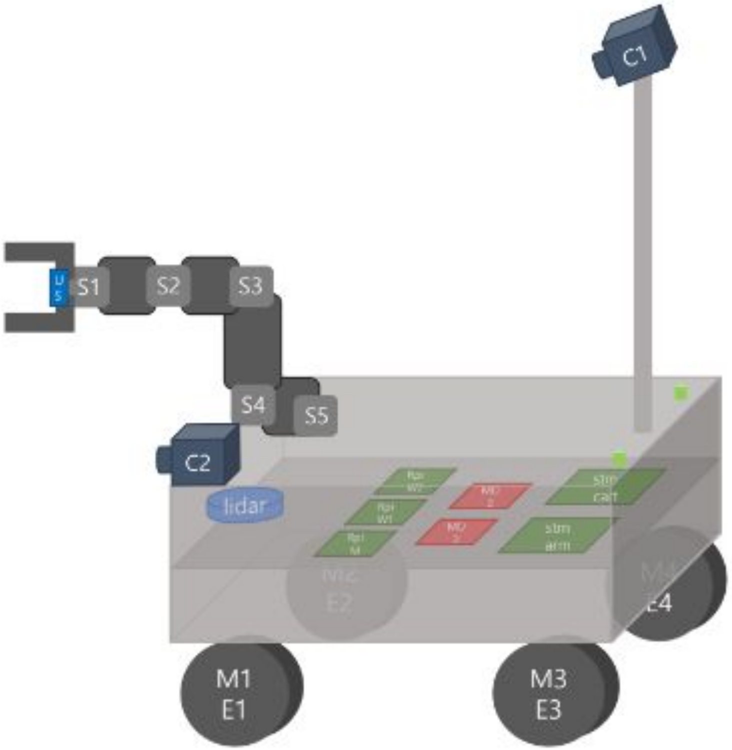
2021 ICNS
Self-Driving Cart Manual

목 차

1. Self-Driving Cart Specifications

- 바퀴 : 96mm Omni Mecanum Wheel
- 모터 : 12V Speed Encoder Motor
- MCU : STM32F407VG
- 보드 : STM32F407G-DISC1
- 배터리
  - Encoder motor : 12v
  - STM : 5v



2. Development Environment

- Cube MX

  Cube MX는 ST사에서 제작한 MCU(STM32 칩)의 초기설정을 쉽게 해주는 프로그램이다.

  GUI를 통해 타이머, 통신(Uart, I2C, SPI), 인터럽트, DMA, GPIO 등을 설정할 수 있으며,

  설정값에 대한 코드를 자동으로 생성해준다.

  그 외에도 MCU의 핀 배열이나 동작 클럭을 확인할 수 있다.

- TrueStudio

  STM32 칩을 컴파일 할 수 있는 무료버전의 IDE이다.

2. Development Environment - JAVA

- JAVA 설치

Cube MX를 사용하기 위해서는 먼저 JAVA 가 설치되어 있어야한다.

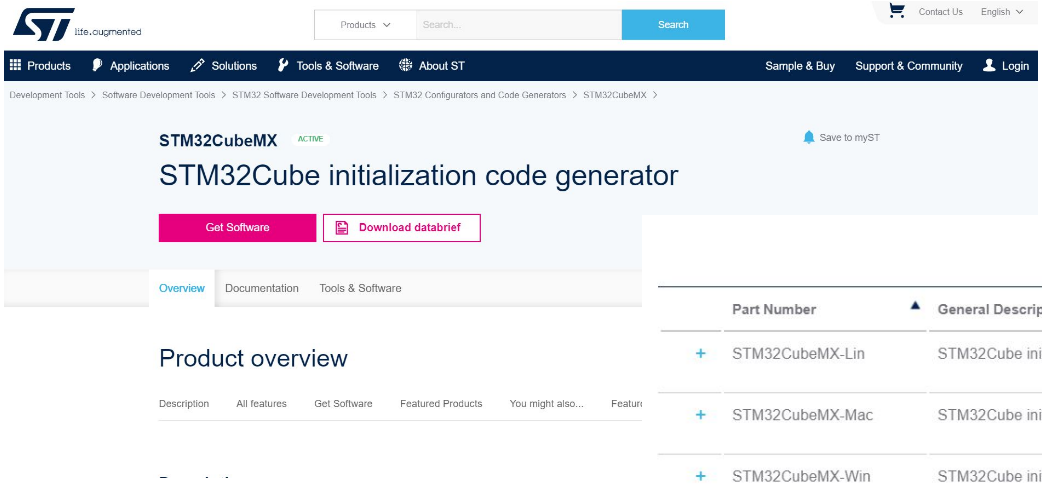
JAVA 설치 링크 : https://www.java.com/ko/download/

