Tutorial 3: Automatic Entrance Door

1. Introduction

1.1 What Am I Learning Here, and Why?

In this tutorial you will learn how an automatic entrance door, triggered by an electronic key card or fob, can be installed as an entrance door in a home. Additionally, you will also learn how to install a motion sensor which will instruct you to present your fob to open the entrance door.

The automatic entrance door is accomplished by having the door connected to a motor which is triggered by a reader device which sends a signal to open the door when presented with a specifically programmed key card. Through these mechanisms and specific computer coding, an automatic entrance door can serve a user with ease. An installation such as this can be very helpful as it simplifies procedures and can save a person time. An automatic entrance door can also have additional security benefits; such as the door automatically closing once the person has entered.

1.2 Learning Objectives

In this tutorial you will learn how to install and use an automatically opening and closing entrance door using a PIR motion sensor, RFID reader, a servo motor and the Raspberry Pi Pico system. The tutorial is based on a scenario where a person approaches an entrance, thus, triggering the motion sensor which instructs them to present their fob. Once the correct fob is presented to the reader, the door will automatically open, granting them access. This is a basic process of how actions, such as opening an entrance, can be done automatically through a computer system.

After you have completed this tutorial, you will be able to

- o Install and use a PIR motion sensor to detect an oncoming person and instruct them to present a fob to open an entrance door.
- o Install and use an SG-90 Servo Motor to automatically open an entrance door.
- o program an RFID Reader and fob to work as a verification system to operate other mechanisms (such as using a fob as an electric key card to open a door).
- o Install, program, and use a RFID Reader to trigger a SG-90 Servo Motor to automatically open an entrance door.
- o demonstrate an automatic entrance door system on the SmartHome4Senior wooden house model.

1.3 What Do I Need?

Software

To successfully carry out the installations shown in this tutorial you must have downloaded the Thonny computer programme on your computer (p. 13). It is recommended that your computer has Windows 11, or a more recent Windows operating system. To achieve this task, you must also have installed the Micro Python firmware on your Raspberry Pi Pico system (p. 14). Instructions can be found in the SmartHome4Seniors manual.

Electrical Hardware

- 1 x Raspberry Pi Pico

- 1 x Full sized breadboard
- 1 X micro-USB cable
- 1 x MB-102 power module
- 6 x AA Batteries
- 1 x SG-90 Servo Motor
- 1 x PIR Motion sensor
- 1 x RFID RC522 module
- 1 x RFID tag
- 10 x Male-to-male jumper wires
- 11 x Male-to-female jumper wires

To attach components at **SmartHome4Seniors house model**, you will need:

- 2 x M2 metal screws
- 2 x M2 metal nuts
- 2 x wood screws
- 2 x metal screws that come with the SG90 servo motor
- 1 x Phillips screw driver

Ability

Only basic physical abilities are needed; including being able to count holes (on the breadboard), insert components and wires, and be able to attach components to the SmartHome4Seniors kit's wooden model house.

2. Learning Content

2.1 Theoretical Background

In this section you will learn of what exactly you are installing, programming and controlling via the actions you take throughout this tutorial.
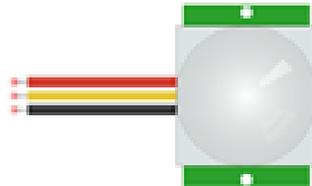
SG-90 Servo Motor:

A servo motor receives a control signal that represents the desired position or speed, and utilizes a feedback system, typically an encoder, to precisely control and adjust its position or speed to match the input command. The motor's controller compares the actual position or speed of the motor to the input command, and if there is a discrepancy, it generates a corrective signal to adjust the motor's position or speed accordingly, making servo motors highly accurate for positioning tasks. This makes it ideal for tasks such as creating entrances; for example, barriers or garage doors. They are highly functional, operable and can be programmed for specific needs.
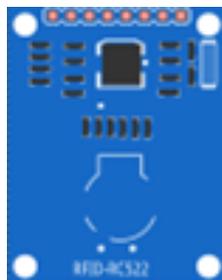
PIR Motion Sensor:

A passive infrared (PIR) sensor is an electronic sensor that measures infrared light radiating from objects in its field of view. When an object or person passes in front of this sensor, which could be stationed on a wall or within an object, it can detect the fluctuation in infrared temperature. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage. This triggers the detection and allows for the sensor to send a signal to the connecting system alerting it of the change. This makes the sensor an ideal trigger for mechanisms which prefer to operate automatically upon approach; for example, entrance doors or hand sanitising stations.

