

The BeagleY-AI Handbook

A Practical Guide to AI, Python,
and Hardware Projects



More than
50
projects
inside!



beagleboard.org

Dogan Ibrahim
Ahmet Ibrahim

The BeagleY-AI Handbook

A Practical Guide to AI, Python, and Hardware Projects



Dr. Dogan Ibrahim
Ahmet Ibrahim BSc, MSc



-
- This is an Elektor Publication. Elektor is the media brand of Elektor International Media B.V.
PO Box 11, NL-6114-ZG Susteren, The Netherlands
Phone: +31 46 4389444
 - All rights reserved. No part of this book may be reproduced in any material form, including photocopying, or storing in any medium by electronic means and whether or not transiently or incidentally to some other use of this publication, without the written permission of the copyright holder except in accordance with the provisions of the Copyright Designs and Patents Act 1988 or under the terms of a licence issued by the Copyright Licensing Agency Ltd., 90 Tottenham Court Road, London, England W1P 9HE. Applications for the copyright holder's permission to reproduce any part of the publication should be addressed to the publishers.

● **Declaration**

The author and publisher have made every effort to ensure the accuracy of the information contained in this book. They do not assume, or hereby disclaim, any liability to any party for any loss or damage caused by errors or omissions in this book, whether such errors or omissions result from negligence, accident, or any other cause.

● **ISBN 978-3-89576-656-5** Print

ISBN 978-3-89576-657-2 eBook

● © Copyright 2025 Elektor International Media

www.elektor.com

Editor: Glauçileine Vieira

Prepress Production: D-Vision, Julian van den Berg

Printers: Ipkamp, Enschede, The Netherlands

Elektor is the world's leading source of essential technical information and electronics products for pro engineers, electronics designers, and the companies seeking to engage them. Each day, our international team develops and delivers high-quality content - via a variety of media channels (including magazines, video, digital media, and social media) in several languages - relating to electronics design and DIY electronics. www.elektormagazine.com

Contents

Chapter 1 • Introduction	11
1.1 The BeagleY-AI Single Board Computer (SBC).....	11
1.2 BeagleY-AI Features.....	11
1.3 BeagleY-AI Board Component Layout.....	12
1.4 Comparison with the Raspberry Pi 5	14
1.5 Pros and Cons.....	15
Chapter 2 • Installing the Operating System.....	17
2.1 Overview	17
2.2 The Installation of the Operating System	17
2.3 Connection to a Wi-Fi.....	20
2.4 Accessing Your BeagleY-AI Console from Your PC – The PuTTY Program	22
2.4.1 Configuring PuTTY.....	24
2.5 BeagleY-AI CPU Temperature	25
Chapter 3 • Using the Console Commands.....	27
3.1 Overview	27
3.2 The Command Prompt	27
3.3 Useful Console Commands	27
3.3.1 System and user information	27
3.3.2 Some useful commands.....	30
3.3.3 Resource monitoring on BeagleY-AI.....	39
3.3.4 Shutting Down	41
3.3.5 Networking	42
3.3.6 System information and other useful commands	43
Chapter 4 • GUI Desktop Applications	45
4.1 Overview	45
4.2 The GUI Desktop	45
4.2.1 Applications Menu.....	45
Chapter 5 • Using a Text Editor in Console Mode.....	57
5.1 Overview	57
5.2 The nano Text Editor	57