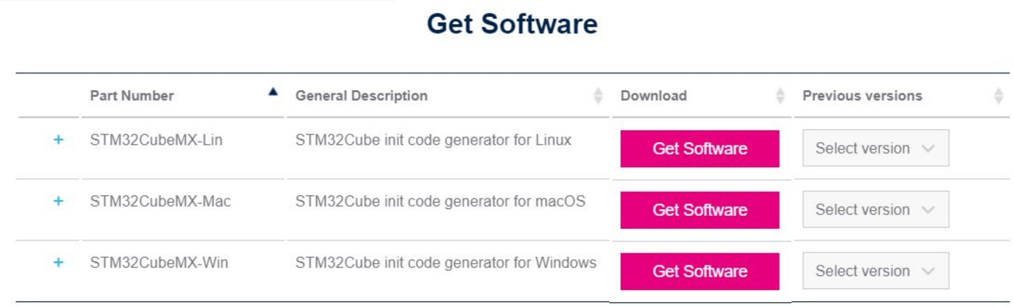
2. Development Environment - CubeMX

- CubeMX 설치

Cube MX 설치 링크 : https://www.st.com/en/development-tools/stm32cubemx.html

1. 링크로 이동하여 ‘Get Software’ 클릭





2. Development Environment - CubeMX

- CubeMX 설치

2. OS에 따라 'Get Software'클릭 후 이메일 입력

Get Software

	Part Number	General Description	Download	Previous versions
+	STM32CubeMX-Lin	STM32Cube init code generator for Linux	Get Software	Select version
+	STM32CubeMX-Mac	STM32Cube init code generator for macOS	Get Software	Select version
+	STM32CubeMX-Win	STM32Cube init code generator for Windows	Get Software	Select version

Get Software

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First Name:

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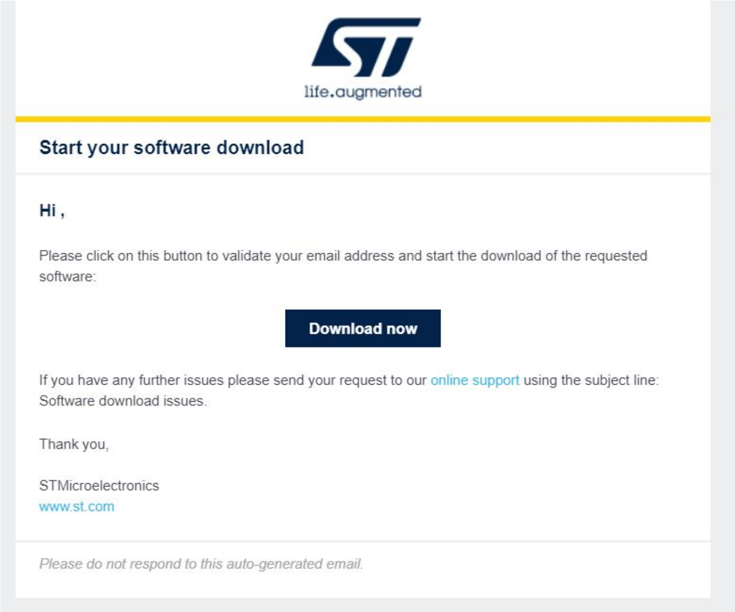
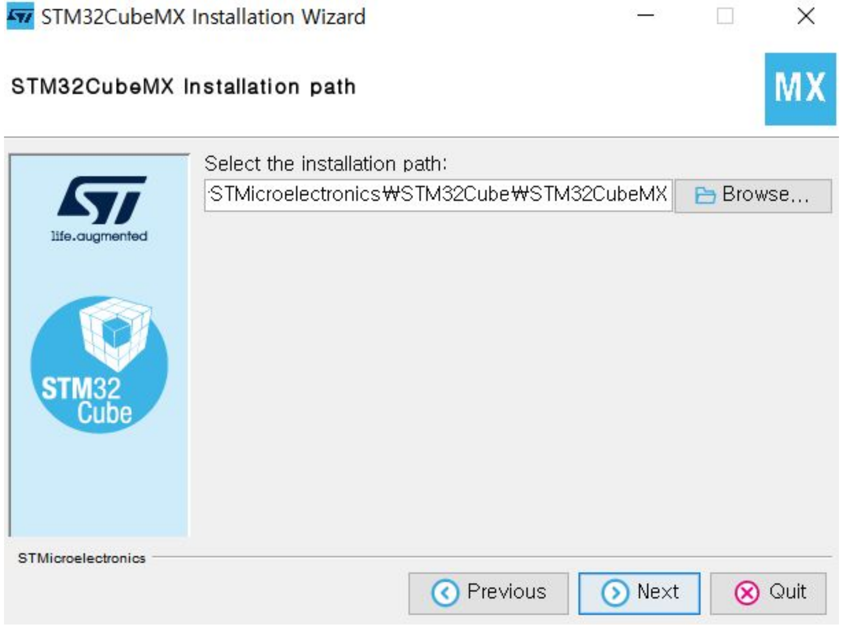
2. Development Environment - CubeMX

