An autonomous crawling robot

Generated by Doxygen 1.8.13

Contents

Chapter 1

Data Structure Index

1.1 Data Structures

Here are the data structures with brief descriptions:

Chapter 2

File Index

2.1 File List

Here is a list of all files with brief descriptions:

Chapter 3

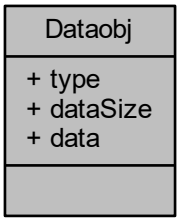
Data Structure Documentation

3.1 Dataobj Struct Reference

This struct contains the parameters of the data object that can be used to transmit data.

`#include <protocol.h>`

Collaboration diagram for Dataobj:



Data Fields

- unsigned char type
- unsigned char dataSize
- int data

3.1.1 Detailed Description

This struct contains the parameters of the data object that can be used to transmit data.

Parameters

type	this parameter contains the representation of the data
DataSize	contains the amount of bytes of the data

3.1.2 Field Documentation

3.1.2.1 data

```
int data
```

3.1.2.2 dataSize

```
unsigned char dataSize
```

3.1.2.3 type

```
unsigned char type
```

The documentation for this struct was generated from the following file:

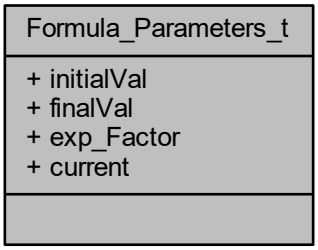
- lib/protocol/protocol.h

3.2 Formula_Parameters_t Struct Reference

This struct contains the parameters of the Q-learning formula. Some other functions are specificly designed to change those parameters by using an exponential function.

```
#include <q_learning.h>
```

Collaboration diagram for Formula_Parameters_t:



Data Fields

- unsigned char initialVal
- unsigned char finalVal
- float exp_Factor
- float current

3.2.1 Detailed Description

This struct contains the parameters of the Q-learning formula. Some other functions are specificly designed to change those parameters by using an exponential function.

3.2.2 Field Documentation

3.2.2.1 current

```
float current
```

3.2.2.2 exp_Factor

```
float exp_Factor
```

3.2.2.3 finalVal

```
unsigned char finalVal
```

3.2.2.4 initialVal

```
unsigned char initialVal
```

The documentation for this struct was generated from the following file:

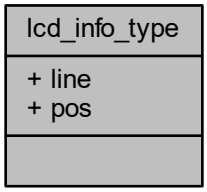
- lib/q_learning/q_learning.h

3.3 lcd_info_type Struct Reference

Stores the current line and position of the cursor.

`#include <DwenguinoLCD.h>`

Collaboration diagram for lcd_info_type:



Data Fields

- unsigned char line
- unsigned char pos

3.3.1 Detailed Description

Stores the current line and position of the cursor.

3.3.2 Field Documentation

3.3.2.1 line

`unsigned char line`

line number lcd_info_type::a.

3.3.2.2 pos

`unsigned char pos`

position in the line lcd_info_type::b.

The documentation for this struct was generated from the following file:

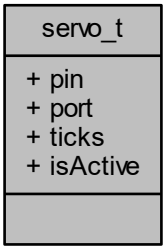
- lib/dwenguinoLCD/DwenguinoLCD.h

3.4 servo_t Struct Reference

This struct contains the parameters of a servo. Some other functions are specificly designed to change those parameters.

`#include <servo.h>`

Collaboration diagram for servo_t:



Data Fields

- unsigned char pin
  pointer to the pin
- volatile unsigned char * port
  pointer to the port
- unsigned int ticks
  contains amount of prescaled ticks
- unsigned char isActive
  0 = inactive

3.4.1 Detailed Description

This struct contains the parameters of a servo. Some other functions are specificly designed to change those parameters.

3.4.2 Field Documentation

3.4.2.1 isActive

`unsigned char isActive`

0 = inactive

3.4.2.2 pin

```
unsigned char pin
```

pointer to the pin

3.4.2.3 port

```
volatile unsigned char* port
```

pointer to the port

3.4.2.4 ticks

```
unsigned int ticks
```

contains amount of prescaled ticks

The documentation for this struct was generated from the following file:

- lib/servo/servo.h

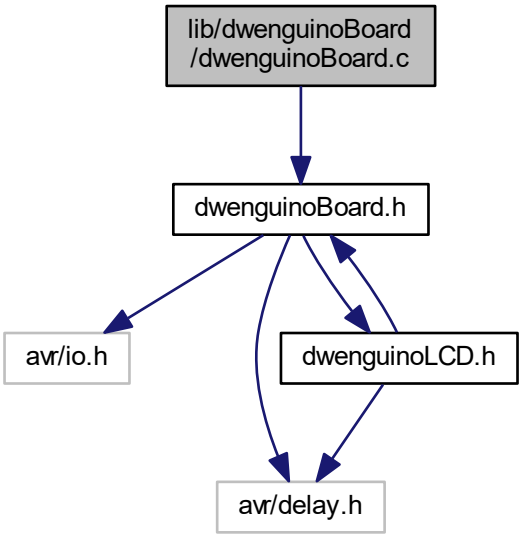
Chapter 4

File Documentation

4.1 lib/dwenguinoBoard/dwenguinoBoard.c File Reference

```
#include "dwenguinoBoard.h"
```

Include dependency graph for dwenguinoBoard.c:



Functions

- void initBoard (void)

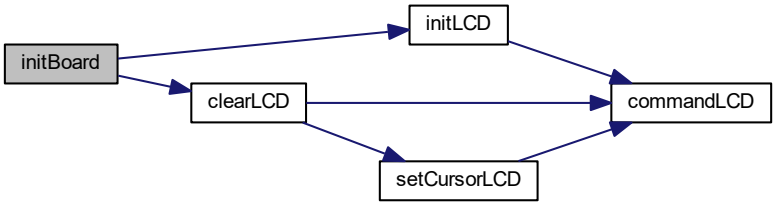
4.1.1 Function Documentation

4.1.1.1 initBoard()

```
void initBoard (
            void  )
```

dwenguinoBoard.c

Created on: Jan 19, 2016 Author: Tom Here is the call graph for this function:

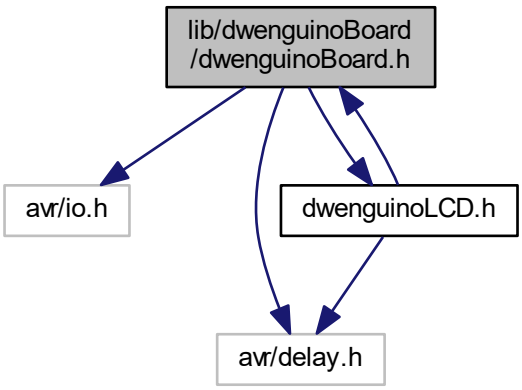


4.2 lib/dwenguinoBoard/dwenguinoBoard.h File Reference

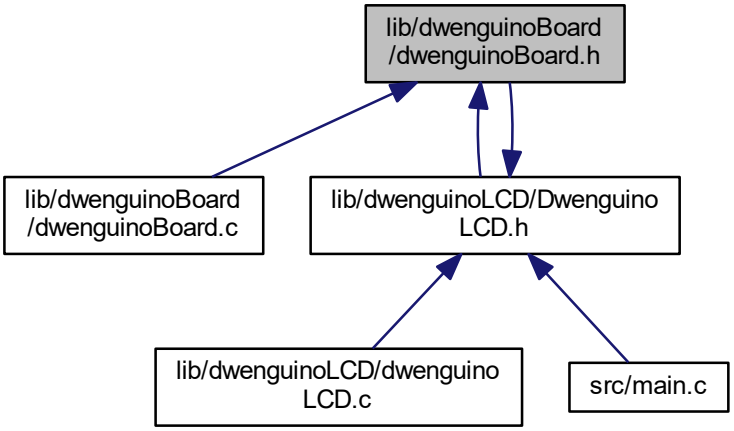
This library contains pin assingments and basic macros for Dwenguino boards.

```
#include <avr/io.h>
#include <avr/delay.h>
#include "dwenguinoLCD.h"
```

Include dependency graph for dwenguinoBoard.h:



This graph shows which files directly or indirectly include this file:



Macros

- #define TRUE 1
- #define FALSE 0
- #define HIGH 1
- #define LOW 0
- #define PORT_HIGH 0xFF
- #define PORT_LOW 0x00
- #define INPUT 0
- #define OUTPUT 1
- #define SET_PIN_HIGH(PORT, PIN) PORT |= (1 << PIN)
- #define SET_PIN_LOW(PORT, PIN) PORT &= ~(1 << PIN)
- #define SET_BIT_HIGH(REG, BIT) REG |= (1 << BIT)
- #define SET_BIT_LOW(REG, BIT) REG &= ~(1 << BIT)
- #define BYTE unsigned char
- #define LEDS_DIR DDRA
- #define LEDS PORTA
- #define LED_ON(LED) SET_PIN_HIGH(PORTA, LED)
- #define LED_OFF(LED) (SET_PIN_LOW(PORTA, LED)
- #define SW_C_HIGH SET_PIN_HIGH(PORTC, 6)
- #define SW_C_LOW SET_PIN_LOW(PORTC, 6)
- #define SW_C_IN SET_PIN_LOW(DDRC, 6)
- #define SW_C_OUT SET_PIN_HIGH(DDRC, 6)
- #define SW_W_HIGH SET_PIN_HIGH(PORTE, 4)
- #define SW_W_LOW SET_PIN_LOW(PORTE, 4)
- #define SW_W_IN SET_PIN_LOW(DDRE, 4)
- #define SW_W_OUT SET_PIN_HIGH(DDRE, 4)
- #define SW_S_HIGH SET_PIN_HIGH(PORTE, 5)
- #define SW_S_LOW SET_PIN_LOW(PORTE, 5)
- #define SW_S_IN SET_PIN_LOW(DDRE, 5)
- #define SW_S_OUT SET_PIN_HIGH(DDRE, 5)

- #define SW_E_HIGH SET_PIN_HIGH(PORTE, 6)
- #define SW_E_LOW SET_PIN_LOW(PORTE, 6)
- #define SW_E_IN SET_PIN_LOW(DDRE, 6)
- #define SW_E_OUT SET_PIN_HIGH(DDRE, 6)
- #define SW_N_HIGH SET_PIN_HIGH(PORTE, 7)
- #define SW_N_LOW SET_PIN_LOW(PORTE, 7)
- #define SW_N_IN SET_PIN_LOW(DDRE, 6)
- #define SW_N_OUT SET_PIN_HIGH(DDRE, 6)
- #define LCD_DATA PORTA
- #define LCD_DATA_DIR DDRA
- #define LCD_BACKLIGHT_ON SET_PIN_HIGH(PORTE, 3)
- #define LCD_BACKLIGHT_OFF SET_PIN_LOW(PORTE, 3)
- #define LCD_BACKLIGHT_OUT SET_PIN_HIGH(DDRE, 3)
- #define LCD_BACKLIGHT_IN SET_PIN_LOW(DDRE, 3)
- #define LCD_RW_HIGH SET_PIN_HIGH(PORTE, 1)
- #define LCD_RW_LOW SET_PIN_LOW(PORTE, 1)
- #define LCD_RW_OUT SET_PIN_HIGH(DDRE, 1)
- #define LCD_RS_HIGH SET_PIN_HIGH(PORTE, 0)
- #define LCD_RS_LOW SET_PIN_LOW(PORTE, 0)
- #define LCD_RS_OUT SET_PIN_HIGH(DDRE, 0)
- #define LCD_EN_HIGH SET_PIN_HIGH(PORTE, 2)
- #define LCD_EN_LOW SET_PIN_LOW(PORTE, 2)
- #define LCD_EN_OUT SET_PIN_HIGH(DDRE, 2)
- #define SERVO1 PORTC0
- #define SERVO2 PORTC1
- #define MOTOR1_0_HIGH SET_PIN_HIGH(PORTC, 3)
- #define MOTOR1_0_LOW SET_PIN_LOW(PORTC, 3)
- #define MOTOR1_1_HIGH SET_PIN_HIGH(PORTC, 4)
- #define MOTOR1_1_LOW SET_PIN_LOW(PORTC, 4)
- #define MOTOR2_0_HIGH SET_PIN_HIGH(PORTC, 2)
- #define MOTOR2_0_LOW SET_PIN_LOW(PORTC, 2)
- #define MOTOR2_1_HIGH SET_PIN_HIGH(PORTC, 5)
- #define MOTOR2_1_LOW SET_PIN_LOW(PORTC, 5)

Functions

- void initBoard (void)

4.2.1 Detailed Description

This library contains pin assingments and basic macros for Dwenguino boards.

