OpenAR v1.0

How To Build Your Own AR Glasses

To create your own AR glasses, you will need a way to reflect an image that brings new information to your field of view without blocking your real-world view. These instructions will tell how to build such a device using low-cost components.

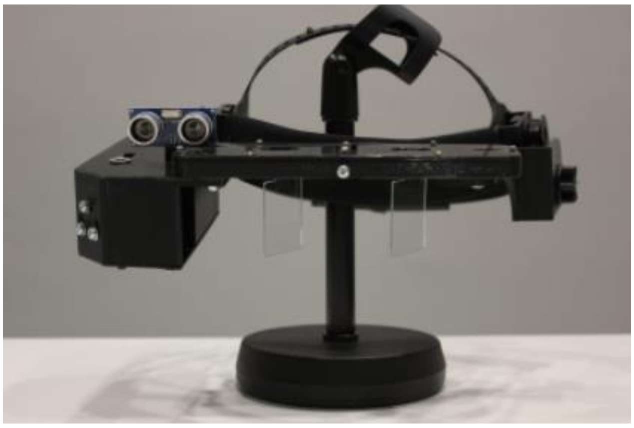

Figure 1. V1.0 AR glasses assembled.

The image comes from a small OLED display and goes through a lens. Light first reflects from a mirror and then partially reflects from glass plates into the viewer's eyes. This works much in the same way as a red dot sight, except that it is built for both eyes. The distance of the visible images is adjusted by changing the angle of the glass plates. A simplified principle of the device is shown in Figure 2. Find out more about how the image is transferred from display to the user's eyes: https://sites.uef.fi/openar/background-information/#Light-traveling

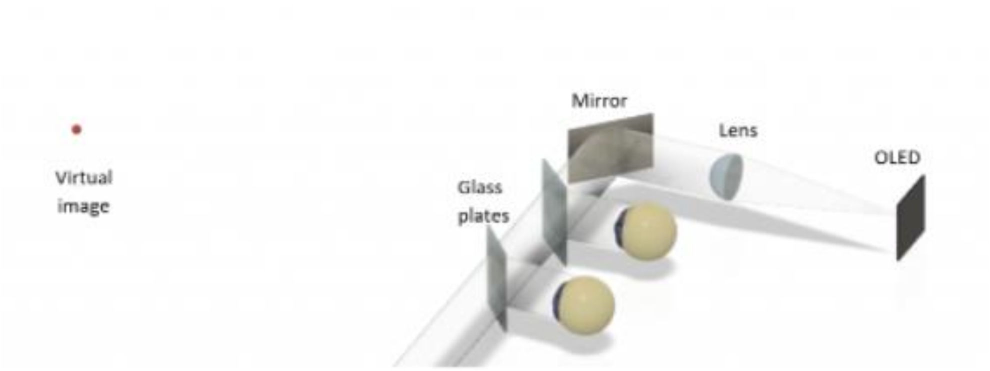

Figure 2. A simplified plan of Open AR glasses.

OpenAR glasses work by tricking the brain a bit. When looking at an object close to us, our eyes turn inwards; the closer the object is, the greater the angle. When we tilt the glass plates, our eyes adjust accordingly to focus on the reflected light. Our brain concludes the distance of the image by the amount of movement the eyes have to make. And our brain has no idea what we see; it is not really there. Find more about human 3D vision: https://sites.uef.fi/openar/background-information/#3Dvision.

Any random image is not augmented reality, however. Additional sensors could be useful to provide meaningful information for the user. OpenAR prototype glasses have an ultrasonic sensor to measure distances. Other sensors, Bluetooth, phone apps, etc., can be used in the device with appropriate changes.

Building It

1. The Needed Components

Here is a list of components and links to some shops where you can buy them.

Lens

3D printed plano-convex lens with focal length 100 mm and 25 mm diameter. Plano-convex means that the lens has one spherical surface and one flat surface. Plano-convex lenses are very suitable for collimating light. For example, you may find an equivalent lens from Thorlabs.

Mirror

An about 30 mm x 30 mm first surface mirror. A first surface mirror is a mirror with the reflecting surface on the first layer. If a reasonably priced first surface mirror is not available, use a regular mirror. Also, Thorlabs sells First surface mirrors.

Reflecting surfaces

Clear glass or plastic plates. For example, a microscope slide halves of size about 26 mm x 38 mm x 1 mm. Nearly any transparent plane plate big enough to cover your eyes will do the trick; however, the amount of light reflected varies with different materials.