RFID Reader:

Radio frequency identification devices (RFID) are an essential part of many security systems as they work as a personalised electronic lock and key system. Programmes or electronic modules which are to be kept secure are often hidden behind RFID systems. RFID cards act as the 'key', often referred to as a fob, and card readers act as the electronic barrier between the service user and then service secured by the RFID system. RFID cards store a unique identification number that is wirelessly detected by a RFID card reader attached to a wall. If the RFID card's identification number matches an identification number from a stored list of authorized cards, the service or door is unlocked and the cardholder can enter the room.

2.2 Step-by-Step Guide
So let's get started.

Introduction

1. The automatic entrance door is achieved through the amalgamation of the SG-90 Servo Motor tutorial (p. 49), the PIR Motion Sensor tutorial (p. 63) and the RFID Reader (p.65). Before committing to this exercise, it is recommended that you first become familiar with these previous three tutorials. Otherwise, continue to step 2.
2. Gather all needed materials mentioned above to install and programme the automatic entrance door.

3. If not completed already, install the Thonny computer programme on your computer. Furthermore, install the Raspberry Pi Pico firmware. For more information on this see pp. 13-14 of the SmartHome4Seniors manual.
4. Connect the Raspberry Pi Pico Micro controller to the breadboard. Once connected, connect the Raspberry Pi Pico micro controller to your computer/laptop using the USC cable.

2.2.1 Attaching the components to the SmartHome4Seniors House Model

It is assumed that you have already constructed the SmartHome4Seniors wooden house model as you should have completed the previous tutorials.

1. Place the microcontroller and breadboard, and all components attached to it inside the SmartHome4Seniors wooden house model.
   o Remember to keep the wooden house model within reach of your computer/laptop.
   o All wires (male-to-male & male-to-female) can be exchanges for longer or shorter wires if needed. However, remember to install the wires exactly where they were beforehand. Use the installation images shown above as a guide.

2. Install the SG-90 motor (looking from the outside) on the left-hand side of the door entrance.
   o The motor has to be put in place from the inside of the wooden model house. Thereafter, the screws are used to hold it place (screwing from the outside of the house towards the inside).
   o Make sure to place the motor in the correct way; making sure that rotary blade has room to manoeuvre so it can act as an entrance door.
   o Use 2 x M2 metal wood screws to hold the sensor in place

See image(s) below for guidance:

3. Install the PIR Motion Sensor (looking from the outside) above the door entrance.
   - The sensor must be put in place from the outside of the wooden model house. To do this, remove the wires connecting to the sensor, place it within the window above the door with the area where wires connect sticking through the top window.
   - Once in place, reconnect the wires. Make sure to connect them exactly how they were before they were removed. For guidance look and the imagery provided above.
   - Use 2 x M2 metal screws and nuts to hold the sensor in place.
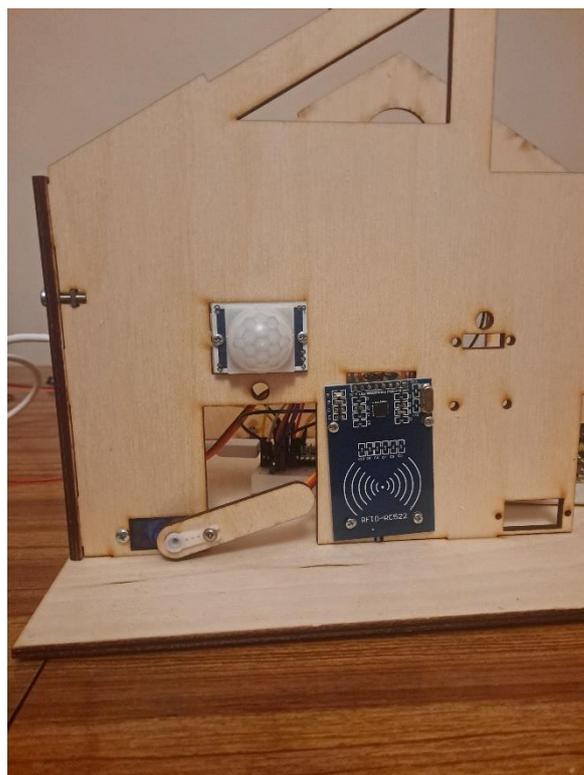
See image(s) below or guidance:

4. Place the RFID reader on the front of the SmartHome4Senior wooden model house.
   - The male-to-female wires will fit through the gap in the wood and extend down to the breadboard within the house model.
   - Use 4 x M2 metal screws and bolts to hold it in position

See image(s) for guidance:

5. Finally, you must create the door by attached the wooden door to the motor.
   o Remove the plastic rotor from the motor.
   o Place the rotor on top of the wooden door
   o Use the wood screws located in the plastic bag holding the motor's spare rotors, screw the plastic rotor into the wood near the tip.
   o Press the rotor, with the wood attached onto the motor again.

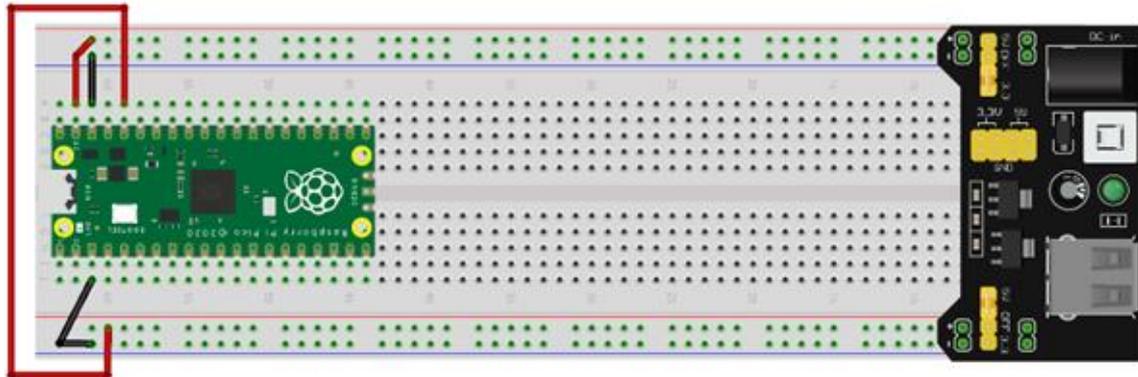See image(s) for guidance:

2.2.2 Preparing the Physical Components

Now, prepare the breadboard with the advanced tutorial setup indicated on p.42 of the SmartHome4Seniors manual.
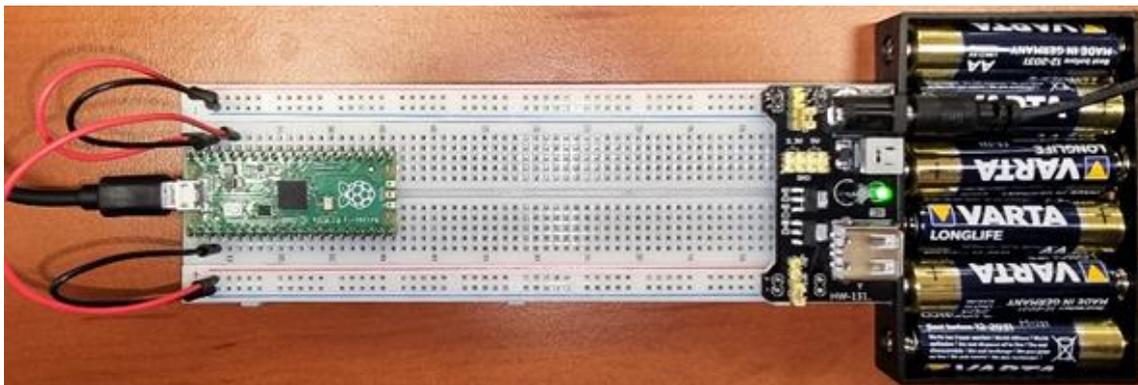
See steps below:

- o Top side connections: VSYS 5V ((+) red) and GND ((-) black)
- o Bottom side connections: 3V3 ((+) red) and GND ((-) black)
- o Place the power supply module on the opposite end to the micro controller.
- o Place 6 AA batteries into the battery holder and connect it to the supply module using the wire attached.

See image(s) below for guidance:

Input the SG-90 Sensor motor first.

