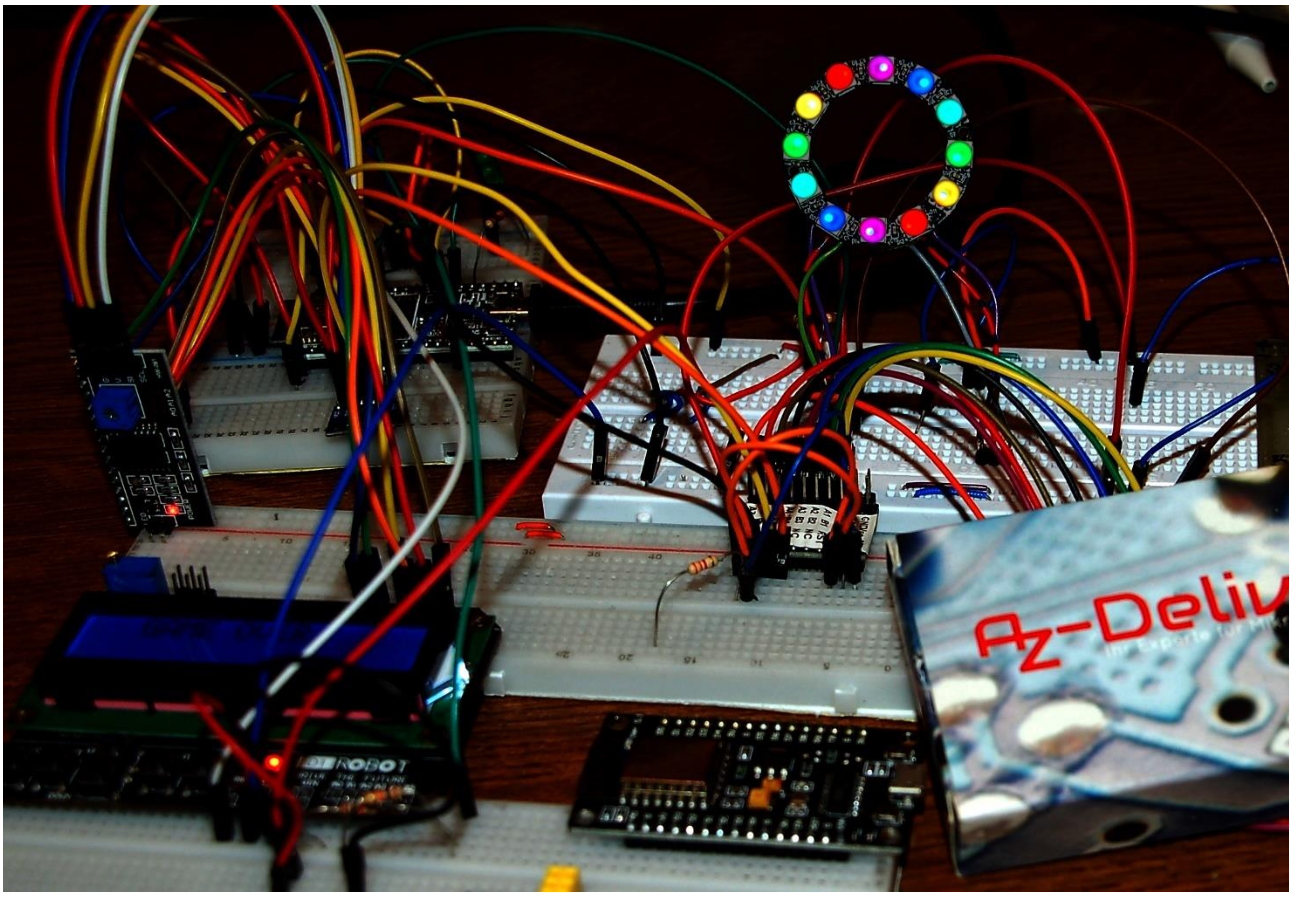


Diesen Beitrag gibt es auch als:
PDF in deutsch

This episode is also available as:
PDF in english

In this post, I'll introduce a game that involves guessing colors. The aim is to guess the four colors with as few passes as possible. Strategy is required. The use of hardware is very similar to that in the blogs about the use of GPS, SMS and telephony with the ESP32. However, this time the topic of wireless connections is completely absent. No sensors are needed either. Be curious. So welcome to the introduction of the game

Ring Master 1 –
Games with the ESP32 in MicroPython

The LCD keypad from other blog episodes is used again, as are the buttons and the display. The RST button again fulfills the function of an emergency brake. As an alternative to the LCD keypad, I will present an OLED display in the second episode, because a few potential lines of text do no harm when evaluating the game results. Of course, a different keyboard is also required.

The game is controlled in this sequence using the five buttons on the LDC keypad. UP and DOWN scroll through the list of six LED colors, while LEFT and RIGHT move to one of the four LED positions. I like to use the RST button as an emergency brake during development.

Using the emergency brake means terminating the current program precisely without restarting it immediately. The name "reset button" is therefore rather misleading and only applies if you use the keypad shield in the arduino's orbit, where it belongs natively.

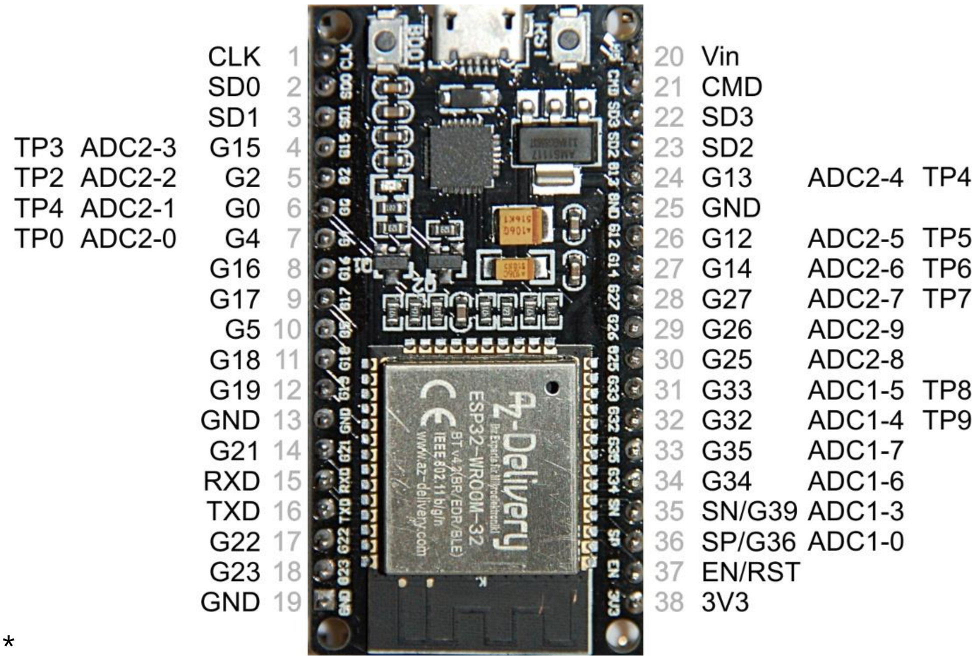
All objects, variable contents and function definitions created up to the point of cancellation are retained for manual access via REPL, the MicroPython command line. In this way, for example, functions and program parts can be tested without having to re-enter a whole series of imports and declarations, etc. each time. The fact that such tests can be carried out easily via the REPL command line is a decisive advantage of the MicroPython environment.

