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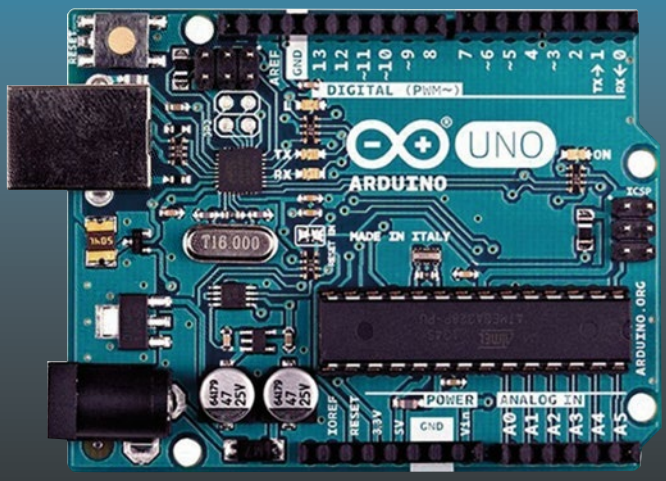

Arduino Programming with .NET and Sketch

Agus Kurniawan

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Contents at a Glance

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About the Author

Agus Kurniawan is a lecturer, IT consultant, and an author. He has 16 years of experience in various software and hardware development projects, delivering materials in training and workshops, and technical writing. He has been awarded the Microsoft Most Valuable Professional (MVP) award 14 years in a row.

He is currently doing some research and also getting involved in teaching activities related to networking and security systems at the Faculty of Computer Science, Universitas Indonesia and Samsung R&D Institute, Indonesia. Currently, he is pursuing a PhD in computer science at the Freie Universität Berlin, Germany. He can be reached on his blog at http://blog.aguskurniawan.net and on Twitter at @agusk2010.

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Fabio Claudio Ferracchiati is a senior consultant and a senior analyst/developer using Microsoft technologies. He works for React Consulting (www.reactconsulting.it). He is a Microsoft Certified Solution Developer for .NET, a Microsoft Certified Application Developer for .NET, a Microsoft Certified Professional, and a prolific author and technical reviewer. Over the past ten years, he's written articles for Italian and international magazines and coauthored more than ten books on a variety of computer topics.

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We would also like to thank the Arduino and .NET communities anywhere in the world for contributing and making learning Arduino programming easy.

Last, but not least, a thank you to my wife, Ela, and my children, Thariq and Zahra, for their great support in completing this book.

Introduction

Arduino is a board development platform with which we can develop an embedded application with several sensor and actuator devices. Arduino is an open source-based hardware. There are many Arduino models that you can use to develop. This book is designed for developers (especially for .NET developers) that want to build Arduino programs for general and specific purposes.

For the Readers

This book assumes you may have previous programming experience. The book is also written for someone who may have developed programs using .NET and wants to develop an embedded program with Arduino boards.

How This Book Is Organized

This book is designed with a step-by-step approach. You will learn how to build Arduino programs using sketch and .NET, and explore Arduino capabilities such as digital and analog I/O processing, serial communication, SPI, and I2C bus.

You will find out how .NET collaborates with sketch programs on Arduino to control sensor and actuator devices remotely. The Internet of Things (IoT) topic is introduced, including its implementation. Finally, a cloud server is used to connect to the Arduino board.

Required Software, Materials, and Equipment

In general, a computer with Windows OS. Windows 10 installed is recommended. You should install Arduino software and Visual Studio on your computer.

You need several Arduino models to implement our demo. Furthermore, you should provide several sensor and actuator devices and several network modules such as WiFi, Bluetooh, GPS, and LoRa.

CHAPTER 1

Introduction to Arduino Boards and Development

Arduino is one of the most famous development boards. You can attach sensor and actuator devices easily into the board. This chapter will explore how to work with Arduino development and prepare for a development machine. To work on this chapter, you should have one of the Arduino board models for implementation.

This chapter covers the following topics:

- Exploring Arduino boards.
- Setting up development.
- Building your first project.
- Sketch programming.
- Arduino programming using Visual Studio.

Exploring Arduino Boards

Arduino is a board development platform with which we can develop an embedded application with several sensor and actuator devices. Arduino is an open source-based hardware. It means we can develop our own Arduino board, but you should not use the Arduino name because it's a trademark. Currently Arduino boards are produced by Arduino LLC (`www.arduino.cc`) and Arduino SRL (`www.arduino.org`). Some Arduino models which are produced by Arduino LLC and Arduino SRL are different.

In general, an Arduino board has several digital and analog I/O pins, which are used to sense and actuate with external devices. In addition, Arduino provides UART, SPI, and I2C protocols. Each Arduino model has unique features and forms. Make sure you don't choose the wrong board model. One of the Arduino board samples can be seen in Figure 1-1.