- o Connect red cable to 5V rail (+)
- o Connect black/brown cable to GND rail (-)
- o Connect orange cable to GPIO0 pin

Input the PIR Motion Sensor onto the breadboard alongside the SG-90 Sensor Motor's setup.
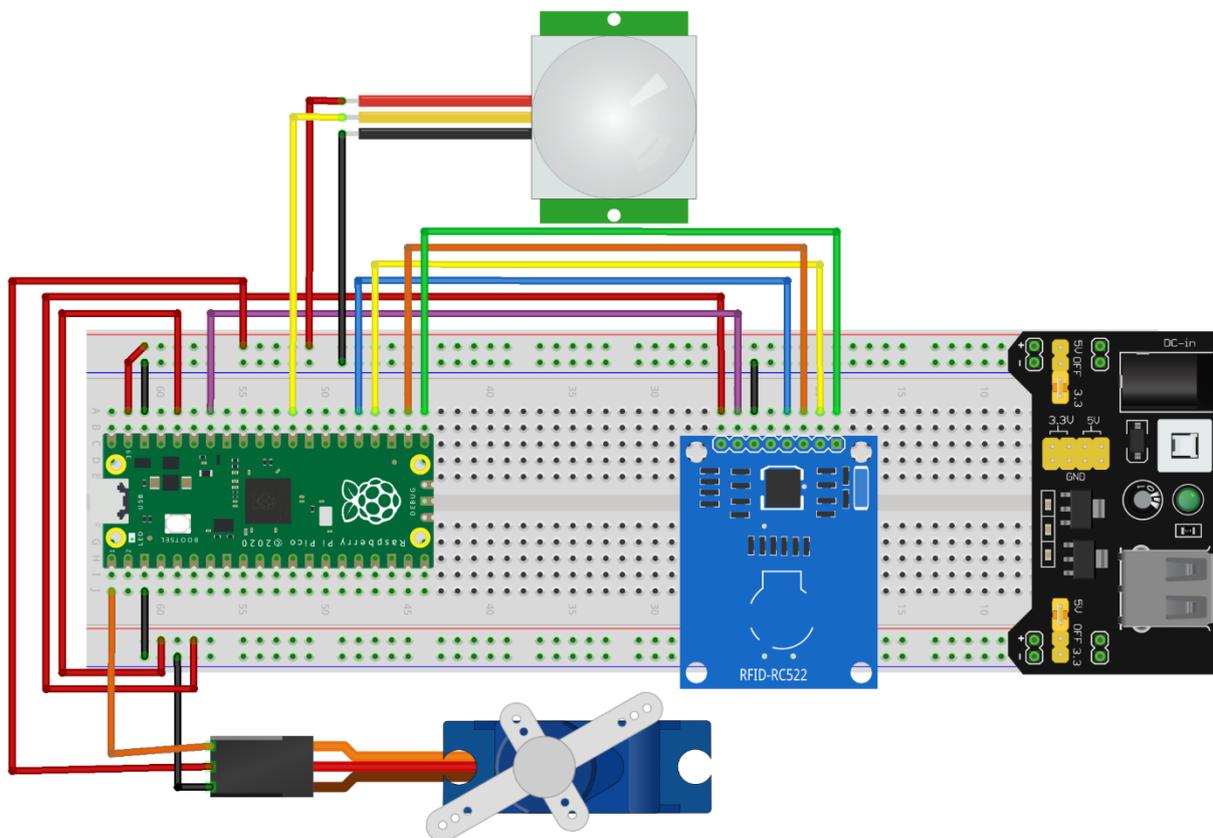
- o Connect VCC (red cable) to 5V rail (+)
- o Connect GND (black cable) to GND rail (-)
- o Connect OUT (yellow cable) to GPIO22 pin.

Input the RFID Reader RC522 onto the breadboard alongside the Servo motor and the PIR motion sensor. As there are a lot of wires, be careful that everything is installed correctly. Be aware that, because the RFID Reader is to be mounted onto the wooden house model, you

will need to use 8 x male-to-female jump wire to connect the RFID Reader to the Breadboard.

- o Connect 3v3 (red cable) to 3v3 rail (+)
- o Connect GND (black cable) to GND rail (-)
- o Connect RST (purple cable) to GPIO28 pin
- o Connect SDA (green cable) to GPIO16 pin
- o Connect SCK (yellow cable) to GPIO18 pin
- o Connect MOSI (orange cable) to GPIO17 pin
- o Connect MISO (blue cable) to GPIO19 pin
- o To allow for the RFID reader to be placed on the house model, you will need to use 8 x male-to-female jump wires connecting the RFID reader to the same points in the breadboard as in the images below

See image(s) below for guidance:

fritzing

2.2.2 Inputting the Code and programming the Components

Before completing this task, you need an additional library that controls the RFID module, namely the MFRC522 library. You will need to install this library to your Raspberry Pi Pico using the "Install Packages" option on the menu of Thonny Python.

