

elektor

树莓派 高级编程

(影印版)

RASPBERRY PI : Advanced Programming

Dogan Ibrahim 著



东南大学出版社
SOUTHEAST UNIVERSITY PRESS

树莓派高级编程(影印版)

Dogan Ibrahim 著

南京 东南大学出版社

图书在版编目(CIP)数据

树莓派高级编程:英文/(英)易卜拉欣(Ibrahim, D.)著. —影印本. —南京:东南大学出版社,2015.9

书名原文:RASPBERRY PI: Advanced Programming

ISBN 978-7-5641-5979-5

I. ①树… II. ①易… III. ①软件工具—程序设计—英文 IV. ①TP311.56

中国版本图书馆 CIP 数据核字(2015)第 198130 号

© 2014 by Elektor International Media BV

Reprint of the English Edition, jointly published by Elektor International Media BV and Southeast University Press, 2015. Authorized reprint of the original English edition, 2015 Elektor International Media BV, the owner of all rights to publish and sell the same.

All rights reserved including the rights of reproduction in whole or in part in any form.

英文原版由 Elektor International Media BV 出版 2014。

英文影印版由东南大学出版社出版 2015。此影印版的出版和销售得到出版权和销售权的所有者——Elektor International Media BV 的许可。

版权所有,未得书面许可,本书的任何部分和全部不得以任何形式重制。

树莓派高级编程(影印版)

出版发行:东南大学出版社

地 址:南京四牌楼 2 号 邮编:210096

出 版 人:江建中

网 址:<http://www.seupress.com>

电子邮件:press@seupress.com

印 刷:常州市武进第三印刷有限公司

开 本:787 毫米×980 毫米 16 开本

印 张:22.75

字 数:446 千字

版 次:2015 年 9 月第 1 版

印 次:2015 年 9 月第 1 次印刷

书 号:ISBN 978-7-5641-5979-5

定 价:72.00 元

本社图书若有印装质量问题,请直接与营销部联系。电话(传真):025-83791830

To my wife Nadire, my daughter Alev, and my son Ahmet, for their love and wisdom.

Declaration

The author and publishers have used their best efforts in ensuring the correctness of the information contained in this book. They do not assume, and 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.

Acknowledgements

The following material is reproduced in this book with the kind permission of the respective copyright holders and may not be reprinted, or reproduced in any way without their prior consent.

Figure 9-3 – Figure 9-6, Figure 9-16, Figure 9-17 are taken from the website of Adafruit

Figure 9-8, Figure 9-10 – Figure 9-12 are taken from the website of ModMyPi

Figure 9-9 is taken from the website of PiBorg

Figure 9-13 and Figure 9-14 are taken from the website of Amazon

Figure 9-19 is taken from the website of Kano

Figure 9-20 and Figure 9-21 are taken from AB Electronics (UK)

About the Author

Prof Dr Dogan Ibrahim has a BSc degree in electronic engineering, an MSc degree in automatic control engineering, and a PhD in digital signal processing. Dogan has worked in many industrial organizations before he returned to academic life. He was the head of computer engineering department and the biomedical engineering department at the Near East University in Cyprus. Dogan is the author of over 50 technical books on microcontrollers, microprocessors and related fields. He is a Chartered electrical engineer and a Fellow of the Institution of Engineering Technology.

