Raspberry Pi with sensors for temperature and humidity

Version 1.0 *(this help file) for* ***Weather Station 2023*** *(desktop app)*

Content

1 Introduction

In this project a Raspberry Pi will be used to collect temperature and humidity sensor data for several formicariums, which are basically terrariums for ants, but monitoring of any other species is supported. The basic idea is to monitor several of these sensors, even if they are in the same room. But of course, instead of a “species” “room names” could be used to monitor a house or a building.

The project is accompanied by a video playlist on YouTube (in German).

Playlist

2 Project

This project is divided in several steps which could be called milestones. The section of this document contains these milestones which need to completed in the following order:

1. Solder a circuit board
2. Configure the sensors
3. Setup the objects to be monitored
4. Setup the Raspberry Pi to collect sensor data[1]
5. Setup the Desktop app to display data visually

3 Soldering the circuit board

This part of the project is highly depending on what someone wants to achieve. It depends on the RasPi that will be used as well as the number of sensors that should be used. During this project a circuit board for **five** sensors will be used, but the maximum number is limited by the connection pins of the RasPi model used.

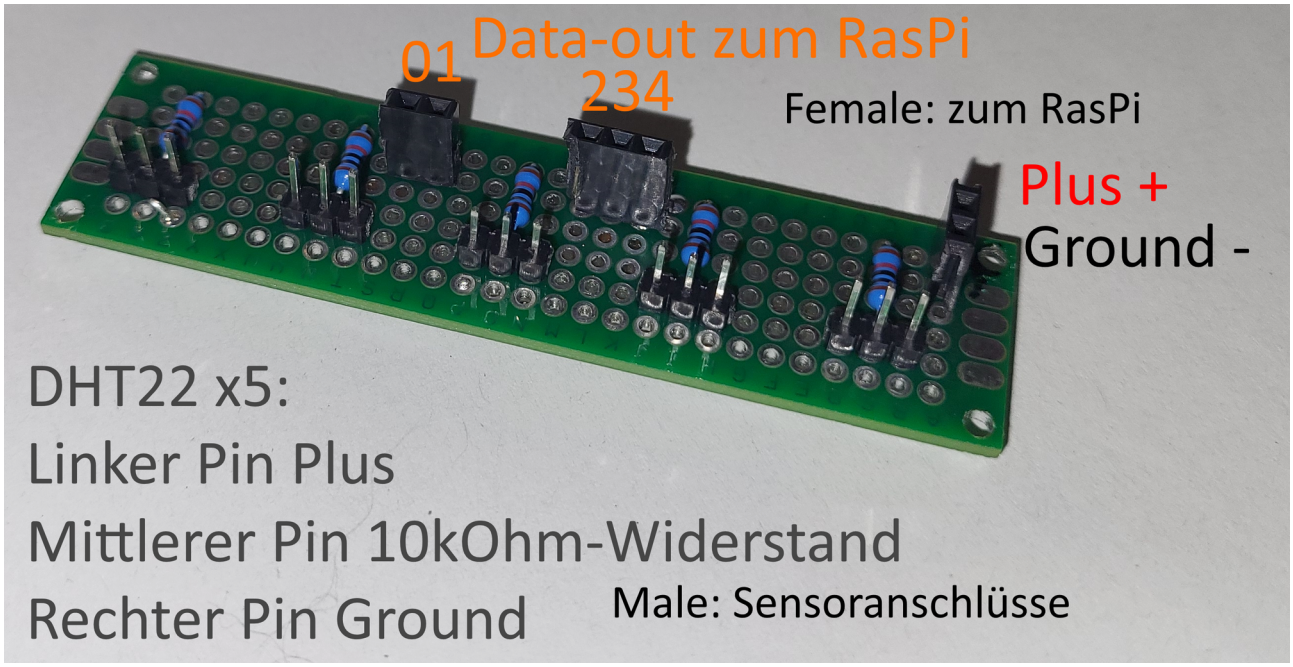
3.1 Item list

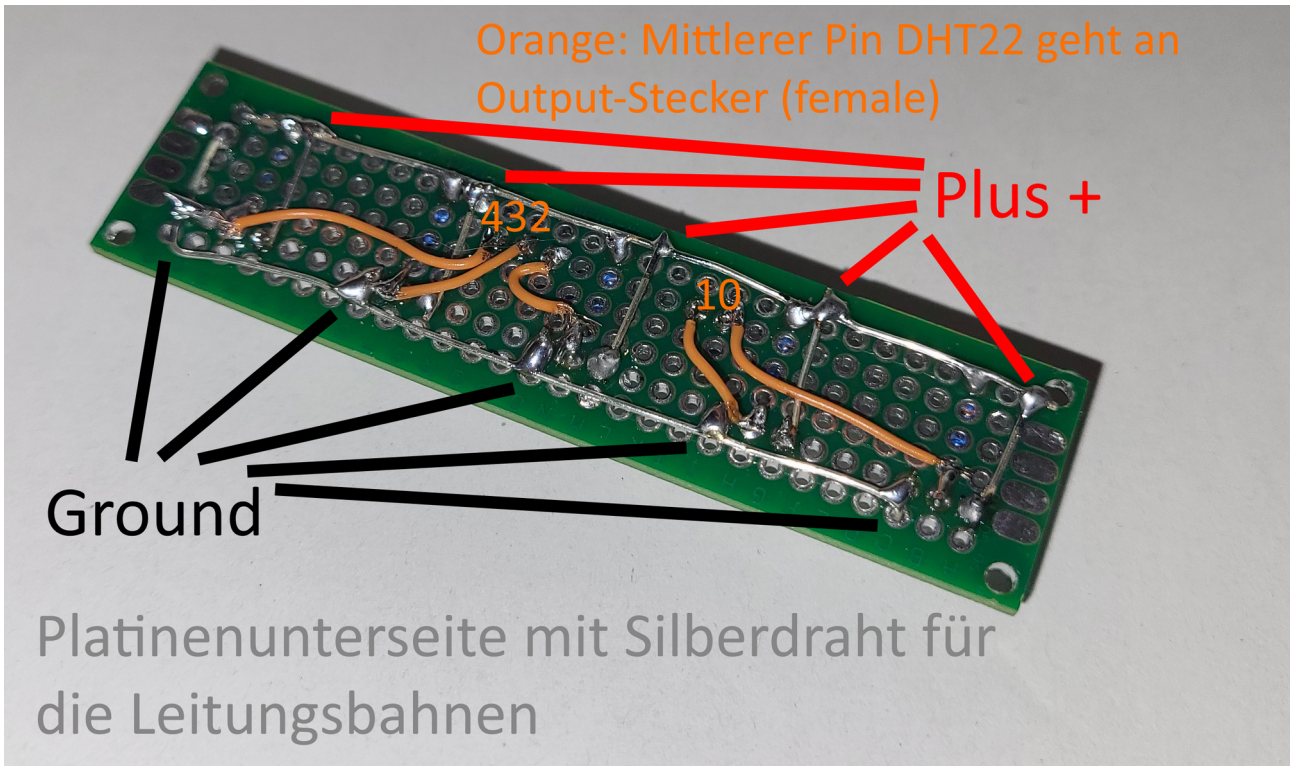
For five sensors:

- 5x DHT22 sensors
- 5x 10kΩ resistants
- 1x circuit board (28x6 holes)
- Silver wire
- 7x female plugs (out to RasPi)
- 5x 3pin-male (input for the sensors)

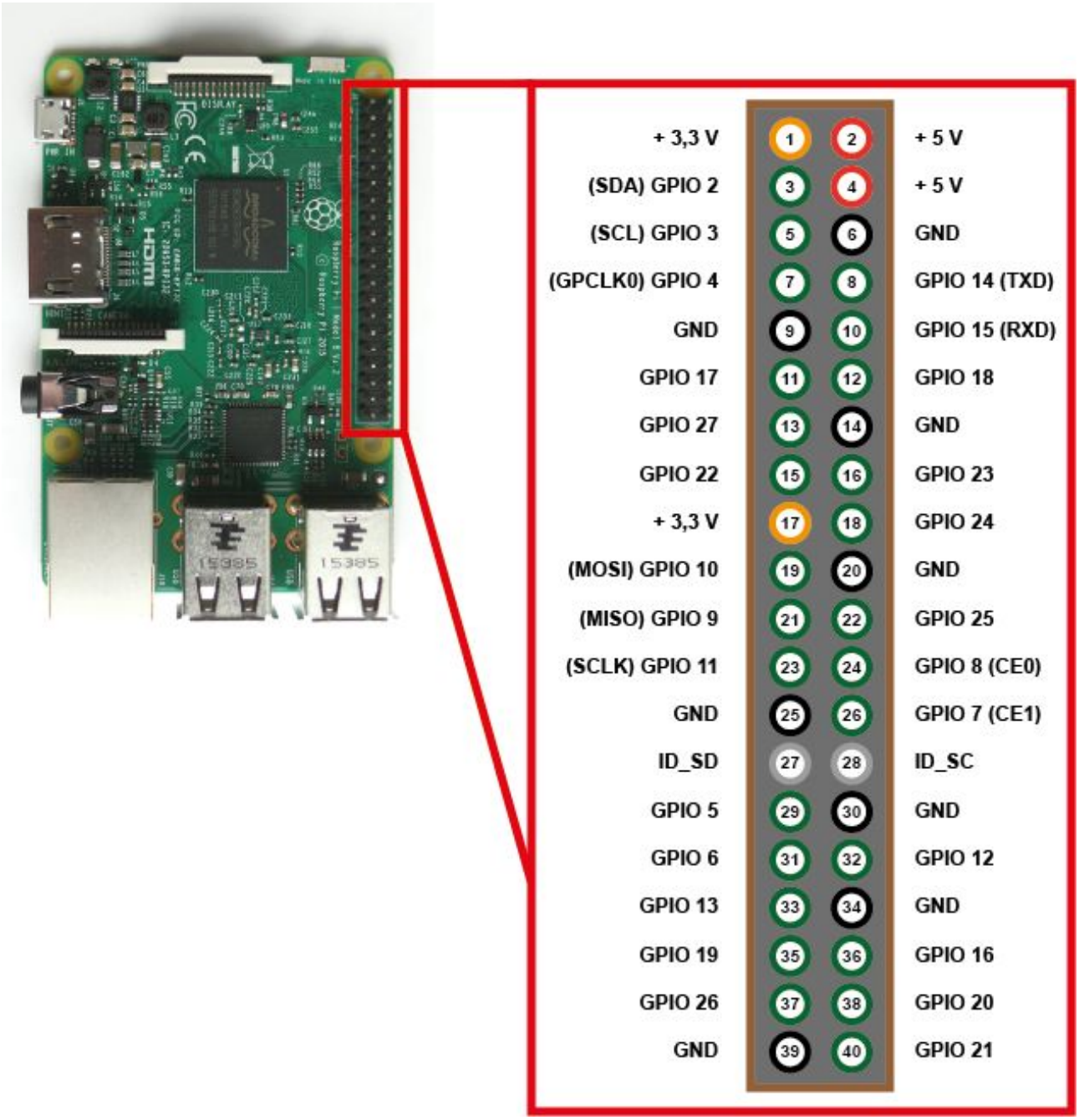
1 The “Raspberry Pi” will in the following be abbreviated as “RasPi”

- Schrumpfschlauch
- Wire: e.g. 3 different colors (red, orange, black), 10m each




Orange: Mittlerer Pin DHT22 geht an Output-Stecker (female)
Plus +
432
10
Ground
Platinenunterseite mit Silberdraht für die Leitungsbahnen

3.2 Connect the circuit board to the Raspi



In this project a very old RasPi is used and the GPIO layout might change for different RasPis or their clones. So it is very important to check the pin layout carefully.