Hardware

A MicroPython program is created for "Ring Master". That means we need a MicroPython-capable controller. The choice fell on an ESP32, because no large screen like the Raspi, but only an LCD should be controlled. The ESP8266-12F is not available due to insufficient RAM memory, it lacks a good 1200 bytes. As already mentioned, we are satisfied with the five keys on the LCD keypad for the time being. The display is operated via an I2C parallel adapter, which also adjusts the level from 3.3V on the ESP32 to 5V on the LCD keypad. There is a built-in module in the MicroPython firmware for the neopixel ring, which makes programming child's play. A few comments on the function of the ring follow below. Its current consumption is around 20mA.

1	ESP32 NodeMCU Module WLAN WiFi Development Board mit CP2102 oder ähnlich
1	LCD1602 Display Keypad Shield HD44780 1602 Modul mit 2x16 Zeichen
1	I2C IIC Adapter serielle Schnittstelle für LCD Display 1602 und 2004
4	Widerstand 10kΩ
1	Battery Expansion Shield 18650 V3 inkl. USB Kabel
1	Li-Akku Typ 18650
1	LED Ring 5V RGB WS2812B 12-Bit 37mm oder ähnlich

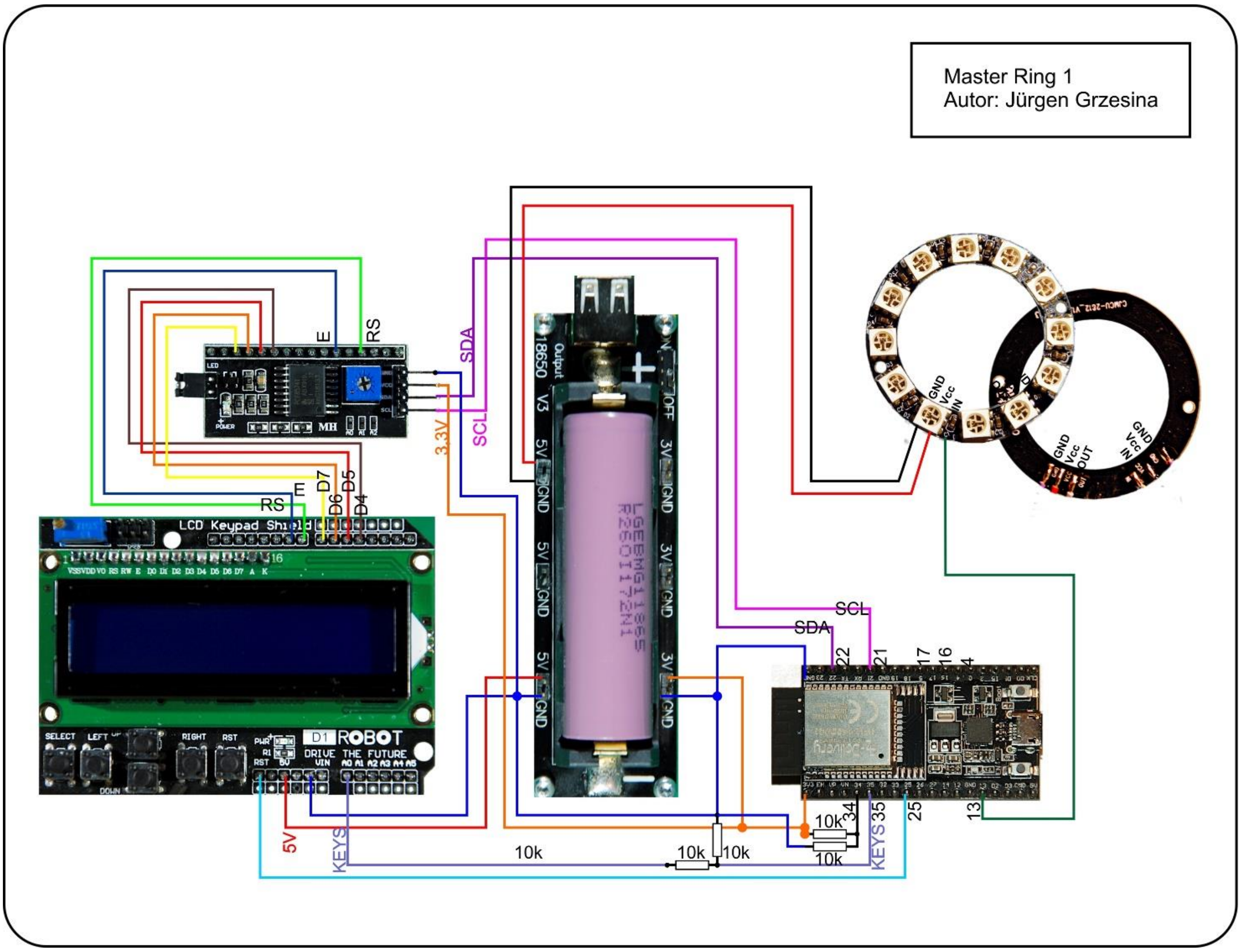
The circuit for "Ring Master 1" is largely taken from the fifth episode of the GPS blog. If you want to use a 5V power supply instead of the battery holder and the Li battery, you have to connect the 5V to pin 20, Vin, of the ESP32. The 3.3V pin of the ESP32 then supplies the I2C parallel converter.



*

The supply from a 4.5V block of alkaline cells would be sufficient for the controller board, but the display is not satisfied with that. An extra 5V regulator must be used for supply voltages above 5V, because the neopixel ring must not receive more than 5.3V. Old PC power supplies are very suitable for experimenting because they provide 3.3V and 12V in addition to 5V.

The following figure shows the circuit diagram. A more readable copy in A4 can be downloaded as a PDF file.



12 Neopixel LEDs of type WS2812B are installed on the LED ring. Power is supplied in parallel. The data line runs serially from one LED unit to the next and represents a special type of bus. Each unit contains an RGB LED and a controller that reacts to the first incoming 24-bit sequence of color information. The signals are generated by a microcontroller such as the ESP32. 24 bits are generated for each neopixel unit (8 each for green, red and blue). The duration for one bit is 1.25µs +/- 0.150µs, the transmission frequency is thus approx. 800kHz. For a 1 the line is 0.8µs on HIGH and 0.45µs on LOW, a 0 is coded with 0.4µs HIGH and 0.85µs LOW. The first incoming 24 bits are processed by each WS2812B unit, all following bits are amplified and passed on to the next unit. The signal sequence from the microcontroller is therefore 24 bits shorter from LED to LED. In contrast to a conventional data bus, the WS2812B units do not receive the data at the same time, but with a time delay of 24 bits times 1.25 µs / bit = 30 µs.

A frame buffer in the RAM of the ESP32 temporarily stores the color values (3 x 256 = 16.7 million), and the NeoPixel.write () command sends the information over the "bus" that is attached to a GPIO output (in our case GPIO13). Several rings can be cascaded just like individual LEDs by connecting the input of the next ring to the output of the previous one. The connections are made at the rear, preferably using thin strands. To protect the eyes, I use a maximum brightness level of 32. The total current consumption of the ring is less than 20mA on average. The easiest way to determine the components for the mixed colors is by experiment using REPL. The brightness of the individual partial LEDs is quite different. The color codes in the tuples will therefore rarely have the same value.

```
>>> from neopixel import NeoPixel
>>> neoPin=Pin(13)
>>> neoCnt=12
>>> np=NeoPixel(neoPin,neoCnt)
```
>>> np[0]=(32,16,0)
>>> np.write()

For comparison, the last two commands are repeated with a different RGB code. The values given here produce "yellow".

At full luminosity, the LED units suck 50mA each, which requires a good constant voltage source and cooling of the ring.