- CubeMX 설치

3. 받은 메일함으로 가서 ‘Download now’ 클릭, 압축 해제 후 설치파일 실행



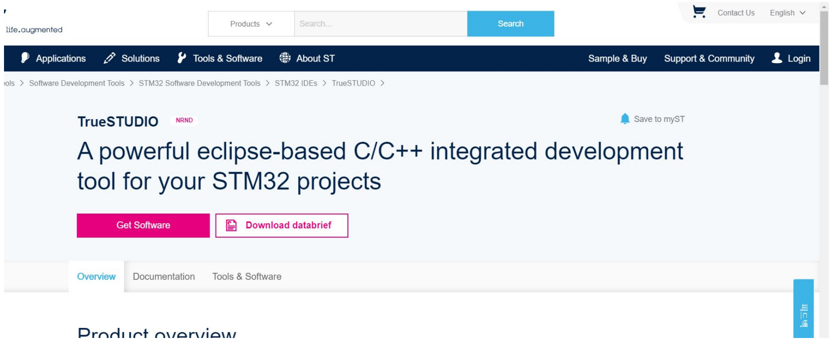


2. Development Environment - TrueStudio

- TrueStudio 설치

True Studio 설치 링크 : https://www.st.com/content/st_com/en/products/development-tools/software-development-tools/stm32-software-development-tools/stm32-ides/truestudio.html

1. 링크로 이동 후 ‘Get Software’ 클릭



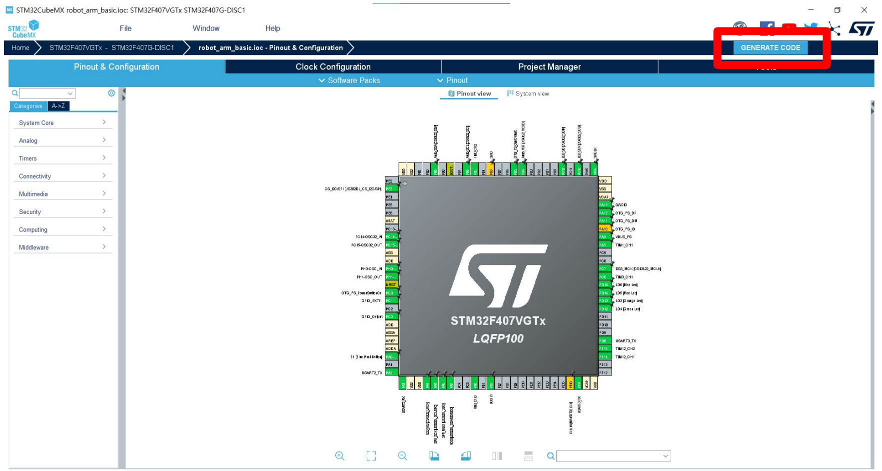
2. Development Environment - TrueStudio

- TrueStudio 설치

  2. OS에 따라 선택 후 다운로드

3. Project - Generate Code

- 프로젝트 생성
    1. CNS Robot Arm Github Repository 클론 https://github.com/icns-distributed-cloud/Self-driving-project
    2. .ioc 파일 열기 (2021_self_driving_cart/cart)
    3. ‘GENERATE CODE’ 클릭 (ICNS project의 설정을 그대로 가져올 수 있어 별도의 설정이 필요없음)

