Journal of Computation Physics and Earth Science
ISSN: 2776-2521 (online)
Volume 4, Number 2, October 2024, Page 62 - 68
https://journal.physan.org/index.php/jocpes/index

Implementation of LVGL and LovyanGFX into a Portable Datalogger Embedded System

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Article Info

Article history:

Received August 10, 2024
Revised September 31, 2024
Accepted October 10, 2024

Keywords:

LVGL,
LovyanGFX,
Datalogger,
User Interface,
Microcontroller,
ESP32,
Emvedded Systems.

A B S T R A C T

Integrating a Graphic User Interface (GUI) into an embedded system remains difficult due to hardware limitations and the complexity of graphics programming. This study examines the implementation of LVGL (Light and Versatile Graphics Library) and LovyanGFX to create an efficient and user-friendly interface for portable data logging systems developed with the ESP32-S3 microcontroller. The system is intended to accumulate, process and display environmental data such as the MQ-7 carbon monoxide sensor, DHT21 temperature and moisture sensor, and BME280 temperature and humidity sensor. A structured experimental approach was adopted to evaluate the feasibility and performance of the proposed system. The ESP32-S3 was chosen for its superior memory capacity and wireless communication capabilities, while the ILI9488 TFT screen was selected for real-time data visualization. The research focused on optimizing the GUI for responsiveness, data readability, and user interaction. The results appear that LVGL and LovyanGFX work well together to make an intelligently and valuable GUI that can appear real-time sensor information. This also indicate that LVGL and LovyanGFX effectively render graphical elements, enabling smooth transitions and efficient data representation. Furthermore, the system successfully integrates sensor data, demonstrating its potential for real-time monitoring applications. This study contributes to the development of embedded GUI systems by demonstrating a cost-effective approach to graphical interface design in dataloggers. Future research can explore expanding the system's functionality, optimizing SPI communication, and enhancing graphical rendering capabilities.

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1. INTRODUCTION

Dataloggers have been an essential element in all kinds of data processing and retention around the world. Not only recording the data received, today's data loggers also use the latest technology that can provide diagnoses about the condition of the connected sensors, process the data they record, and transmit the data wirelessly in today's IoT era [1]. The existence of a sophisticated datalogger can certainly increase the accuracy and density of data which is the main key in analysis and decision making in the future [2]. On the other hand, air quality has become a hot issue discussed in various world forums lately. As a result of the industrial revolution and the widespread use of fuel oil, air quality monitoring has become crucial. Portable dataloggers can certainly be one of the most promising solutions, considering that technology has made everything more compact nowadays [3].

The high complexity of creating graphical interfaces is also a factor that hinders the development of innovation in this field. Graphical interface programming requires mastery of certain knowledge, which is quite difficult to obtain. In addition, the lack of existing references is also an inevitable obstacle [4]. In this research, we want to develop and apply the use of LVGL along with LovyanGFX as the basis for creating user display graphics on a portable datalogger system based on the ESP32 microcontroller. With the combination of these two graphics libraries, it is expected to create an interface system that is cost-effective and user-friendly, as well as an answer to the challenges in developing a datalogger with a graphical display embedded on board [5].

However, there are still many challenges that hinder the development of the system, especially in the development of an adequate user interface system on the embedded device [6]. Most of today's dataloggers already use displays, but the displays that can be generated are still quite limited. This has led to the demand for innovation in this area. The high intricacy of establishing graphical interfaces is also a factor that hinders the development of innovation in this field. Graphical interface programming requires mastery of certain knowledge, which is quite difficult to obtain. In addition, the lack of existing references is also an inevitable barrier.

Therefore, in this research we want to develop and apply the use of LVGL together with LovyanGFX as the basis for creating user display graphics on a portable datalogger system based on the ESP32 microcontroller. With the combination of these two graphics libraries, it is expected to create an interface system that is efficient and easy to apply, as well as an answer to the challenge of making a datalogger with a graphic display embedded in it.

2. RESEARCH METHOD

This research uses a hybrid approach oriented towards implementing LVGL and LovyanGFX as graphics processing in the MCU used. There are a number of planning and testing stages to ensure the best performance can be generated.

2.1 Research Approach

This research uses merely an experimental approach to implement LVGL (Light and Versatile Graphics Library) and LovyanGFX as graphic libraries on ESP32 S3 N16R8 series-based devices for datalogger applications with graphical displays. This experiment was held to find out how the two libraries function in configuring the graphical display on the screen and interacting with the data taken from the sensor.