You can download it from https://github.com/wendlers/micropython-mfrc522/blob/master/mfrc522.py
- o Download the file and open it in Thonny Python.

    o   Then click File → Save as… choose Raspberry Pi Pico and save your file under the name mfrc522.py.

Then, you need to identity the fob's ID to make the RFID reader to work. To do that you need to create a program that reads the RFID Fob and gives its ID.

    -   Input the code below.

```
from mfrc522 import MFRC522
import utime

PIN_SDA = 16
PIN_SCK = 18
PIN_MOSI = 17
PIN_MISO = 19
PIN_RST = 28

RFID = MFRC522(spi_id=0, sck=PIN_SCK, miso=PIN_MISO, mosi=PIN_MOSI,
cs=PIN_SDA, rst=PIN_RST)

print("Bring RFID FOB closer...")
print("")


while True:
    RFID.init()
    (stat, tag_type) = RFID.request(RFID.REQIDL)
    if stat == RFID.OK:
        (stat, uid) = RFID.SelectTagSN()
        if stat == RFID.OK:
            fob = int.from_bytes(bytes(uid),"little",False)
            print("FOB ID: "+str(fob))
            utime.sleep_ms(500)
```

Click Play and scan the fob. This will give you its ID.

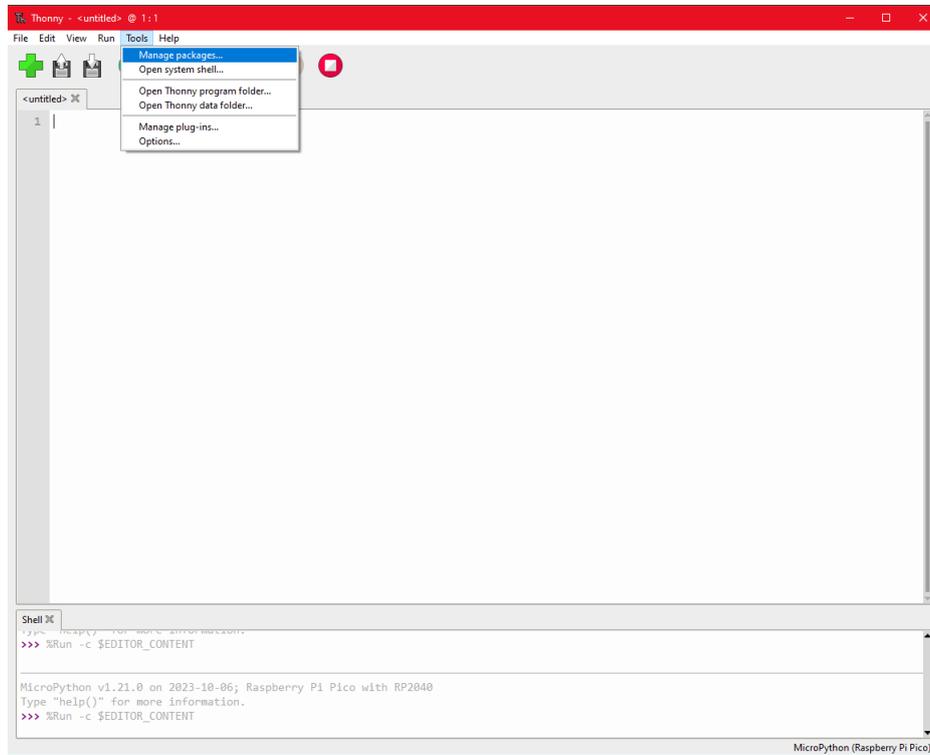   -   **Save the fob ID** as you will need this later.

The tutorial, uses a MicroPython package, called servo.py. You will need to add this package to your Raspberry Pi Pico. Please follow the instructions below.