Die Software

Verwendete Software:
Fürs Flashen und die Programmierung des ESP32:
Thonny oder
µPyCraft

Verwendete Firmware:
MicropythonFirmware
Bitte eine Stable-Version aussuchen

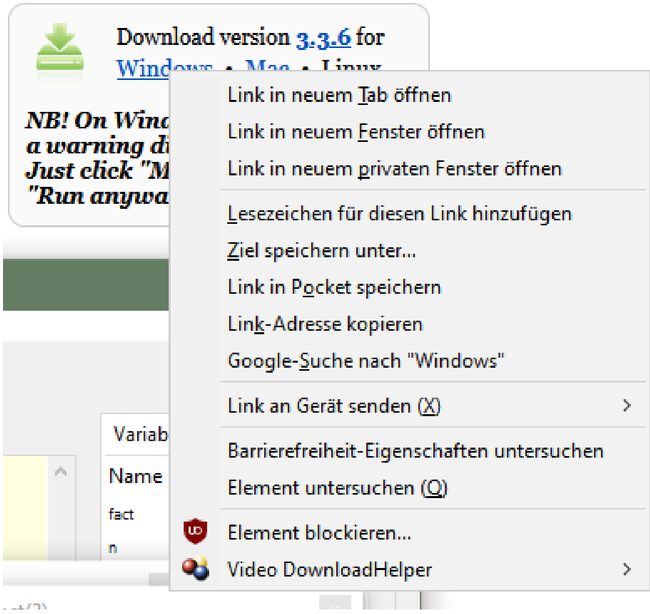
MicroPython-Module und Programme
LCD-Standard-Modul
HD44780U-I2C-Erweiterung zum LCD-Modul
keypad.py Modul für Tastenfeld-Unterstützung

[mcp.py](mcp.py) Modul für Porterweiterungsbaustein MCP23017
ringmaster1.py Hauptprogramm

The development environment - example: Thonny

Thonny ist unter MicroPython das Gegenstück zur Arduino-IDE. In Thonny sind ein Programmeditor und ein Terminal sowie weitere interessante Entwicklungstools in einer Oberfläche vereint. So haben sie das Arbeitsverzeichnis auf dem PC, das Dateisystem auf dem ESP32, Ihre Programme im Editor, die Terminalconsole und zum Beispiel den Object inspector in einem Fenster übersichtlich im Zugriff.

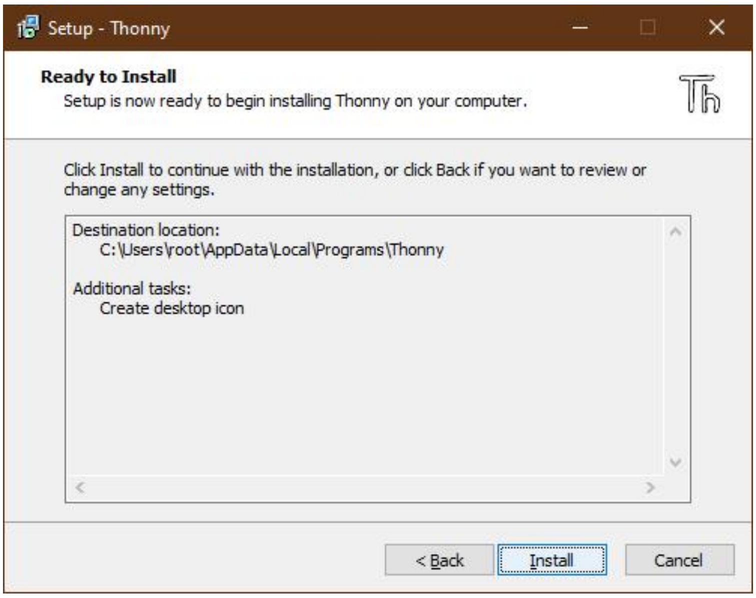
The resource for Thonny is the file thonny-3.3.x.exe, the latest version of which can be downloaded directly from the product page. There you can also get an initial overview of the features of the program.



Right-click on Windows and save target as to download the file to any directory of your choice. Alternatively, you can also follow this direct link.
In addition to the IDE itself, the Thonny bundle also includes Python 3.7 for Windows and esptool.py. Python 3.7 (or higher) is the basis for Thonny and esptool.py. Both programs are written in Python and therefore require the Python runtime environment. esptool.py also serves as a tool in the Arduino IDE to transfer software to the ESP32 (and other controllers).

Now start the installation of Thonny by double-clicking on your downloaded file, if you only want to use the software for yourself. If Thonny & Co. is to be available to all users on your computer, you have to run the exe file as administrator. In this case, right click on the file entry in Explorer and select Run as administrator.

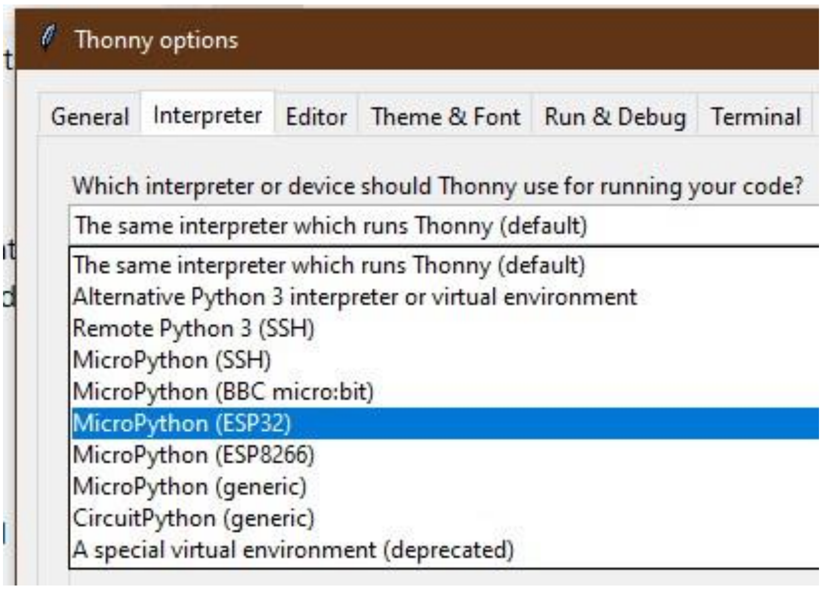
Most likely, Windows Defender (or your antivirus software) will answer you. Click on more information and, in the window that opens, click on Run anyway. Now just follow the user guidance with Next



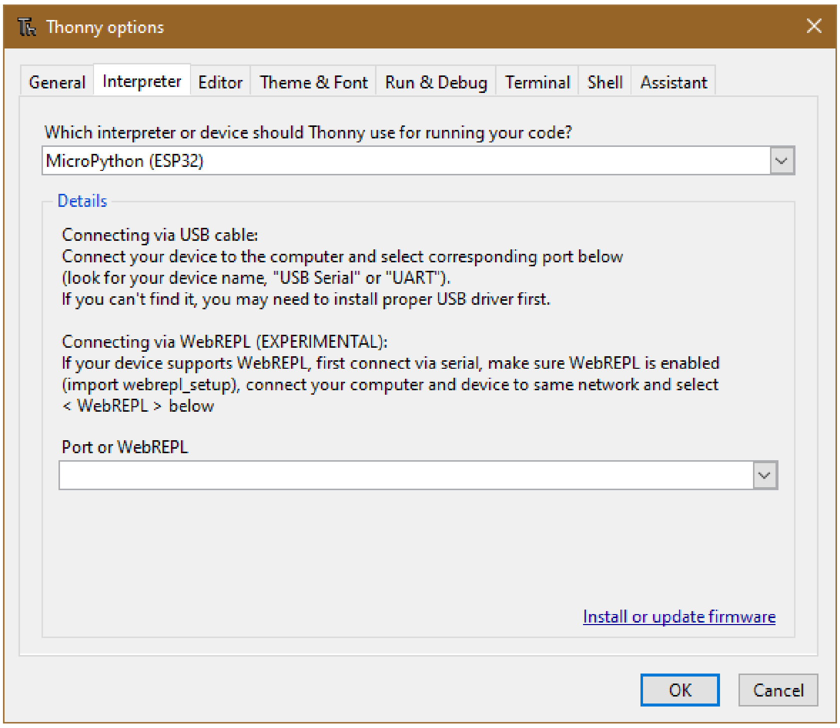
Click on Install to start the installation process.