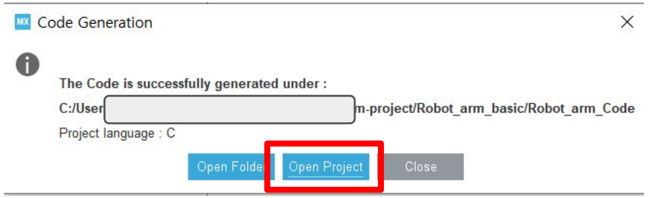


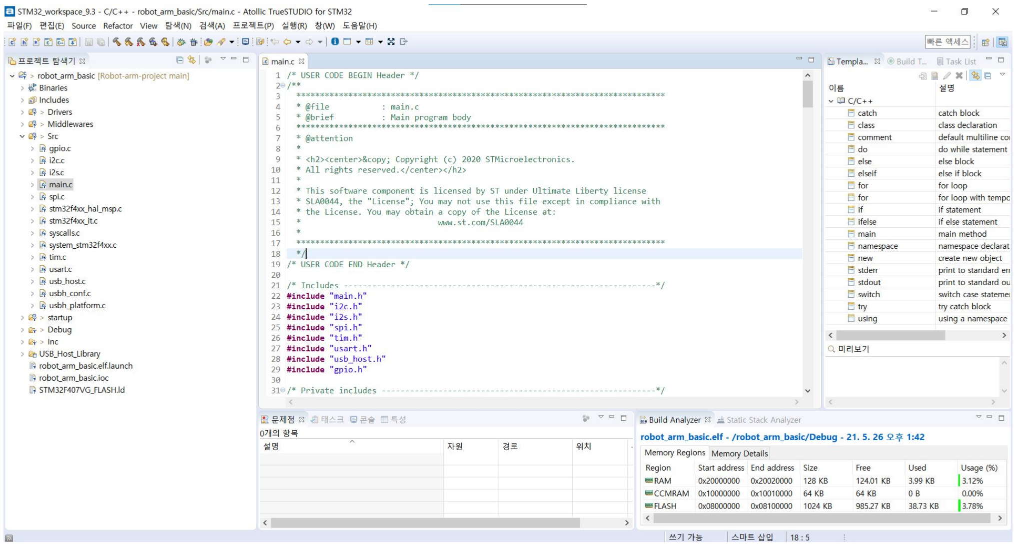
3. Project - Generate Code

- 프로젝트 생성

4. 'Open Project' 클릭 -> 생성완료

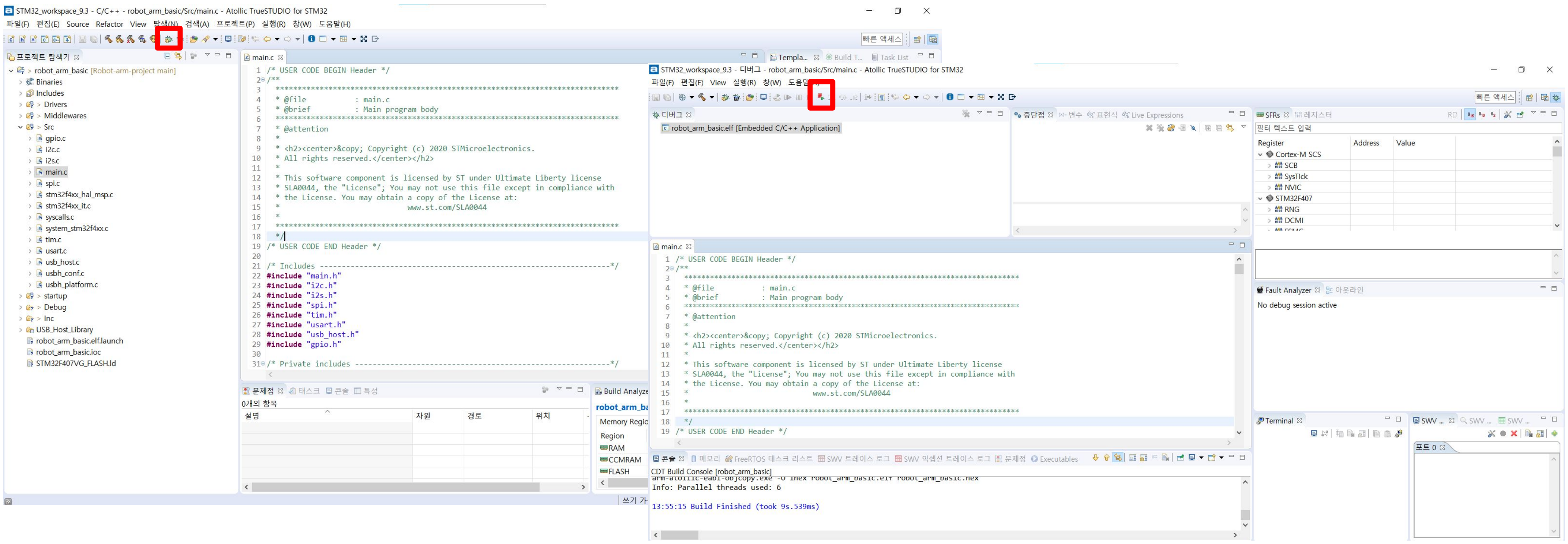