2.2 Research Plan

This research was carried out through several stages of experiments involving the application of ESP32, LVGL, LovyanGFX, and other additional supporting components such as sensors and screens. The research design used consists of:

1) Selection of ESP32 Platform as the main microcontroller that has Wi-Fi and Bluetooth capabilities for data communication, as well as good graphics capabilities. The series used (S3 N16R8) was chosen because it has 16MB Flash memory and 8MB SRAM that supports more complex and larger programmes [7].
2) The application of LVGL and LovyanGFX to create a graphical user interface (GUI) that allows interaction with data and device control. These two libraries are fairly common and easy to use, but can still produce powerful graphics.
3) Integration with sensors used to collect environmental data (such as temperature, humidity, or pressure sensors) that will be displayed on the screen.
4) Data processing and storage using ESP32 memory and external storage media (SD Card) for data logging.

2.3 Research Variable

Research variables are characteristics, features, or attributes that can be measured or experimentally changed during a study. Variables are used to describe aspects that influence the research's outcome in both observed studies and experiments. A thorough understanding of variables is necessary for both designing suitable investigations and accurately assessing the data collected.[8]

One standalone variable is the type of graphics library used. In this case, we'll use LVGL that featured into LovyanGFX library. How versatile the system managing sensor data, how easy it is for users to interact with the interface, and how the system evolves are examples of dependent variables. Sensor kind, TFT display type, and ESP32 microcontroller usage are examples of control variables.

2.4 Schematic Circuit

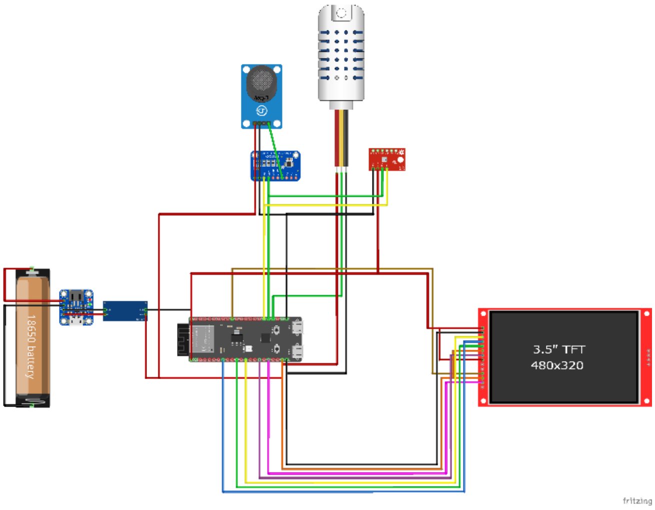

Fig. 1 Schematic Circuit

The circuit consists of three main section, the first one is the power circuit (Left side) which consists of a battery, charger module and also a voltage stabiliser. In the middle and right side is the main circuit consisting of esp32-s3 and tft screen. while on the top side is the sensor circuit used. There is a carbon monoxide (CO) gas sensor, DHT21 temperature and humidity sensor, and BME280 air pressure sensor. In the ads1115 section there are still a number of pins that can be used for more sensors with analogue output types to produce more accurate data.

2.5 Component detail and specifications

The following are all components that used in this research. several components used have the same basic specifications but different features depending on the manufacturer.

1) Esp32-S3 Devkitc-1 N16R8

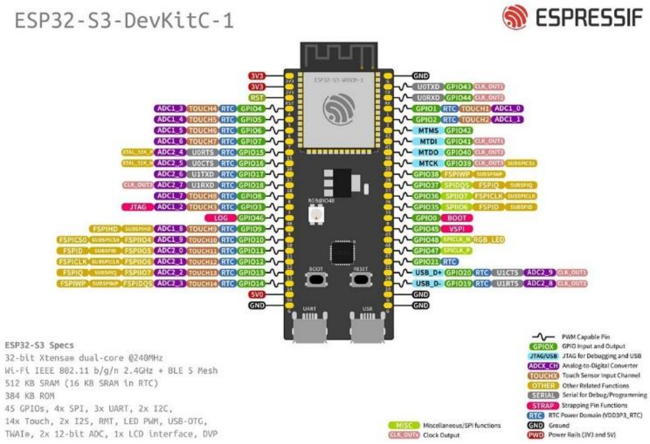

Fig. 2 ESP32-S3 diagrams

Esp32-s3 is one of the esp32 series that is quite capable. in addition to its large sram and flash memory which is larger than other esp32 series, this series also has a pin to connect the antenna using an external antenna to increase its wifi range. This microcontroller has also proven to be one of the favourite microcontrollers of most students who are learning coding.