Since the servo motor operate using the PWM principle, this tutorial makes it easy for you to calculate the correct angle the garage door should open. To do that, first you will need to add a library to your Raspberry Pi Pico.
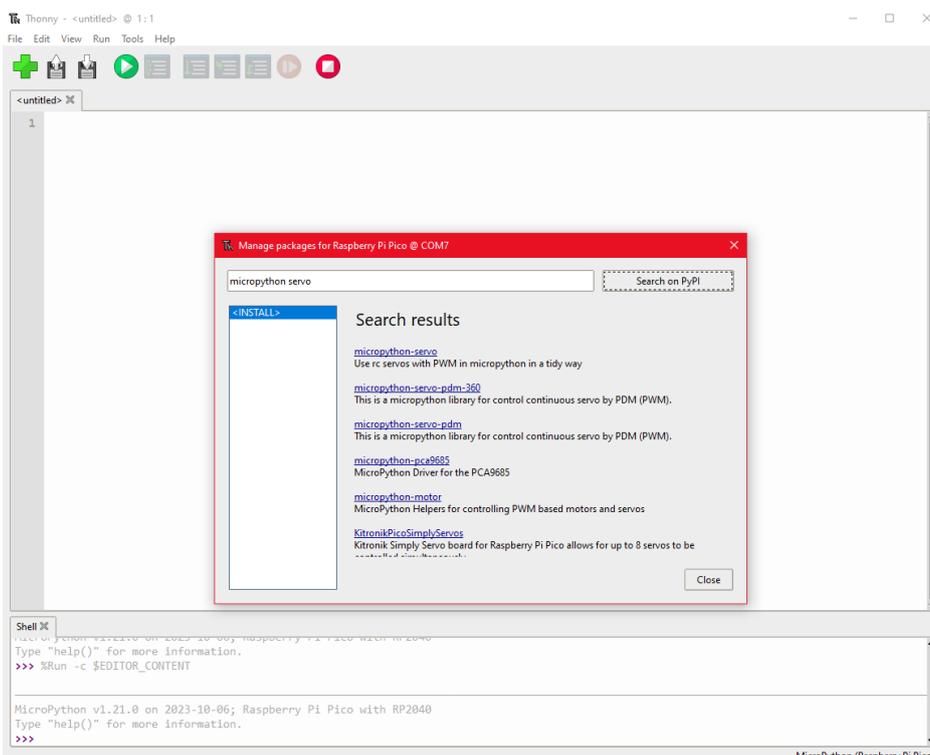
Open Thonny Python and create a new file by clicking File → New or by hitting Ctrl+N on your keyboard.

Then make sure the Raspberry Pi Pico is connected. You should see on the right corner of Thonny's window the message "MicroPython (Raspberry Pi Pico)". If this is not the case, please jump back to the Kit's manual and follow the instructions on how to properly install the firmware.
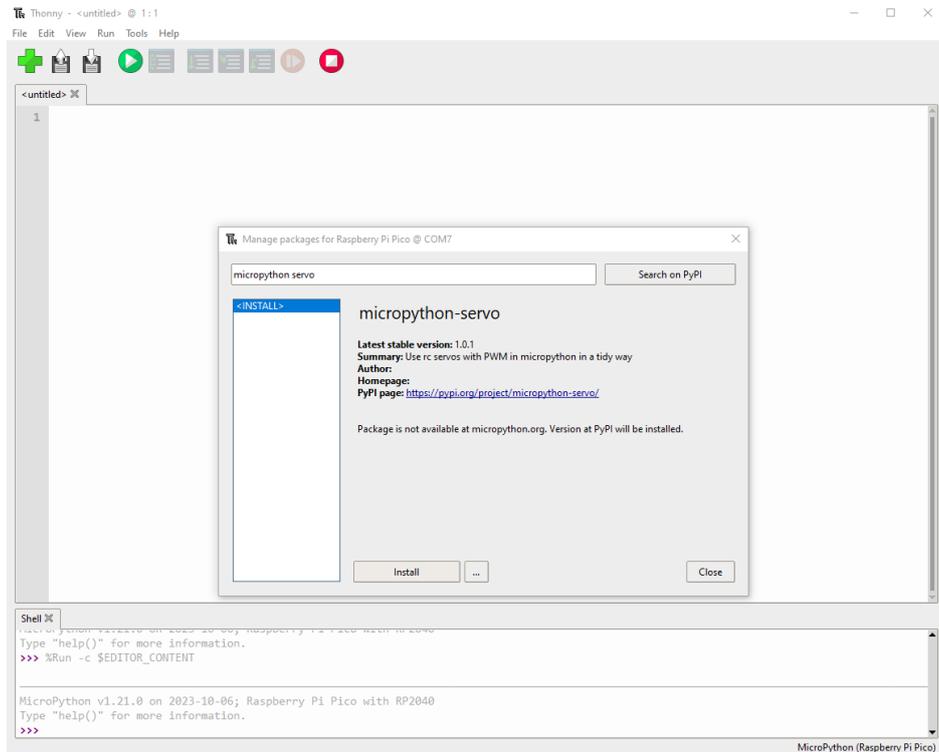
After making sure the Pico is connected, you should click on Tools → Manage packages.