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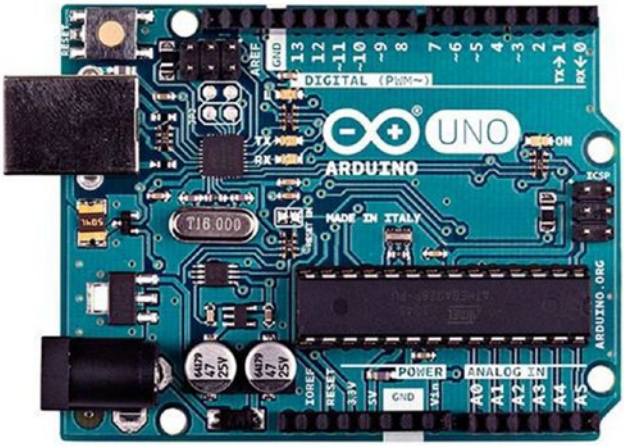

Figure 1-1. *Arduino UNO R3 board*

The advantage of an Arduino board is it's easy to use. You don't need to solder electronics components. An Arduino board is ready to use. You just attach sensor and actuator devices into the board via jumper cables.

In this section, we explore various Arduino boards from Arduino LLC and Arduino SRL. Each Arduino model has unique features. To optimize Arduino board usage, you should know and understand what kind of Arduino model it is. I will introduce various Arduino models based on complexity level and usage range.

Let's start to explore Arduino boards.

Arduino Boards for Beginners

An Arduino UNO board is a development board which I recommend to anyone who wants to learn Arduino programming. There are many Arduino shields which are attached to the board. Furthermore, most tutorials and books use Arduino UNO as an experimental board. Arduino UNO has completed I/O protocols, such as digital and analog I/O, SPI, UART, and I2C/TWI, so you can utilize these I/O pins to work with sensor and actuator devices. Arduino UNO is easier to find and buy.

You can review the Arduino UNO board on this website: https://www.arduino.cc/en/Main/ArduinoBoardUno. You can also review Arduino UNO from Arduino SRL on this site: http://www.arduino.org/products/boards/arduino-uno.

Figure 1-2. *Arduino UNO board from Arduino LLC*

Arduino Boards for Advanced Users

In some cases you want to optimize your board's I/O or want to debug your programs. The Arduino MEGA 2560 board provides more I/O pins (about 54 I/O pins) and advanced MCU to accelerate your program. This board runs on the top of MCU Atmega 2560 with an internal flash memory of 256 KB. The Arduino MEGA 2560 board also has two UARTs. You can review this board on this site: `https://www.arduino.cc/en/Main/ArduinoBoardMega2560`. For Arduino MEGA 2560 from Arduino SRL, you can review it on `http://www.arduino.org/products/boards/arduino-mega-2560`. You can see the Arduino MEGA 2560 board in Figure 1-3.

Figure 1-3. *Arduino MEGA 2560*

Most Arduino boards don't have a built-in debug chip, so if you want to debug our program, you should add an additional debug tool. Fortunately, we can use the Arduino ZERO board (https://www.arduino.cc/en/Main/ArduinoBoardZero) from Arduino LLC and the Arduino M0 PRO board (http://www.arduino.org/products/boards/arduino-m0-pro) from Arduino SRL, which are supported for debugging without additional tools. These boards have Atmel's Embedded Debugger (EDBG) to be used for debugging. I suggest you to use these Arduino models if you have concerns about debugging without additional tools. A form of Arduino Zero board is shown in Figure 1-4.

Figure 1-4. *Arduino ZERO*

Arduino for Internet of Things

Today the Internet is a common term used to describe how to access data from a remote site. We can access the data from any device and anywhere. In the context of Arduino, it's very useful if our boards can be connected to the Internet. Imagine your boards sense the physical object and then send it to our smartphone. This happens if our boards are connected to Internet.

There are many options for Arduino shields for network modules to make our Arduino boards connect to the Internet. This means you should buy additional modules to make your boards connect to the Internet. Fortunately, various Arduino board models have a built-in network module in the board. We explore some Arduino board models with Internet connectivity capability.

Arduino UNO WiFi is an Arduino UNO board with an additional chip (ESP8266). This chip can be used to connect existing WiFi networks and also can work as an access point (AP) node. Arduno UNO WiFi is manufactured by Arduino SRL. You can see the Arduino UNO WiFi form in Figure 1-5. To obtain more information about Arduino UNO WiFi, you can review it on this site: http://www.arduino.org/products/boards/arduino-uno-wifi.