Table of Contents

Chapter 1 – Introducing the Raspberry Pi 9

1.1 The Raspberry Pi Models 9

1.2 The Anatomy of the Raspberry Pi 10

1.3 Setting Up Your Raspberry Pi 12

1.3.1 Power Supply 12

1.3.2 Monitor 13

1.3.3 TV 14

1.3.4 USB Keyboard and Mouse 14

1.3.5 Powered USB Hub 15

1.3.6 SD Card 16

1.3.7 Speakers 16

1.3.8 Case 16

1.3.9 USB Flash Memory Drive 17

1.3.10 USB Flash Hard Disk 17

1.3.11 USB Wi-Fi Adapter 17

1.4 Connecting Everything Together 17

1.5 Downloading and Installing the Operating System 18

1.5.1 Downloading the Operating System 18

1.5.2 Installing the Operating System onto the SD Card 21

1.6 Logging in to the Raspberry Pi 29

1.7 Summary 30

Chapter 2 – Connecting the Raspberry Pi to Wired Network 31

2.1 Connecting to a Wired Network 31

2.1.1 Unable to Connect to a Wired Network 32

2.2 Connecting to your Raspberry Pi Remotely 33

2.2.1 The SSH Client 33

2.3 Summary 36

Chapter 3 – Using the Desktop 37

3.1 Installing the VNC Software 37

3.2 The Desktop Environment 40

3.3 The Task Bar 41

3.4 The Start Menu 42

3.5 Using External USB Flash Memory Drive 43

3.6 Using Wi-Fi With Raspberry Pi 44

3.7 Summary 46

RASPBERRY PI® - Advanced Programming

Chapter 4 – Using the Linux Command Line	47
4.1 The Command Prompt	47
4.2 Useful Linux Commands	47
4.2.1 The Directory Structure.	47
4.2.2 Command Examples	48
4.3 Screen Capture	60
4.4 Foreground and Background Processing	61
4.5 Task Scheduling	62
4.5.1 Task Scheduling Management	66
4.6 Linux Script Files	67
4.6.1 User input to script files.	68
4.6.2 Reading text from the keyboard	69
4.6.3 Conditions in script files	70
4.6.4 Loops in script files	70
4.6.5 Multiple decisions – Using the case statement	71
4.6.6 Script functions	72
4.7 Running a Program or Script Automatically on System Startup.	72
4.7.1 Using /etc/rc.local	72
4.7.2 Using crontab.	72
4.7.3 Using /etc/init.d	73
4.8 Resource Monitoring on Raspberry Pi	73
4.9 Adding Users	80
4.10 Removing Users.	82
4.11 Network Printing	82
4.12 Command Aliases	85
4.13 SD Card Backup	86
4.14 Shutting Down	87
4.15 Summary	87
Chapter 5 – Python Programming.	89
5.1 Starting Python	89
5.2 Variable Names.	91
5.3 Reserved Words	91
5.4 Comments	92
5.5 Indentation	92
5.6 Line Continuation	92
5.7 Blank Lines	93
5.8 More Than One Statement on a Line	93
5.9 Python Data Types.	93
5.9.1 Numeric Variables	93
5.9.2 String Variables	94
5.9.3 List Variables	96
5.9.4 Tuple Variables	97

5.9.5	Dictionary Variables	97
5.10	Python Operators	98
5.10.1	Arithmetic Operators	98
5.10.2	Comparison Operators	98
5.10.3	Logical Operators	98
5.10.4	Assignment Operators	99
5.10.5	Bitwise Operators	99
5.11	Control of Flow	100
5.11.1	if, if..else, and elif	100
5.11.2	for Statement	101
5.11.3	while Statement	102
5.11.4	continue Statement	103
5.11.5	break Statement	104
5.12	Number Type Conversion	104
5.13	Trigonometric Functions	105
5.14	Mathematical Functions	106
5.15	Integer Random Number Generation	107
5.16	Using Non-printable ASCII Characters	107
5.17	Print Statement	107
5.18	String Manipulation	108
5.19	String Functions	109
5.20	List Functions	110
5.21	Dictionary Functions	111
5.22	Date & Time Functions	112
5.23	User Defined Functions	112
5.24	Keyboard Input	115
5.25	Files	115
5.26	Exceptions	117
5.27	Object Oriented Programming	118
5.28	Example Programs	120
5.28.1	Using the Editor to Create Programs	120
5.29	Argument List	139
5.30	Summary	141
Chapter 6 – Python Graphics User Interface (GUI) Programming		143
6.1	Using the Label Widget	143
6.2	Adding a Button Widget	145
6.3	The Entry Widget	147
6.4	The Text Widget	148
6.5	Prompted Input	150
6.6	Placing Widgets	151
6.6.1	Default packing	151
6.6.2	Packing to a side	152