As the layout of the circuit board needs only one +3.3V (1) and one GND (6) using a circuit board saves a couple of connections as normally each sensor would need its own +3.3V and GND lines.

E.g. in this help file the data pins used are the following and thus will be shown in screenshots for the desktop application as examples:

- GPIO 2 → Sensor 2
- GPIO 3 → Sensor 3

- GPIO 4 → Sensor 4
- GPIO 7 → Sensor 7
- GPIO 8 → Sensor 8

4 Sensors

The requirement for each sensor is that it could be used between 3 and 5V and that it has got three outputs. In this project DHT22-sensors are used, but any sensor that fulfills the requirements should work.

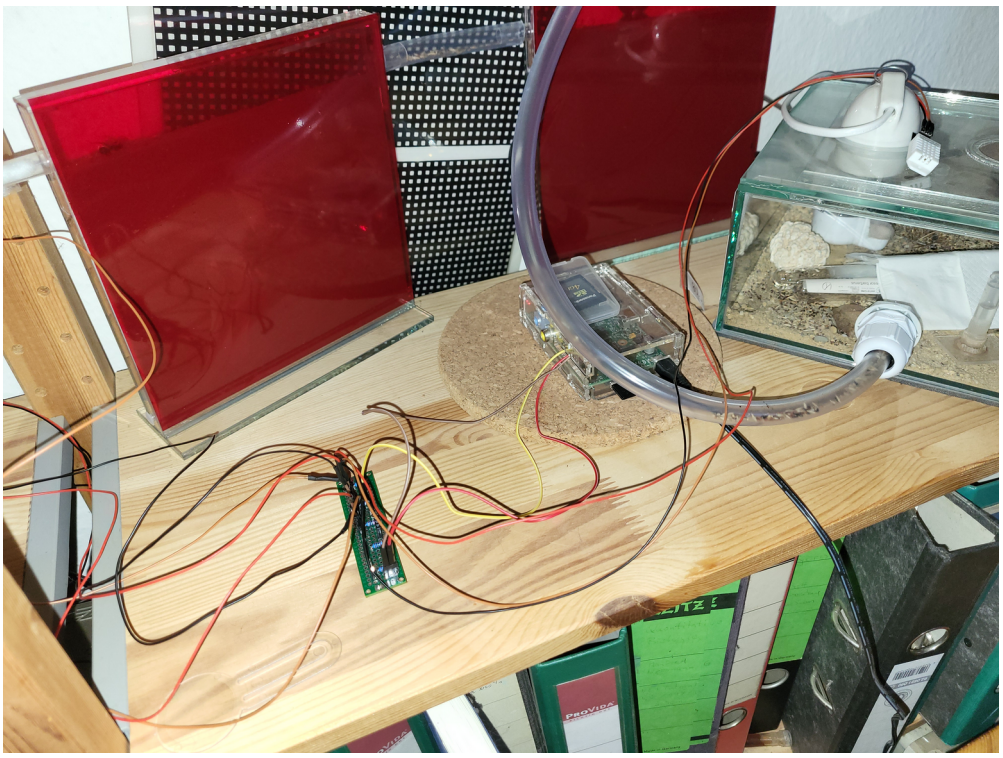
Each sensor owns three output lines:

- GROUND (black)
- DATA (yellow/orange)
- PLUS (red)

5 Setup of a formicarium/terrarium

A “formicarium” is a special type of terrarium. They are used in this example for the sensors, but any type of terrarium is supported. Therefore a species name can be defined for each monitoring object. The wires of the sensor should be long enough to connect both, the formicarium and the RasPi.

6 Setup of a Raspberry Pi



6.1 Headless installation via WiFi

The RasPi can be installed without monitor via SSH-client. Putty for Windows can be used to access the RasPi which is obviously a Linux system[2].

6.2 User configuration

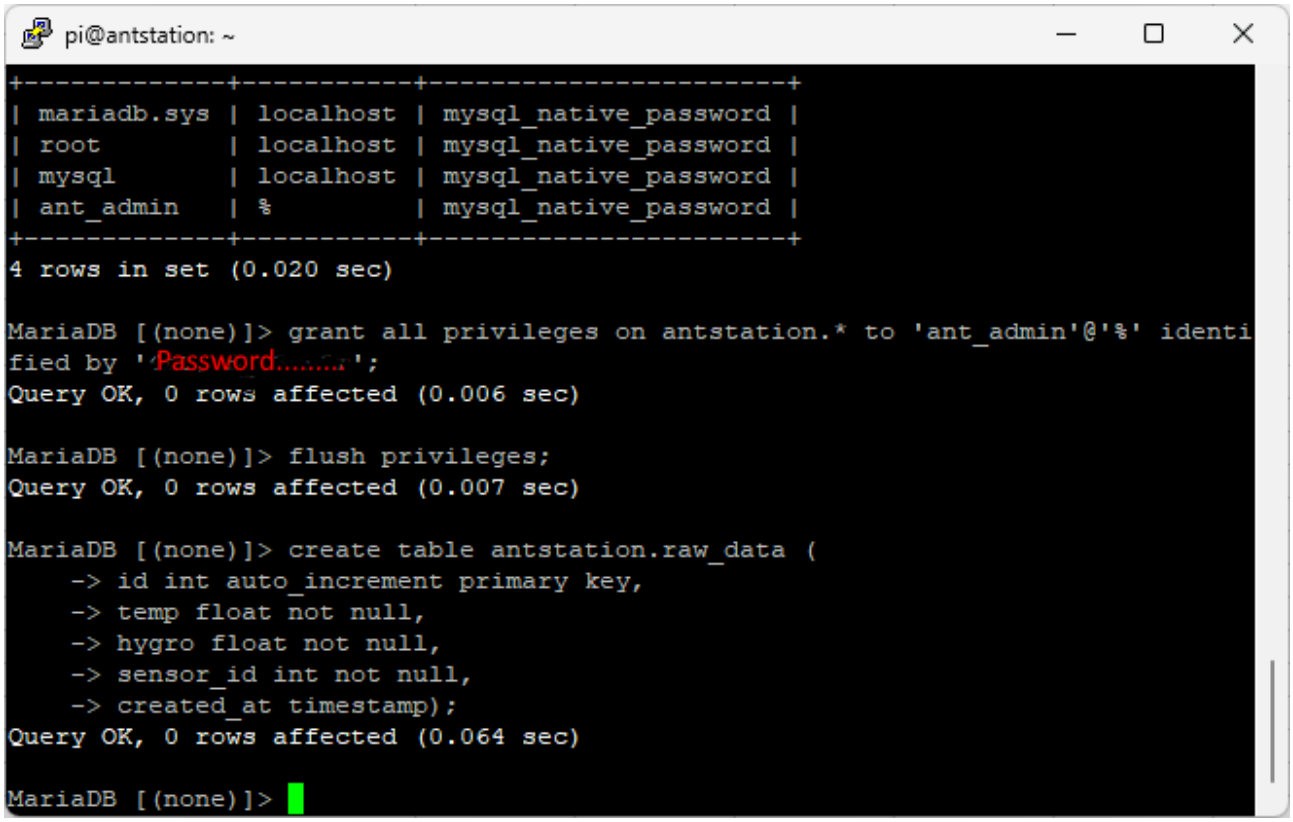
The user “root” is only to be used to setup the RasPi, but to access the database via a desktop application the user “ant_admin” is created. Ideally, this user should only have read rights while only the DHT2SQL.py can write to the database.