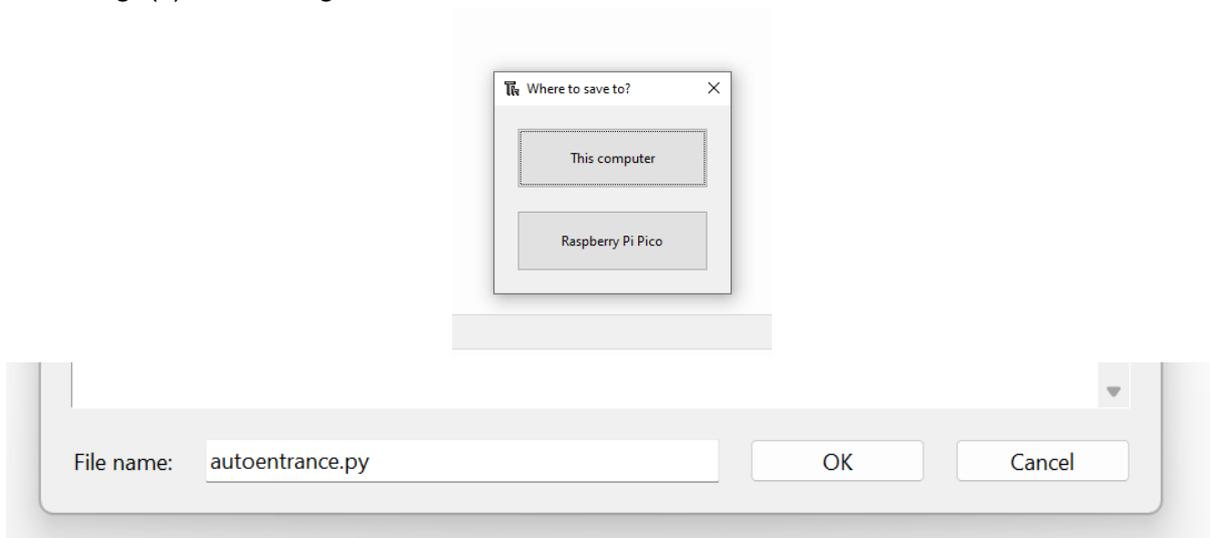On the search bar write "micropython servo" and click Search.

Click on micropython-servo and then click on Install. Wait for installation to complete and then click Close.

5. You are ready to create the automatic entrace door program. Now, On the Thonny computer programme, Open a new file. Then, save file to the Raspberry Pico with the name 'autoentrance.py'.
   o Click the save icon on the top left of the Thonny window or click 'file', followed by 'save', or the CTR+S keys.
   o A window will appear asking "where to save to?". Choose Raspberry Pi Pico.
   o Save filename as 'autoentrance.py'

See image(s) below for guidance.

The coding for this tutorial is an amalgamation of the servo motor, PIR sensor and the RFID reader. Copy and paste the code below, also see the image for guidance.

```python
from machine import Pin
from servo import Servo
from mfrc522 import MFRC522
from time import sleep

#Define pins for each component
PIN_DOOR = 0
PIN_PIR = 22
PIN_SDA = 16
PIN_SCK = 18
PIN_MOSI = 17
PIN_MISO = 19
PIN_RST = 28

#Setup entrance door
door = Pin(PIN_DOOR)
entrance_door = Servo(pin_id=door)
entrance_door.write(120) #number should be adjusted depending on
at what angle you have placed the door on the servo motor
sleep(0.5)

#Setup PIR sensor
PIR = Pin(PIN_PIR, Pin.IN, Pin.PULL_UP)

#Setup RFID Reader RC522
RFID = MFRC522(spi_id=0, sck=PIN_SCK, miso=PIN_MISO,
mosi=PIN_MOSI, cs=PIN_SDA, rst=PIN_RST)

while True:
    if PIR.value() == 1:
        print("Scan your Key!")
        sleep(3)
    if PIR.value() == 0:
        print("")
        sleep(3)

    RFID.init()
    (stat, tag_type) = RFID.request(RFID.REQIDL)
    if stat == RFID.OK:
        (stat, uid) = RFID.SelectTagSN()
        if stat == RFID.OK:
            fob = int.from_bytes(bytes(uid),"little",False)
            if fob == 470550832: #change number to your fob ID
                print("Fob ID: "+ str(fob))
                #enable servo motors
```

```
                entrance_door.write(200) #number should be
adjusted depending on at what angle you have placed the door on
the servo motor
                sleep(5)
                entrance_door.write(125)
            else:
                print("Fob is not accepted")
```