메인 코드 위치 : Src/main.c





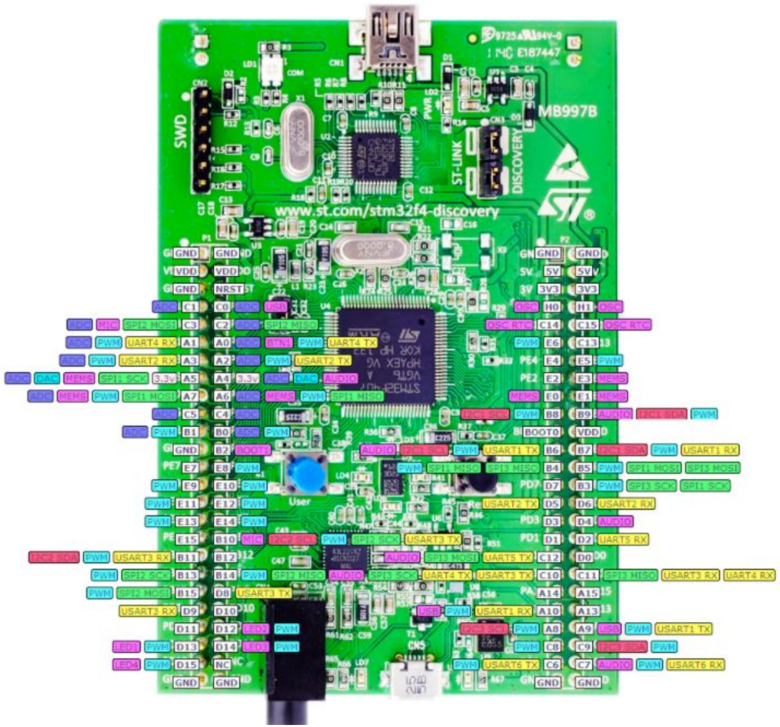
3. Project - Debug

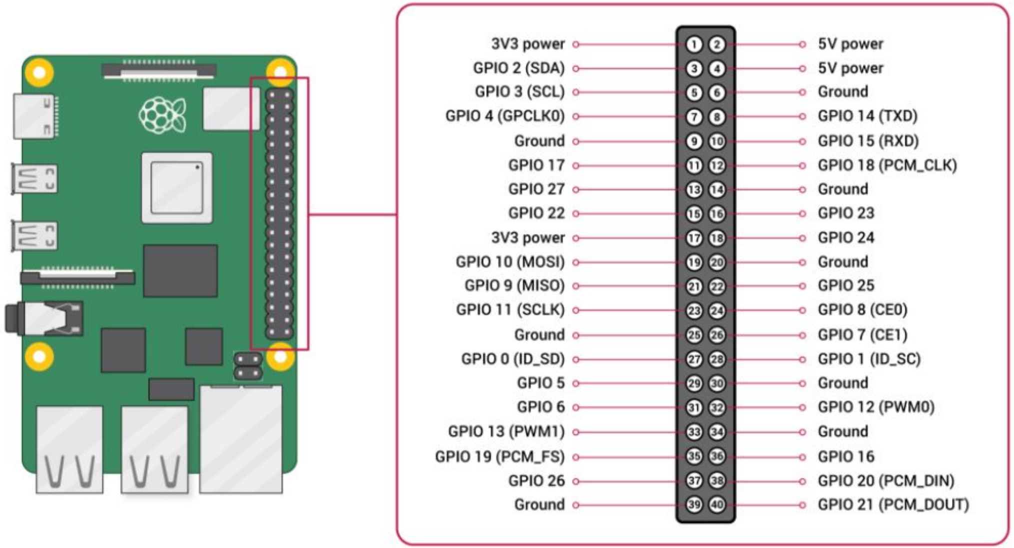
- 프로젝트 열기 : .cproject 파일 열기
- 디버깅 : 디버그 아이콘 클릭 후 다음 화면에서 정지 아이콘 클릭