RASPBERRY PI® - Advanced Programming

6.7	Using the grid() method	153
6.8	The MessageBox Widget.	154
6.9	The Spinbox Widget	156
6.10	The Scale Widget	157
6.11	The Listbox Widget.	158
6.12	The Message Widget	161
6.13	The Radiobutton Widget.	162
6.14	The Checkbutton Widget	164
6.15	The Menubutton Widget.	165
6.16	The Canvas Widget.	167
6.17	Examples.	168
6.18	Summary	175
Chapter 7 – Python Network Programming		177
7.1	Sending E-mail	177
7.2	Web Server Program.	178
7.3	Socket Programming	184
7.4	Summary	189
Chapter 8 – Python Systems Programming		191
8.1	The sys Module	191
8.2	The os Module	192
8.2.1	Running shell commands.	194
8.3	Multitasking	195
8.3.1	Process Forks	195
8.3.2	Process Threads	197
8.3.3	Process spawn calls	201
8.3.4	Multiprocessing process calls.	202
8.3.5	Interprocess synchronisation.	203
8.3.6	Inter-process communication	206
8.4	Summary	212
Chapter 9 – Raspberry Pi Hardware Interfacing.		213
9.1	GPIO Pin Definitions	213
9.2	Raspberry Pi Hardware Development Boards and Hardware Tools	215
9.2.1	Pi Cobbler.	216
9.2.2	PiPlate.	216
9.2.3	T-Cobbler.	217
9.2.4	PiFace	217
9.2.5	RasPiComm – Piggyback Extension Board.	218
9.2.6	PiBorg – TriBorg – GPIO Triple Header Extender.	218
9.2.7	Gertboard.	219
9.2.8	BerryClip – LED and Buzzer	219
9.2.9	MyPi – Push Your Pi -8 LED & 8 Button Breakout Board	220

9.2.10	Raspberry Pi Electronic Starter Kit.	220
9.2.11	Starter Kit-A for Raspberry Pi.	221
9.2.12	Camera Board.	222
9.2.13	Raspi Robot Board	222
9.2.14	LCD with Keypad.	223
9.2.15	Raspberry Pi Expansion Board	223
9.2.16	Raspberry Pi Kano Starter Kit.	224
9.2.17	RTC Pi	224
9.2.18	ADC Pi.	225
9.3	Summary	226
Chapter 10 – Raspberry Pi GPIO Software		227
10.1	Installing the RPiGPIO Library.	227
10.2	RPiGPIO Library Functions.	227
10.2.1	Pin Numbering	227
10.2.2	Channel(I/O pin) Configuration	228
10.3	Wiringpi Library	230
10.4	Program Development	231
10.4.1	Using the Program Description Language and Flow Charts	232
10.4.2	Calling Subprograms.	235
10.4.3	Subprogram Structure	236
10.5	Examples.	237
10.6	Representing <i>for</i> Loops in Flow Charts	242
10.7	Summary	245
Chapter 11 – Raspberry Pi Hardware Projects		247
11.1	PROJECT 1 – Flashing an LED	247
11.2	PROJECT 2 – Independently Flashing 3 LEDs	254
11.3	PROJECT 3 – Independently Flashing 3 LEDs With Event Flags.	256
11.4	PROJECT 4 – Flashing LED With Push-Button Switch - Multitasking	257
11.5	PROJECT 5 – LED with Graphical User Input	260
11.6	PROJECT 6 – Web Server LED Control	261
11.7	PROJECT 7 – Web Server Using <i>flask</i>	264
11.8	PROJECT 8 – GUI Based Light Dimmer.	267
11.9	PROJECT 9 – Using 4x4 Keypad	270
11.10	PROJECT 10 – Calculator Using 4x4 Keypad	274
11.11	PROJECT 11 – Displaying the Temperature	275
11.12	PROJECT 12 – Sending the Temperature to a PC Over the Network.	278
11.13	PROJECT 13 – Temperature and Humidity Display	281
11.14	PROJECT 14 – Using DAC to Change LED Brightness.	288
11.15	PROJECT 15 – The PiFace I/O Board.	294
11.16	PROJECT 16 – PiFace DC Motor Controller.	301
11.17	PROJECT 17 – PiFace Stepper Motor Controller	303