See image(s) for guidance:

```
[ autoentrance.py ] ✖
 1  from machine import Pin
 2  from servo import Servo
 3  from mfrc522 import MFRC522
 4  from time import sleep
 5
 6  #Define pins for each component
 7  PIN_DOOR = 0
 8  PIN_PIR = 22
 9  PIN_SDA = 17
10  PIN_SCK = 18
11  PIN_MOSI = 19
12  PIN_MISO = 16
13  PIN_RST = 28
14
15  #Setup entrance door
16  door = Pin(PIN_DOOR)
17  entrance_door = Servo(pin_id=door)
18  entrance_door.write(120) #number should be adjusted depending on at what angle you have placed the
19  sleep(0.5)
20
21  #Setup PIR sensor
22  PIR = Pin(PIN_PIR, Pin.IN, Pin.PULL_UP)
23
24  #Setup RFID Reader RC522
25  RFID = MFRC522(spi_id=0, sck=PIN_SCK, miso=PIN_MISO, mosi=PIN_MOSI, cs=PIN_SDA, rst=PIN_RST)
26
27  while True:
28      if PIR.value() == 1:
29          print("Scan your Key!")
30          sleep(1)
```

```
[ autoentrance.py ] ✖

20
21   #Setup PIR sensor
22   PIR = Pin(PIN_PIR, Pin.IN, Pin.PULL_UP)
23
24   #Setup RFID Reader RC522
25   RFID = MFRC522(spi_id=0, sck=PIN_SCK, miso=PIN_MISO, mosi=PIN_MOSI, cs=PIN_SDA, rst=PIN_RST)
26
27   while True:
28       if PIR.value() == 1:
29           print("Scan your Key!")
30           sleep(1)
31       if PIR.value() == 0:
32           print("")
33           sleep(1)
34
35       reader.init()
36       (stat, tag_type) = reader.request(reader.REQIDL)
37       if stat == reader.OK:
38           (stat, uid) = reader.SelectTagSN()
39           if stat == reader.OK:
40               fob = int.from_bytes(bytes(uid),"little",False)
41
42               if fob == 481642800: #change number to your fob ID
43                   print("Fob ID: "+ str(fob))
44                   #enable servo motors
45                   entrance_door.write(200) #number should be adjusted depending on at what angle you
46                   sleep(3)
47               else:
48                   print("Fob is not accepted")
49
```

The code contains information to detect motion (PIR value is 1) and if so it prints a message instructing the user to scan their key and then waits for 1 second. Next, the code starts the RFID reader checking if it reads and RFID card. If so it compares the ID with a specific number and opens the door using the servo motor installation if the numbers match.

2.2.3 Application
You have now completed installing an automatic entrance door on the SmartHome4Seniors house model.

If you try this now by clicking "run" / play button, the following should happen: The PIR motion sensor should detect when something or someone approaching the entrance door. Then, upon placing the fob on the RFID Reader the motor should rotate.

3. Summary
In this tutorial you have learned one way that an automatic entrance door could be installed and programmed in a home using some basic components and computer programming. These components were the PIR Sensor, the SG-90 Motor and the RFID Reader. You have achieved the following:

- o Successfully inputted all the components and wires into the breadboard.
- o Successfully programmed the 3 components two work together using Micro Python through the Thonny computer programme.
- o Successfully demonstrated how an automatic entrance door on the SmartHome4Seniors wooden house model.

Now that you have completed the tutorial, you should have a better understanding of all the mechanisms that work together to serve a user in their home.

References

SmartHome4Seniors Kit Manual (2023)