since the desk light functions as a robot with joints this concept can be used to generate the position for every dynamixel motor. However, to be able to use this concept exact information of the xyz position of the most interesting object is needed. In figures 14.1 and 14.2 a drawing is shown which shows how inverse kinematics would have to be implemented for the desk light. The equations shown in equation 1 show how the angle of the two most important joints can be calculated.

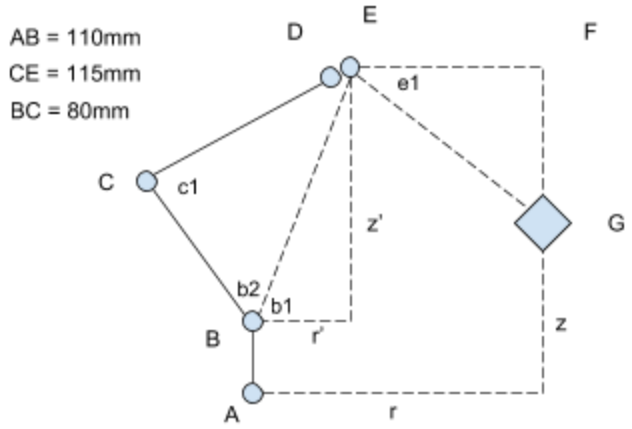


figure (14.1): side view joints desk light

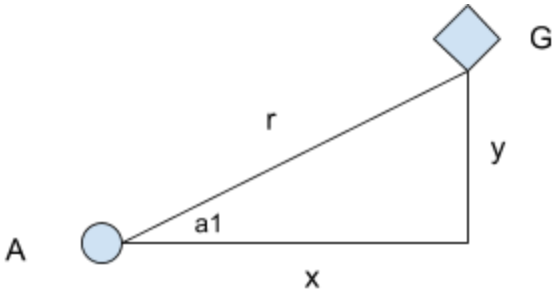


figure (14.2): top view joints desk light

$$r = \sqrt{x^2 + y^2}$$
$$r' = r - (sin(e1) * EG)$$
$$z' = z - AB + (cos(e1) * EG)$$
$$BE = \sqrt{z'^2 + r'^2}$$
$$b1 = acos(\frac{r'^2}{z'^2})$$
$$b2 = acos(\frac{BC^2+BE^2-CE^2}{2*BC*BE})$$
$$c1 = acos(\frac{BC^2+CE^2-BE^2}{2*BC*CE})$$

Equation 1

Because z and r are unknown an approximation of z’ and r’ was used to calculate the corners, this approximation was done by measuring z’ and r’ with known joint positions of the desk light. With the use of inverse kinematics one big downside of this system was unveiled, because the angle of the joints is calculated the outcome will always be the same which results in a very one sided robot. This is not desirable for the desk light since it is wanted that the desk light shows humanlike features in order to interact more effectively with its user.
The other way of controlling the movement of the desk light is by preprogramming different types of movements for every emotion. This allows for a more natural type of moving, but this

also lowers the accuracy of the movements since there are no calculations involved. Next to this, preprogrammed movements also have the advantage that it can be seen as a plug and play concept. This means that for every user a different set of movements can be used to maximize the effectiveness of the desk light.
The movements that the desk light is able to make will be addressed randomly which is done by generating a random number. This randomly generated number generates a certain action with the use of cases. The preprogrammed movements that are implemented in the prototype are as follows; follow objects, nod, shake, lean in, lean back, look down and look away. The code for all of these preprogrammed movements can be found within the complete code.

5.2.4 Neopixel ring

To control the neopixel ring with the arduino a library has to be installed called adafruit_neopixel, after installing the library it has to be initiated in the code. Base on the examples that come with the library a function was created which makes the neopixel ring pulsate, with the color of the object that it is interested in mirrored, in order to show that the desk light is processing newly gained information. One other function is used to generate the bored emotional state, while within this state the desk light will be searching for interesting objects. To show the user that the desk light is searching the lighting will make a circular motion using a rainbow color palette to mimic a loading animation.

5.3 Lampshade

For the desk light a custom lampshade had to be designed, this was done by first of all drawing some sketches of different sorts of shapes as shown in figure 15.