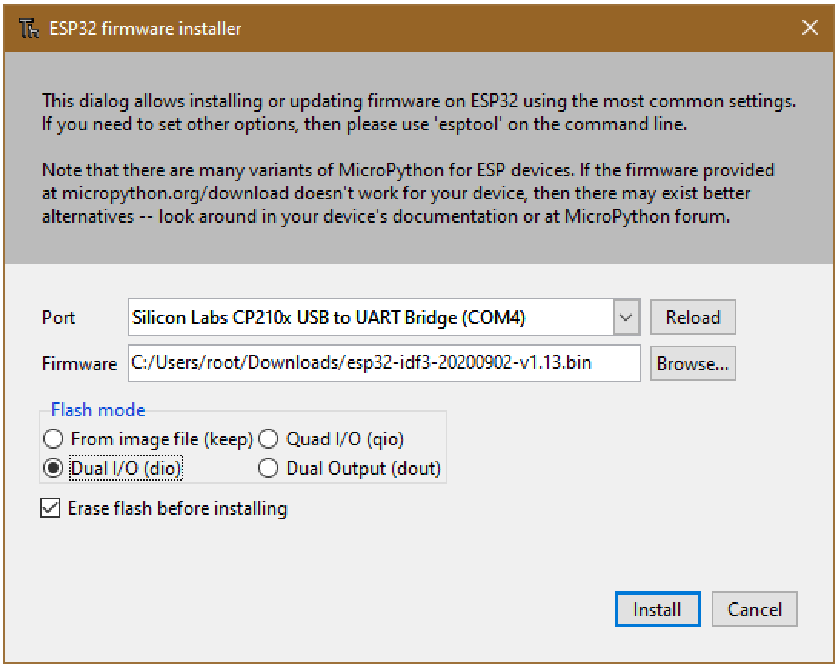
When you start the program for the first time, you specify the language, then the editor window is displayed together with the terminal area.

As the first action set the type of controller used. With Run - Select Interpreter… you land in the options. For this project, please set Micropython (ESP32).



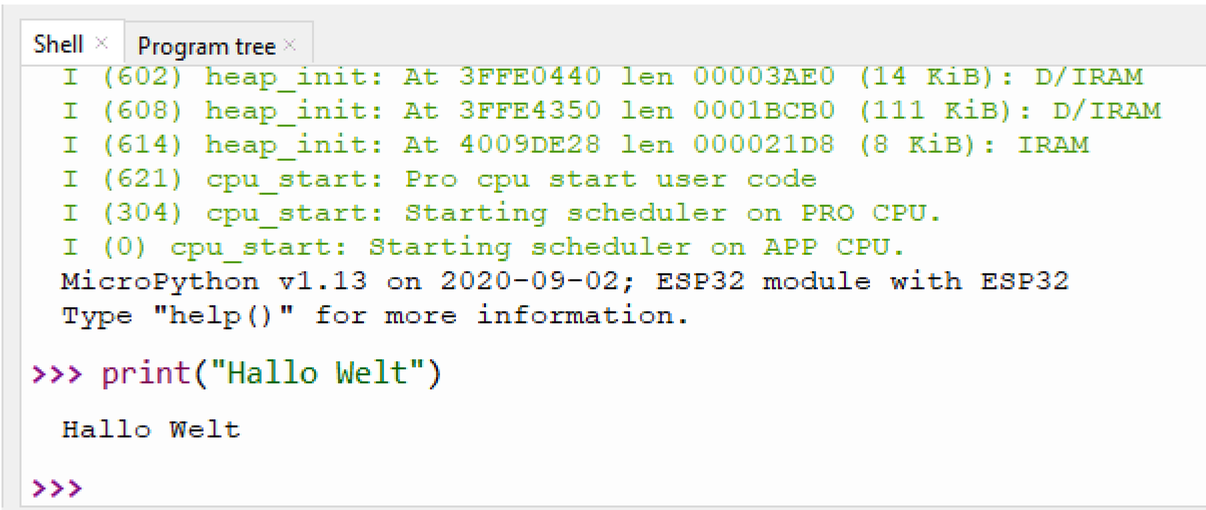
Now download the Micropython firmware for the ESP32 from the selection page and save this file in a directory of your choice. The bin file must first be transferred to the ESP32. This also happens to Thonny. Call up Thonny Options again with Run - Select Interpreter…. At the bottom right click on Install or update Firmware.





Select the serial port to the ESP32 and the downloaded firmware file. Start the process with Install. After a short time, the MicroPython firmware is on the controller and you can send the first commands to the controller via REPL, the MicroPython command line. For example, enter the following command in the Terminal window.

print("Hallo Welt")



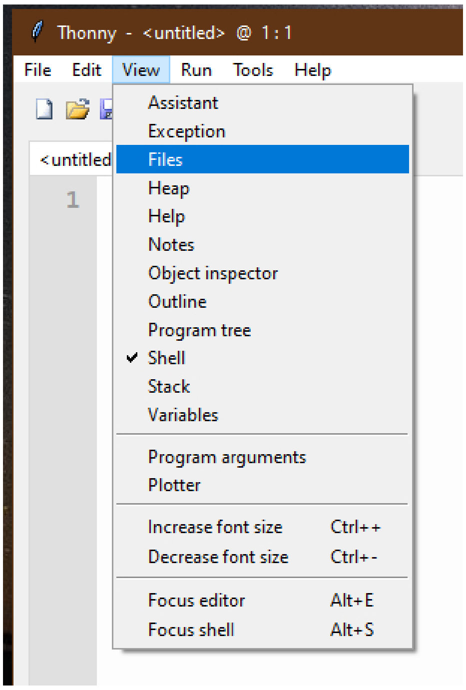
Unlike in the Arduino IDE, you can send individual commands to the ESP32 and, if it is MicroPython instructions, it will respond well. On the other hand, if you send a text that is incomprehensible to the MicroPython interpreter, it will alert you to this with an error message.

>>> print"hallo nochmal"

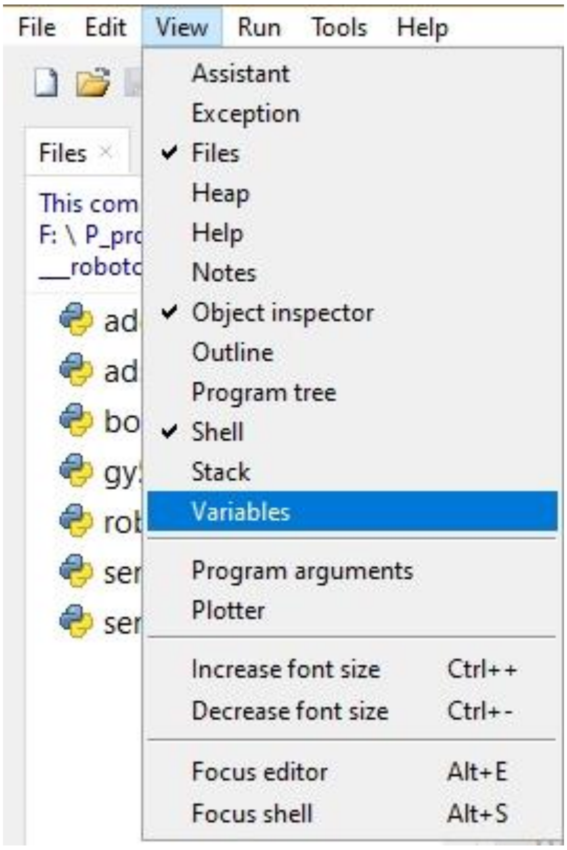
SyntaxError: invalid syntax
Traceback (most recent call last):
  File "<stdin>", line 1
SyntaxError: invalid syntax

To work, however, the overview of the workspace and the device directory is still missing. The workspace is a directory on the PC in which all files that are important for a project are located. In Thonny his name is This Computer. The device directory is the counterpart on the ESP32. In Thonny it is called MicroPython device. You can display it as follows.