Headset

3D print the included parts and assembly them as instructed. You may attach the parts to a headband, for example, from a helmet. If you don't have access to a 3D printer, check if there is a library near you where it is possible to make 3D prints.

OLED display

A 0.96" 128×64 Joy-IT OLED SBC-OLED01 with an SSD1306 controller.

Ultrasonic sensor

Ultrasonic distance sensor PCB 5V HC-SR04.

Arduino Nano microcontroller

Jumper wires, female

Small parts

2.0×6 screws, 2.0×5, bolts M3x8-15, nuts M3, washers M3, hand tap M3, drill bit 2.5 mm, glue, sandpaper, etc.

Mini-B USB cable and a small USB power bank

2. Program Arduino Nano

Arduino IDE is needed for the programming of the Arduino Nano. Readymade codes can be found from https://github.com/Open-Source-Community-for-AR/OpenAR-software. Codes for Arduino Nano can be pasted to Arduino IDE and sent to the Arduino. Instructions for using Arduino IDE can be found here https://sites.uef.fi/openar/background-information/#ArduinoIDE.

There are also plenty of tutorials and ready built programs for Arduino on the internet. If you just want to try how to get an image on OpenAR-glasses, you can find some examples from Random Nerd Tutorials (https://randomnerdtutorials.com/guide-for-oled-display-with-arduino/).

3. Connect the Ultrasonic Sensor and the Display to Arduino

Once the program has been uploaded to the Arduino, you can connect the display and the ultrasonic sensor to Arduino with female jumper wires. The connected components are shown in figure 3.

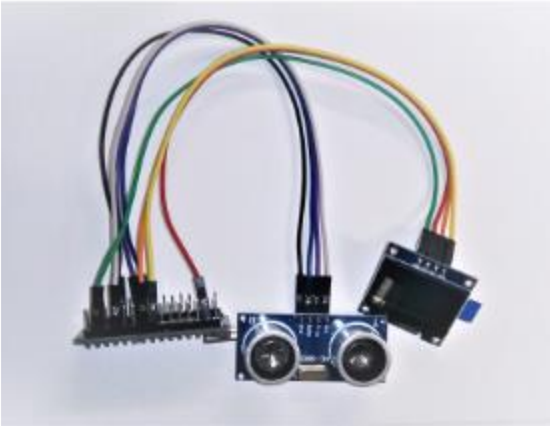

Figure 3. Arduino, Ultrasonic sensor and OLED display wired.

OLED display to Arduino Nano:

SDA to A4

SCL to A5

VCC to 3V3

GND to GND

Ultrasonic sensor to Arduino Nano:

VCC to 5V

Trig to D3

Echo to D4

Gnd to GND

The schematic is shown in figure 4.

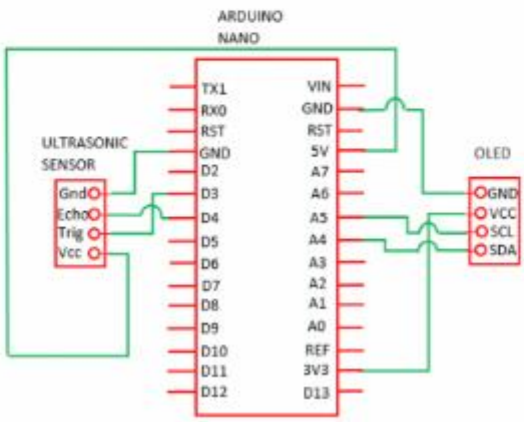

Figure 4. Schematic of Arduino Nano, Ultrasonic sensor and OLED display.

4. Testing the electronics

Everything should be ready for The Arduino Nano to be connected to the power bank. The distances measured by the ultrasonic sensor should show on the OLED display screen after powering up the Arduino.

Calibrate the ultrasonic sensor by placing it 1 meter from a wall. If the displayed measurement is incorrect, you will have to adjust the conversion factor k in your Arduino Nano program in the "My variables" section. One easy way to do this is to reprogram your Arduino by setting the conversion factor to k = 1000.0. If, for example, the display then gives a reading of 1.18 m, the conversion factor should be adjusted to k = 1180.0. Upload the updated program to your Arduino, and it should now give you the correct distance.

```
// My variables ------------------------------

float dis;          // distance
int t;              // time, counter value
int echo=4;           // sensor's Echo to pin D4
int trig=3;           // sensor's Trig to pin D3
float k=1180.0;           // conversion factor from time to distance, must be calibrated
```

Figure 5. My variable section of Arduino Nano program.