Author

Tom Neutens

Date

Jan 19, 2016

See also

http://www.dwengo.org/tutorials

4.2.2 Macro Definition Documentation

4.2.2.1 BYTE

```
#define BYTE unsigned char
```

4.2.2.2 FALSE

```
#define FALSE 0
```

4.2.2.3 HIGH

```
#define HIGH 1
```

4.2.2.4 INPUT

```
#define INPUT 0
```

4.2.2.5 LCD_BACKLIGHT_IN

```
#define LCD_BACKLIGHT_IN SET_PIN_LOW(DDRE, 3)
```

4.2.2.6 LCD_BACKLIGHT_OFF

```
#define LCD_BACKLIGHT_OFF SET_PIN_LOW(PORTE, 3)
```

4.2.2.7 LCD_BACKLIGHT_ON

```
#define LCD_BACKLIGHT_ON SET_PIN_HIGH(PORTE, 3)
```

4.2.2.8 LCD_BACKLIGHT_OUT

```
#define LCD_BACKLIGHT_OUT SET_PIN_HIGH(DDRE, 3)
```

4.2.2.9 LCD_DATA

```
#define LCD_DATA PORTA
```

4.2.2.10 LCD_DATA_DIR

```
#define LCD_DATA_DIR DDRA
```

4.2.2.11 LCD_EN_HIGH

```
#define LCD_EN_HIGH SET_PIN_HIGH(PORTE, 2)
```

4.2.2.12 LCD_EN_LOW

```
#define LCD_EN_LOW SET_PIN_LOW(PORTE, 2)
```

4.2.2.13 LCD_EN_OUT

```
#define LCD_EN_OUT SET_PIN_HIGH(DDRE, 2)
```

4.2.2.14 LCD_RS_HIGH

```
#define LCD_RS_HIGH SET_PIN_HIGH(PORTE, 0)
```

4.2.2.15 LCD_RS_LOW

```
#define LCD_RS_LOW SET_PIN_LOW(PORTE, 0)
```

4.2.2.16 LCD_RS_OUT

```
#define LCD_RS_OUT SET_PIN_HIGH(DDRE, 0)
```

4.2.2.17 LCD_RW_HIGH

```
#define LCD_RW_HIGH SET_PIN_HIGH(PORTE, 1)
```

4.2.2.18 LCD_RW_LOW

```
#define LCD_RW_LOW SET_PIN_LOW(PORTE, 1)
```

4.2.2.19 LCD_RW_OUT

```
#define LCD_RW_OUT SET_PIN_HIGH(DDRE, 1)
```

4.2.2.20 LED_OFF

```
#define LED_OFF(
              LED ) (SET_PIN_LOW(PORTA, LED)
```

4.2.2.21 LED_ON

```
#define LED_ON(
              LED ) SET_PIN_HIGH(PORTA, LED)
```

4.2.2.22 LEDS

```
#define LEDS PORTA
```

4.2.2.23 LEDS_DIR

```
#define LEDS_DIR DDRA
```

4.2.2.24 LOW

```
#define LOW 0
```

4.2.2.25 MOTOR1_0_HIGH

```
#define MOTOR1_0_HIGH SET_PIN_HIGH(PORTC, 3)
```

4.2.2.26 MOTOR1_0_LOW

```
#define MOTOR1_0_LOW SET_PIN_LOW(PORTC, 3)
```

4.2.2.27 MOTOR1_1_HIGH

```
#define MOTOR1_1_HIGH SET_PIN_HIGH(PORTC, 4)
```

4.2.2.28 MOTOR1_1_LOW

```
#define MOTOR1_1_LOW SET_PIN_LOW(PORTC, 4)
```

4.2.2.29 MOTOR2_0_HIGH

```
#define MOTOR2_0_HIGH SET_PIN_HIGH(PORTC, 2)
```

4.2.2.30 MOTOR2_0_LOW

```
#define MOTOR2_0_LOW SET_PIN_LOW(PORTC, 2)
```

4.2.2.31 MOTOR2_1_HIGH

```
#define MOTOR2_1_HIGH SET_PIN_HIGH(PORTC, 5)
```

4.2.2.32 MOTOR2_1_LOW

```
#define MOTOR2_1_LOW SET_PIN_LOW(PORTC, 5)
```

4.2.2.33 OUTPUT

```
#define OUTPUT 1
```

4.2.2.34 PORT_HIGH

```
#define PORT_HIGH 0xFF
```

4.2.2.35 PORT_LOW

```
#define PORT_LOW 0x00
```

4.2.2.36 SERVO1

```
#define SERVO1 PORTC0
```

4.2.2.37 SERVO2

```
#define SERVO2 PORTC1
```

4.2.2.38 SET_BIT_HIGH

```
#define SET_BIT_HIGH(
              REG,
              BIT ) REG |= (1 << BIT)
```

4.2.2.39 SET_BIT_LOW

```
#define SET_BIT_LOW(
              REG,
              BIT ) REG &= ~(1 << BIT)
```

4.2.2.40 SET_PIN_HIGH

```
#define SET_PIN_HIGH(
              PORT,
              PIN ) PORT |= (1 << PIN)
```

4.2.2.41 SET_PIN_LOW

```
#define SET_PIN_LOW(
              PORT,
              PIN ) PORT &= ~(1 << PIN)
```

4.2.2.42 SW_C_HIGH

```
#define SW_C_HIGH SET_PIN_HIGH(PORTC, 6)
```

4.2.2.43 SW_C_IN

```
#define SW_C_IN SET_PIN_LOW(DDRC, 6)
```

4.2.2.44 SW_C_LOW

```
#define SW_C_LOW SET_PIN_LOW(PORTC, 6)
```

4.2.2.45 SW_C_OUT

```
#define SW_C_OUT SET_PIN_HIGH(DDRC, 6)
```

4.2.2.46 SW_E_HIGH

```
#define SW_E_HIGH SET_PIN_HIGH(PORTE, 6)
```

4.2.2.47 SW_E_IN

```
#define SW_E_IN SET_PIN_LOW(DDRE, 6)
```

4.2.2.48 SW_E_LOW

```
#define SW_E_LOW SET_PIN_LOW(PORTE, 6)
```

4.2.2.49 SW_E_OUT

```
#define SW_E_OUT SET_PIN_HIGH(DDRE, 6)
```

4.2.2.50 SW_N_HIGH

```
#define SW_N_HIGH SET_PIN_HIGH(PORTE, 7)
```

4.2.2.51 SW_N_IN

```
#define SW_N_IN SET_PIN_LOW(DDRE, 6)
```

4.2.2.52 SW_N_LOW

```
#define SW_N_LOW SET_PIN_LOW(PORTE, 7)
```

4.2.2.53 SW_N_OUT

```
#define SW_N_OUT SET_PIN_HIGH(DDRE, 6)
```

4.2.2.54 SW_S_HIGH

```
#define SW_S_HIGH SET_PIN_HIGH(PORTE, 5)
```

4.2.2.55 SW_S_IN

```
#define SW_S_IN SET_PIN_LOW(DDRE, 5)
```

4.2.2.56 SW_S_LOW

```
#define SW_S_LOW SET_PIN_LOW(PORTE, 5)
```

4.2.2.57 SW_S_OUT

```
#define SW_S_OUT SET_PIN_HIGH(DDRE, 5)
```

4.2.2.58 SW_W_HIGH

```
#define SW_W_HIGH SET_PIN_HIGH(PORTE, 4)
```

4.2.2.59 SW_W_IN

```
#define SW_W_IN SET_PIN_LOW(DDRE, 4)
```

4.2.2.60 SW_W_LOW

```
#define SW_W_LOW SET_PIN_LOW(PORTE, 4)
```

4.2.2.61 SW_W_OUT

```
#define SW_W_OUT SET_PIN_HIGH(DDRE, 4)
```

4.2.2.62 TRUE

```
#define TRUE 1
```

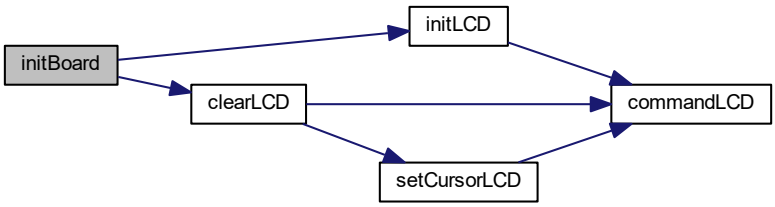
4.2.3 Function Documentation

4.2.3.1 initBoard()

```
void initBoard (
            void  )
```

dwenguinoBoard.c

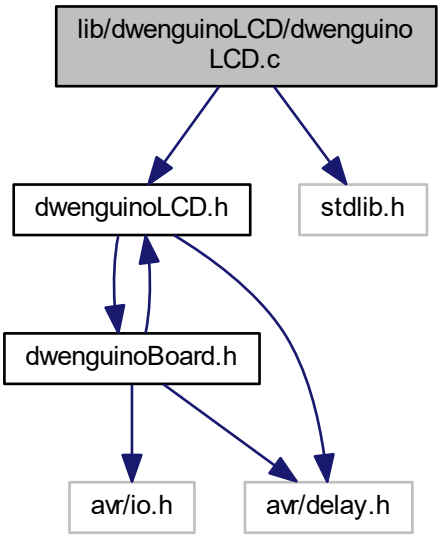
Created on: Jan 19, 2016 Author: Tom Here is the call graph for this function:



4.3 lib/dwenguinoLCD/dwenguinoLCD.c File Reference

```
#include "dwenguinoLCD.h"
#include <stdlib.h>
```

Include dependency graph for dwenguinoLCD.c:



Functions

- void initLCD (void)

  initializes the LCD screen This function sets up the lcd for displaying the data we will send
- void clearLCD (void)

  clears the LCD screen This function removes all the content from the LCD screen
- void commandLCD (const BYTE c)

  sends a command to the LCD This function sends a low level command to the LCD. The command is represented as a byte and is transferred to the LCD screen through the PORTA register.
- void setCursorLCD (BYTE l, BYTE p)

  Move the cursor on the screen Sets the cursor to a specified line on a certain position.
- void appendCharToLCD (const char c)

  Append a character to the LCD Adds a character at the current cursor positon then moves the cursor to the next position.
- void printCharToLCD (const char c, BYTE l, BYTE p)

  Print character to LCD Prints a character to a specified position.
- void appendStringToLCD_ (const char ∗message)
- void printStringToLCD (char ∗message, BYTE l, BYTE p)
- void appendStringToLCDcharptr (char ∗message)
- void appendIntToLCD (int i)

  Append an integer to the lcd screen Prints the integer at the current cursor position and moves the cursor to the position afther the printed integer.
- void printIntToLCD (int i, BYTE l, BYTE p)

  Prints an integer to the LCD screen Prints an integer to a specified line and position on the screen.

Variables

- struct lcd_info_type lcd_info

4.3.1 Function Documentation

4.3.1.1 appendCharToLCD()

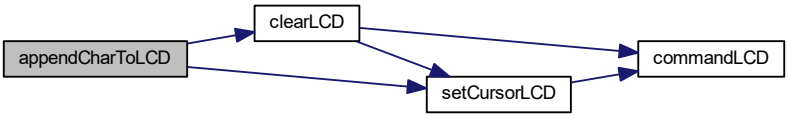
```
void appendCharToLCD (
            const char c )
```

Append a character to the LCD Adds a character at the current cursor positon then moves the cursor to the next position.

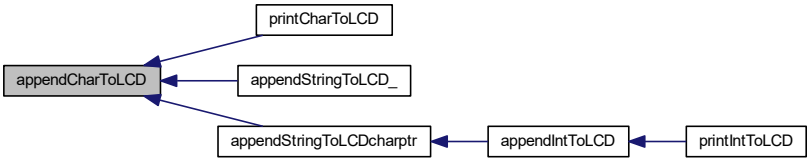
Parameters

c	the character to append

Here is the call graph for this function:



Here is the caller graph for this function:



4.3.1.2 appendIntToLCD()

```
void appendIntToLCD (
            int i )
```

Append an integer to the lcd screen Prints the integer at the current cursor position and moves the cursor to the position afther the printed integer.

Parameters

i	the integer to print

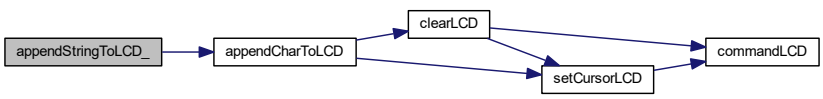
Here is the call graph for this function:

Here is the caller graph for this function:

4.3.1.3 appendStringToLCD_()

```
void appendStringToLCD_ (
            const char * message )
```

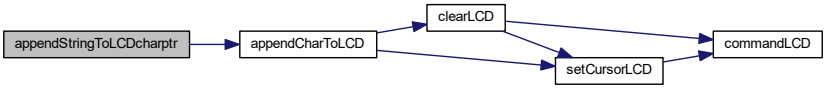
Here is the call graph for this function:



4.3.1.4 appendStringToLCDcharptr()

```
void appendStringToLCDcharptr (
            char * message )
```

Here is the call graph for this function:



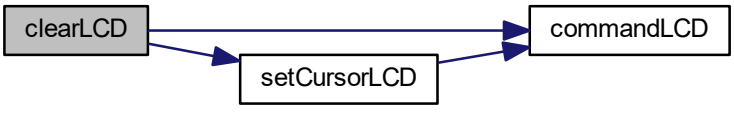
Here is the caller graph for this function:

4.3.1.5 clearLCD()

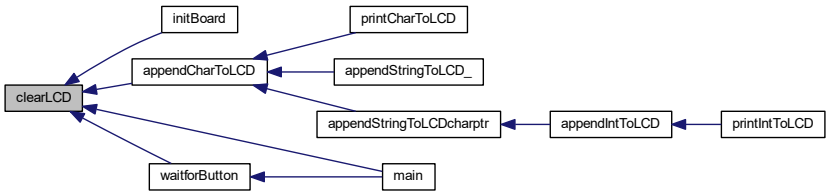
```
void clearLCD (
            void  )
```

clears the LCD screen This function removes all the content from the LCD screen

Here is the call graph for this function:



Here is the caller graph for this function:



4.3.1.6 commandLCD()

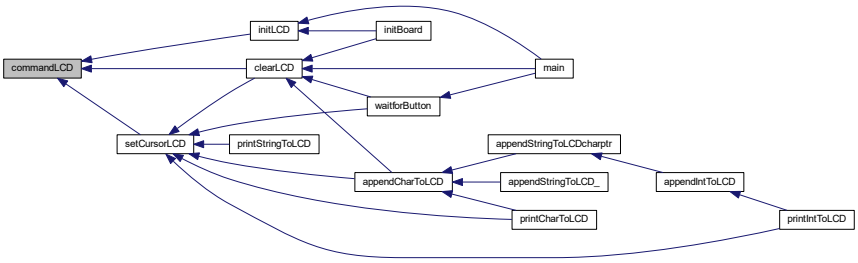
```
void commandLCD (
            const BYTE c )
```

sends a command to the LCD This function sends a low level command to the LCD. The command is represented as a byte and is transferred to the LCD screen through the PORTA register.

