Presidential Initiative for Artificial Intelligence and Computing (PIAIC)

https://www.piaic.org

Artificial Intelligence of Things (AIoT) Specialist Program

Course Syllabus

Quarter II: IoT-201 Embedded Programming in Rust

Version 1.0.0 - 2020 (12 Weeks)

Teaching Team: Imran Ali, Dr. Gufran Khan, Muhammad Inzamam Malik, Faheem Uz Zaman, Shahrukh Haider, Anas Baig, Zain Ul Abdin, Zobia Kanwal, Ukasha Sohail, Sheikh Hassaan Bin Nadeem, Muhammad Naufil, Muhammad Hammad, Ali Raza Qureshi, Muhammad Rajab Raza, Mohd Jamshaid Tahiri, Muhammad Talha Desai, Muhammad Areeb Siddiqui, Muhammad Ovais, Saif Ali, Kashif Haider Ali, Amir Nakhwa, Mirza Hassan, Muhammad Owais, Muhammad Jawwad, Abdul Rehman Siddiqui, Muhammad Umer, Muhammad Danial Siddiqui, Hanzala Ejaz, Arsalan Nawaz Khan, Syed Hasan Ali, Muhammad Anas, and Gulfam Asif

Class Duration: 4 hours

Course Description: An embedded system is a microcontroller with a dedicated function within a larger mechanical or electrical system, often with real-time computing constraints. It is embedded as part of a complete device often including hardware and mechanical parts. Embedded systems control many devices in common use today. 98% of all microprocessors manufactured are used in embedded systems. Embedded systems are commonly found in consumer, industrial, automotive, medical, commercial and military applications. In this quarter we will learn embedded systems programming using Rust. We will learn how to write, build, flash and debug an "embedded" (Rust) program. Also the functionality ("peripherals") commonly found in microcontrollers: digital input and output, Pulse Width Modulation (PWM), Analog to Digital Converters (ADC), common communication protocols like Serial, I2C and SPI, etc. Multitasking concepts: cooperative vs preemptive multitasking, interrupts, schedulers, etc. Control systems concepts: sensors, calibration, digital filters, actuators, open loop control, closed loop control, etc. We will also learn Git, the distributed version control system.

Please bring a Laptop and STM32F3 Discovery Board with you for the Classes (Required, but not mandatory)

Textbooks:

1. The Embedded Discovery Book: https://docs.rust-embedded.org/discovery/
2.

Reference books:

1. https://rust-embedded.github.io/book/
2. Git Essentials by Ferdinando Santacroce

PIAIC Announcements Facebook Group: https://www.facebook.com/groups/piaic/
Course Facebook Group: https://www.facebook.com/groups/aiot.edu/

Portal for online and onsite students:
https://portal.piaic.org/

Ask Questions:

https://ask.piaic.org/

Chat on Telegram:
Channel Name: PIAIC-IoT
https://t.me/piaic_iot

Facebook Group:
https://www.facebook.com/groups/aiot.edu/

Grading:
Students will be graded based on Percentile
https://en.wikipedia.org/wiki/Percentile
https://en.wikipedia.org/wiki/Percentile_rank

A-Grade: 78 - 99 Percentile
B-Grade: 41 - 77 Percentile
C-Grade: 23 - 40 Percentile
D-Grade: 1 - 22 Percentile
F-Grade: Anyone who doesn't appear in two or more exams

Note: Anyone who receives a F-Grade will be removed from the program. Students who receive a D-Grade will be put on probation, and be required to earn a grade of C or above in the next quarter, to remain in the program. Anyone absent from an exam will be deemed to have received a score of zero.

Important Note:
If a PIAIC candidate doesn't appear in a Quiz at the scheduled time announced by management 10% score will be deducted from the test score for every week of delay.