Click on View and then click on Files



Both areas are now displayed, the workspace at the top and the device directory at the bottom. You can display additional tools via the View menu.

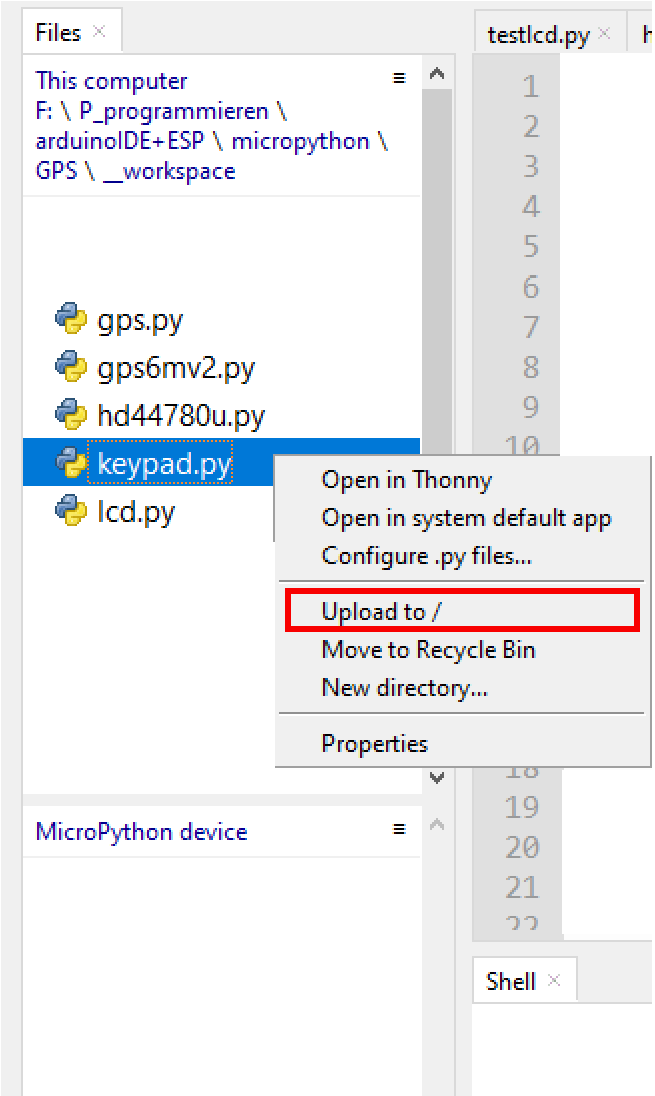


We enter our programs in the editor area. For a new program, open an editor window by clicking the New button or by pressing the key sequence Ctrl + N.

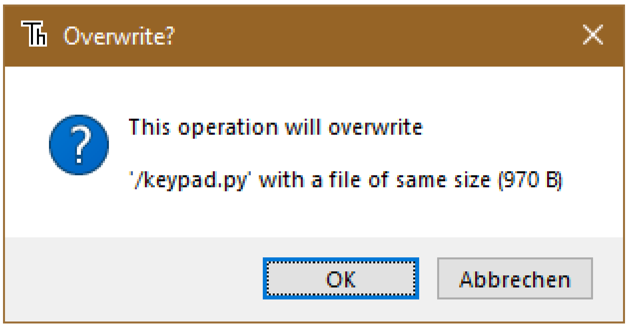
In the Arduino IDE, libraries are recompiled every time the program is compiled and integrated into the program text. In MicroPython you only have to upload finished modules, they correspond to the libraries of the Arduino IDE, to the flash of the ESP32 at the beginning. I will show this with an example.

Create a project folder on your computer in any directory in Explorer. In this directory you create a folder with the name workspace. All further actions start in this directory and all programs and program parts will live there.

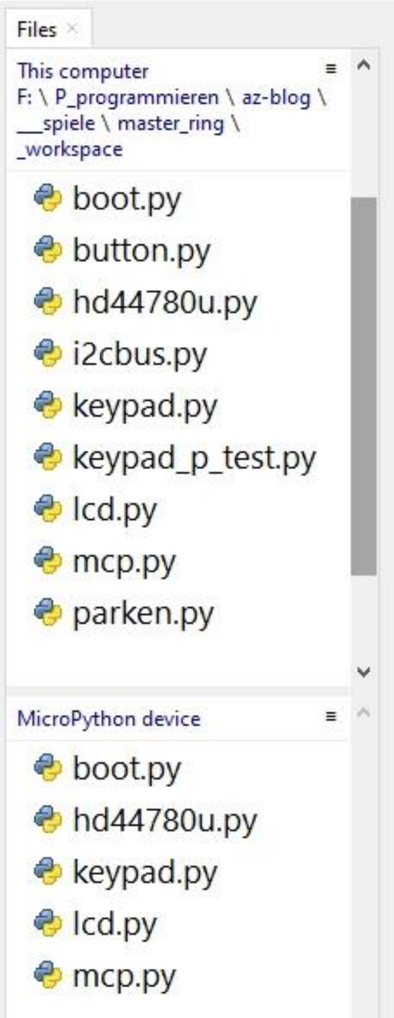
The KEYPAD class is required in the project. The text for this is in the keypad.py file. The best thing to do is to load all modules into your workspace right away. If you have not already done so, start Thonny and navigate to your working directory in the "This Computer" window. The downloaded files should now appear in the workspace. A right click opens the context menu and the process is started by clicking on Upload to /.



If you have changed something on a module, it must be uploaded again, but only this one. Then answer the security question about overwriting with OK.



After uploading the first 4 modules it looks like this. The boot.py file in the device directory is automatically created when the firmware is flashed. At the end, when everything has been tested, we will copy the content of our program into this file. The ESP32 will then run the program autonomously each time it is started. A connection to the PC is then no longer necessary.



Tricks and Infos on MicroPython

MicroPython is an interpreter language. The main difference to the Arduino IDE, where you always and exclusively flash entire programs, is that you only have to flash the MicroPython firmware once at the beginning on the ESP32 before the controller understands MicroPython instructions. You can use Thonny, µPyCraft or esptool.py for this. For Thonny I have described the process above.

As soon as the firmware is flashed, you can have a casual conversation with your controller, test individual commands and immediately see the answer without first having to compile and transfer an entire program. This is exactly what bothers me about the Arduino IDE. You simply save an enormous amount of time if you can do simple tests of the syntax and hardware through to trying out and refining functions and entire program parts via the command line before you knit a program out of it. For this purpose I also like to create small test programs over and over again. As a kind of macro, they combine recurring commands. From such program fragments, entire applications can develop. If the program is to start autonomously when the controller is switched on, copy the program text into a newly created blank file. Save this file under boot.py in the workspace and upload it to the ESP32 / ESP8266-01. The program starts automatically the next time it is reset or switched on.