Parameters

c	command to be transfered to the LCD

Here is the caller graph for this function:

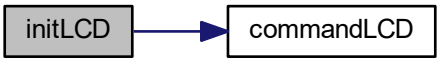


4.3.1.7 initLCD()

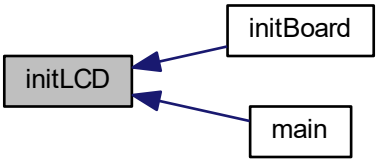
```
void initLCD (
            void  )
```

initializes the LCD screen This function sets up the lcd for displaying the data we will send

Here is the call graph for this function:



Here is the caller graph for this function:



4.3.1.8 printCharToLCD()

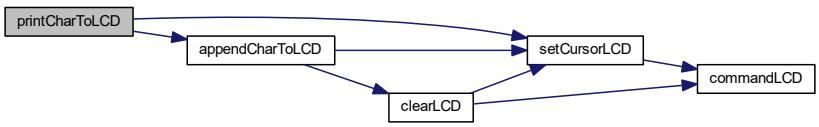
```
void printCharToLCD (
            const char s,
            BYTE l,
            BYTE p )
```

Print character to LCD Prints a character to a specified position.

Parameters

s	the character to print
l	the line
p	the position in the line

Here is the call graph for this function:



4.3.1.9 printIntToLCD()

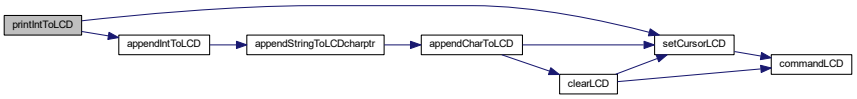
```
void printIntToLCD (
            int i,
            BYTE l,
            BYTE p )
```

Prints an integer to the LCD screen Prints an integer to a specified line and position on the screen.

Parameters

i	the integer to print
l	the line
p	the position in the line

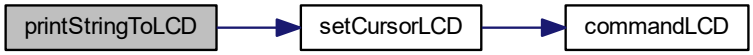
Here is the call graph for this function:



4.3.1.10 printStringToLCD()

```
void printStringToLCD (
            char * message,
            BYTE l,
            BYTE p )
```

Here is the call graph for this function:



4.3.1.11 setCursorLCD()

```
void setCursorLCD (
            BYTE l,
            BYTE p )
```

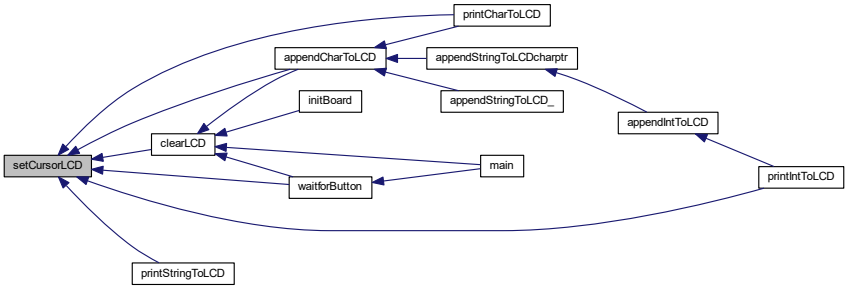
Move the cursor on the screen Sets the cursor to a specified line on a certain position.

Parameters

l	line number
p	position in line

Here is the call graph for this function:

Here is the caller graph for this function:



4.3.2 Variable Documentation

4.3.2.1 lcd_info

```
struct lcd_info_type lcd_info
```

dwenguinoLCD.c

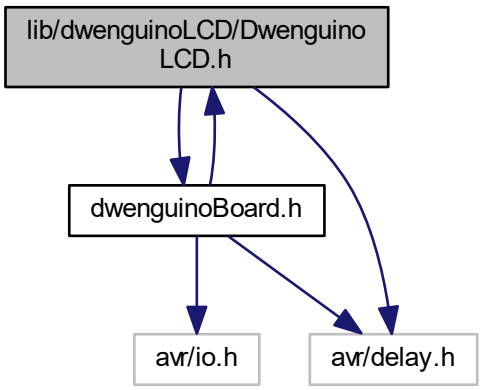
Created on: Jan 19, 2016 Author: Tom

4.4 lib/dwenguinoLCD/DwenguinoLCD.h File Reference

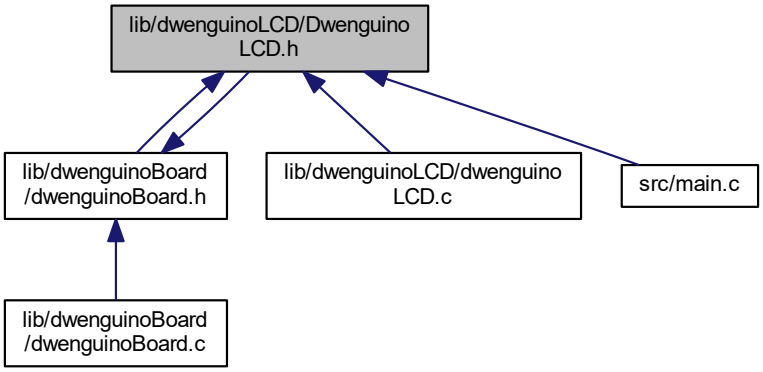
This library contains function declarations which allow you to communicate with the lcd screen on the Dwenguino board.

```
#include "dwenguinoBoard.h"
#include <avr/delay.h>
```

Include dependency graph for DwenguinoLCD.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct lcd_info_type

  Stores the current line and position of the cursor.

Macros

- #define LCD_WIDTH 16
- #define LCD_HEIGHT 2
- #define LCD_LASTLINE (LCD_HEIGHT - 1)
- #define LCD_LASTPOS (LCD_WIDTH - 1)
- #define backlightOn() (LCD_BACKLIGHT_ON)
- #define backlightOff() (LCD_BACKLIGHT_OFF)
- #define appendStringToLCD(message) appendStringToLCD_((const char∗)(message));

Functions

- void initLCD (void)

  initializes the LCD screen This function sets up the lcd for displaying the data we will send
- void clearLCD (void)

  clears the LCD screen This function removes all the content from the LCD screen
- void commandLCD (const BYTE c)

  sends a command to the LCD This function sends a low level command to the LCD. The command is represented as a byte and is transferred to the LCD screen through the PORTA register.
- void setCursorLCD (BYTE l, BYTE p)

  Move the cursor on the screen Sets the cursor to a specified line on a certain position.
- void appendCharToLCD (const char c)

  Append a character to the LCD Adds a character at the current cursor positon then moves the cursor to the next position.
- void printCharToLCD (const char s, BYTE l, BYTE p)

  Print character to LCD Prints a character to a specified position.
- void appendIntToLCD (int i)

  Append an integer to the lcd screen Prints the integer at the current cursor position and moves the cursor to the position afther the printed integer.
- void printIntToLCD (int i, BYTE l, BYTE p)

  Prints an integer to the LCD screen Prints an integer to a specified line and position on the screen.

Variables

- struct lcd_info_type lcd_info

4.4.1 Detailed Description

This library contains function declarations which allow you to communicate with the lcd screen on the Dwenguino board.

See also

∗ For more information on the dwenguino board visit: http://www.dwengo.org/tutorials

Author

Tom Neutens

Date

11/01/2017 Before you can use the lcd you should call the initLCD() function. Afterwards you can either append or print characters or integers to the screen.

4.4.2 Macro Definition Documentation

4.4.2.1 appendStringToLCD

```
#define appendStringToLCD(
            message ) appendStringToLCD_((const char*)(message));
```

4.4.2.2 backlightOff

```
#define backlightOff( ) (LCD_BACKLIGHT_OFF)
```

4.4.2.3 backlightOn

```
#define backlightOn( ) (LCD_BACKLIGHT_ON)
```

4.4.2.4 LCD_HEIGHT

```
#define LCD_HEIGHT 2
```

4.4.2.5 LCD_LASTLINE

```
#define LCD_LASTLINE (LCD_HEIGHT - 1)
```

4.4.2.6 LCD_LASTPOS

```
#define LCD_LASTPOS (LCD_WIDTH - 1)
```

4.4.2.7 LCD_WIDTH

```
#define LCD_WIDTH 16
```

4.4.3 Function Documentation

4.4.3.1 appendCharToLCD()

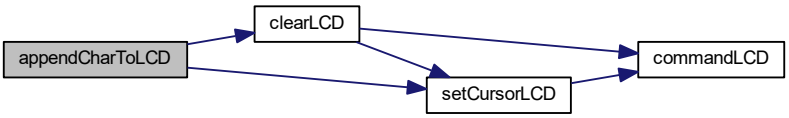
```
void appendCharToLCD (
            const char c )
```

Append a character to the LCD Adds a character at the current cursor positon then moves the cursor to the next position.

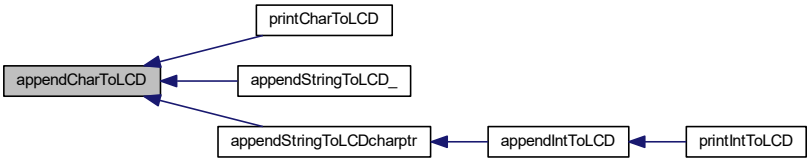
Parameters

c	the character to append

Here is the call graph for this function:



Here is the caller graph for this function:



4.4.3.2 appendIntToLCD()

```
void appendIntToLCD (
            int i )
```

Append an integer to the lcd screen Prints the integer at the current cursor position and moves the cursor to the position afther the printed integer.

Parameters

i	the integer to print

Here is the call graph for this function:

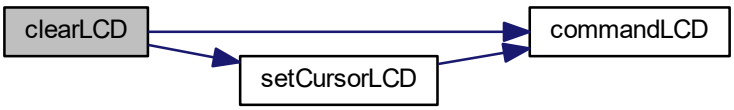
Here is the caller graph for this function:

4.4.3.3 clearLCD()

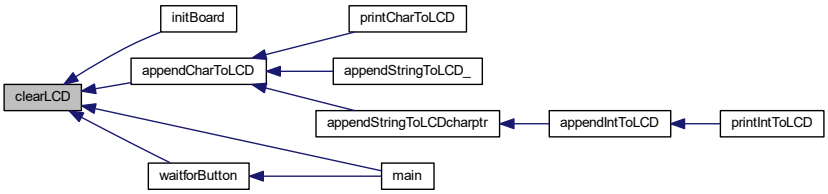
```
void clearLCD (
            void  )
```

clears the LCD screen This function removes all the content from the LCD screen

Here is the call graph for this function:



Here is the caller graph for this function:



4.4.3.4 commandLCD()

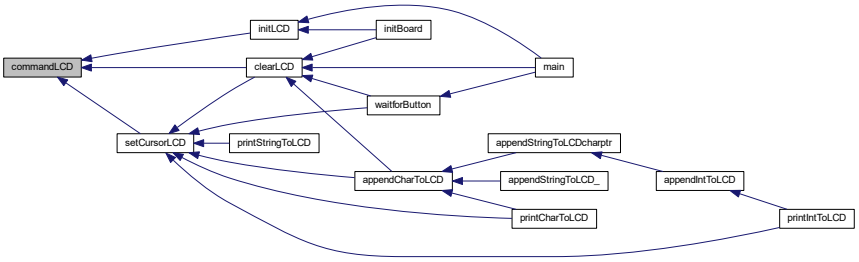
```
void commandLCD (
            const BYTE c )
```

sends a command to the LCD This function sends a low level command to the LCD. The command is represented as a byte and is transferred to the LCD screen through the PORTA register.

Parameters

c	command to be transfered to the LCD

Here is the caller graph for this function:

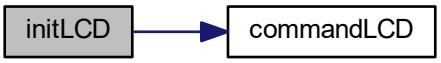


4.4.3.5 initLCD()

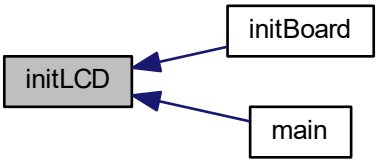
```
void initLCD (
              void  )
```

initializes the LCD screen This function sets up the lcd for displaying the data we will send

Here is the call graph for this function:



Here is the caller graph for this function:



4.4.3.6 printCharToLCD()

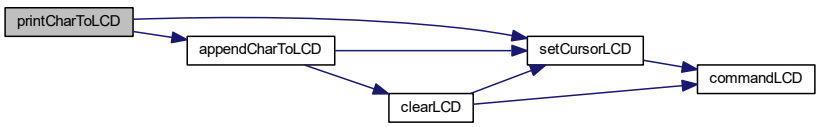
```
void printCharToLCD (
            const char s,
            BYTE l,
            BYTE p )
```

Print character to LCD Prints a character to a specified position.

