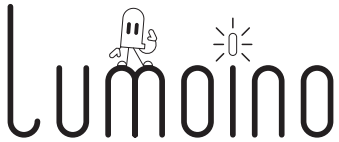


talking lights

Hi there!

You are holding the booklet to the toolkit “lumoino” in your hands. With the help of this booklet you are going to learn a bit about how machines can talk to one another through light. This is know as “Visible Light Communication”.

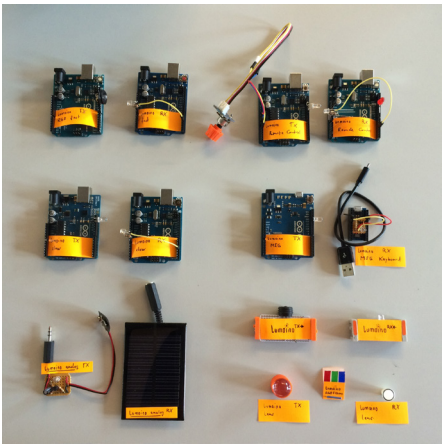
Lumu the LED will be your guide through these experiments. Together with friends, like foto and Arduino, you will conduct experiments and explore how Visible Light Communication works.

The experiments will help you to get a feel for this technology. You will learn about how machines talk to one another and how light as a communication medium works.

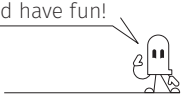
You will see curiosities and what properties this technology has. We won’t touch the nitty-gritty details of programming code, math or physics. That is for you to explore and find out. The examples in this booklet might give you a hint where you can start looking for such details.

To get started you will need an Arduino UNO board and the dedicated software to upload instruction to the Arduino boards. Download everything from arduino.cc.

Furthermore you need a library for Arduino which also contains the instruction to program the UNO board. Download the lumoino library from bit.do/lumoino.



Stay hungry, stay foolish and have fun!



lumu the LED

Listen to light

How to transmit music through a light stream

We are going to play around with this very simple technique and some electronics to see or actually hear how light can be used to transmit music!

You are going to use a simple circuit and a solar cell to make this happen. Have a look for the building instructions in the lumoino library from bit.do/lumoino.

What you need

- An audio player like your smart phone
- A pair of headphones or a stereo
- The lumoino emitter analog TX
- The lumoino receiver analog RX
- A 9V block battery

Plug the lumoino emitter TX and attach the 9V block battery. Plug it into your smart phone and play back a song of your choice.

Use the receiver RX with your headphones or stereo plugged in. Hold the cell over the LED light of the emitter.

Now you should hear your music!

EXPLORE & OBSERVE

Look at the LED. ***What do you see?***

Change the distance between the emitter and receiver. ***What do you hear?***

Try the listen to other light sources with the receiver. ***What do you hear?***

Try to listen to music and another light source at the same time. ***What do you hear?***

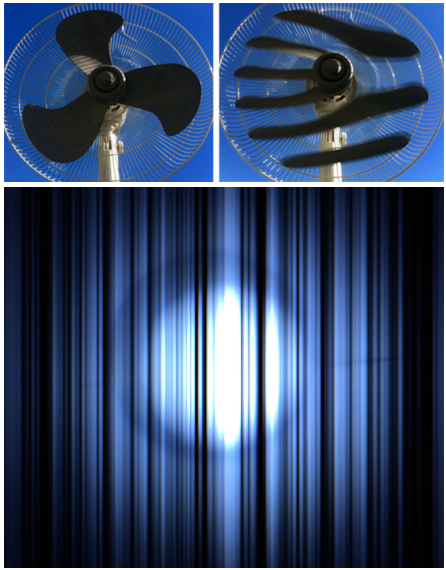
Look who's talking

Rolling shutter and light communication

To understand a bit better what happens between the emitter and receiver we are going to your smart phone camera.

If you take a picture of a fan you see all kinds of weird effects happening (see pictures). This happens because the camera "reads" the image to take line by line. This effect is called "rolling shutter effect".

With the help of this effect we can slow down the flickering of the light into something that humans can see.



Top left: global shutter / Top right and bottom: rolling shutter

What you need

- Two smart phone
- Any lumoino emitter TX (start with analog)
- A 9V block battery

Plug the lumoino emitter TX and attach the 9V block battery. Plug it into one of the smart phone and play back a song of your choice.

Use the other smart phone and open the camera app. Now look with camera straight into the LED light of the emitter TX.

Now you should see the flickering due to the rolling shutter!