Follow this guide to setup MariaDB for LAN access and user creation:

https://mariadb.com/kb/en/configuring-mariadb-for-remote-client-access/

6.3 Database configuration

2 I’m writing this as a Windows user. Linux users might laugh about me and could do it better, but everything in this project was done on a Windows 11 laptop, while the RasPi is controlled via Putty.



6.4 DHT2SQL.py

This script is used to write data from the sensors via CronJob (6.5) to a MariaDB, thus it needs to have database access as well. The script can be found in *Sources*, but the database connection should be changed. Otherwise the script will not be working.

DHT2SQL.py

In this script the SQL connection needs to be changed to the root user of the RasPi.

```
233  #ANTSTATION SQL
234  try:
235      conn = mariadb.connect(
236          user="root",            # We're using root as this script runs only on localhost
237          password="password",    # I'm using a different pwd, of course ;)
238          host="127.0.0.1",       # localhost, no access from outside
239          port=3306,              # same port as from outside
240          database="antstation"   # Ants.Cologne: in this db we're storing our sensor data!
241      )
242  except mariadb.Error as e:
243      print(f"Error connecting to MariaDB Platform: {e}")
244      sys.exit(1)
245
246  # Get Cursor
247  cur = conn.cursor()
248  #print("SQL works")
```

6.5 The CronJob

6.6 Moving the database to an external Solid State Drive (SSD)

As the RasPi is used as a database server changing from the default SD-card to an SSD is highly recommended.

6.7 Security

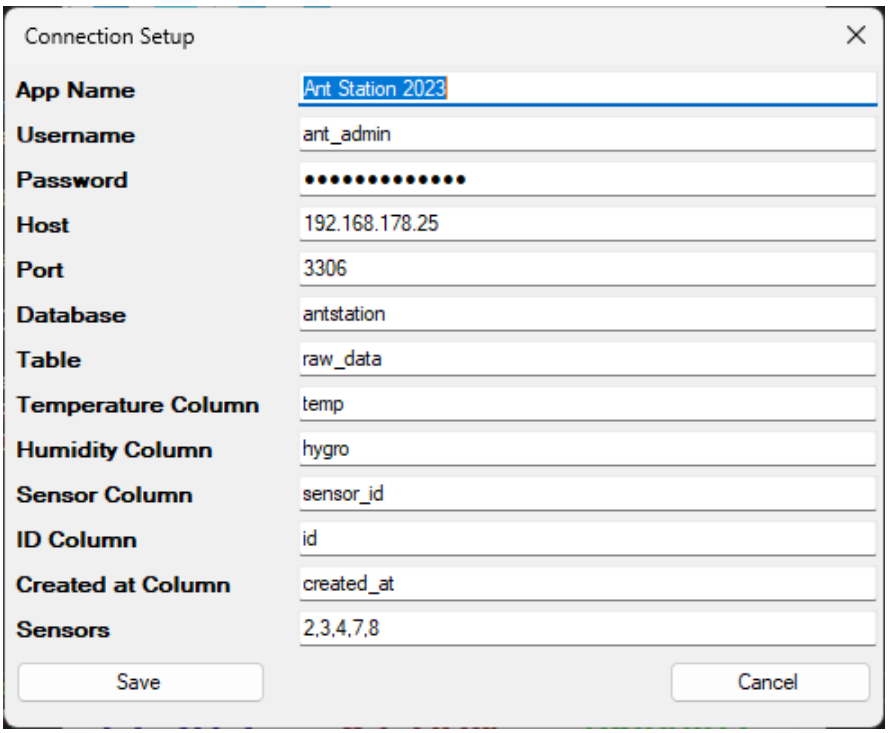
In my case the Raspi is only available in LAN, via SSH and a different user than root for the database connection. Therefore I can only recommend to follow more in-depth security advises if you want to put this solution on the internet.

It is not recommended to use this “home grown solution” in any production environment without further security audits. Feel free to download from Github and modify for your own needs.

7 Desktop app „Weather Station 2023“

The desktop app can be used after all sensors have been connected to the RasPi, which also writes data via cron job every *x* minutes to the database.