Course Outline:

Rust book summary, very good source for revision: https://github.com/psibi/rust-book-summary

1. **Fundamentals of Version Control with Git**
   (Videos and reading material available on Student Portal to prepare for Git Quiz, Git will not be covered in class to save class time)
   Chapters 1, 2, 3, and 4 Learn Version Control with Git: A step-by-step course for the complete beginner by Tobias Günther

   We will also covers these readings:
   https://help.github.com/articles/markdown-basics/
   http://stackoverflow.com/questions/5009600/difference-between-fork-and-branch-on-github
   http://stackoverflow.com/questions/3329943/git-branch-fork-fetch-merge-rebase-and-clone-what-are-the-differences
   https://git-scm.com/book/en/v2/Git-Branching-Rebasing
   http://git-scm.com/book/en/v2/Git-Branching-Remote-Branches#Tracking-Branches

   For practice: https://try.github.io/levels/1/challenges/1

   Git Quiz in Week 2
   Total Questions: 50, Total Time: 60 minutes

2. **Advanced Rust Programming** (Weeks 1 to 3)
   Topics 10.1 of https://doc.rust-lang.org/nightly/book/
   https://doc.rust-lang.org/nightly/book/ch10-02-traits.html#traits-as-parameters
   Topics 10.2, 10.3, 13.1, and 16.1 of https://doc.rust-lang.org/nightly/book/

   Final: Advanced Rust Programming Quiz in Week 4

Total Questions: 54, Total Time: 75 minutes

3. **Embedded Rust Programming Part 1** (Week 4 to 6)
   Chapters 1, 5, and 6 of:
   https://docs.rust-embedded.org/discovery/index.html

   https://www.mathsisfun.com/binary-number-system.html

   https://doc.rust-lang.org/std/fmt/trait.Binary.html

   https://www.tutorialspoint.com/rust/rust_bitwise_operators

   https://doc.rust-lang.org/nightly/book/ch19-01-unsafe-rust.html#dereferencing-a-raw-pointer

   Note: Dereferencing a pointer means getting the value that is stored in the memory location pointed by the pointer. The operator * is used to do this, and is called the dereferencing operator.

   https://docs.rust-embedded.org/discovery/07-registers/index.html

   Note: Only topic 7 is included in this quiz; topics 7.1 to 7.5 are not included in this quiz.

   Mid-Term I: Embedded Rust Quiz 1 in Week 7
   Total Questions: 32, Total Time: 50 minutes

4. **Embedded Rust Programming Part 2** (Week 7 to 9)
   Sections 7.1 to 7.5 of:
   https://docs.rust-embedded.org/discovery/index.html

   Chapters 8, 9 and 10 of:
   https://docs.rust-embedded.org/discovery/index.html

   Mid-Term II: Embedded Rust Quiz 2 in Week 10
   Total Questions: 32, Total Time: 50 minutes

5. **Embedded Rust Programming Part 3** (Week 10 to 12)
   Chapters 11, 14, 15, and 16 of:
   https://docs.rust-embedded.org/discovery/index.html

   Final: Embedded Rust Quiz 3 in Week 13
   Total Questions: 32, Total Time: 50 minutes

   Programming Assignments will also be given.

The speed of the class will depend on how much students are able to absorb the material. If some material is left after the end of the second quarter it will be taught in the third quarter but the sequence will remain exactly as above.

Important Notice: In this quarter we will be learning Rust Embedded Programming. In order to practice embedded programming using Rust every student will need to buy an STM32F3 Discovery Board. The F3 boards are in short supply in Pakistan due high demand from our students. Therefore, all students should buy the F3 boards immediately.

The STM32F3 Discovery Board Details:

https://www.st.com/en/evaluation-tools/stm32f3discovery.html

You may order the F3 boards from these or other sources:

https://electronation.pk/product/stm32f3discovery-stm32f3-discovery-kit/
https://www.digikey.com/product-detail/en/stmicroelectronics/STM32F3DISCOVERY/497-13192-ND/3522185

https://www.aliexpress.com/item/1-pcs-x-STM32F3DISCOVERY-Development-Boards-Kits-ARM-STM32F3-Discovery-

32-Bit-ARM-M4-72MHz/32336381671.html