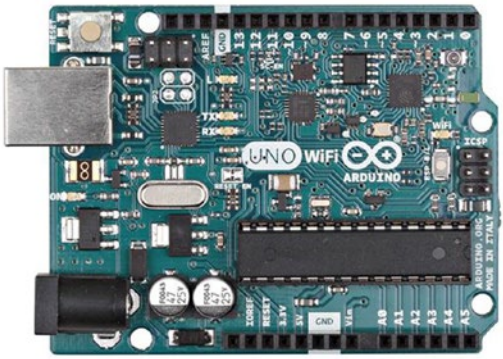

Figure 1-5. *Arduino UNO WiFi*

Arduino/Genuino MKR1000 is a development board with a ready-for-IoT scenario which is manufactured by Arduino LLC. The board runs with ATSAMW25 SoC, which consists of SAMD21 Cortex-M0+, WINC1500 WiFi module, and ECC508 CryptoAuthentication. It's designed for IoT connectivity, including accessing the cloud server. Further information about Arduino/Genuino MKR1000 can be read on `https://www.arduino.cc/en/Main/ArduinoMKR1000`. This board size, which is shown in Figure 1-6, is small.

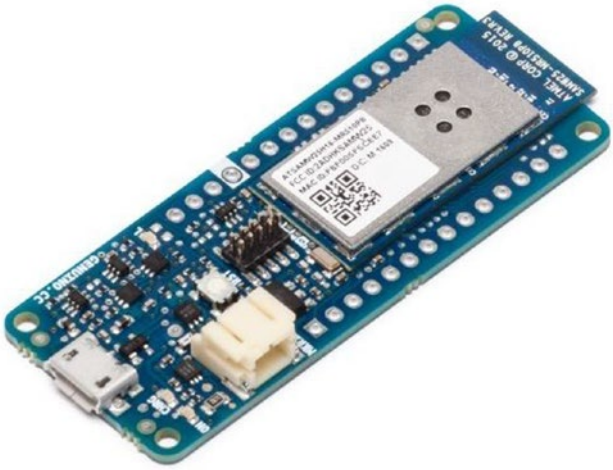

Figure 1-6. *Arduino/Genuino MKR1000*

Most Arduino boards work with an RTOS environment. Arduino YUN combines MCU and WiFi MCU, which runs OpenWrt Linux (called Linino OS). This board likes a mini-computer with Linux OS. You can control Arduino MCU ATmega32u4 from Linux. We also can access Linux API from the Arduino program. The Arduino YUN board has built-in WiFi and Ethernet modules to solve your IoT cases. Figure 1-7 is a form of Arduino YUN. You can review and buy this board on this site: http://www.arduino.org/products/boards/arduino-yun.

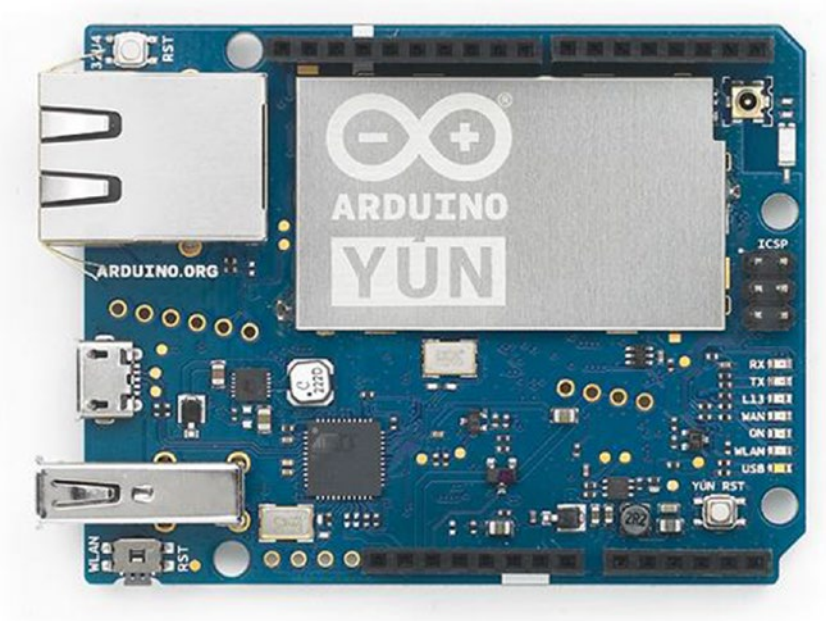

Figure 1-7. *Arduino YUN*

If you're looking for an Arduino with BLE connectivity capability, you can consider using the Arduino/Genuino 101 board, which is shown in Figure 1-8. This board uses Intel Curie as MCU, which has a built-in BLE module. You can control this board through Bluetooth on your smartphone, such as Android and iPhone smartphones. For further information about Arduino/Genuino 101, I recommend reading this website: https://www.arduino.cc/en/Main/ArduinoBoard101.