2) 3.5” TFT ILI9488

Fig. 3 3.5” TFT Screen ILI9488

Ili9488 is a tft screen module with a size of 3.5 inches which has a resolution of 320x480 pixels. the screen on this module also uses a type of lcd screen that is quite good. ease of use is also one of the reasons for using this module.

3) 18650 Battery

Fig. 4 18650 Li-Ion Battery

18650 batteries are a type of lithium ion battery that has been widely used throughout the world. its fairly small size with the energy density it can store is the reason why this type of battery is quite often used.[9]

4) USB Battery Charging Board

Fig. 5 USB Battery Charging Board

This module is a module that can charge 18650 batteries. this module has many types of ports such as mini usb, micro usb, to usb type c. this module can also charge drained batteries such as in cases of too long storage or excessive use. this module is equipped with overvoltage protection, leakage current prevention and led devices for battery indicators.

5) 5V Step Up voltage stabilizer

Fig. 6 DC-DC Buck Converter

This module is used to increase the battery output which is only in the range of 3.3v to a stable 5v for the operation of esp32 and other devices. the way it works is to store a certain amount of power in it so that the output voltage becomes greater.

6) ADS1115

Fig. 7 ADS1115

Ads1115 is a module that can convert analogue signals into digital signals. this module has an i2c connection system and has 4 analogue ports. with an integrated amplifier in it so as to increase the accuracy of reading analogue signals from sensors.

7) MQ7 Carbon Monoxide Sensor

Fig. 8 MQ7 Carbon Monoxide Sensor

The MQ-7 gas sensor contains SnO_2, which has lower conductivity in clean air. It can eliminate particles other than carbon monoxide, which makes it one of the most capable air quality sensors.

8) DHT21

Fig. 9 DHT21

dht21 sensor is a temperature and humidity sensor that has good accuracy and is reliable. This sensor has been proven to be able to be used in the long term without experiencing significant deviation.

9) BME280

Fig. 10 BME280

BME280 is an air pressure sensor that is able to measure the surrounding air pressure. with its compact size, this sensor is one of the favorites in its kind.

3. RESULT AND DISCUSSION

The application of LovyanGFX and LVGL as an embedded system on esp32 with ili9488 screen shows promising results. ili9488 screen successfully displays good enough graphics and is able to process input into a good enough graphic display with a fairly small size. LovyanGFX also provides a special setting, which facilitates the sensor with the same communication system as the display, namely the serial peripheral interface (SPI) communication system to allow receiving data from the sensor device and sending signals to the display separately.

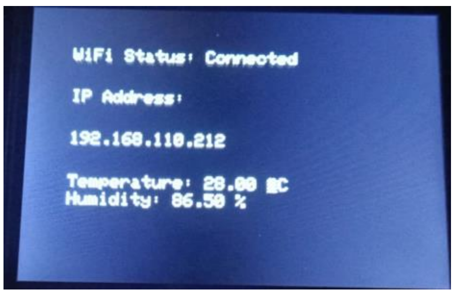

Fig. 1 WiFi status Result

In the image above, it can be seen that the screen can display words quite well. we can adjust the font, size, and spacing between lines of each text and even the duration of the display on the screen. also we can integrating data that has been processed by esp to display real-time to the screen.

Fig. 2 Data Result

In this picture it can be seen that esp32 can receive data from the sensor which is then processed into a graphical ratio as well. the screen used also produces contrasting colors and is quite optimal.

4. CONCLUSION

Overall, the LVGL and LovyanGFX systems work well together and produce a pretty good GUI. The use of ESP32-S3 is also quite capable of recording, processing, and sending data simultaneously without experiencing errors. Of course, there are still many developments from this system considering the many potentials and also things that have not been further reviewed from the collaboration of the two libraries into other embedded systems. As a suggestion, more in-depth testing can be done regarding the use of the SPI communication system to prove whether it can connect with more SPI devices. Code development to display optimized and high-resolution images can also be done.

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