5.3 The vi Text Editor	62
5.4 Using Thonny	65
5.4.1 The Thonny IDE	65
5.5 The gedit Text Editor	66
5.5.1 Using gedit	66
Chapter 6 • Creating and Running a Python Program	68
6.1 Overview	68
6.2 Method 1 – Interactively from Command Prompt in Console Mode.	68
6.3 Method 2 – Create a Python File in Console Mode	68
6.4 Method 3 – Create a Python File in GUI Desktop Mode.	69
6.5 Which Method?	70
Chapter 7 • Python Programming and Simple Programs.	71
7.1 Overview	71
7.2 Variable Names	71
7.3 Reserved Words	71
7.4 Comments	72
7.5 Line Continuation	72
7.6 Blank Lines	72
7.7 More Than One statement on a Line	72
7.8 Indentation.	73
7.9 Python Data Types.	73
7.10 Numbers.	73
7.11 Strings	77
7.11.1 String functions	78
7.11.2 Escape sequences	79
7.12 Print Statement.	80
7.13 List Variables.	80
7.13.1 List functions	81
7.14 Tuple Variables	82
7.15 Dictionary Variables	83
7.15.1 Dictionary functions	83
7.16 Keyboard Input	83

7.17 Comparison Operators	84
7.18 Logical Operators.	84
7.19 Assignment Operators	84
7.20 Control of Flow	85
7.20.1 The if, if..else, and elif	85
7.20.2 The for statement.	86
7.20.3 The while statement	87
7.20.4 The continue statement.	88
7.20.5 The break statement.	88
7.20.6 The pass statement.	89
7.21 Example 1 – 4 Band Resistor Color Code Identifier.	89
7.22 Example 2 – Series or Parallel Resistors	91
7.23 Example 3 - Resistive Potential Divider.	93
7.24 Trigonometric Functions	96
7.25 User Defined Functions.	96
7.26 Examples	100
7.27 Recursive Functions	111
7.28 Exceptions	111
7.29 try/final Exceptions	114
7.30 Date and Time.	115
7.31 Creating Your Own Modules.	116
Chapter 8 • BeagleY-AI LED Projects.	120
8.1 Overview	120
8.2 BeagleY-AI GPIO pin Definitions	120
8.3 Project 1 – Flashing an LED	121
8.4 Project 2 – Alternately Flashing LEDs.	125
8.5 Project 3 – Binary Counting with 8 LEDs.	127
8.6 Project 4 – Christmas Lights (Random Flashing 8 LEDs)	133
8.7 Project 5 – Chasing LEDs	135
8.8 Project 6 – Rotating LEDs with Pushbutton Switch.	137
8.9 Project 7 – Morse Code Exerciser with LED or Buzzer.	140
8.10 Project 8 – Electronic Dice	145

8.11 Project 9 – Varying the LED Flashing Rate	149
Chapter 9 • Using an I²C LCD	152
9.1 Overview	152
9.2 The I ² C Bus	152
9.3 I ² C Pins of BeagleY-AI	153
9.4 Project 1 – Using an I ² C LCD – Seconds Counter	154
9.5 Project 2 – Using an I ² C LCD – Display Time	158
9.6 Project 3 – Using an I ² C LCD – Display the IP address of BeagleY-AI	160
9.7 Project 4 – Reaction Timer – Output to Screen	161
9.8 Project 5 – Reaction Timer – Output to LCD	163
9.9 Project 6 – Automatic Dusk Lights	166
9.10 Project 7 – Ultrasonic Distance Measurement	168
9.11 Project 8 – Car Parking Sensors	172
Chapter 10 • Plotting Graphs With Python and BeagleY-AI	176
10.1 Overview	176
10.2 The Matplotlib Graph Plotting Library	176
10.3 Project 1 – RC Transient Circuit Analysis - Charging	190
10.4 Project 2 – RC Transient Circuit Analysis - Discharging	193
10.5 Transient RL Circuits	195
10.6 Project 3 – RCL Transient Circuit Analysis	196
10.7 Project 4 – Temperature, Pressure, and Humidity Measurement – Display on the Screen	200
10.8 Project 5 – Temperature, Pressure, and Humidity Measurement – Plotting the Data	203
Chapter 11 • Using a 4 x 4 Keypad	206
11.1 Overview	206
11.2 Project 1 – Using a 4x4 Keypad	206
11.3 Project 2 – Security Lock with Keypad and LCD	214
Chapter 12 • I²C, SPI Bus, and PWM Projects	217
12.1 Overview	217
12.2 Project 1 - I ² C Port Expander	217
12.3 Project 2 - SPI ADC - Voltmeter	220
12.3.1 The SPI bus	221