Parameters

s	the character to print
l	the line
p	the position in the line

Here is the call graph for this function:



4.4.3.7 printIntToLCD()

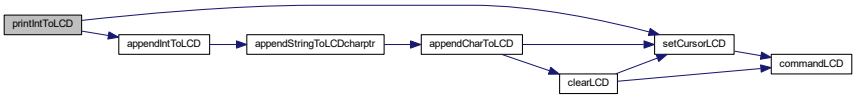
```
void printIntToLCD (
            int i,
            BYTE l,
            BYTE p )
```

Prints an integer to the LCD screen Prints an integer to a specified line and position on the screen.

Parameters

i	the integer to print
l	the line
p	the position in the line

Here is the call graph for this function:



4.4.3.8 setCursorLCD()

```
void setCursorLCD (
            BYTE l,
            BYTE p )
```

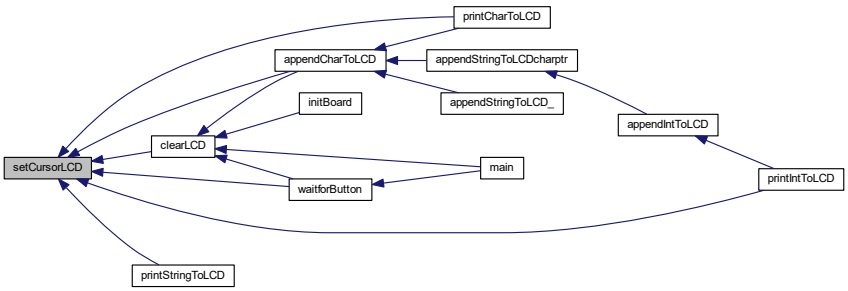
Move the cursor on the screen Sets the cursor to a specified line on a certain position.

Parameters

l	line number
p	position in line

Here is the call graph for this function:

Here is the caller graph for this function:



4.4.4 Variable Documentation

4.4.4.1 lcd_info

```
struct lcd_info_type lcd_info
```

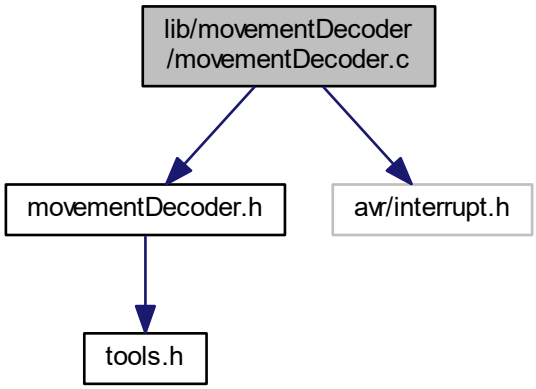
dwenguinoLCD.c

Created on: Jan 19, 2016 Author: Tom

4.5 lib/movementDecoder/movementDecoder.c File Reference

```
#include "movementDecoder.h"
#include <avr/interrupt.h>
```

Include dependency graph for movementDecoder.c:



Functions

- void initMovementDecoder ()

  Initializes the optosensor. This function sets up the optosensores to generate interrupts and using other functions implemented in this library to retrieve the movement of the agent.
- void checkMovementDir ()

  Determines the movement direction of the agent. This function uses the current and previous state of the optosensors to determine the direction.
- int getMovementDirCount ()

  Returns the dirCount value.
- void clearDirCount ()

  Clears the dirCount value.
- ISR (DECODER1_INT)
- ISR (DECODER2_INT)

Variables

- BYTE prevAngleState = 0
- int dirCount = 0

  Value = movement, sign = direction.

4.5.1 Function Documentation

4.5.1.1 checkMovementDir()

```
void checkMovementDir ( )  [inline]
```

Determines the movement direction of the agent. This function uses the current and previous state of the optosensors to determine the direction.

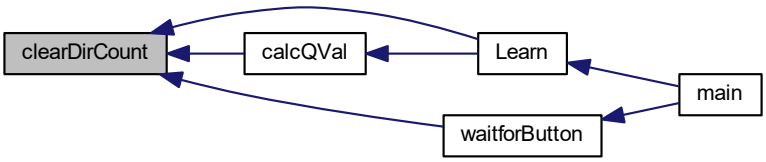
Here is the caller graph for this function:

4.5.1.2 clearDirCount()

```
void clearDirCount ( )
```

Clears the dirCount value.

Here is the caller graph for this function:

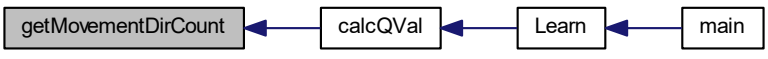


4.5.1.3 getMovementDirCount()

```
int getMovementDirCount ( )
```

Returns the dirCount value.

Here is the caller graph for this function:

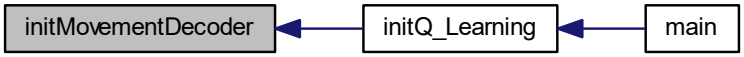


4.5.1.4 initMovementDecoder()

```
void initMovementDecoder ( )
```

Initializes the optosensor. This function sets up the optosensores to generate interrupts and using other functions implemented in this library to retrieve the movement of the agent.

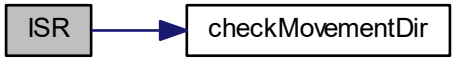
Here is the caller graph for this function:



4.5.1.5 ISR() [1/2]

```
ISR (
            DECODER1_INT  )
```

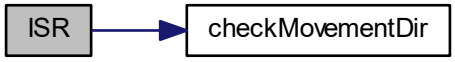
Here is the call graph for this function:



4.5.1.6 ISR() [2/2]

```
ISR (
            DECODER2_INT  )
```

Here is the call graph for this function:



4.5.2 Variable Documentation

4.5.2.1 dirCount

```
int dirCount = 0
```

Value = movement, sign = direction.

4.5.2.2 prevAngleState

```
BYTE prevAngleState = 0
```

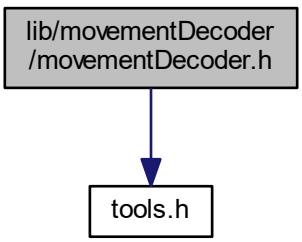
The first time prevAngleState is unknown, represented by the MSB of prevAngleState BIT 7: (MSB) bool prev↩ AngleStateKnown BIT 0-1: the binary value of prevAngleState

4.6 lib/movementDecoder/movementDecoder.h File Reference

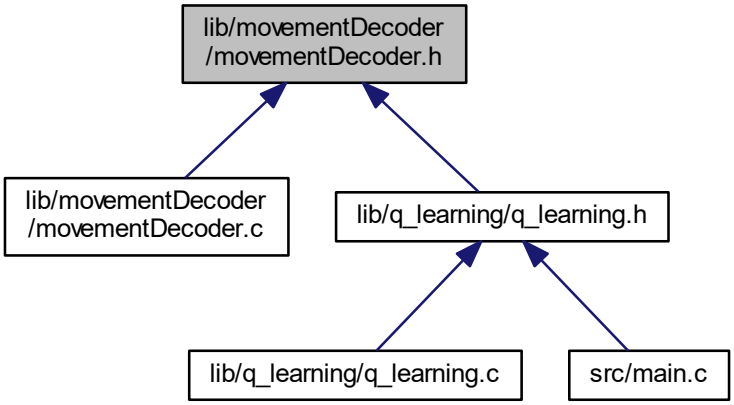
This library contains functions to determine the direction by using 2 optosensores. Before using the movement↩ Decoder's methods, call the initMovementDecoder() function.

```
#include "tools.h"
```

Include dependency graph for movementDecoder.h:



This graph shows which files directly or indirectly include this file:



Macros

- #define DECODER1_PORT PORTD
- #define DECODER1_DIR DDRD
- #define DECODER1_DATA PIND
- #define DECODER1 PORTD0

  connect the DO pin of optosensor 1 to this port
- #define DECODER1_INT INT0_vect

  the interrupt used by optosensor 1
- #define DECODER2_PORT PORTD
- #define DECODER2_DIR DDRD
- #define DECODER2_DATA PIND
- #define DECODER2 PORTD1

  connect the DO pin of optosensor 1 to this port
- #define DECODER2_INT INT1_vect

  the interrupt used by optosensor2
- #define GRAY_TO_BIN(GRAY) (GRAY & (1 << 1)) ? (TOGGLE_BIT(GRAY, 0)) : (0)

Functions

- void initMovementDecoder ()

  Initializes the optosensor. This function sets up the optosensores to generate interrupts and using other functions implemented in this library to retrieve the movement of the agent.
- void checkMovementDir ()

  Determines the movement direction of the agent. This function uses the current and previous state of the optosensors to determine the direction.
- int getMovementDirCount ()

  Returns the dirCount value.
- void clearDirCount ()

  Clears the dirCount value.

4.6.1 Detailed Description

This library contains functions to determine the direction by using 2 optosensores. Before using the movement↩ Decoder's methods, call the initMovementDecoder() function.

Author

Jonas Van Der Donckt

Date

13/05/2017

4.6.2 Macro Definition Documentation

4.6.2.1 DECODER1

```
#define DECODER1 PORTD0
```

connect the DO pin of optosensor 1 to this port

4.6.2.2 DECODER1_DATA

```
#define DECODER1_DATA PIND
```

4.6.2.3 DECODER1_DIR

```
#define DECODER1_DIR DDRD
```

4.6.2.4 DECODER1_INT

```
#define DECODER1_INT INT0_vect
```

the interrupt used by optosensor 1

4.6.2.5 DECODER1_PORT

```
#define DECODER1_PORT PORTD
```

4.6.2.6 DECODER2

```
#define DECODER2 PORTD1
```

connect the DO pin of optosensor 1 to this port

4.6.2.7 DECODER2_DATA

```
#define DECODER2_DATA PIND
```

4.6.2.8 DECODER2_DIR

```
#define DECODER2_DIR DDRD
```

4.6.2.9 DECODER2_INT

```
#define DECODER2_INT INT1_vect
```

the interrupt used by optosensor2

4.6.2.10 DECODER2_PORT

```
#define DECODER2_PORT PORTD
```

4.6.2.11 GRAY_TO_BIN

```
#define GRAY_TO_BIN(
             GRAY ) (GRAY & (1 << 1)) ?  (TOGGLE_BIT(GRAY, 0)) :  (0)
```

4.6.3 Function Documentation

4.6.3.1 checkMovementDir()

```
void checkMovementDir ( )  [inline]
```

Determines the movement direction of the agent. This function uses the current and previous state of the optosensors to determine the direction.

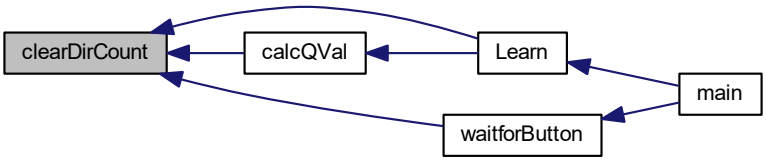
Here is the caller graph for this function:

4.6.3.2 clearDirCount()

```
void clearDirCount ( )
```

Clears the dirCount value.

Here is the caller graph for this function:

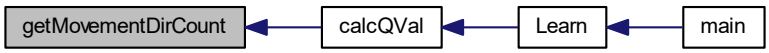


4.6.3.3 getMovementDirCount()

```
int getMovementDirCount ( )
```

Returns the dirCount value.

Here is the caller graph for this function:

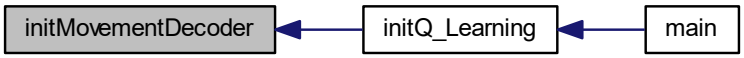


4.6.3.4 initMovementDecoder()

```
void initMovementDecoder ( )
```

Initializes the optosensor. This function sets up the optosensores to generate interrupts and using other functions implemented in this library to retrieve the movement of the agent.

Here is the caller graph for this function:

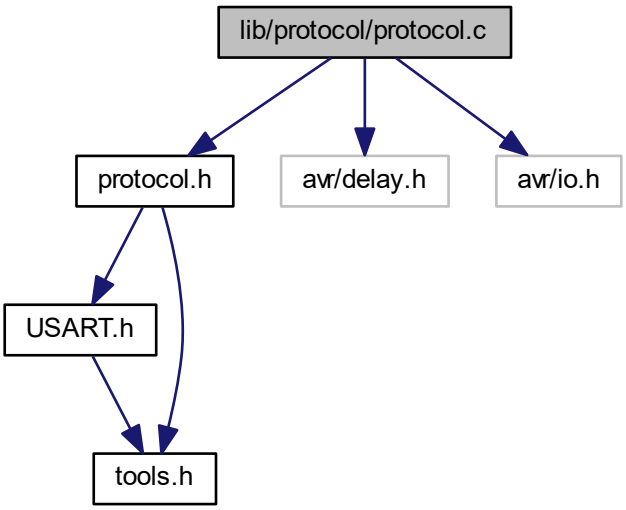


4.7 lib/protocol/protocol.c File Reference

```
#include "protocol.h"
#include <avr/delay.h>
```

```
#include <avr/io.h>
```

Include dependency graph for protocol.c:



Functions

- void transmit_data (struct Dataobj *dObj)

  Transmits the datastruct.
- void init_QvalProtocol (int QVal, struct Dataobj *Q_Data)

  Initializes a Q_value data object.
- void init_PositionProtocol (unsigned char position[2], struct Dataobj *posObj)

  Initializes a position data object.
- void init_SizeProtocol (unsigned char size[2], struct Dataobj *sizeObj)

  Initializes a size data object.