RASPBERRY PI® - Advanced Programming

Appendix A. PDL and Program Listings	311
A.1 Program listing - Solution 5.3	311
A.2 PDL listing - PROJECT 2.	312
A.3 Program Listing - PROJECT 2.	313
A.4 Program Listing - PROJECT 2 - Modified Listing	315
A.5 PDL Listing - Project 3	317
A.6 Program Listing - Project 3	318
A.7 Program Listing - Project 4	320
A.8 Program Listing - Project 4 - Modified.	322
A.9 PDL Listing - Project 5	324
A.10 Program List - Project 5	325
A.11 Program Listing - Project 9	326
A.12 PDL Listing - Project 10	328
A.13 Program Listing - Project 10	329
A.14 Program Listing - Project 11	332
A.15 Program Listing - Project 11 - Modified.	334
A.16 PDL Listing - Project 12	336
A.17 UDP Server Program - Project 12	337
A.18 PDL Listing - Project 13	339
A.19 Program Listing - Project 13	340
A.20 Program Listing - Project 14	344
A.21 Program Listing - Project 15 - PIFACE-1.py.	346
A.22 Program Listing - Project 15 - PIFACE-2.py	347
A.23 Program Listing - Project 15 - PIFACE-3.py	348
A.24 Program Listing - Project 16	349
Index	351

Table of Contents

Chapter 1 – Introducing the Raspberry Pi 9

1.1 The Raspberry Pi Models 9

1.2 The Anatomy of the Raspberry Pi 10

1.3 Setting Up Your Raspberry Pi 12

1.3.1 Power Supply 12

1.3.2 Monitor 13

1.3.3 TV 14

1.3.4 USB Keyboard and Mouse 14

1.3.5 Powered USB Hub 15

1.3.6 SD Card 16

1.3.7 Speakers 16

1.3.8 Case 16

1.3.9 USB Flash Memory Drive 17

1.3.10 USB Flash Hard Disk 17

1.3.11 USB Wi-Fi Adapter 17

1.4 Connecting Everything Together 17

1.5 Downloading and Installing the Operating System 18

1.5.1 Downloading the Operating System 18

1.5.2 Installing the Operating System onto the SD Card 21

1.6 Logging in to the Raspberry Pi 29

1.7 Summary 30

Chapter 2 – Connecting the Raspberry Pi to Wired Network 31

2.1 Connecting to a Wired Network 31

2.1.1 Unable to Connect to a Wired Network 32

2.2 Connecting to your Raspberry Pi Remotely 33

2.2.1 The SSH Client 33

2.3 Summary 36

Chapter 3 – Using the Desktop 37

3.1 Installing the VNC Software 37

3.2 The Desktop Environment 40

3.3 The Task Bar 41

3.4 The Start Menu 42

3.5 Using External USB Flash Memory Drive 43

3.6 Using Wi-Fi With Raspberry Pi 44

3.7 Summary 46

RASPBERRY PI® - Advanced Programming

Chapter 4 – Using the Linux Command Line	47
4.1 The Command Prompt	47
4.2 Useful Linux Commands	47
4.2.1 The Directory Structure.	47
4.2.2 Command Examples	48
4.3 Screen Capture	60
4.4 Foreground and Background Processing	61
4.5 Task Scheduling	62
4.5.1 Task Scheduling Management	66
4.6 Linux Script Files	67
4.6.1 User input to script files	68
4.6.2 Reading text from the keyboard	69
4.6.3 Conditions in script files	70
4.6.4 Loops in script files	70
4.6.5 Multiple decisions – Using the case statement	71
4.6.6 Script functions	72
4.7 Running a Program or Script Automatically on System Startup	72
4.7.1 Using /etc/rc.local	72
4.7.2 Using crontab.	72
4.7.3 Using /etc/init.d	73
4.8 Resource Monitoring on Raspberry Pi	73
4.9 Adding Users	80
4.10 Removing Users.	82
4.11 Network Printing	82
4.12 Command Aliases	85
4.13 SD Card Backup	86
4.14 Shutting Down	87
4.15 Summary	87
Chapter 5 – Python Programming.	89
5.1 Starting Python	89
5.2 Variable Names.	91
5.3 Reserved Words	91
5.4 Comments	92
5.5 Indentation	92
5.6 Line Continuation	92
5.7 Blank Lines	93
5.8 More Than One Statement on a Line	93
5.9 Python Data Types.	93
5.9.1 Numeric Variables	93
5.9.2 String Variables	94
5.9.3 List Variables	96
5.9.4 Tuple Variables	97