5. Build the Headset

The main things when building your headset:

First and foremost, the display, the lens, the mirror, and the glass plates should be all on the same optical axis. This means that the centre of the display, the centre of the lens, the centre of the mirror and the centre of both glass plates should be in a straight line, as illustrated in figure 6..

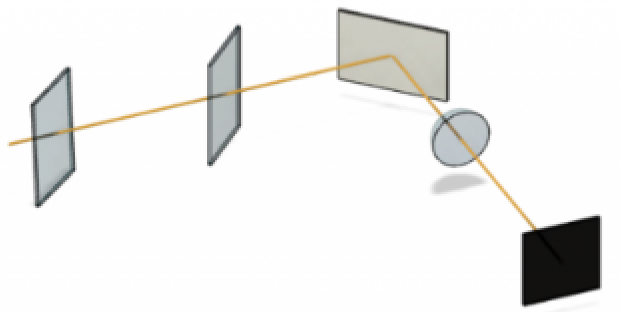

Figure 6. The Placement of the optical components on the same optical axis.

The distance between the display and the lens must be the same as the lens's focal length. Some way to adjust the distance between these components is useful. Also, it is good to have a mechanism for adjusting the mirror's tilt.

The distance between the display and the lens must be the same as the lens's focal length. Some way to adjust the distance between these components is useful. Also, three different kinds of glass plate adjustments are needed.

First, you need to be able to set the distance between the glass plates according to the distance between your pupils so that you can see at least some reflection with your left and right eye.

Second, the glass plates have turned at an angle that your brain can combine the images from the left and right eye together as one image.

Third, a fine-tuning for rotation for setting the position of the visible image. Note that when the left glass plate rotates clockwise, the right must rotate counterclockwise and vice versa.

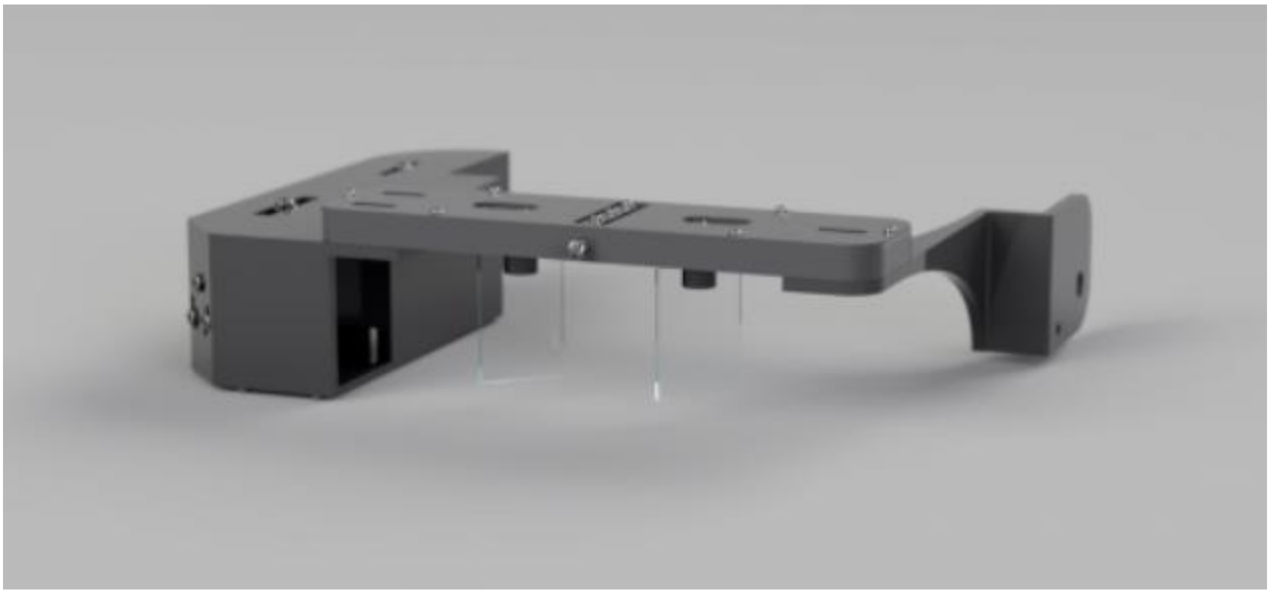

Figure 7. An assembled headset prototype. It is designed and drawn with Fusion 360 program. It is modified to g-code with Ultimaker Cura 4.7 and printed with Ultimaker 3 using black Ultimaker PLA filament. With this design, you can adjust the apparent distance of the image by rotating the screw on the front.

Then, of course, a structure to attach the whole system firmly around the user's head, for example, a helmet headband.