4.7.1 Function Documentation

4.7.1.1 init_PositionProtocol()

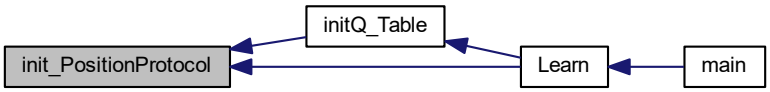
```
void init_PositionProtocol (
            unsigned char position[2],
            struct Dataobj * posObj )
```

Initializes a position data object.

Parameters

position	the indices of the position (row, column)
dataObj1	passes areference to the Dataobj that needs to be initialized

Here is the caller graph for this function:



4.7.1.2 init_QvalProtocol()

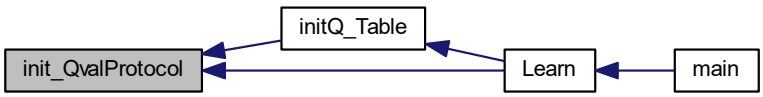
```
void init_QvalProtocol (
            int QVal,
            struct Dataobj * Q_Data )
```

Initializes a Q_value data object.

Parameters

Qval	the Q value
Q_Data	passes a reference to the Dataobj that needs to be initialized

Here is the caller graph for this function:



4.7.1.3 init_SizeProtocol()

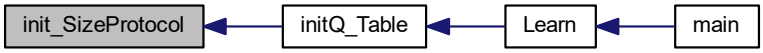
```
void init_SizeProtocol (
            unsigned char size[2],
            struct Dataobj * sizeObj )
```

Initializes a size data object.

Parameters

size	the indices of the Q_table's size (row, column)
sizeObj	passes a reference to the Dataobj that needs to be initialized

Here is the caller graph for this function:



4.7.1.4 transmit_data()

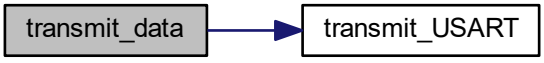
```
void transmit_data (
            struct Dataobj * dObj )
```

Transmits the datastruct.

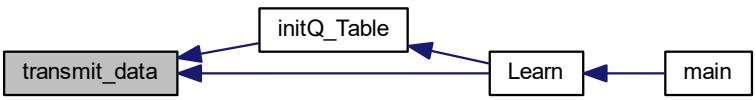
Parameters

dObj	passes a reference to the Dataobj that needs to be transmitted

Here is the call graph for this function:



Here is the caller graph for this function:

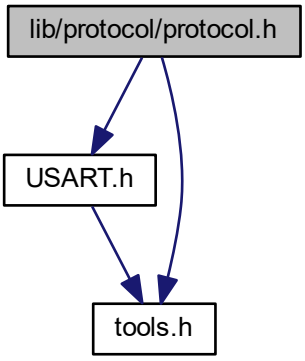


4.8 lib/protocol/protocol.h File Reference

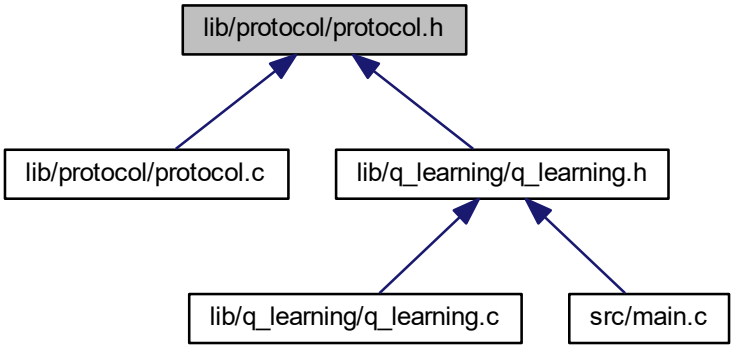
This library contains the custom protocol used to send data to a peripheral device which uses the same protocol to receive them.

```
#include "USART.h"
#include "tools.h"
```

Include dependency graph for protocol.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct Dataobj

  This struct contains the parameters of the data object that can be used to transmit data.

Macros

- #define Q_VALUE_TYPE 'q'
- #define POSITION_TYPE 'p'
- #define TABLE_TYPE 't'
- #define START_TYPE 's'
- #define END_TYPE 'e'
- #define UCHAR_SIZE (sizeof(unsigned char))
- #define CHAR_SIZE (sizeof(char))
- #define INT_SIZE (sizeof(int))
- #define FLOAT_SIZE (sizeof(float))

Functions

- void transmit_data (struct Dataobj *dObj)

  Transmits the datastruct.
- void init_QvalProtocol (int QVal, struct Dataobj *Q_Data)

  Initializes a Q_value data object.
- void init_PositionProtocol (unsigned char position[2], struct Dataobj *posObj)

  Initializes a position data object.
- void init_SizeProtocol (unsigned char size[2], struct Dataobj *sizeObj)

  Initializes a size data object.

4.8.1 Detailed Description

This library contains the custom protocol used to send data to a peripheral device which uses the same protocol to receive them.

Author

Jonas Van Der Donckt

Date

14/05/2017

4.8.2 Macro Definition Documentation

4.8.2.1 CHAR_SIZE

```
#define CHAR_SIZE (sizeof(char))
```

4.8.2.2 END_TYPE

```
#define END_TYPE 'e'
```

4.8.2.3 FLOAT_SIZE

```
#define FLOAT_SIZE (sizeof(float))
```

4.8.2.4 INT_SIZE

```
#define INT_SIZE (sizeof(int))
```

4.8.2.5 POSITION_TYPE

```
#define POSITION_TYPE 'p'
```

4.8.2.6 Q_VALUE_TYPE

```
#define Q_VALUE_TYPE 'q'
```

4.8.2.7 START_TYPE

```
#define START_TYPE 's'
```

4.8.2.8 TABLE_TYPE

```
#define TABLE_TYPE 't'
```

4.8.2.9 UCHAR_SIZE

```
#define UCHAR_SIZE (sizeof(unsigned char))
```

4.8.3 Function Documentation

4.8.3.1 init_PositionProtocol()

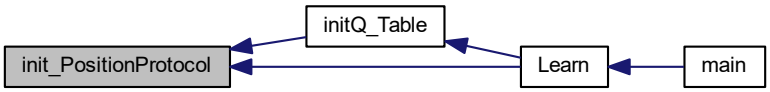
```
void init_PositionProtocol (
            unsigned char position[2],
            struct Dataobj * posObj )
```

Initializes a position data object.

Parameters

position	the indices of the position (row, column)
dataObj1	passes areference to the Dataobj that needs to be initialized

Here is the caller graph for this function:



4.8.3.2 init_QvalProtocol()

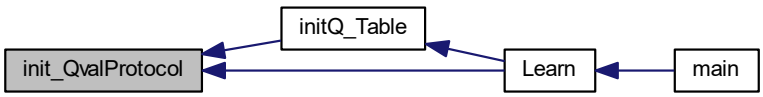
```
void init_QvalProtocol (
            int QVal,
            struct Dataobj * Q_Data )
```

Initializes a Q_value data object.

Parameters

Qval	the Q value
Q_Data	passes a reference to the Dataobj that needs to be initialized

Here is the caller graph for this function:



4.8.3.3 init_SizeProtocol()

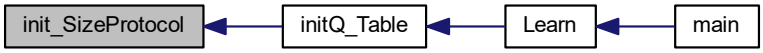
```
void init_SizeProtocol (
            unsigned char size[2],
            struct Dataobj * sizeObj )
```

Initializes a size data object.

Parameters

size	the indices of the Q_table's size (row, column)
sizeObj	passes a reference to the Dataobj that needs to be initialized

Here is the caller graph for this function:



4.8.3.4 transmit_data()

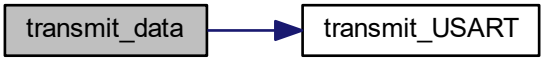
```
void transmit_data (
            struct Dataobj * dObj )
```

Transmits the datastruct.

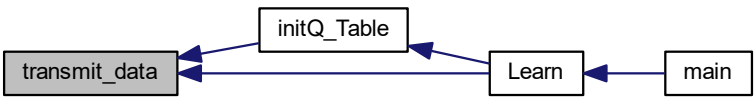
Parameters

dObj	passes a reference to the Dataobj that needs to be transmitted

Here is the call graph for this function:



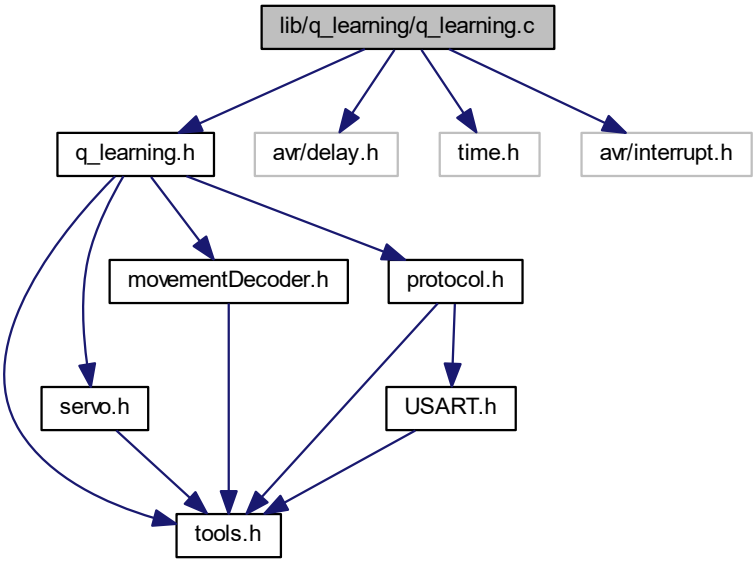
Here is the caller graph for this function:



4.9 lib/q_learning/q_learning.c File Reference

```
#include "q_learning.h"
#include <avr/delay.h>
#include <time.h>
#include <avr/interrupt.h>
```

Include dependency graph for q_learning.c:



Functions

- void initQ_Learning ()

  Initializes the Q-learning algorithm. This function sets up the pins and the interrupt for the button. It also initialzes the needed components for the Q-learning algorithm (servo.h, movementDecoder.h)
- void initQ_Table ()

  Initializes the Q_Table with random values.
- void Learn ()
- int calcQVal ()

  This function calculates the Q-value. It should be only called by the learn() method.
- unsigned char calcNextAction ()

  This function calculates the next action. It should be only called by the learn() method.
- unsigned char CalcStateIndex (unsigned char stateArr[])

  Calculates the state index.
- int calcMaxQval (unsigned char state)

  This function calculates the maximum Q-value for a certain state. It should be only called by the learn() method.
- unsigned char calcMaxActionIndex (unsigned char state)

  This function calculates the maximum state index. It should be only called by the learn() method.
- void waitBTN ()
- void adjustParameters ()

  Adjusts the parameters in the Q-learning formule.
- void calcParameter (struct Formula_Parameters_t *paramVal)

  Calculates the new value of the parameters used in the Q-learning formula.
- ISR (INT5_vect)

Variables

- unsigned char dataByte
- int ** Q_Table

  dynamically allocated Q_Table
- int * temp

  pointer used to allocate Q_Table
- unsigned char prevServoStateArr [NUMB_SERVOS] = {STARTSTATES1,STARTSTATES2}
- unsigned char nextServoStateArr [NUMB_SERVOS] = {STARTSTATES1,STARTSTATES2}
- int numbIterations = 0

  the amount of iterations the agent has done through the learn method
- struct Formula_Parameters_t parameters [NUMB_PARAMETERS]

4.9.1 Function Documentation

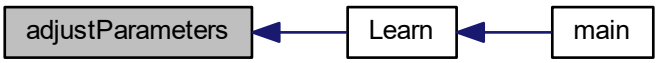
4.9.1.1 adjustParameters()

```
void adjustParameters ( )
```

Adjusts the parameters in the Q-learning formule.

Here is the call graph for this function:

Here is the caller graph for this function:



4.9.1.2 calcMaxActionIndex()

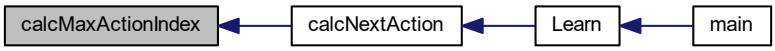
```
unsigned char calcMaxActionIndex (
            unsigned char state )
```

This function calculates the maximum state index. It should be only called by the learn() method.

Parameters

state	this is the state of the robot

Here is the caller graph for this function:



4.9.1.3 calcMaxQval()

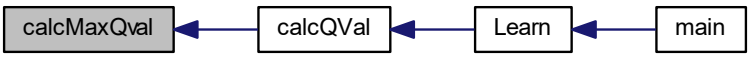
```
int calcMaxQval (
            unsigned char state )
```

This function calculates the maximum Q-value for a certain state. It should be only called by the learn() method.

Parameters

state	this is the state of the robot

Here is the caller graph for this function:

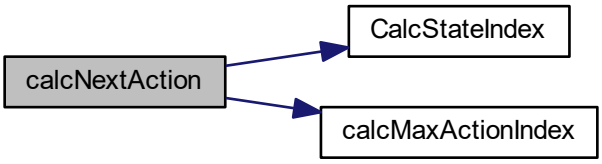


4.9.1.4 calcNextAction()

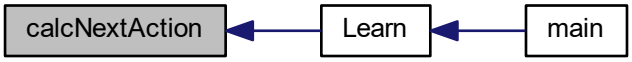
```
unsigned char calcNextAction ( )
```

This function calculates the next action. It should be only called by the learn() method.