Programs are started manually from the current editor window in the Thonny IDE using the F5 key. This is faster than clicking the start button or using the Run menu. Only the modules used in the program must be in the flash of the ESP32.

If you later want to use the controller together with the Arduino IDE again, simply flash the program in the usual way. However, the ESP32 / ESP8266 then forgot that it ever spoke MicroPython. Conversely, any Espressif chip that contains a compiled program from the Arduino IDE or the AT firmware or LUA can easily be provided with the MicroPython firmware. The process is always as described above.

Before we start programming the game, I'll briefly introduce you to a few important MicroPython structures and commands that I used in the program.

Data fields
In addition to the simple data types such as integers and floating point numbers, strings (aka character strings) and the Boolean values True and False as well as the exotic none, we encounter lists, dicts (dictionaries aka hash arrays) and tuples in the program. Lists replace the arrays you may know from the Arduino IDE. Both types belong to the iterable objects. That means you can edit them with the help of loops. We do this at various points in the program.

So-called slicing allows subsets of lists and strings to be extracted. The ":" is used for this purpose. Individual elements of a list are addressed by their index. This is the place number in the list or the key term in a dict. The following structures appear in our program. The following statement defines a list. Unlike in the Arduino IDE, data of different types can be combined in a list or a dict.

List = [34, "Test", 3.1415, [4,5,6]]
Indexing: Addressing individual elements
List [2] returns 3.1415, because indexing starts with 0, not with 1

Slicing: Cut out a part of the list
List [1: 3] returns ["Test", 3.1415], because the 3 limits the range, but is always left out.
List [: 2] returns [34, "Test"], because the index 0 does not have to be specified.
List [2:] delivers [3.1415, [4,5,6]] thus everything from the 2nd element to the last. List elements such as [4,5,6] can also be any structure.
List [2: -1] returns [3.1415], from the 2nd element to the last only
List [2: -2] = [] from the 2nd element to only the penultimate one. There is nothing left.
List [-2] = 3.1415, the penultimate element

palette is a dictionary whose keys are strings. It is written with curly brackets. The values follow the ":", here they are so-called tuples. They are written with round brackets. Each tuple consists of the three color information for red, green and blue. Commas separate the individual elements of the tuple. palette ["yellow"] has the value (32,16,0). You can also simply print out dicts. However, there is no guarantee that the elements will appear in the order in which they were defined. With hashlists you have to live with it.

```
>>> palette= { # (r,g,b)
    "red":(32,0,0),
    "green":(0,16,0),
    "blue":(0,0,16),
```

```
    "yellow":(32,16,0),
    "magenta":(16,0,8),
    "cyan":(0,16,8),
    "white":(12,12,12),
    "black":(0,0,0)
    }
```

```
>>> palette
{'magenta': (16, 0, 8), 'yellow': (32, 16, 0), 'cyan': (0, 16, 8), 'blue': (0, 0, 16), 'white': (12, 12, 12), 'black': (0, 0, 0), 'red': (32, 0, 0), 'green': (0, 16, 0)}
```

color is a normal, indexed list. It is defined with square brackets. Lists begin with the index 0. color [3] therefore references the fourth entry, the string "yellow".

```
color=[
    "red",
    "green",
    "blue",
    "yellow",
    "magenta",
    "cyan",
    "white",
    "black",
    ]
```

The color list assigns a unique location number to the color codes. This makes it possible to address the color codes in the palette in counting loops (for loops) using numbers as index values in a targeted and reproducible manner. We do this at different points in the program.

MicroPython behaves similarly to the assignment of simple variables when assigning lists.

```
a = 7
b = a
ListA = [1,2,3,4]
ListB = ListA
```

b and ListB are not new variables, just new names for the same object. You can check this with the help of REPL.

```
>>> a=7
>>> b=a
>>> a is b
True
>>> id(a)
15
>>> id(b)
15
>>> ListeA=[1,2,3]
>>> ListeB=ListeA
>>> ListeB is ListeA
```

True
A look into the object inspector confirms this based on the memory address of ListA and ListB.

We have to keep this in mind if we really want to create a copy of an object. It's not a big act for simple variables. As soon as a or b is assigned a new value, the two go their separate ways. But we noticed a nasty side effect with lists.

```
>>> ListA = [1,2,3]
>>> ListB = ListA
>>> ListA [2] = 5
>>> List B.
[1, 2, 5]
>>> ListA is ListB
True
```

ListA is still identical to ListB. The two names refer to the same memory location. If a list element is changed under the name ListA, this also affects the name ListB, because both point to the same memory location, the beginning of the list [1,2,5]. In order to really create an independent copy of ListA, all elements must be copied individually. In addition to a for loop, this is much easier with the following notation, which is also used in the program. Such subtleties often seem inexplicable and are often overlooked.

```
>>> ListB = ListA [:]
>>> ListA is ListB
False
```

colors = len (color) determines the number of entries in the color list.

With a trick called comprehension, you can even get a list or dict to define itself.

```
neoCnt = 12
...
...
...
kringle = [7 for i in range (neoCnt)]
```

Our neopixel ring has 12 LEDs. The list kringel should contain color information for each LED as a shadow variable and should be preset with 7, i.e. black (= off). Because the number of LEDs can change, we do not define the list with a constant length. range (neoCnt) includes the whole numbers from 0 to 11, because MicroPython always excludes the upper limit of ranges, as we know. The comprehension

```
7 for i in range (neoCnt)
```

so creates a list with 12 times the 7 as elements. If you change neoCnt to 36, you get a list with 36 sevens for kringel without changing the program.

The following for loop is used in the lightKringel () function to display the current assignment of kringel.

```
for i in range(neoCnt):
    np[i]=palette[color[kringel[i]]]
```

As a running index, i runs through the values from 0 to 12. Kringel [i] contains the color index 0 to 5. This determines the color string from the list color, which finally fetches the corresponding tuple as a key from the dict palette. This is finally transferred to the neopixel list np [] with the same index.

A central operation should perhaps be briefly discussed before finally programming. At several points in the program, increasing and decreasing indexes is about maintaining the range of values. The color numbers may only be in the range between 0 and 5, the LED positions between 0 and 3. So that after cyan comes red immediately and not white or after black an index error occurs because there is no color with the number 8, a range check must be performed each time the index increases or decreases. Instead of cumbersome with if and else, I chose the more elegant method of ring addition. The normal addition / subtraction paired with the modulo division, which delivers the rest of the operation instead of the quotient value for an integer division (operator //). Your operator is the "%" sign.

- What do you mean, this is too complicated? - Yes of course, I understand, you prefer examples to general presentation, no problem, well then:

13% 6 = 1, because 13 // 6 = 2 and therefore remainder = 1.
5% 6 = 5 because 5 // 6 = 0 and remainder = 5
(3 + 1)% 6 = 4, because 4 // 6 = 0 and remainder = 4
but:
(5 + 1)% 6 = 0, because 6 // 6 = 1 and remainder = 0
With the addition we stay within the group of numbers from 0 to 5 and after 5 comes 0 when counting.
This also works with summands other than 1
(5 + 4)% 6 = 3, because ... but you can certainly justify that yourself now.

It gets exciting when subtracting.
(4-1)% 6 = 3, of course!

but what do we do with this?
(0-1)% 6 =? REPL says 5. But why?

Actually, this is what happens. To avoid negative numbers, module 6 is added first. I could do that several times. Modulo 6, the values 0, 6, 12, ... are equivalent, they all have the same 6's remainder, namely 0. Now you can subtract 1 without going into the negative range.

(0-1)% 6 = (0 + 6-1)% 6 = 5, because 5 // 6 = 0 and remainder = 5.