12.4 Project 3 – Voltmeter – Output to LCD	227
12.5 Project 4 – Analog Temperature Sensor Thermometer – Output to the Screen	230
12.6 Project 5 – Analog Temperature Sensor Thermometer – Output on LCD	232
12.7 Using a Digital to Analog Converter (DAC)	235
12.7.1 The MCP4921 DAC	235
12.7.2 Project 6 - Generating square wave signal with any peak voltage up to +3.3 V.	236
12.7.3 Project 7 - Generating sawtooth wave signal	240
12.7.4 Project 8 - Generating triangle wave signal	242
12.7.5 Project 9 - Generating arbitrary wave signal.	244
12.7.6 Project 10 - Generating sine wave signal	247
12.7.7 Project 11 – SPI Port Expander.	251
12.8 Pulse Width Modulation (PWM)	256
12.8.1 PWM channels of BeagleY-AI	258
12.8.2 Project 12 – Generate 1000Hz PWM waveform with 50% duty cycle	258
12.8.3 Project 13 – Changing the brightness of an LED	261
12.8.4 Project 14 – Mosquito repeller	262
Chapter 13 • Communication Over the Wi-Fi.	265
13.1 Overview	265
13.2 UDP and TCP.	265
13.2.1 UDP communication	266
13.2.2 TCP communication.	266
13.3 Project 1 – Sending a Text Message to a Smartphone Using TCP	267
13.4 Project 2 – Two-way Communication with the Smartphone Using TCP	271
13.5 Project 3 – Communicating with a PC Using TCP.	273
13.6 Project 4 – Controlling an LED Connected to BeagleY-AI from a Smartphone Using TCP	276
13.7 Project 5 – Sending a Text Message to a Smartphone Using UDP.	278
13.8 Project 6 – Controlling an LED Connected to BeagleY-AI from a Smartphone Using UDP	281
13.9 Communicating with the Raspberry Pi Pico W over Wi-Fi.	283
13.9.1 Project 7 – BeagleY-AI and Raspberry Pi Pico W communication – controlling a relay over Wi-Fi	286

13.10 Project 8 - Storing Ambient Temperature and Atmospheric Pressure Data on the Cloud	289
13.11 Using Flask to Create a Web Server to Control BeagleY-AI GPIO Ports from the Internet	297
13.12 Project 9 – Web Server - Controlling an LED Connected to BeagleY-AI Using the Flask	300
Chapter 14 • Using Serial Communication	303
14.1 Overview	303
14.2 USB – TTL Serial Conversion Modules.	304
14.3 BeagleY-AI and PC Communication Over Serial Port – Testing the Hardware and Software Configurations.	306
14.4 Project 1 – BeagleY-AI – PC Two-Way Communication Over Serial Port – Using Python	308
14.5 Reading Geographical Coordinates – Using a GPS	311
14.5.1 Project 2 – Displaying geographical coordinates on the monitor	312
14.5.2 Project 3 – Displaying geographical coordinates on LCD.	317
14.5.3 Project 4 – BeagleY-AI – Raspberry Pi 4 communication over a serial link	321
Chapter 15 • Real Time Clock (RTC)	325
15.1 Overview	325
15.2 The Hardware	325
15.3 Setting the RTC Time	326
Chapter 16 • Artificial Intelligence (AI) with the BeagleY-AI	327
16.1 Overview	327
16.2 BeagleY-AI Detailed Hardware Specifications.	327
16.3 Project 1 - BeagleY-AI TensorFlow Lite Object Detection	328
16.4 BeagleY-AI ChatGPT	335
16.5 BeagleY-AI Smart Assistant.	335
16.6 BeagleY-AI Robotics	336
16.7 BeagleY-AI Machine Learning	336
Chapter 17 • Useful Websites	337
Index	338