5.9.5 Dictionary Variables	97
5.10 Python Operators	98
5.10.1 Arithmetic Operators	98
5.10.2 Comparison Operators.	98
5.10.3 Logical Operators.	98
5.10.4 Assignment Operators	99
5.10.5 Bitwise Operators.	99
5.11 Control of Flow	100
5.11.1 if, if..else, and elif	100
5.11.2 for Statement	101
5.11.3 while Statement	102
5.11.4 continue Statement	103
5.11.5 break Statement	104
5.12 Number Type Conversion	104
5.13 Trigonometric Functions	105
5.14 Mathematical Functions	106
5.15 Integer Random Number Generation	107
5.16 Using Non-printable ASCII Characters	107
5.17 Print Statement	107
5.18 String Manipulation	108
5.19 String Functions	109
5.20 List Functions.	110
5.21 Dictionary Functions.	111
5.22 Date & Time Functions	112
5.23 User Defined Functions	112
5.24 Keyboard Input	115
5.25 Files.	115
5.26 Exceptions.	117
5.27 Object Oriented Programming	118
5.28 Example Programs	120
5.28.1 Using the Editor to Create Programs.	120
5.29 Argument List.	139
5.30 Summary	141

Chapter 6 – Python Graphics User Interface (GUI) Programming 143

6.1 Using the Label Widget	143
6.2 Adding a Button Widget	145
6.3 The Entry Widget	147
6.4 The Text Widget	148
6.5 Prompted Input	150
6.6 Placing Widgets	151
6.6.1 Default packing	151
6.6.2 Packing to a side	152

RASPBERRY PI® - Advanced Programming

6.7	Using the grid() method	153
6.8	The MessageBox Widget.	154
6.9	The Spinbox Widget	156
6.10	The Scale Widget	157
6.11	The Listbox Widget.	158
6.12	The Message Widget	161
6.13	The Radiobutton Widget.	162
6.14	The Checkbutton Widget	164
6.15	The Menubutton Widget.	165
6.16	The Canvas Widget	167
6.17	Examples.	168
6.18	Summary	175
Chapter 7 – Python Network Programming		177
7.1	Sending E-mail	177
7.2	Web Server Program.	178
7.3	Socket Programming	184
7.4	Summary	189
Chapter 8 – Python Systems Programming		191
8.1	The sys Module.	191
8.2	The os Module	192
8.2.1	Running shell commands.	194
8.3	Multitasking	195
8.3.1	Process Forks.	195
8.3.2	Process Threads	197
8.3.3	Process spawn calls	201
8.3.4	Multiprocessing process calls.	202
8.3.5	Interprocess synchronisation.	203
8.3.6	Inter-process communication	206
8.4	Summary	212
Chapter 9 – Raspberry Pi Hardware Interfacing.		213
9.1	GPIO Pin Definitions	213
9.2	Raspberry Pi Hardware Development Boards and Hardware Tools	215
9.2.1	Pi Cobbler.	216
9.2.2	PiPlate.	216
9.2.3	T-Cobbler	217
9.2.4	PiFace	217
9.2.5	RasPiComm – Piggyback Extension Board.	218
9.2.6	PiBorg – TriBorg – GPIO Triple Header Extender.	218
9.2.7	Gertboard.	219
9.2.8	BerryClip – LED and Buzzer	219
9.2.9	MyPi – Push Your Pi -8 LED & 8 Button Breakout Board	220