Here is the call graph for this function:



Here is the caller graph for this function:



4.9.1.5 calcParameter()

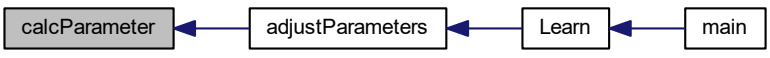
```
void calcParameter (
            struct Formula_Parameters_t * paramVal )
```

Calculates the new value of the parameters used in the Q-learning formula.

Parameters

∗paramVal	this is the parameter that will be updated

Here is the caller graph for this function:

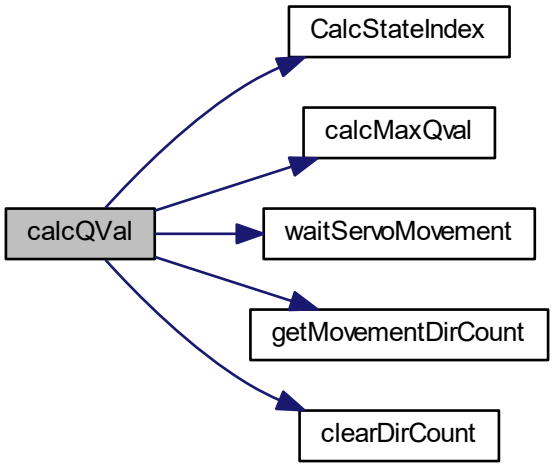


4.9.1.6 calcQVal()

```
int calcQVal ( )
```

This function calculates the Q-value. It should be only called by the learn() method.

Here is the call graph for this function:



Here is the caller graph for this function:

4.9.1.7 CalcStateIndex()

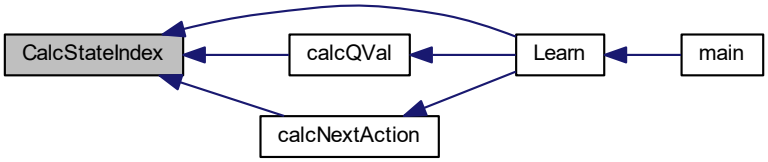
```
unsigned char CalcStateIndex (
            unsigned char stateArr[] )
```

Calculates the state index.

Parameters

stateArr[ ]	this array contains the stateval of each servo

Here is the caller graph for this function:

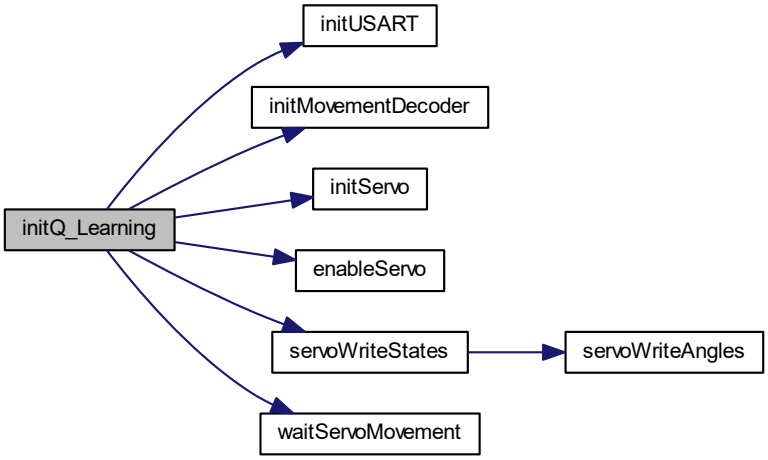


4.9.1.8 initQ_Learning()

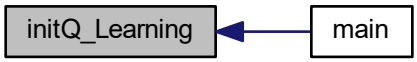
```
void initQ_Learning ( )
```

Initializes the Q-learning algorithm. This function sets up the pins and the interrupt for the button. It also initialzes the needed components for the Q-learning algorithm (servo.h, movementDecoder.h)

Here is the call graph for this function:



Here is the caller graph for this function:

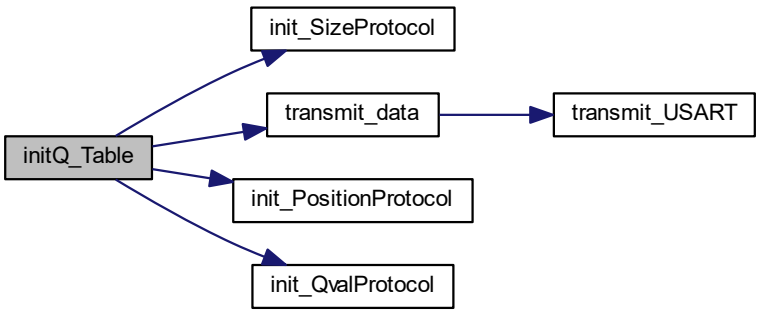


4.9.1.9 initQ_Table()

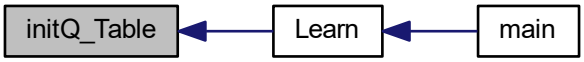
```
void initQ_Table ( )
```

Initializes the Q_Table with random values.

Here is the call graph for this function:



Here is the caller graph for this function:



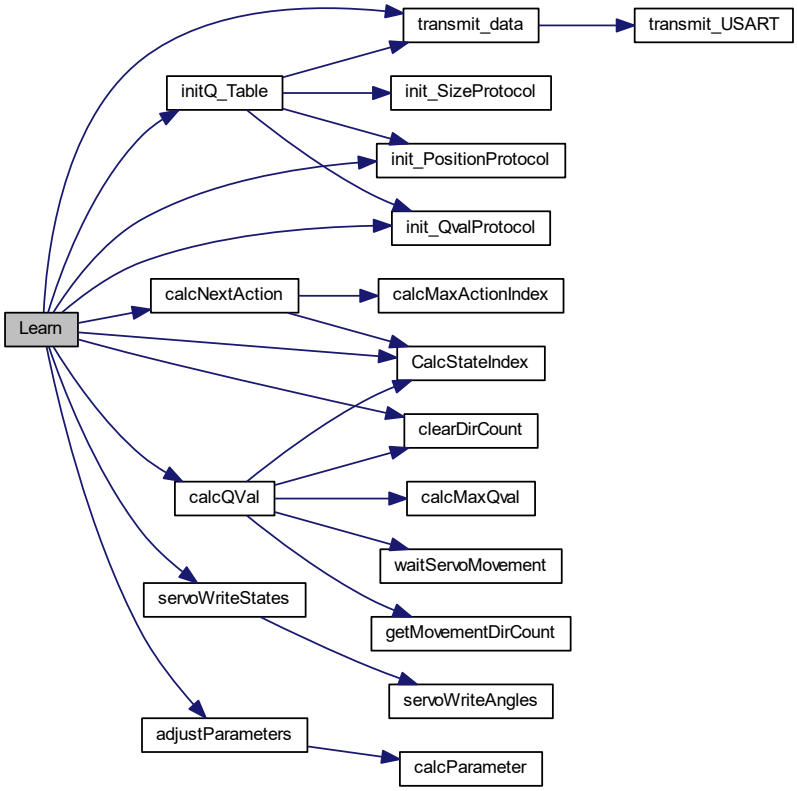
4.9.1.10 ISR()

```
ISR (
             INT5_vect  )
```

4.9.1.11 Learn()

```
void Learn ( )
```

Here is the call graph for this function:



Here is the caller graph for this function:

4.9.1.12 waitBTN()

```
void waitBTN ( )
```

Here is the caller graph for this function:

4.9.2 Variable Documentation

4.9.2.1 dataByte

```
unsigned char dataByte
```

this dataByte contains data of multiple parameters BIT 7: Bool btnPressed (true when the button is pressed) BIT 0-3: Nibble prevAction (max omount of servos is 8 –> 2 actions per servo = 16 = 2^4 = NIbble)

4.9.2.2 nextServoStateArr

```
unsigned char nextServoStateArr[NUMB_SERVOS] = {STARTSTATES1,STARTSTATES2}
```

4.9.2.3 numbIterations

```
int numbIterations = 0
```

the amount of iterations the agent has done through the learn method

4.9.2.4 parameters

```
struct Formula_Parameters_t parameters[NUMB_PARAMETERS]
```

4.9.2.5 prevServoStateArr

```
unsigned char prevServoStateArr[NUMB_SERVOS] = {STARTSTATES1,STARTSTATES2}
```

4.9.2.6 Q_Table

```
int** Q_Table
```

dynamically allocated Q_Table

4.9.2.7 temp

```
int* temp
```

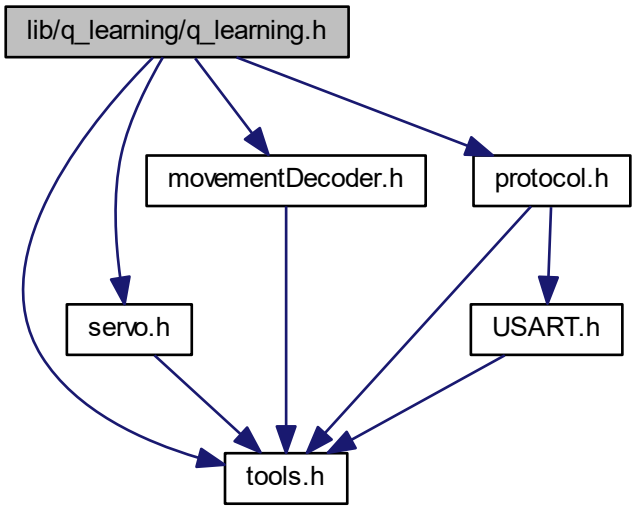
pointer used to allocate Q_Table

4.10 lib/q_learning/q_learning.h File Reference

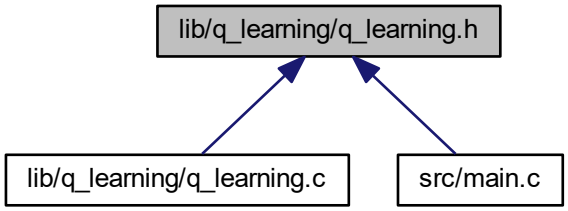
This library contains the Q-learning algorithm. before you can use the learn method function you should call the initQ_Learning() function. Afterwards you can call the learn() function.

```
#include "tools.h"
#include "servo.h"
#include "movementDecoder.h"
#include "protocol.h"
```

Include dependency graph for q_learning.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct Formula_Parameters_t

  This struct contains the parameters of the Q-learning formula. Some other functions are specificly designed to change those parameters by using an exponential function.

Macros

- #define NUMB_ACTIONS (2∗NUMB_SERVOS)
- #define OPT_PER_SERVO 2

  options of actions per servo
- #define NUMB_STATES ((unsigned char)pow(NUMB_SERVO_STATES,NUMB_SERVOS))
- #define RAND_INITQ_B 1

  0 if the Q table doesn't need a random initialisation
- #define EXP_ENABLED 1

  bool; 1 if the
- #define EULER (double)2.71828
- #define NUMB_PARAMETERS 3
- #define RADIX 100

  fixed point notation
- #define MAX_FACTOR 100

  fixed point notation is used –> this is maximum
- #define EXP_REWARD_FACTOR (double)0.1

  the exponential reward factor
- #define MAX_COUNT 80
- #define LEARNING_RATE_INDEX 0
- #define INIT_LEARNING_RATE 90

  alpha 0.5
- #define EXP_FACTOR_LEARNING (float)1
- #define FINAL_LEARING_RATE 40
- #define GREEDY_FACTOR_INDEX 1
- #define INIT_GREEDY_FACTOR 90

  epsillon 0.1
- #define EXP_GREEDY_FACTOR (float)1
- #define FINAL_GREEDY_FACTOR 0

- #define DISCOUNT_FACTOR_INDEX 2
- #define INIT_DISCOUNT_FACTOR 99

  gamma 0.99
- #define EXP_FACTOR_DISCOUNT (float)1
- #define FINAL_DISCOUNT_FACTOR 50
- #define STARTSTATES1 0

  this value should be < than NUMB_STATES
- #define STARTSTATES2 3
- #define STARTSTATES3 0
- #define TRESHMOVFW 2

  threshold value for moving forward
- #define DELAYVAL 700

  value in ms that is used to wait until the robot stopped moving
- #define BTN_S PORTE5
- #define BTN_S_PORT PORTE
- #define BTN_S_DIR DDRE
- #define BTN_S_INT INT5
- #define PREVACTION_INDEX_NIBBLE 0
- #define BTNPRESSED_INDEX 7
- #define CALC_STATE_INDEX(STATES1, STATES2) (STATES1∗4 + STATES2)
- #define GETSIZE(QTABLE) (sizeof(QTABLE[0])/ sizeof(QTABLE[0][0]))
- #define ENABLE_BTN (SET_BIT_HIGH(EIMSK, BTN_S_INT))

Functions

- void initQ_Learning ()

  Initializes the Q-learning algorithm. This function sets up the pins and the interrupt for the button. It also initialzes the needed components for the Q-learning algorithm (servo.h, movementDecoder.h)
- void initQ_Table ()

  Initializes the Q_Table with random values.
- void learn ()

  The Q-learning algorithm itself. This function executes the Q_learning algorithm itself.
- int calcQVal ()

  This function calculates the Q-value. It should be only called by the learn() method.
- unsigned char calcNextAction ()

  This function calculates the next action. It should be only called by the learn() method.
- unsigned char CalcStateIndex (unsigned char stateArr[ ])

  Calculates the state index.
- int calcMaxQval (unsigned char state)

  This function calculates the maximum Q-value for a certain state. It should be only called by the learn() method.
- unsigned char calcMaxActionIndex (unsigned char state)

  This function calculates the maximum state index. It should be only called by the learn() method.
- unsigned char wait_BTN_S ()

  This function waits until button south is pressed.
- void adjustParameters ()

  Adjusts the parameters in the Q-learning formule.
- void calcParameter (struct Formula_Parameters_t ∗paramVal)

  Calculates the new value of the parameters used in the Q-learning formula.