7.1 Database setup



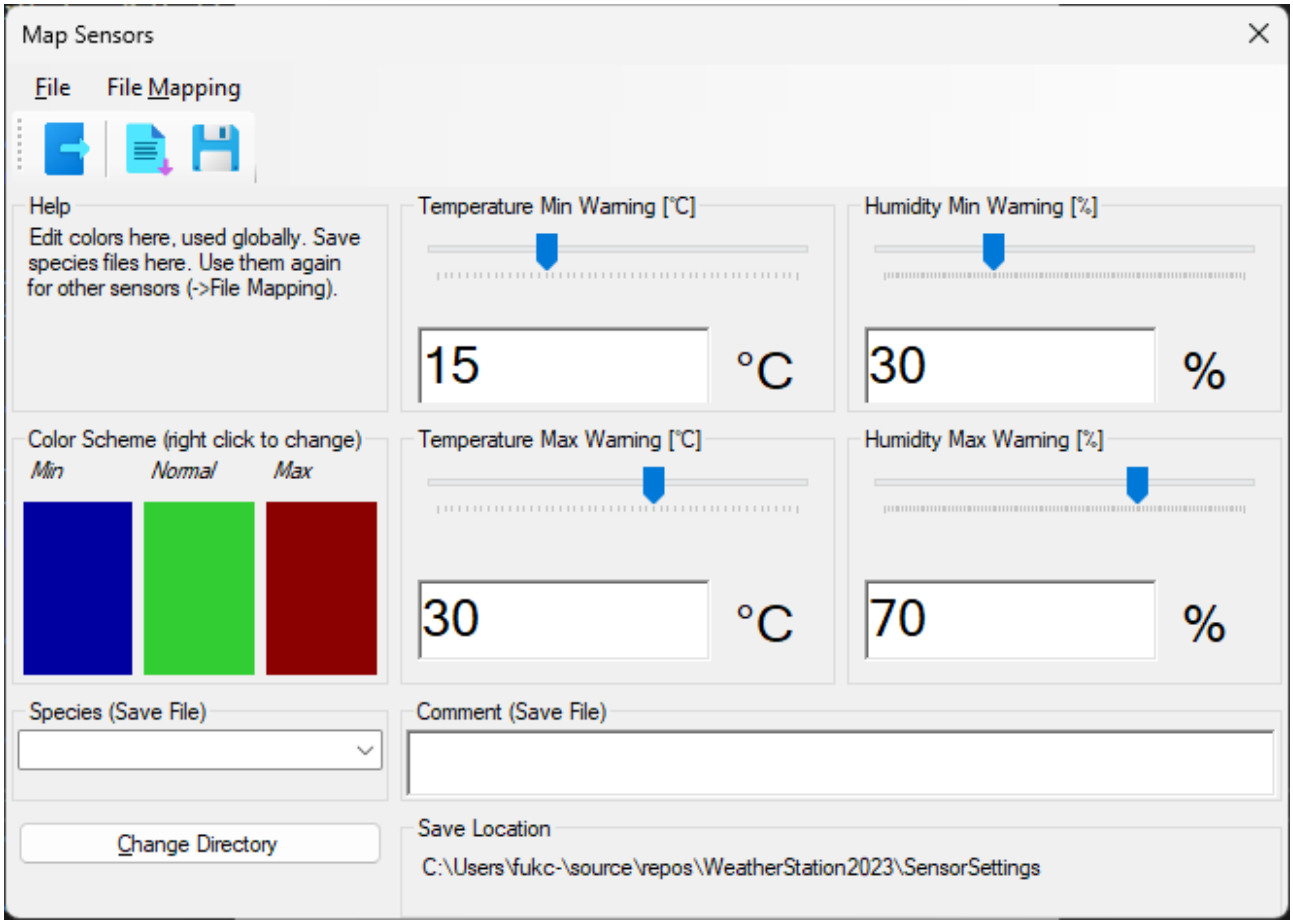
Without filling in the correct values to this form the app will not run. Make sure that the database and user is set up correctly and that the database is accessibly from the client computer.

App Name	The title of the main window, as shown e.g. in the taskbar, can be changed, e.g. if someone wants to monitor frogs instead of ants. **Default**: *Weather Station 2023*
Username	Name of the MariaDB user used to write to the database.
Password	Password of this user.
Host	IP-address of the RasPi – should be LAN only, thus IPv4 is used in this project. IPv6 could work, but was not tested.
Port	MariaDB port **Default**: *3306*
Database	Name of the database as defined during setup.
Table	Table of sensor data used by DHT2SQL.py.
Temperature Column	Name of the temperature column.

Humidity Column	Name of the humidity column.
Sensor Column	Name of the sensor column.
ID Column	Name of the database ID column.
Created at Column	Name of the created_at column (timestamp).
Sensors	List of Sensor-IDs (int), can be separated by " " (space), ";" or ",". A sensor is defined by the pin (sensor id) to which the data cable of the DHT22 sensor is connected. It is the same ID that is used by the Python script DHT2SQL.py for writing to the database.

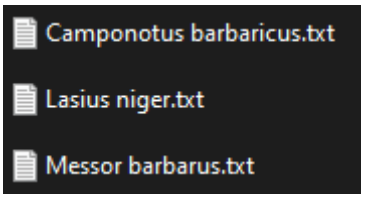
7.2 Species setup

Basically, and what makes the difference to other weather monitoring applications, this app is designed to monitor certain animal species in their terrariums (closed spaces).