EXPLORE & OBSERVE

Try the look at other light sources with your smart phone camera. ***What do you see?***

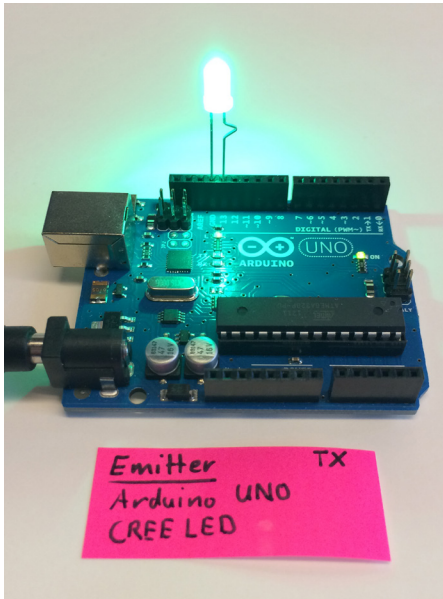
Try to look at several different light sources with different color and frequencies at the same time (This might work best if you try it out with the following experiments). ***What do you see?***

At the speed of light

How speed affects communication

Now we are going to look into how Visible Light Communication works. What does it mean to communicate through light? How does speed affect the communication? And how does it look like and what does this tell us about communication between machines?

For that you need to know how to use an Arduino UNO board. Don't worry, you just need to know how to upload a instructions onto an Arduino UNO Board. That's pretty easy! (More information @ arduino.cc)



What you need

- An LED of your choice
- An Arduino UNO board + USB cable
- The lumoino library (download @ bit.do/lumoino)
- A computer with the Arduino IDE installed

Upload the sketch “Number_VLC_TX” from the lumoino library to your Arduino UNO board.

Plug the LED into the pin number 13, Pay attention that the shorter leg of the LED is plugged in the pin called “GND” next to pin 13.

Now you have setup your first communicating LED device!

EXPLORE & OBSERVE

Change the transmission speed from “MAN_1200” to MAN_300” in the Arduino sketch. ***What do you see?***

Use the emitter analog RX and listen to your LED on different speeds. ***What do you hear?***

Use the rolling shutter technique and look at your LED at different speeds. ***What do you see?***

Try the sketch “RGB_LED_VLC_TX”.

Talking to each other

Communication between devices

Lets try to set up two Arduino talking to each other. For this to happen we need a photo diode. Let's try to get a message across to see what is possible!

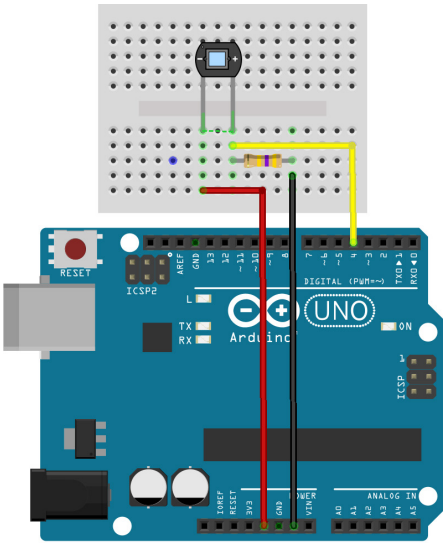
What you need

- Two LEDs of your choice
- A photo diode (SFH203)
- Resistor (470kΩ)
- Two Arduino UNO board + USB cables
- The lumoino library (download @ bit.do/lumoino)
- A computer with the Arduino IDE installed

Upload the sketch "Number_VLC_TX" from the lumoino library to one Arduino UNO board equipped with a LED as shown in the previous chapter. This is your Emitter.

Attach the photo diode and resistor as shown in the picture "receiver setup" to the other UNO board. Notice that the photo diode has a shorter leg? Connect this leg to pin "V5". Upload the sketch "Number_VLC_RX" to this board. This is your receiver.

Hold the LED on the emitter towards the photo diode. If you see the LED blinking on the receiver too your Arduino is talking through light with the other one!