4.10.1 Detailed Description

This library contains the Q-learning algorithm. before you can use the learn method function you should call the initQ_Learning() function. Afterwards you can call the learn() function.

Author

Jonas Van Der Donckt, Jules Noppe

Date

6/05/2017

4.10.2 Macro Definition Documentation

4.10.2.1 BTN_S

```
#define BTN_S PORTE5
```

4.10.2.2 BTN_S_DIR

```
#define BTN_S_DIR DDRE
```

4.10.2.3 BTN_S_INT

```
#define BTN_S_INT INT5
```

4.10.2.4 BTN_S_PORT

```
#define BTN_S_PORT PORTE
```

4.10.2.5 BTNPRESSED_INDEX

```
#define BTNPRESSED_INDEX 7
```

4.10.2.6 CALC_STATE_INDEX

```
#define CALC_STATE_INDEX(
              STATES1,
              STATES2 ) (STATES1*4 + STATES2)
```

4.10.2.7 DELAYVAL

```
#define DELAYVAL 700
```

value in ms that is used to wait until the robot stopped moving

4.10.2.8 DISCOUNT_FACTOR_INDEX

```
#define DISCOUNT_FACTOR_INDEX 2
```

4.10.2.9 ENABLE_BTN

```
#define ENABLE_BTN (SET_BIT_HIGH(EIMSK, BTN_S_INT))
```

4.10.2.10 EULER

```
#define EULER (double)2.71828
```

4.10.2.11 EXP_ENABLED

```
#define EXP_ENABLED 1
```

bool; 1 if the

4.10.2.12 EXP_FACTOR_DISCOUNT

```
#define EXP_FACTOR_DISCOUNT (float)1
```

4.10.2.13 EXP_FACTOR_LEARNING

```
#define EXP_FACTOR_LEARNING (float)1
```

4.10.2.14 EXP_GREEDY_FACTOR

```
#define EXP_GREEDY_FACTOR (float)1
```

4.10.2.15 EXP_REWARD_FACTOR

```
#define EXP_REWARD_FACTOR (double)0.1
```

the exponential reward factor

4.10.2.16 FINAL_DISCOUNT_FACTOR

```
#define FINAL_DISCOUNT_FACTOR 50
```

4.10.2.17 FINAL_GREEDY_FACTOR

```
#define FINAL_GREEDY_FACTOR 0
```

4.10.2.18 FINAL_LEARING_RATE

```
#define FINAL_LEARING_RATE 40
```

4.10.2.19 GETSIZE

```
#define GETSIZE(
              QTABLE ) (sizeof(QTABLE[0])/ sizeof(QTABLE[0][0]))
```

4.10.2.20 GREEDY_FACTOR_INDEX

```
#define GREEDY_FACTOR_INDEX 1
```

4.10.2.21 INIT_DISCOUNT_FACTOR

```
#define INIT_DISCOUNT_FACTOR 99
```

gamma 0.99

4.10.2.22 INIT_GREEDY_FACTOR

```
#define INIT_GREEDY_FACTOR 90
```

epsillon 0.1

4.10.2.23 INIT_LEARNING_RATE

```
#define INIT_LEARNING_RATE 90
```

alpha 0.5

4.10.2.24 LEARNING_RATE_INDEX

```
#define LEARNING_RATE_INDEX 0
```

4.10.2.25 MAX_COUNT

```
#define MAX_COUNT 80
```

4.10.2.26 MAX_FACTOR

```
#define MAX_FACTOR 100
```

fixed point notation is used –> this is maximum

4.10.2.27 NUMB_ACTIONS

```
#define NUMB_ACTIONS (2*NUMB_SERVOS)
```

4.10.2.28 NUMB_PARAMETERS

```
#define NUMB_PARAMETERS 3
```

4.10.2.29 NUMB_STATES

```
#define NUMB_STATES ((unsigned char)pow(NUMB_SERVO_STATES,NUMB_SERVOS))
```

4.10.2.30 OPT_PER_SERVO

```
#define OPT_PER_SERVO 2
```

options of actions per servo

4.10.2.31 PREVACTION_INDEX_NIBBLE

```
#define PREVACTION_INDEX_NIBBLE 0
```

4.10.2.32 RADIX

```
#define RADIX 100
```

fixed point notation

4.10.2.33 RAND_INITQ_B

```
#define RAND_INITQ_B 1
```

0 if the Q table doesn't need a random initialisation

bool; 1 if Q table needs to get randomly initialized

4.10.2.34 STARTSTATES1

```
#define STARTSTATES1 0
```

this value should be < than NUMB_STATES

4.10.2.35 STARTSTATES2

```
#define STARTSTATES2 3
```

4.10.2.36 STARTSTATES3

```
#define STARTSTATES3 0
```

4.10.2.37 TRESHMOVFW

```
#define TRESHMOVFW 2
```

threshold value for moving forward

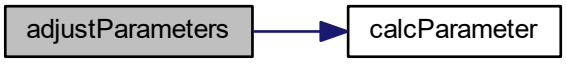
4.10.3 Function Documentation

4.10.3.1 adjustParameters()

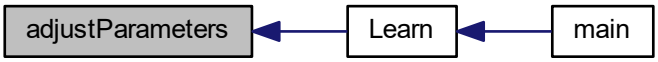
```
void adjustParameters ( )
```

Adjusts the parameters in the Q-learning formule.

Here is the call graph for this function:



Here is the caller graph for this function:



4.10.3.2 calcMaxActionIndex()

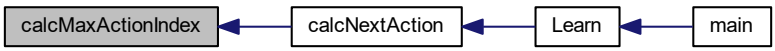
```
unsigned char calcMaxActionIndex (
            unsigned char state )
```

This function calculates the maximum state index. It should be only called by the learn() method.

Parameters

state	this is the state of the robot

Here is the caller graph for this function:



4.10.3.3 calcMaxQval()

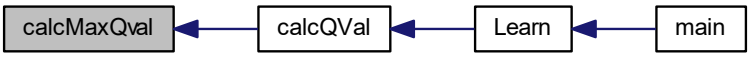
```
int calcMaxQval (
            unsigned char state )
```

This function calculates the maximum Q-value for a certain state. It should be only called by the learn() method.

Parameters

state	this is the state of the robot

Here is the caller graph for this function:

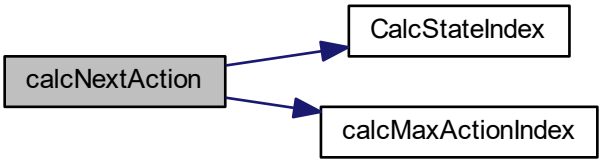


4.10.3.4 calcNextAction()

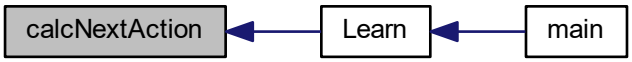
```
unsigned char calcNextAction ( )
```

This function calculates the next action. It should be only called by the learn() method.

Here is the call graph for this function:



Here is the caller graph for this function:



4.10.3.5 calcParameter()

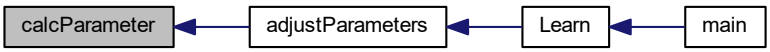
```
void calcParameter (
            struct Formula_Parameters_t * paramVal )
```

Calculates the new value of the parameters used in the Q-learning formula.

Parameters

∗paramVal	this is the parameter that will be updated

Here is the caller graph for this function:

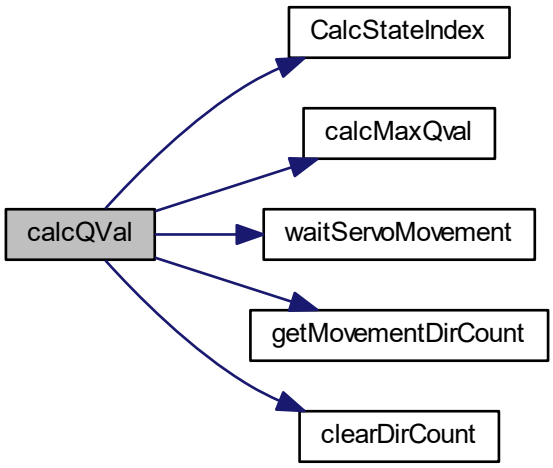


4.10.3.6 calcQVal()

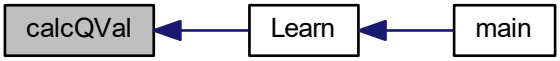
```
int calcQVal ( )
```

This function calculates the Q-value. It should be only called by the learn() method.

Here is the call graph for this function:



Here is the caller graph for this function:



4.10.3.7 CalcStateIndex()

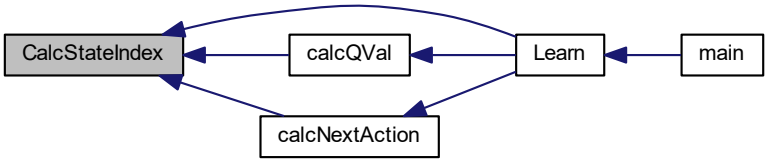
```
unsigned char CalcStateIndex (
            unsigned char stateArr[] )
```

Calculates the state index.

Parameters

stateArr[]	this array contains the stateval of each servo

Here is the caller graph for this function:

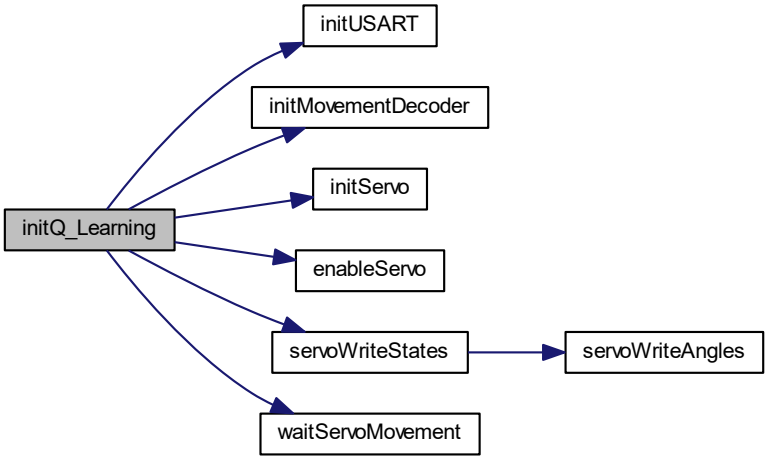


4.10.3.8 initQ_Learning()

```
void initQ_Learning ( )
```

Initializes the Q-learning algorithm. This function sets up the pins and the interrupt for the button. It also initialzes the needed components for the Q-learning algorithm (servo.h, movementDecoder.h)

Here is the call graph for this function:



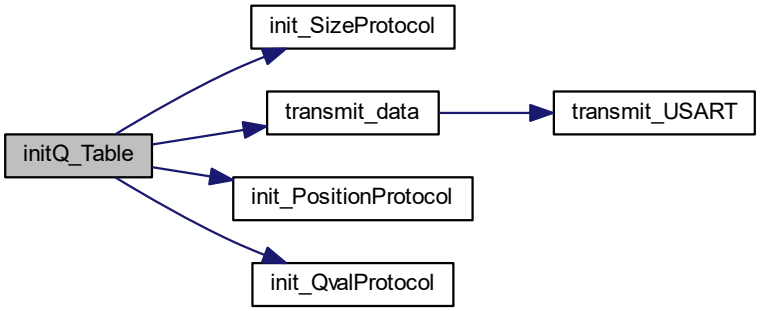
Here is the caller graph for this function:

4.10.3.9 initQ_Table()

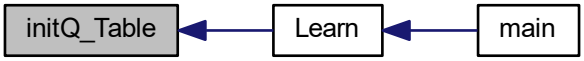
```
void initQ_Table ( )
```

Initializes the Q_Table with random values.

Here is the call graph for this function:



Here is the caller graph for this function:



4.10.3.10 learn()

```
void learn ( )
```

The Q-learning algorithm itself. This function executes the Q_learning algorithm itself.

4.10.3.11 wait_BTN_S()

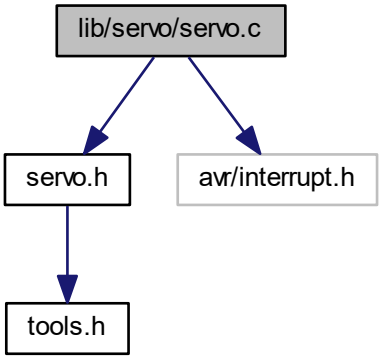
```
unsigned char wait_BTN_S ( )
```

This function waits until button south is pressed.