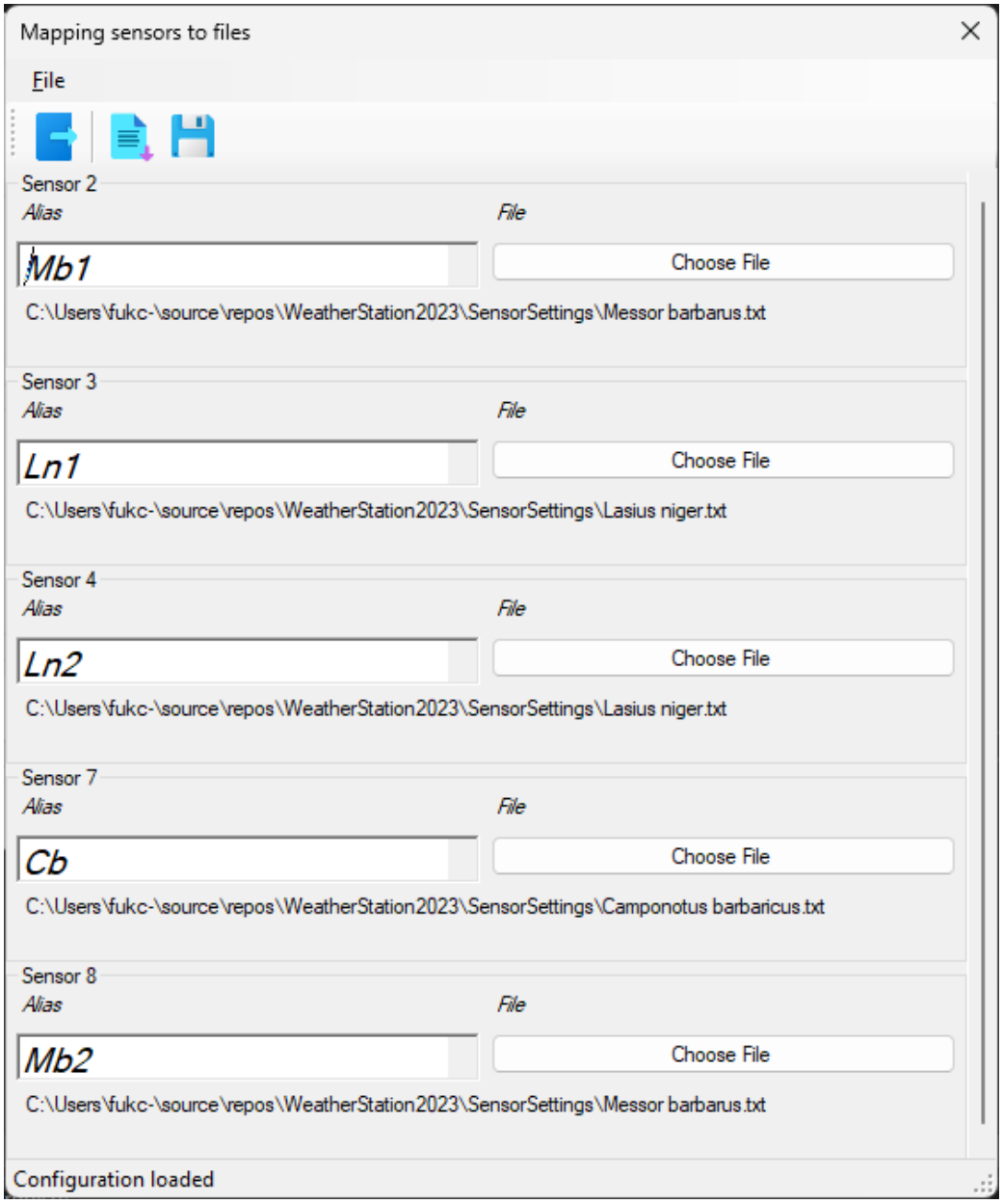


This form is used to create *species files* ("*.txt"). As a *species file* could be used by more than one sensor no specific details are used here. It is only used to color the temperature and humidity values, but the color scheme changes also some other coloring. The colors can be changed so that people with e.g. a red/green-malvision could set better colors for them which are used globally.

If you want to use the possibility to monitor several different species, you should start creating as many different *species files* as needed, even if they only contain the default values first. Values can be changed later, as long as a *species file* exists.



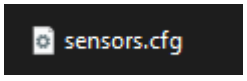
7.3 Sensor configuration



In this form everything is put together. The "**Choose File**" button loads a *species file* for each sensor and an **alias** can be given.

This is completely optional and can be skipped if no coloring of the sensor data is needed.

If used, everything will be saved in "sensors.cfg" in the working directory, which is the only "*.cfg"-file in the directory. As it is the only *configuration file* allowed, there is no dialog to select it. Only the last status can be loaded or a changed status be saved.



7.4 Error codes

Even though the focus during the development of this application was to make it thread-safe by using background workers and exception handling, still errors can occur, e.g. if the RasPi is not reachable. Errors related to Background Workers might show that there are problems with the database, e.g. because the RasPi is busy and does not respond. If restarting the application does not help, it might be a good start to **reboot** the RasPi[3].

Error code	Component	Message	Solution
0001_BgwMf-<n>	MainForm Background Worker <n>		
0002_BgwSen	Sensor Background Worker		
0003_BgwSsf	SensorStatisticsForm Background Worker		

7.5 Github

The C#-code for the desktop application can be found here:

https://github.com/Ants-Cologne/WeatherStation2023

Also, updates to this help file will also be placed there, so that only this PDF file needs to be downloaded to the application installation directory without updating the application itself.

3 Try if a SSH connection to the RasPi is possible. Enter “sudo reboot” in the prompt. If the RasPi does not respond, disconnect power to restart.

8 YouTube videos (German)

8.1 Playlist

This project was accompanied by a German YouTube tutorial playlist which can be found here:

Ants Cologne RasPi DHT22-Sensor-Tutorial

8.2 Videos

If you need more details, maybe one of these videos can give advise, especially about how to solder the circuit board. English translation on YouTube should work.