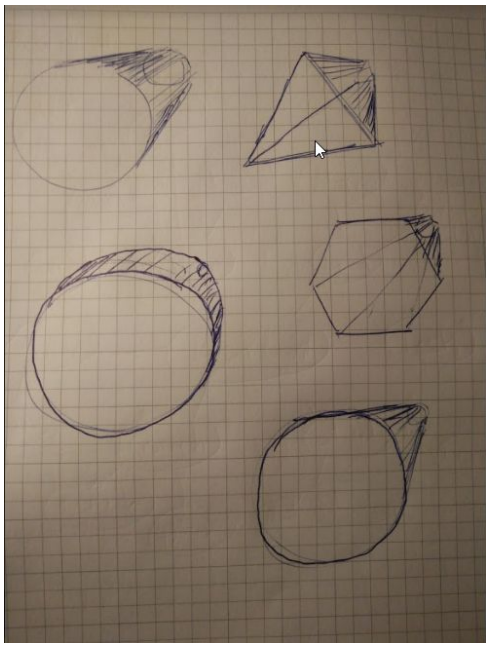


Figure 15: lampshade sketches

After making the sketches a 3d model had to be made to eventually 3d print the design. The program used for the 3d model is called FreeCAD. The final 3d model for the lampshade is shown in figure 16.1 and 16.2

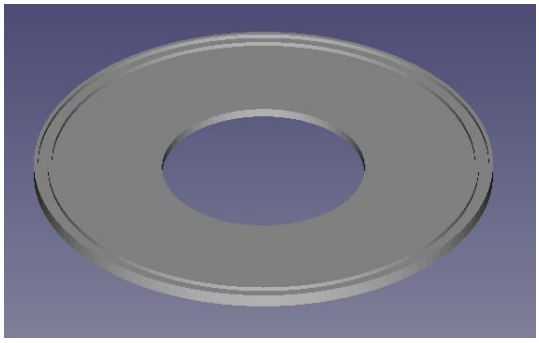


figure 16.1: lid of the lampshade

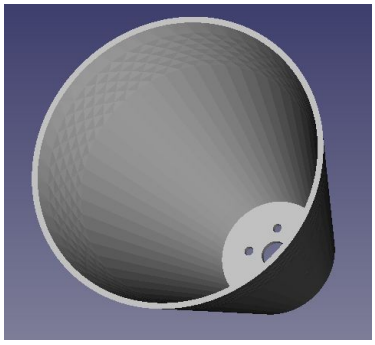


figure 16.2: body of the lampshade

In order to 3d print the model the final version had to be converted to a mesh which could then be used to 3d print with a program called Cura2.0 as can be seen in figure 17.

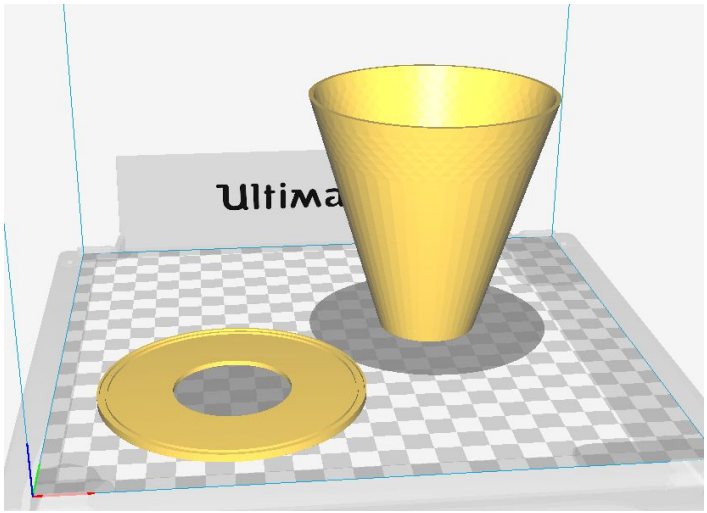


figure 17: 3d printing the lampshade

Chapter 6

Evaluation

Evaluation

For the purpose of this research the prototype of the desk light has to be evaluated, the goal of this evaluation is to find out if users of the desk light are able to interact with the desk light. This means that the users have to understand what the desk light is trying to communicate towards the users and next to this the users have to react accordingly for the desk light to have the desired effect. The prototype is very limited at the moment which means that for this evaluation the most important thing is to find out if the users are able to understand the actions of the desk light.

6.1 Test plan

To get the desired results from the evaluation a test plan was constructed. To have the user interact with all of the functions of the prototype objects with the colors red, green and yellow have to be used. For convenience purposes three pens were used, where every pen is colored red, green or yellow. The users make use of these pens consecutively where they write a small story with every pen. During this process the desk light will react to these colored objects.
After the writing task the user should have an idea of the functionality of the desk light, and will now answer specific question about the desk light that will evaluate on the test itself and next to that also the possibilities of the desk light. The whole user evaluation form can be found in appendix C.

6.2 Results

The questions asked after the test are divided into three different topics which are the overall experience that the user had, what they think of the functionality of the desk light and finally what they think off the future concepts for the desk light. In this section the main results of these topics are addressed.