It is in this form in various places in the program. If you cut out the part of the number line and bend it into a curl, you have the graphic illustration of the whole. Oh yes, with our LED ring, LED 0, modulo 12, comes after LED number 11.

In order for the ringmaster1.py program to be executed, all modules listed above must be uploaded to the ESP32's flash memory. These are the files hd44780u.py, i2cbus.py, lcd.py and mcp.py. When this is done, we can start the program ringmaster1.py in the editor window with F5 - provided the hardware is assembled and the ESP32 is connected to the PC.

Here is the listing of the program.

```
# ringmaster1.py
# Author: Juergen Grzesina
# Revision: 1.1
#    Score-Bug geloest
#    Anzeige verdeckter Farben korrigiert
#    Abbruch durch Taste A eingebaut
#    kleinere Bugs beseitigt
# Stand: 04.06.2021
# ********************************************************
# Importgeschaeft
# ********************************************************
import os,sys       # System- und Dateianweisungen

import esp          # nervige Systemmeldungen aus
esp.osdebug(None)

import gc           # Platz fuer Variablen schaffen
gc.collect()
#
from machine import Pin, I2C
from neopixel import NeoPixel
from keypad import KEYPAD_LCD, KEYPAD
#from i2cbus import I2CBus
from time import sleep, time, ticks_ms
from lcd import LCD
from hd44780u import HD44780U, PCF8574U_I2C
#from button import BUTTON32,BUTTONS
#
# **************** Objekte declarieren *****************
# Pins fuer parallelen Anschluss des 4x4-Pads

i2c=I2C(-1,scl=Pin(21),sda=Pin(22),freq=400000)
#ibus=I2CBus(i2c)

disp=LCD(i2c,adr=0x27,cols=16,lines=2) # LCDPad am I2C-Bus

keyHwadr=0x20 # HWADR des Portexpanders fuer das 4x4-Pad
#kp=KEYPAD_I2C(ibus,keyHwadr) #  Hardware Objekt am I2C-Bus
#cols=(15,5,18,19)
#rows=(13,12,14,27)
#kp=KEYPAD_P(rows,cols) #  HW-objekt mit Parallel-Anschluss
kp=KEYPAD_LCD(pin=35) # LCD-Keypad-Tastatur an ADC35
k=KEYPAD(kp,d=disp) # hardwareunabhaengige Methoden

rstNbr=25
#rst=BUTTON32(rstNbr,True,"RST")
```

```
ctrl=Pin(rstNbr,Pin.IN,Pin.PULL_UP)
#t=BUTTONS() # Methoden fuer Taster bereitstellen

neoPin=Pin(13)
neoCnt=12
np=NeoPixel(neoPin,neoCnt)

palette= { # (r,g,b)
    "red":(32,0,0),
    "green":(0,16,0),
    "blue":(0,0,16),
    "yellow":(32,16,0),
    "magenta":(16,0,8),
    "cyan":(0,16,8),
    "white":(12,12,12),
    "black":(0,0,0)
    }

color=[
    "red",
    "green",
    "blue",
    "yellow",
    "magenta",
    "cyan",
    "white",
    "black",
    ]
colors=len(color)
red=0; green=1; blue=2; yellow=3
magenta=4; cyan=5; white=6; black=7

kringel=[7 for i in range(neoCnt)]
ready=False

gameState=[7,7,7,7]
myState=gameState[:]
positions=len(gameState)
numberOfTrials=0

def lightKringel():
    for i in range(neoCnt):
        np[i]=palette[color[kringel[i]]]
    np.write()

def clearKringel():
    global kringel
    kringel=[7 for i in range(neoCnt)]
    for i in range(neoCnt):
        np[i]=(0,0,0)
    np.write()
    sleep(0.03)
```

```
def clearRing():
    for i in range(neoCnt):
        np[i]=(0,0,0)
    np.write()
    sleep(0.03)

def rainbowKringel(colList,cnt=3,delay=0.3):
    colors=len(colList)
    cols=colList[:]
    cols.extend([7 for i in range(colors,neoCnt)])
    colors=len(cols)
    global kringel
    global ready
    ready = False
    clearKringel()
    for m in range(colors):
        #print(m)
        for n in range(m+1):
            kringel[m-n]=cols[n]
            #print(m,n)
        #print(kringel)
        lightKringel()
        sleep(delay)
    for m in range (cnt-1):
        for k in range(neoCnt):
            h11=kringel[neoCnt-1]
            for n in range(neoCnt-1):
                kringel[(neoCnt-1)-n]=kringel[(neoCnt-1)-n-1]
            kringel[0]=h11
            #print(kringel)
            lightKringel()
            sleep(delay)
    ready=True

def dimKringel(delay=0.1,stufen=8,down=True):
    global ready
    ready=False
    for h in range(stufen+1):
        for i in range(neoCnt):
            r,g,b=palette[color[kringel[i]]]
            if down:
                col=(r*(stufen-h))//stufen
                rn=(col if h<stufen else 0)
                col=(g*(stufen-h))//stufen
                gn=(col if h<stufen else 0)
                col=(b*(stufen-h))//stufen
                bn=(col if h<stufen else 0)
            else:
                col=(r*(h))//stufen
                rn=(col if h<stufen else r)
                col=(g*(h))//stufen
```

```
                gn=(col if h<stufen else g)
                col=(b*(h))//stufen
                bn=(col if h<stufen else b)
            np[i]=(rn,gn,bn)
        np.write()
        sleep(delay)
    ready=True

def blinkKringel(on=0.3,off=0.7,cnt=1):
    c=cnt
    for i in range (c):
        lightKringel()
        sleep(on)
        clearRing()
        sleep(off)

def randomKringel():
    global kringel
    kringel=[int(i)%7 for i in os.urandom(neoCnt)]
    lightKringel()

def showStatus(stat):
    for i in range(len(stat)):
        kringel[i*3]=stat[i]
    lightKringel()

def initGame():
    clearKringel()
    edge=[int(i)%6 for i in os.urandom(4)]
    #print(edge)
    for i in range(positions):
        #np[i*3]=palette[color[edge[i]]]
        print(color[edge[i]],end="*")
        pass
    #np.write()
    print("")
    rainbowKringel([red,yellow,green,cyan,blue,magenta],\
                   cnt=2,delay=0.03)
    dimKringel(stufen=8)
    clearKringel()
    return edge # goes to gameState

def startGame():
    # Keyblock:
    # Taste  Funktion
    # *      Position back  (n+9)%12 (n+3)%4
    # #      Position next  (n+3)%12 (n+1)%4
    # A      Abbruch
    # D      OK, set myStatus
    state=[7,7,7,7]
    clearKringel()
    getColorStatus(state)
```

```
    return state

def compareToSolution(mystat):
    global kringel
    global numberOfTrials
    numberOfTrials+=1
    reply=True
    for i in range(positions):
        kringel[3*i+1]=7
        if mystat[i]==gameState[i]:
            kringel[3*i+1]=gameState[i]
            reply=reply & True
        elif mystat[i] in gameState:
            kringel[3*i+1]=6
            reply=False
        else:
            reply=False
    lightKringel()
    sleep(0.3)
    return reply

def getColorStatus(myStat,delay=0.3):
    ms=myStat
    showStatus(ms)
    i=0
    w=ms[i]
    np[neoCnt-1]=palette[color[white]]
    np.write()
    disp.clearAll()
    disp.writeAt("up=2, down=0  {}".format(numberOfTrials),0,0)
    while 1:
        disp.writeAt("Position {}".format(i),0,1)
        ch=k.asciiKey()
        if ch != "\xFF":
            if ch=="*":
                rp=(i*3+(neoCnt-1))%neoCnt
                np[rp]=palette[color[black]]
                i=(i+3)%positions # 1 Position zurueck
                rp=(i*3+(neoCnt-1))%neoCnt
                np[rp]=palette[color[white]]
                np.write()
                w=ms[i]
                sleep(delay)
            elif ch=="+":
                rp=(i*3+(neoCnt-1))%neoCnt
                np[rp]=palette[color[black]]
                i=(i+1)%positions # 1 Position vor
                rp=(i*3+(neoCnt-1))%neoCnt
                np[rp]=palette[color[white]]
                np.write()
                w=ms[i]
                sleep(delay)
```

```
            elif ch=="\x0d":
                rp=(i*3+(neoCnt-1))%neoCnt
                np[rp]=palette[color[black]]
                np.write()
                disp.clearAll()
                return ms
            elif ch=="2":
                w=ms[i]
                w=(w+1)%(colors-2) # mod (colors-2) Addition
                np[i*3]=palette[color[w]]
                ms[i]=w
                np.write()
                sleep(delay)
            elif ch=="0":
                w=ms[i]
                w=(w+colors-3)%(colors-2) # mod (colors-2) Subtr.
                np[i*3]=palette[color[w]]
                ms[i]=w
                np.write()
                sleep(delay)
            elif ch=="\x08":
                print("Game Over")
                disp.clearAll()
                disp.writeAt("  GAME OVER",0,0)
                clearKringel()
                sleep(delay)
                sys.exit()
        if ctrl.value()==0:
            print("Game Over")
            disp.clearAll()
            disp.writeAt("  GAME OVER",0,0)
            sys.exit()

def play(mystat):
    ms=mystat
    showStatus(ms)
    if compareToSolution(ms):
        disp.clearAll()
        return
    while 1:
        ms=getColorStatus(ms)
        showStatus(ms)
        vergleich=compareToSolution(ms)
        if vergleich:
            disp.writeAt("TRIALS: {}".format(numberOfTrials),6,0)
            sleep(1)
            disp.clearAll()
            return
        sleep(0.5)

# ****************************************************
# ****************** Hauptschleife ******************
```

```
# ******************************************************
disp.clearAll()
disp.writeAt("RINGMASTER 1",0,0)
disp.writeAt("WELCOME",0,1)
sleep(3)
totalScore=0
games=0
while True:
    numberOfTrials=0
    gameState=initGame()
    clearKringel()
    disp.writeAt("Start now",0,1)
    sleep(1)
    myState=startGame() #[1,0,3,1]
    play(myState)
    totalScore=totalScore+numberOfTrials
    games+=1
    disp.clearAll()
    disp.writeAt("Rounds {}".format(games),0,0)
    disp.writeAt("Total score {}".format(totalScore),0,1)
    sleep(1)
    taste=k.waitForKey(0,ascii=True)
    print("Taste",taste)
    if taste=="+":
        print("Game Over")
        disp.clearAll()
        disp.writeAt("  GAME OVER",0,0)
        sys.exit()
    disp.clearAll()
```