RasPi DHT22-Sensor-Tutorial (1) - Hardware (1)	Overview circuit board, DHT22 sensor, RasPi.
RasPi DHT22-Sensor-Tutorial (2) - Hardware (2) - Die Platine	Soldering the circuit board, missing hardware needed (silver wire), preparation of the sensors: wire configuration with different length.
RasPi DHT22-Sensor-Tutorial (3) - Hardware (3) - Finales Platinenlayout	Finalization of the circuit board layout for five DHT22 sensors.
RasPi DHT22-Sensor-Tutorial (4): Das Skript	The circuit board has been tested, sensors are connected and now the RasPi is installed. The DHT2SQL.py script is introduced to read data from sensors and write it to the database.
RasPi DHT22-Sensor-Tutorial (5): Drei Sensoren an der Platine	Finalization of the sensor wiring. Setup of the first formicariums.
Messor barbarus Update 18.12.2022 - Winterruhe?!	All sensors conncected, some problems still exist. At this point data is continuously written to the database.
RasPi DHT22-Sensor-Tutorial (6) - Die Desktop-Anwendung mit C# (1)	Starting the programming of *Weather Station 2.0* to solve some problems experienced with *AntStation 1.0* (2021).
RasPi-DHT22-Sensor-Tutorial (7) - Die Desktop-Anwendung (2): Backgroundworker und Sensor-Klasse	The basic problems with *AntStation 1.0* have been resolved by using background workers which will now be used throughout the project.

9 Stackoverflow Credits

Some problems were not searchable, so I asked some questions on stackoverflow.com and want to thank these persons as they helped me when I could not continue:

IVSoftware for answering https://stackoverflow.com/questions/75277474/groupbox-created-in-code-doesnt-dock-correctly-to-parent-tablelayoutpanel

IVSoftware even provided me with a github example of his solution, which was a great help as he gave an example how to use custom user controls, such as a GroupBox, something that I never used before:

https://github.com/IVSoftware/group-boxes-fill-parent-width

Compman2408 for answering https://stackoverflow.com/questions/75033883/c-sharp-sqlconnection-child-form-closing-but-data-is-not-updated-in-mainform/75034158#75034158

Stackoverflow is a great platform and helped me a lot with answers when searching for C# problems. Therefore: a lot of thanks to **Stackoverflow**!

10 List of software used for this project

10.1 Raspberry Pi

10.2 Windows

10.2.1 DaVinci Resolve

I just started with Video Editing for my YouTube channel. But *DaVinci Resolve* is a good start.

https://www.blackmagicdesign.com/de/products/davinciresolve

10.2.2 Win32DiskImager

Used to backup SD-cards from the RasPi. Also used for installation of images on new drives.

https://win32diskimager.org/

10.2.3 Putty

I use Putty to connect via SSH to the RasPi. There are other ways, but I use Putty since years.

https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html

10.2.4 Microsoft Visual Studio 2022

For me the best code editor (IDE) on the market.

https://visualstudio.microsoft.com/de/downloads/

10.2.5 Paint.NET

I don’t have any graphical skills, so everything I need is in this free application. No need for commercial products.

