The American University in Cairo
School of Science and Engineering
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CSCE4301 – Embedded Systems

Project Report

Dagu Based Autonomous Navigator

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Project Specifications

The purpose of this project is to design and build an embedded system that controls a Dagu based autonomous navigator. The Dagu based autonomous navigator is simply a robotic kit that performs the following two features:

1. The Dagu autonomously navigates from a starting point to an end point.
2. Between the two points, the Dagu has to visit two stops.

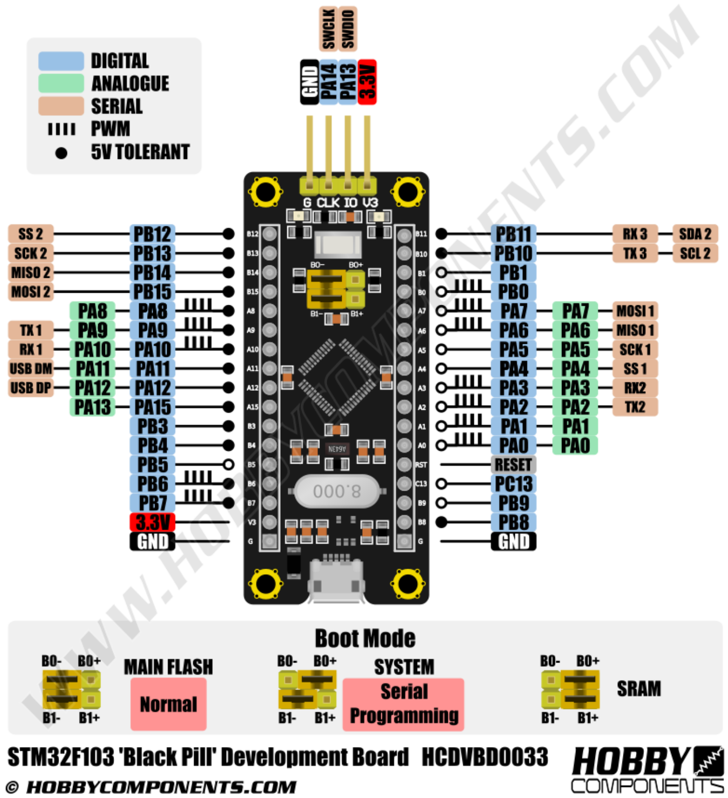
Tools and Components

- STM32 Black pill pinout Microcontroller.
- Dagu Robotic Kit with a motor controller.
- Ultrasonic Sensor HC-SR04.
- MinIMU-9 v5.
- ColorPal Color Sensor.
- GPS.
- STM32 Black Pill ST-Link 2 Debugger
- Power bank and Battery.
- USB to UART Cable.
- Arduino Mega 2560.

Background

STM32 Black Pill Pinout

The STM32F103C8T6 Development Board is a low cost but features rich alternative to an Arduino. The board features an STMicroelectronics STM32F103C8 Arm microprocessor running at 72MHz clock speed. Coupled with 64K of Flash and 20K of SRAM. This development board is also not short on peripherals with 30 I/O pins, 14 of which can be configured as 12 bit ADC inputs, 12 as PWM with most pins being 5V tolerant.



Ultrasonic Sensor HC-SR04

HC-SR04 Ultrasonic sensor is a 4 pin module, whose pin names are VCC, Trigger, Echo, and Ground respectively. This sensor is very popular for measuring the distance or sensing objects are required. The module has two eyes like projects in the front which forms the ultrasonic transmitter and receiver. The sensor works with the simple formula: **Distance = Speed * Time.**

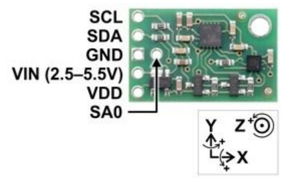
The Ultrasonic transmitter transmits an ultrasonic wave, this wave travels in the air and when it gets objected by any material it gets reflected back toward the sensor this reflected wave is observed by the Ultrasonic receiver module. Now, to calculate the distance using the above formulae, we should know the Speed and time. Since we are using the Ultrasonic wave we know the universal speed of US wave at room conditions which is 330m/s. The circuitry inbuilt on the module will calculate the time taken for the US wave to come back and turns on the echo pin high for that same particular amount of time, this way we can also know the time taken. Now simply calculate the distance using a microcontroller or microprocessor.

ColorPal Sensor

The Parallax ColorPal combines an RGB LED, a light sensor, and a microcontroller to make a color sensor that can also be used as an ambient light detector and a color generator. Readings are reported via a 1-wire asynchronous serial interface.