6.2.1 Overall experience

Most of the users found the desk light interesting, and even started to play with the it a little. This shows that the interaction between the desk light and the users already comes rather naturally after the users note that the desk light reacts to their actions. The users feel comfortable with the desk light while interacting with it. The way that the desk light mirrors the color of the object it is interested is achieved positively in most of the evaluations. The movements however evoke different opinions among the tested people, some think that the movements should be like they are at the moment. Others believe that if the desk light would move in a smoother way it would feel better while interacting with it.
It was also interesting to see that the evaluated people did not really attach certain emotions towards the different colored objects. However, it was noted that the desk light would react different to the different pens.

6.2.2 Functionality

For the functionality of the desk light the tested people shared the opinion that in order to actually change someone's behavior a lot of improvements have to be made. However they did think that the prototype shows a lot of promise towards achieving this goal. One improvement that was suggested considered the accuracy of the movement of the desk light. This was mostly because the desk light would not always follow the most interesting object very well during the user evaluations.

6.2.3 Future concepts

The tested users were also asked what they thought about the future concepts for the desk light. These concept were overall well received by the users, they thought that these concept were very interesting. Some of the concepts are more realistically achievable than others but they would all be very useful.

Chapter 7

Conclusion

Conclusion

7.1 Conclusion

It can be concluded from this research that a robotic desk light could improve someone's working behavior. This can be done when proper feedback is giving with the use of emotions. The prototype of the desk light shows that a desk light that interacts differently towards different objects is interesting for the user who like to interact with it. However, to actually improve someone's working behavior a more advanced desk light has to be made which can be achieved in multiple ways, further research is required to show which concepts would work best for this purpose.

7.2 Future work

It should be noted that since the sample size of the tested people is not significant enough to give a final answer to the research question. However, this research does give an indication on the possibilities of the desk light. To further explore the possibilities of the desk light that will improve someone's working behavior, a bigger sample size of tested people has to be done first of all with this prototype.
Furthermore, the prototype should be build with the use of more advanced sensors that are able to achieve facial recognition, gaze tracking and posture tracking. These functions should allow the desk light to become aware of the working attitude of its users instead of just following the most interesting object which it does right now.
When the prototype has these functions implemented a more significant test can be held with a large sample size in order to draw further conclusions regarding the research question.

Chapter 8

References

References

[1]: K. Dautenhahn, “Socially intelligent robots: dimensions of human–robot interaction” 2007

[2]: T. Nakajima, V. Lehdonvirta, E. Tokunaga, H. Kimura, “Reflecting Human Behavior to Motivate Desirable Lifestyle” 2008

[3]: B. R. Duffy, “Anthropomorphism and the social robot” 2003

[4]: C. Breazeal, “Toward sociable robots” 2003

[5]: T. Fong, I Nourbakhsh, K Dautenhahn, “A survey of socially interactive robots” 2003

[6]: C. F. DiSalvo, F. Gemperle, J. Forlizzi, S. Kiesler, “All Robots Are Not Created Equal: The Design and Perception of Humanoid Robot Heads” 2002

[7]: A. Khalil S. Abdallah, “Harnessing social dynamics through persuasive technology to promote healthier lifestyle” 2013

[8]: J. Ham, R. H. Cuijpers, J. Cabibihan, “Combining Robotic Persuasive Strategies: The Persuasive Power of a Storytelling Robot that Uses Gazing and Gestures” 2015

[9]: N. Jafarinaimi, J. Forlizzi, A. Hurst, J. Zimmerman, “Breakaway: An Ambient Display Designed to Change Human Behavior” 2005

[10]: P. A. Hancock, D. R. Billings, and K. E. Schaefer, “A Meta-Analysis of Factors Affecting Trust in Human-Robot Interaction” Vol. 53, No. 5, October 2011, pp. 517-527

[11]: C. Nass, B. J. Fogg, Y. Moon, “Can computers be teammates?” 1996

[12] http://www.hizook.com/files/users/3/RX-64_Robotis_Dynamixel_Servo_UserGuide.pdf
[13] http://wiki.edwindertien.nl/doku.php?id=projects:dmxmirror
[14] https://en.wikipedia.org/wiki/Inverse_kinematics