4. Self-Driving Control - Pin Configuration Diagram

- STM32407G
- 라즈베리파이4





4. Self-Driving Control - Mecanum Wheel Control

- PWM Start

HAL_TIM_PWM_Start(timer number, channel number)

```
HAL_TIM_PWM_Start(&htim1, TIM_CHANNEL_1);

HAL_TIM_PWM_Start(&htim1, TIM_CHANNEL_2);

HAL_TIM_PWM_Start(&htim1, TIM_CHANNEL_3);

HAL_TIM_PWM_Start(&htim1, TIM_CHANNEL_4);
```

4. Self-Driving Control - Mecanum Wheel Control

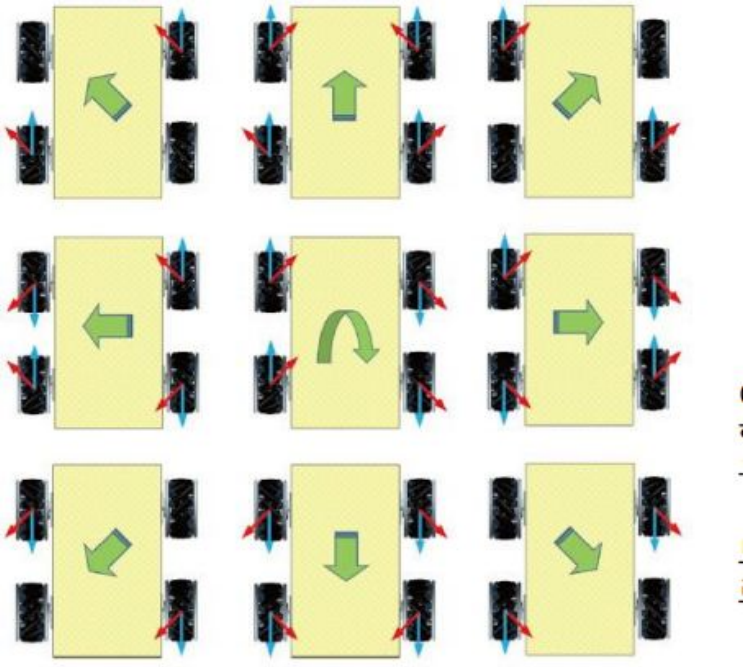
- 방향 제어

SET, RESET -> 정방향 회전

RESET, SET -> 역방향 회전

EX) 4바퀴 모두 정방향 회전

```
HAL_GPIO_WritePin(GPIOB, GPIO_PIN_12, SET);

HAL_GPIO_WritePin(GPIOB, GPIO_PIN_13, RESET);

HAL_GPIO_WritePin(GPIOB, GPIO_PIN_14, SET);

HAL_GPIO_WritePin(GPIOB, GPIO_PIN_15, RESET);

HAL_GPIO_WritePin(GPIOD, GPIO_PIN_8, SET);

HAL_GPIO_WritePin(GPIOD, GPIO_PIN_9, RESET);

HAL_GPIO_WritePin(GPIOD, GPIO_PIN_10, SET);

HAL_GPIO_WritePin(GPIOD, GPIO_PIN_11, RESET);
```



4. Self-Driving Control - Mecanum Wheel Control

- 속도 제어

0 ~ 9999까지 가능

```
TIM1->CCR1 = 0;        //Left Front
TIM1->CCR2 = 0;        //Right Front
TIM1->CCR3 = 0;        // Left Back
TIM1->CCR4 = 0;        // Right Back
```