Receiver setup

EXPLORE & OBSERVE

Try to increase the distance between the LED and the photo diode. ***How far can you go?***

Change the transmission speed from "MAN_1200" to different speeds in both Arduino sketches. ***How does this affect the communication and distance?***

Try to move the emitter around the receiver. ***How fast can you move?***

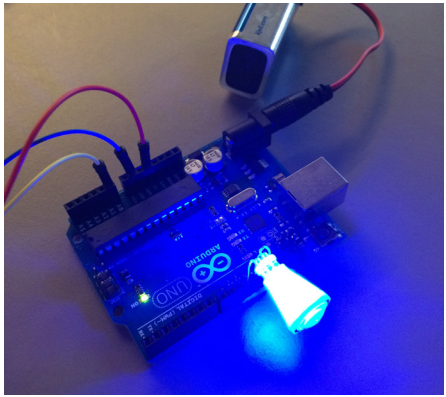
How to get further

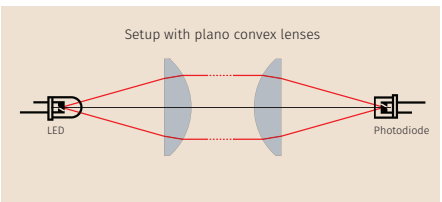
About color, lenses and reception

Let's play around with the light itself and see how we can affect the distance and other aspects of it.

With the lenses you can focus the light and therefore increase the distance between the LED and the photo diode.

With color filters you can "encode" a message. For example a red LED can not be seen through a green filter.





What you need

- Everything from “Talking to each other” (previous chapter)
- LEDs in different colors
- Two plano convex lenses (can be found in old digital cameras)
- Transparent Colored Polyester film in red, green and blue

Attach the lenses in front of the LED and the photo diode like in the picture to the left.

Under the same link where you downloaded the library are files for 3D printable parts for lenses. With these part it easy to attach the lenses to the LED and photo diode.

EXPLORE & OBSERVE

Try to increase the distance between the LED and the photo diode with the lenses. ***How far can you go and what changes?***

Use the color filters with different colored LED. ***How does this affect the communication?***

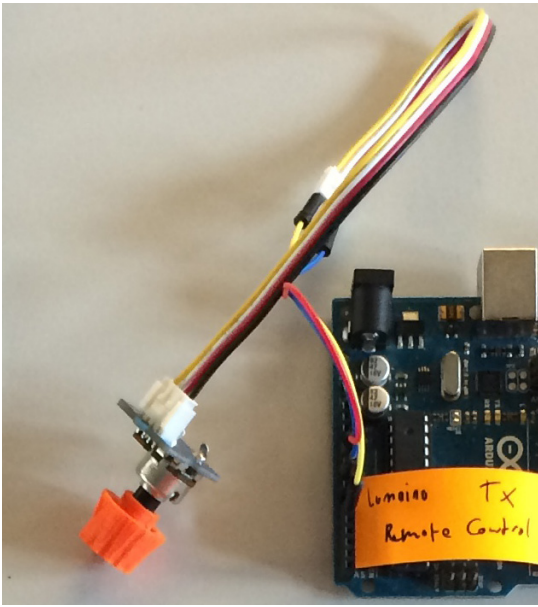
Remote Control!

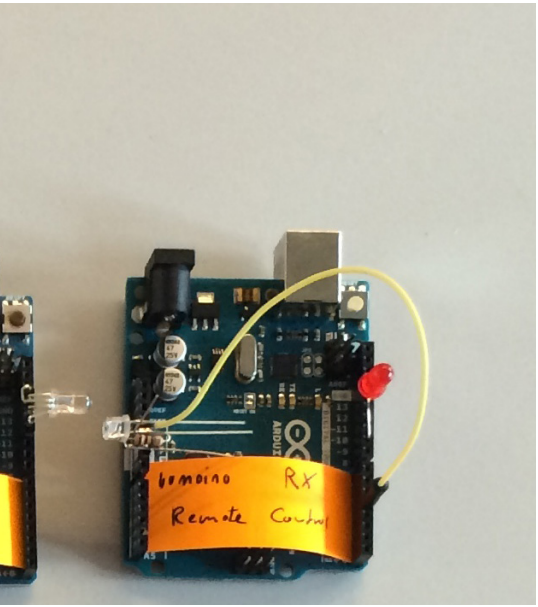
Control a servo or write on your laptop

Now we can try to remote control with the emitter Arduino what happens on the receiver Arduino.

From here on everything that is possible with Arduino can be applied.

Try to control a servo with an potentiometer or use an Arduino Leonardo to use as a keyboard and write a message with an emitter. Whatever comes to mind!





EXPLORE & OBSERVE

Try to think of applications for Visible Communication now that you learn what properties it has. ***What would you invent?***

Have a look at the other sketches in the library like “Hello_World” or “Remote_Control”. ***Have fun!***

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Lumoino

talking lights

download here: bit.do/lumoino