MinIMU-9 v5

The Pololu MinIMU-9 v5 is an inertial measurement unit (IMU) that packs an LSM6DS33 3-axis gyro and 3-axis accelerometer and an LIS3MDL 3-axis magnetometer onto a tiny 0.8″×0.5″ board. An I^2C interface accesses nine independent rotation, acceleration, and magnetic measurements that can be used to calculate the sensor's absolute orientation. The MinIMU-9 v5 board includes a voltage regulator and a level-shifting circuit that allow operation from 2.5 to 5.5V, and the 0.1″ pin spacing makes it easy to use with standard solderless breadboards and 0.1″ perfboards.

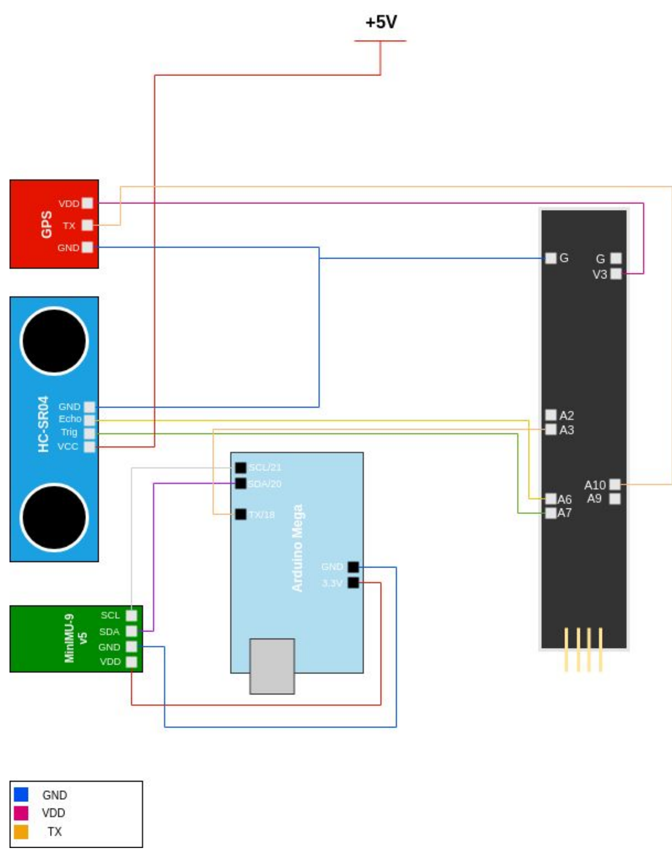


Software Architecture

Development Environment

The embedded application was developed by using the two developing environments: STM32CubeMx and Keil uVision 5. STM32CubeMx is a graphical software configuration tool that generates the c initialization code for the STM32 black pill. Keil uVision 5 IDE was used to edit the main code to meet the project requirement, to compile the code, and to upload the code to the microcontroller.

Design



Pins Connections

Ultrasonic Sensor

Ultrasonic Sensors Pins	STM32 Black Pill Pins
VCC	+5V
Trig	PA7
Echo	PA6
GND	G

ColorPal Sensor

ColorPal Sensor Pins	STM32 Black Pill Pins
+5V	TX & RX
Serial I/O	+5V
GND	G

MinIMU-9 V5

MinIMU-9 V5 Pins	Arduino Mega 2560 Pins
VDD	+3.3V
SCL	SCL/21
SDA	SDA/20
GND	GND

GPS

GPS Pins	STM32 Black Pill Pins
VDD	V3
TX	PA10
GND	G

ST-Link 2 Debugger

ST Link 2 Debugger Pins	**STM32 Black Pill Pins**
3.3V	V3
SWCLK	CLK
SWDIO	IO
GND	G

USB to UART

USB to UART Pins	**STM32 Black Pill Pins**
VCC	+5V
RXD	PA3
GND	GND
TXD	PA2

Arduino Mega 2560

Arduino Mega Pins	**STM32 Black Pill Pins**
TX/18	PA3

Deliverables

One zip file with 3 folders: Software, Hardware, Report.

1. Software folder contains all the source codes.
2. Hardware folder contains a connection diagram shows STM32 used pins and how they are connected to external peripherals.
3. Report folder contains a report document that outlines the specs, challenges, and deliverables, the software architecture, what went wrong and why and the lessons learnt.

Challenges

1. Retrieving correct angles from MinIMU-9 v5.
2. Use the MinIMU-9 v5 readings to make the Dagu self-balanced.

What Went Wrong & Why

1. Couldn't test all modules at the same time due to the limited number of ST-Link 2 Debuggers.
2. Took some time to test the given modules, and they didn't function well so we had to use different modules.

Lessons Learnt

1. Get tested components.
2. Have project milestones.
3. Have sessions on possible challenges.