https://www.getpaint.net/download.html

11 Sources

11.1 DHT2SQL.py

```
#!/usr/bin/env python

# DHT2SQL.py / original: DHT.py
# 2019-11-07 / Ants.Cologne: 2022-12-02
# Public Domain
# Modified for use with ANTSTATION by Ants.Cologne 2022 (I only
```

```
changed __main__)

import time
import pigpio

DHTAUTO=0
DHT11=1
DHTXX=2

DHT_GOOD=0
DHT_BAD_CHECKSUM=1
DHT_BAD_DATA=2
DHT_TIMEOUT=3

class sensor:
   """
   A class to read the DHTXX temperature/humidity sensors.
   """
   def __init__(self, pi, gpio, model=DHTAUTO, callback=None):
      """
      Instantiate with the Pi and the GPIO connected to the
      DHT temperature and humidity sensor.

      Optionally the model of DHT may be specified.  It may be one
      of DHT11, DHTXX, or DHTAUTO.  It defaults to DHTAUTO in
which
      case the model of DHT is automtically determined.

      Optionally a callback may be specified.  If specified the
      callback will be called whenever a new reading is available.

      The callback receives a tuple of timestamp, GPIO, status,
      temperature, and humidity.

      The timestamp will be the number of seconds since the epoch
      (start of 1970).

      The status will be one of:
      0 DHT_GOOD (a good reading)
      1 DHT_BAD_CHECKSUM (receieved data failed checksum check)
      2 DHT_BAD_DATA (data receieved had one or more invalid val-
ues)
      3 DHT_TIMEOUT (no response from sensor)
      """
      self._pi = pi
```

```
      self._gpio = gpio
      self._model = model
      self._callback = callback

      self._new_data = False
      self._in_code = False

      self._bits = 0
      self._code = 0

      self._status = DHT_TIMEOUT
      self._timestamp = time.time()
      self._temperature = 0.0
      self._humidity = 0.0

      pi.set_mode(gpio, pigpio.INPUT)
      self._last_edge_tick = pi.get_current_tick() - 10000
      self._cb_id = pi.callback(gpio, pigpio.RISING_EDGE,
self._rising_edge)

   def _datum(self):
      return ((self._timestamp, self._gpio, self._status,
               self._temperature, self._humidity))

   def _validate_DHT11(self, b1, b2, b3, b4):
      t = b2
      h = b4
      if (b1 == 0) and (b3 == 0) and (t <= 60) and (h >= 9) and (h
<= 90):
         valid = True
      else:
         valid = False
      return (valid, t, h)

   def _validate_DHTXX(self, b1, b2, b3, b4):
      if b2 & 128:
         div = -10.0
      else:
         div = 10.0
      t = float(((b2&127)<<8) + b1) / div
      h = float((b4<<8) + b3) / 10.0
      if (h <= 110.0) and (t >= -50.0) and (t <= 135.0):
         valid = True
      else:
         valid = False
```

```
   return (valid, t, h)

def _decode_dhtxx(self):
   """
         +-------+-------+
         | DHT11 | DHTXX |
         +-------+-------+
   Temp C| 0-50  |-40-125|
         +-------+-------+
   RH%   | 20-80 | 0-100 |
         +-------+-------+

            0      1      2      3      4
         +------+------+------+------+------+
   DHT11 |check-| 0    | temp |  0   | RH%  |
         |sum   |      |      |      |      |
         +------+------+------+------+------+
   DHT21 |check-| temp | temp | RH%  | RH%  |
   DHT22 |sum   | LSB  | MSB  | LSB  | MSB  |
   DHT33 |      |      |      |      |      |
   DHT44 |      |      |      |      |      |
         +------+------+------+------+------+
   """
   b0 =  self._code        & 0xff
   b1 = (self._code >>  8) & 0xff
   b2 = (self._code >> 16) & 0xff
   b3 = (self._code >> 24) & 0xff
   b4 = (self._code >> 32) & 0xff

   chksum = (b1 + b2 + b3 + b4) & 0xFF

   if chksum == b0:
      if self._model == DHT11:
         valid, t, h = self._validate_DHT11(b1, b2, b3, b4)
      elif self._model == DHTXX:
         valid, t, h = self._validate_DHTXX(b1, b2, b3, b4)
      else: # AUTO
         # Try DHTXX first.
         valid, t, h = self._validate_DHTXX(b1, b2, b3, b4)
         if not valid:
            # try DHT11.
            valid, t, h = self._validate_DHT11(b1, b2, b3, b4)
      if valid:
         self._temperature = t
         self._humidity = h
```

```
            self._status = DHT_GOOD
         else:
            self._status = DHT_BAD_DATA
      else:
         self._status = DHT_BAD_CHECKSUM
      self._new_data = True

   def _rising_edge(self, gpio, level, tick):
      edge_len = pigpio.tickDiff(self._last_edge_tick, tick)
      self._last_edge_tick = tick
      if edge_len > 10000:
         self._in_code = True
         self._bits = -2
         self._code = 0
      elif self._in_code:
         self._bits += 1
         if self._bits >= 1:
            self._code <<= 1
            if (edge_len >= 60) and (edge_len <= 150):
               if edge_len > 100:
                  # 1 bit
                  self._code += 1
            else:
               # invalid bit
               self._in_code = False
         if self._in_code:
            if self._bits == 40:
               self._decode_dhtxx()
               self._in_code = False

   def _trigger(self):
      self._new_data = False
      self._timestamp = time.time()
      self._status = DHT_TIMEOUT
      self._pi.write(self._gpio, 0)
      if self._model != DHTXX:
         time.sleep(0.018)
      else:
         time.sleep(0.001)
      self._pi.set_mode(self._gpio, pigpio.INPUT)


   def cancel(self):
      """
      """
```

```
      if self._cb_id is not None:
         self._cb_id.cancel()
         self._cb_id = None

   def read(self):
      """
      This triggers a read of the sensor.

      The returned data is a tuple of timestamp, GPIO, status,
      temperature, and humidity.

      The timestamp will be the number of seconds since the epoch
      (start of 1970).

      The status will be one of:
      0 DHT_GOOD (a good reading)
      1 DHT_BAD_CHECKSUM (receieved data failed checksum check)
      2 DHT_BAD_DATA (data receieved had one or more invalid val-
ues)
      3 DHT_TIMEOUT (no response from sensor)
      """
      self._trigger()
      for i in range(5): # timeout after 0.25 seconds.
         time.sleep(0.05)
         if self._new_data:
            break
      datum = self._datum()
      if self._callback is not None:
          self._callback(datum)
      return datum

if __name__== "__main__":
   import sys
   import pigpio
   import DHT
   import mariadb        #added by Ants.Cologne
   import sys       #added by Ants.Cologne

   def callback(data):
      print("{:.3f} {:2d} {} {:3.1f} {:3.1f} *".
         format(data[0], data[1], data[2], data[3], data[4]))

   argc = len(sys.argv) # get number of command line arguments

   if argc < 2:
```

```
      print("Need to specify at least one GPIO")
      exit()

   pi = pigpio.pi()
   if not pi.connected:
      exit()

   #ANTSTATION SQL
   try:
      conn = mariadb.connect(
         user="root",              # We're using root as this
script runs only on localhost
         password="password", # I'm using a different pwd, of
course ;)
         host="127.0.0.1",         # localhost, no access from out-
side
         port=3306,               # same port as from outside
         database="antstation"     # Ants.Cologne: in this db we're
storing our sensor data!
      )
   except mariadb.Error as e:
      print(f"Error connecting to MariaDB Platform: {e}")
      sys.exit(1)

   # Get Cursor
   cur = conn.cursor()
   #print("SQL works")

   # Instantiate a class for each GPIO
   # for testing use a GPIO+100 to mean use the callback
   S = []
   for i in range(1, argc): # ignore first argument which is com-
mand name
      g = int(sys.argv[i])
      if (g >= 100):
         s = DHT.sensor(pi, g-100, callback=callback)
      else:
         s = DHT.sensor(pi, g)
      S.append((g,s)) # store GPIO and class

   while True:
      try:
         for s in S:
            if s[0] >= 100:
               s[1].read() # values displayed by callback
```

```
            else:       # Only this is relevant for ANTSTATION
               d = s[1].read()
               print("{:.3f} {:2d} {} {:3.1f} {:3.1f}".
                  format(d[0], d[1], d[2], d[3], d[4]))
               if d[2] == 0:         # We only write to db if sen-
sor data was OK
                  try:
                     cur.execute(
                        "INSERT INTO raw_data
(temp,hygro,sensor_id) VALUES (?,?,?)",
                         (d[3],d[4],d[1]))
                     print("Data written to database. Sensor: " +
str(d[1]))
                  except mariadb.Error as e:
                     print(f"error: {e}")

                  conn.commit()
         #time.sleep(2)     #commented out as we're not using the
infinite-loop here (which will be done by CRON)
         break             #added to leave the while-loop
      except KeyboardInterrupt:
         break
   # Close SQL connection
   conn.close()

   for s in S:
      s[1].cancel()
      #print("cancelling {}".format(s[0]))        #removed
   pi.stop()
```