Chapter 9

Appendix

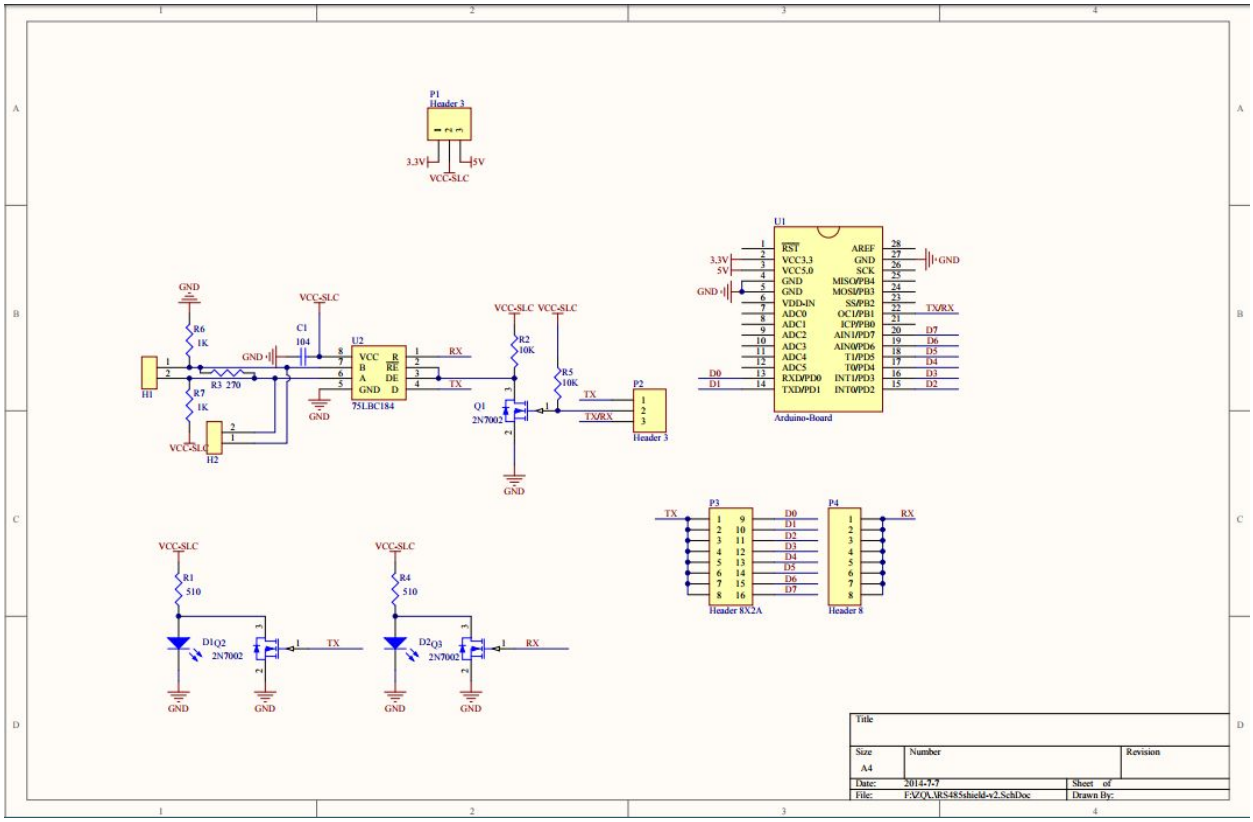
Appendix

Appendix A: Function to control the LED on the dynamixel

```
void controlLED(byte servoID, byte newValue)
{
  startAddress = 0X19;                // Turning on led
  unsigned int checksum_ACK;
  byte notchecksum;

  checksum_ACK =  servoID + 0x04 + 0x03 + startAddress + newValue;
  notchecksum = ~checksum_ACK;
  digitalWrite(9, HIGH);              // Notify 485 transciever to accept tx
  delay(50);                          // Allow this to take effect
  mySerial.write(byte(0xFF));         // start message
  mySerial.write(byte(0xFF));         // start message
  mySerial.write(byte(servoID));      // Id of the target motor
  mySerial.write(byte(0x04));         // Length of string
  mySerial.write(byte(0x03));         // Instruction; write
  mySerial.write(byte(startAddress)); // Start address for data to be written
  mySerial.write(byte(newValue));     // Parameter
  mySerial.write(byte(notchecksum));  // The notchecksum
  delay(100);                         // Allow last byte to go through
  digitalWrite(9, LOW);               // Disable 485 for tx
}
```

Appendix B: Schematic of the RS485 shield



Appendix C: User evaluation form

Describe your study in 50 words with the yellow pen!

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Describe a project you are currently working on in 50 words with the red pen!

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Describe your future dream job in 50 words with the green pen!

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……

Evaluation

Overall experience	
What is your overall experience with Pixy?	
Do you feel comfortable using Pixy, why?	
What do you think of the design of Pixy and how would you change this?	
What do you think of the movements Pixy makes?	
What do you think of the lights?	

Functionality	
Do you think Pixy can be used to change someone's behavior, why?	
Do you think Pixy can be used to change someone's working posture, why?	
How would you improve the functionality of Pixy?	

Future concepts	
What do you think of the idea that Pixy mirrors your posture?	
What do you think of the idea that Pixy mirrors your emotional state?	
What do you think of the idea that Pixy can see if you are focussed and react to that?	
What do you think of the idea that Pixy should notify you when to take a break?	
What do you think of the idea that Pixy should notify you when to start working again?	