The main program is very manageable with its 28 lines due to the relocation of the sub-tasks to the various functions. After the greeting, initGame () creates a new 4-tuple of colors that can be guessed. All colors of the game march in and dance 3 rounds. startGame () prompts for the first dance, that is to say, for the first choice of color. The white LED indicates the input position. This is always the next LED next to it in a clockwise direction. Use the UP and DOWN buttons to scroll through the color scale, and LEFT and RIGHT to move to the next LED position EAST, NORTH, WEST, SOUTH or vice versa. The selection is accepted with SELECT.

With the play () function you enter the hot phase of the game. After checking the first color choice, which in most cases will probably not report an immediate hit, we are asked to make another selection. If the check determines that the color sequence of the gameState matches myState, we have all located the colors correctly - a direct hit. Each correctly guessed color is indicated by switching on the same color on the LED following clockwise. If the color we have chosen is contained in the solution, but can be found in a different direction, then this is communicated to us by the color white. The number of attempts is increased by 1 with each SELECT. This value is shown in the upper right corner of the display.

After finding the agreement for all positions, the program returns from the play () function. The content of the global variable numberOfTrials, the number of attempts, is added to totalScore. This value and the number of game rounds appear in the display. After pressing (almost) any key, a new game round starts. The RIGHT key ends the program at this point.

A few more comments on the key query. The keypad.py module can query the keys of the LCD keypad, but also matrix keypads. We will come to a representative of the last category in the next episode. The module contains several classes so that different hardware components can be queried in the same way. The KEYPAD_LCD class is responsible for the LCD keypad. Like the other classes, it contains a key () method that is adapted to the hardware and returns a key number. This key number can then be translated into an ASCII character. The string asciiCode is responsible for this. The string contains so many character codes that each raw key number corresponds to an ASCII character.

asciiCode = "+ 20 * \ x0d"

The keys RIGHT, UP, DOWN, LEFT, SELECT correspond to the raw key codes 0, 1, 2, 3, 4. The ASCII table results in the following assignment.

RIGHT	UP	DOWN	LEFT	SELECT
+	2	0	*	ENTER= Linefeed

Wondering how I came up with this crazy definition? Well, I want to tell you. It has to do with the next blog post. I use an OLED display there, which of course has no buttons. So I had to use a 4x4 keypad in addition to the display for the advanced game options. Yes, and on this matrix keyboard "up" is on 2, "down" on 0, and so on.

With this trick, you only have to change something at one point in the program, namely at the beginning.

```
from keypad import KEYPAD_LCD, KEYPAD
#from keypad import KEYPAD_I2C, KEYPAD
…
…
keyHwadr=0x20 # HWADR des Portexpanders fuer das 4x4-Pad
#kp=KEYPAD_I2C(ibus,keyHwadr) #  Hardware Objekt am I2C-Bus
#cols=(15,5,18,19)
#rows=(13,12,14,27)
#kp=KEYPAD_P(rows,cols) #  HW-objekt mit Parallel-Anschluss
kp=KEYPAD_LCD(pin=35) # LCD-Keypad-Tastatur an ADC35
k=KEYPAD(kp,d=disp) # hardwareunabhaengige Methoden
```

The comments on the bold lines have to be turned around, that's all. The KEYPAD_I2C and KEYPAD_P classes also have a key () method which returns a key number and a separate ASCII table for translation into ASCII characters.

The KEYPAD class above provides methods for handling keyboards, regardless of the hardware: waitForKey (), asciiKey () and padInput ()

waitForKey takes the two optional parameters timeout and ascii. timeout is the waiting time in seconds until the method returns either -1 or "\ xFF" if no key is pressed. If a key is pressed in time, its raw key number or, if ascii = True was passed, the corresponding ASCII character is returned. timeout = 0 waits forever for the key to be pressed.

The method padInput () expects a character string to be entered at position xp, yp on the display, which is terminated by D. With suitable programming and other ASCII tables, the entire alphabet could even be recorded using the 4x4 keypad.

The modules hd44780u.py and lcd.py have a similar structure. The first module contains classes for operating the hardware and basic output. The class LCD offers methods that are also contained in the class OLED with the same function. By changing the import and the initialization, an LCD can be exchanged for an OLED display at any time. That's exactly what we'll do in the next episode, Ring Master 2.

Oh, I forgot to mention a particular line of code. There is a for loop in the initGame () function, which is only used for cheating.

```
for i in range(positions):
    #np[i*3]=palette[color[edge[i]]]
    #print(color[edge[i]],end="*")
    pass
#np.write()
```

During the test phase, the commented out lines reveal the secret numerical code for the color template. Then they should be commented out again, otherwise the fun of playing will have a hole.

Until then, have fun tinkering, programming and playing!

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