4. Self-Driving Control - Lidar Control

- 라이다 스캔 메커니즘

  스캔 시작 명령을 주면 7bytes 헤더를 송신하고 5bytes 거리 데이터를 연속적으로 송신

  * USART 통신의 송수신 기본단위는 8bit

- 스캔 시작

```
HAL_UART_Transmit(&huart3, &scan_command, 2, 100);
```

4. Self-Driving Control - Lidar Control

- 거리 계산 및 속도 변경

```
if(scan_start){
        if(HAL_UART_Receive(&huart3, &rx3_data, 5, 10) == HAL_OK){

            Q = rx3_data[0]>>2;
            S = (rx3_data[0] & 0x01) ? 1 : 0;
            angle = (rx3_data[2]<<7 | rx3_data[1]>>1)/64;
            d = (rx3_data[4]<<8 | rx3_data[3])/4;
            if(d >= 5000){
                distance[angle] = 5000;
            }
            else{
                distance[angle] = d;
            }
            if(S == 1){
                avg_DIFF = array_avg_compare(distance);
                MOTER_PWM[0] = PID_speed + avg_DIFF;
                MOTER_PWM[1] = PID_speed - avg_DIFF;
                MOTER_PWM[2] = PID_speed + avg_DIFF;
                MOTER_PWM[3] = PID_speed - avg_DIFF;
                memset(distance, 0, 360);
            }
        }
    }
    else{
        if(HAL_UART_Receive(&huart3, &rx3_start, 7, 10) == HAL_OK){
            if (array_element_of_index_equal(rx3_start, scan_response, 7)){
                scan_start = true;
            }
        }
 }
```

1. 거리 값 저장
2. 360도 스캔 완료
3. 헤더 검사

4. Self-Driving Control - Lidar Control

- 평균값 계산

```
int16_t array_avg_compare(uint16_t distance[]){

        uint32_t sum_R = 0;
        uint32_t sum_L = 0;
        uint8_t len_L = 0;
        uint8_t len_R = 0;
        uint16_t avg_R = 0;
        uint16_t avg_L = 0;
        int16_t avg_diff = 0;

        for(int i=0; i<90; i++){
           sum_R += distance[i];
           if(distance[i]!=0){
              len_R++;
           }
        }
        avg_R = sum_R/len_R;

        for(int i=270; i<360; i++){
           sum_L += distance[i];
           if(distance[i]!=0){
              len_L++;
          }
        }
        avg_L = sum_L/len_L;

        avg_diff = avg_R - avg_L;

        return avg_diff;
}
```

4. Self-Driving Control -PID Control

- PID 제어 : 모터에 인가해준 목표 속도와 엔코더로 측정한 실제 측정 속도의 차를 이용하여 목표 속도에 빠르고 정확하게 도달하기 위한 기법
- 엔코더 특정 값을 속도로 변환 : speed = 164.18 * exp(0.01112*encoder)
- PID 계수 튜닝 후 튜닝한 속도값을 모터에 인가

```
uint32_t desired_speed = 3000;

void HAL_TIM_PeriodElapsedCallback(TIM_HandleTypeDef *htim)          //Timer interrupt every 20ms
{
        if(htim->Instance == TIM6){

                //HAL_GPIO_WritePin(GPIOC,GPIO_PIN_13,GPIO_PIN_SET);
                encoder_cnt[0] = TIM2->CNT;
                TIM2->CNT=0;

                encoder_cnt[1] = TIM3->CNT;
                TIM3->CNT=0;

                encoder_cnt[2] = TIM4->CNT;
                TIM4->CNT=0;

                encoder_cnt[3] = TIM5->CNT;
                TIM5->CNT=0;

                encoder_speed[0] = 164.18 * exp(0.0112*encoder_cnt[0]);
                encoder_speed[1] = 164.18 * exp(0.0112*encoder_cnt[1]);
                encoder_speed[2] = 164.18 * exp(0.0112*encoder_cnt[2]);
                encoder_speed[3] = 164.18 * exp(0.0112*encoder_cnt[3]);

                error_speed[0] = desired_speed - encoder_speed[0];
                error_speed[1] = desired_speed - encoder_speed[1];
                error_speed[2] = desired_speed - encoder_speed[2];
                error_speed[3] = desired_speed - encoder_speed[3];

                PID_speed[0] = old_PID_speed[0] + Kp*error_speed[0];
                PID_speed[1] = old_PID_speed[1] + Kp*error_speed[1];
                PID_speed[2] = old_PID_speed[2] + Kp*error_speed[2];
                PID_speed[3] = old_PID_speed[3] + Kp*error_speed[3];

                old_PID_speed[0] = PID_speed[0];
                old_PID_speed[1] = PID_speed[1];
                old_PID_speed[2] = PID_speed[2];
                old_PID_speed[3] = PID_speed[3];
        }
}
```

5. Serial Communication