4.11 lib/servo/servo.c File Reference

```
#include "servo.h"
#include <avr/interrupt.h>
```

Include dependency graph for servo.c:



Functions

- void initServo (unsigned char restStateArr[NUMB_SERVOS])

  Initializes the servo motors. This function sets up the pins and interrupts for the servos. It should be called before you want to use the servos.
- void servoWriteStates (unsigned char stateArr[ ])

  This function makes the servos go to a given state.
- void servoWriteAngles (unsigned char posArr[ ])

  This function makes the servo's go to a given angle.
- void servoWriteState (unsigned char state, BYTE servoIndex)

  This function makes a specific servo go to a given state.
- void servoWriteAngle (unsigned char angle, BYTE servoIndex)

  This function makes the servo's go to a given angle.
- void interpollate ()

  Interpollates the movement of the servo's. This function should only be used within this library.
- void setServoState ()

  This function helps to generate a PWM-signal. This function should only be used by servo timer interrupt (TIMER1_COMPA_vect)
- void enableServo (int index)

  This function enables the servo. It should be called before writing a position to the servos.
- void disableServo (int index)

  This function disables the servo. Writing a position to the servo will have no effect. When you enable the servo, it will go to the last written position.
- void waitServoMovement ()

  This function waits until the servo reached the goal position.
- ISR (TIMER1_COMPA_vect)

Variables

- BYTE dataB
- struct servo_t servos [NUMB_SERVOS]

  Contains all the data of the servos.
- unsigned char stateAngles [NUMB_SERVO_STATES]

  Contains the angles of the predefined states.
- unsigned int CurrentTicks [NUMB_SERVOS]

  Contains the amount of ticks that the servo is high.
- int interpollateTime = 0

  Contains the amount of ticks before we interpollate the servo.

4.11.1 Function Documentation

4.11.1.1 disableServo()

```
void disableServo (
            int index )
```

This function disables the servo. Writing a position to the servo will have no effect. When you enable the servo, it will go to the last written position.

Parameters

index	the index of the servo that should be disabled

4.11.1.2 enableServo()

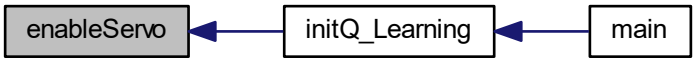
```
void enableServo (
            int index )
```

This function enables the servo. It should be called before writing a position to the servos.

Parameters

index	the index of the servo that should be enabled

Here is the caller graph for this function:



4.11.1.3 initServo()

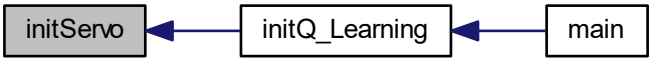
```
void initServo (
            unsigned char restStateArr[NUMB_SERVOS] )
```

Initializes the servo motors. This function sets up the pins and interrupts for the servos. It should be called before you want to use the servos.

Parameters

restStateArr	these are the restStates of the servos

Here is the caller graph for this function:

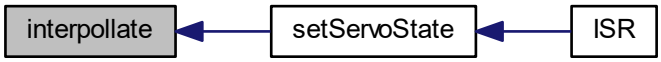


4.11.1.4 interpollate()

```
void interpollate ( )  [inline]
```

Interpollates the movement of the servo's. This function should only be used within this library.

Here is the caller graph for this function:



4.11.1.5 ISR()

```
ISR (
             TIMER1_COMPA_vect  )
```

Here is the call graph for this function:

4.11.1.6 servoWriteAngle()

```
void servoWriteAngle (
             unsigned char angle,
             BYTE servoIndex )
```

This function makes the servo's go to a given angle.

Parameters

angle	this contains the angle the servo needs to go to
servoIndex	this contains the index of the servo

Here is the caller graph for this function:

4.11.1.7 servoWriteAngles()

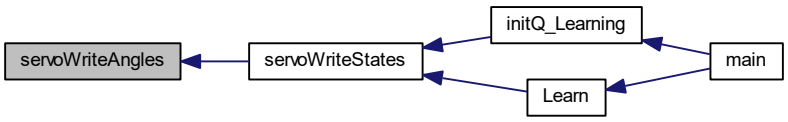
```
void servoWriteAngles (
            unsigned char posArr[] )
```

This function makes the servo's go to a given angle.

Parameters

posArr[]	this contains the angle values of the servo's

Here is the caller graph for this function:



4.11.1.8 servoWriteState()

```
void servoWriteState (
            unsigned char state,
            BYTE servoIndex )
```

This function makes a specific servo go to a given state.

Parameters

state	this contains the state index corresponding servo
servoIndex	this contains the index of the servo

Here is the call graph for this function:

4.11.1.9 servoWriteStates()

```
void servoWriteStates (
            unsigned char stateArr[] )
```

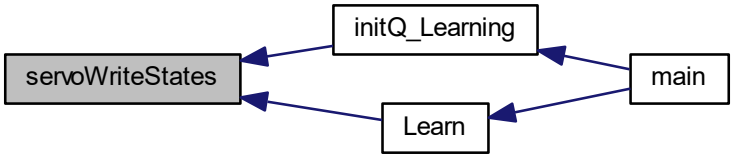
This function makes the servos go to a given state.

Parameters

stateArr[]	this contains the state index corresponding servo

Here is the call graph for this function:

Here is the caller graph for this function:



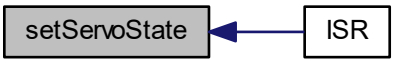
4.11.1.10 setServoState()

```
void setServoState ( )  [inline]
```

This function helps to generate a PWM-signal. This function should only be used by servo timer interrupt (TIME↩ R1_COMPA_vect)

Here is the call graph for this function:

Here is the caller graph for this function:

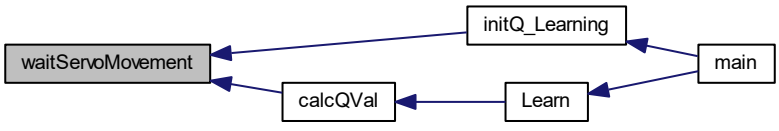


4.11.1.11 waitServoMovement()

```
void waitServoMovement ( )
```

This function waits until the servo reached the goal position.

Here is the caller graph for this function:



4.11.2 Variable Documentation

4.11.2.1 CurrentTicks

```
unsigned int CurrentTicks[NUMB_SERVOS]
```

Contains the amount of ticks that the servo is high.

4.11.2.2 dataB

```
BYTE dataB
```

servo.c

Created on: Mar 16, 2017 Author: Jonas Van Der Donckthis dataByte contains data of multiple parameters BIT7: Bool isMoving (true if servos are moving BIT4: stateIndex(of switch state) BIT0-3: Nibble servoIndex (max amount of servos is 1)

4.11.2.3 interpollateTime

```
int interpollateTime = 0
```

Contains the amount of ticks before we interpollate the servo.

4.11.2.4 servos

```
struct servo_t servos[NUMB_SERVOS]
```

Contains all the data of the servos.

4.11.2.5 stateAngles

```
unsigned char stateAngles[NUMB_SERVO_STATES]
```

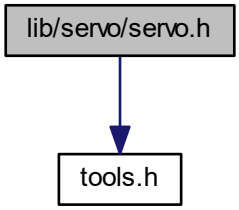
Contains the angles of the predefined states.

4.12 lib/servo/servo.h File Reference

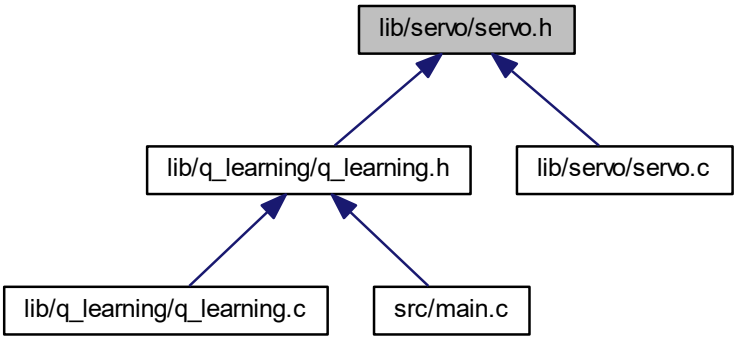
This library contains functions whom help to control multiple servos. Before using any of the the servo methods, call the initServo() function.

```
#include "tools.h"
```

Include dependency graph for servo.h:



This graph shows which files directly or indirectly include this file:



Data Structures

- struct servo_t

  This struct contains the parameters of a servo. Some other functions are specificly designed to change those parameters.

Macros

- #define CLK_TICKS_US 16

  the unprescaled clock uses 16 ticks per µs
- #define PRESCALER 8

  the prescaler of the clock
- #define MAXANGLE 180

  just informative
- #define MIN_STATE_ANGLE 10

  must be smaller than MAX_STATE_ANGLE
- #define MAX_STATE_ANGLE 110

  must be smaller than MAXANGLE
- #define MAX_NUMB_SERVOS 8

  this is the maximum amount of servos
- #define MIN_PULSE_WIDTH 600

  the shortest pulse sent to a servo in µs
- #define MAX_PULSE_WIDTH 2400

  the longest pulse sent to a servo
- #define DEFAULT_PULSE_WIDTH 1500

  default pulse width when servo is attached
- #define PERIOD 20000

  this is the refresh interval
- #define NUMB_SERVOS 2
- #define NUMB_SERVO_STATES 4
- #define INTERPOLLATEINT 1500

  refresh inte rval for interpollation
- #define INTERPOLLATEVAL 1

  angle change wich each interpollation
- #define NUMB_SWITCH_STATES 2
- #define PULSE 0
- #define WAIT 1
- #define ISMOVING_INDEX 7

  index of the bool isMoving in the data byte
- #define SERVO_INDEX_NIBBLE 0

  start index of the nibble that contains the servo index
- #define STATE_INDEX_POS 4

  single bit value that contains the switch state index
- #define SERVO1 PORTC0
- #define SERVO1_PORT PORTC

  will be used as a pointer
- #define SERVO1_DIR DDRC

  will be used as a pointer
- #define SERVO2 PORTC1
- #define SERVO2_PORT PORTC

  will be used as a pointer
- #define SERVO2_DIR DDRC

  will be used as a pointer
- #define SERVO3 PORTB1
- #define SERVO3_PORT PORTB

  will be used as a pointer
- #define SERVO3_DIR DDRB

will be used as a pointer

- #define SERVO4 0
- #define SERVO4_PORT PORTC

  will be used as a pointer
- #define SERVO4_DIR DDRC

  will be used as a pointer
- #define SERVO5 0
- #define SERVO5_PORT PORTC

  will be used as a pointer
- #define SERVO5_DIR DDRC

  will be used as a pointer
- #define SERVO6 0
- #define SERVO6_PORT PORTC

  will be used as a pointer
- #define SERVO6_DIR DDRC

  will be used as a pointer
- #define SERVO7 0
- #define SERVO7_PORT PORTC

  will be used as a pointer
- #define SERVO7_DIR DDRC

  will be used as a pointer
- #define SERVO8 0
- #define SERVO8_PORT PORTC

  will be used as a pointer
- #define SERVO8_DIR DDRC

  will be used as a pointer
- #define STATE_ANGLE_WIDTH ((MAX_STATE_ANGLE - MIN_STATE_ANGLE)/(NUMB_SERVO_STAT↩ ES - 1))
- #define BASE_TIME_WIDTH (PERIOD/NUMB_SERVOS)

  val in µs
- #define ANGLE_TO_TICKS_INTERP(ANG) (((US_TO_TICKS(MAX_PULSE_WIDTH - MIN_PULSE_WID↩ TH)/180)∗ANG))
- #define US_TO_TICKS(US) (US∗(CLK_TICKS_US/PRESCALER))
- #define ANGLE_TO_US(ANG) (MIN_PULSE_WIDTH + ((MAX_PULSE_WIDTH - MIN_PULSE_WID↩ TH)/180)∗ANG)
- #define ANGLE_TO_TICKS(ANG) (US_TO_TICKS(ANGLE_TO_US(ANG)))
- #define TICKS_TO_ANGLE(TCK) ((TCK - US_TO_TICKS(MIN_PULSE_WIDTH))/(US_TO_TICKS((MAX↩ _PULSE_WIDTH - MIN_PULSE_WIDTH)/180)))

Functions

- void initServo (unsigned char restStateArr[NUMB_SERVOS])

  Initializes the servo motors. This function sets up the pins and interrupts for the servos. It should be called before you want to use the servos.
- void servoWriteStates (unsigned char stateArr[ ])

  This function makes the servos go to a given state.
- void servoWriteAngles (unsigned char posArr[ ])

  This function makes the servo's go to a given angle.
- void servoWriteState (unsigned char state, BYTE servoIndex)

  This function makes a specific servo go to a given state.
- void servoWriteAngle (unsigned char angle, BYTE servoIndex)

This function makes the servo's go to a given angle.

- void interpollate ()

  Interpollates the movement of the servo's. This function should only be used within this library.

- void setServoState ()

  This function helps to generate a PWM-signal. This function should only be used by servo timer interrupt (TIMER1_COMPA_vect)

- void enableServo (int index)

  This function enables the servo. It should be called before writing a position to the servos.

- void disableServo (int index)

  This function disables the servo. Writing a position to the servo will have no effect. When you enable the servo, it will go to the last written position.

- void waitServoMovement ()

  This function waits until the servo reached the goal position.

4.12.1 Detailed Description

This library contains functions whom help to control multiple servos. Before using any of the the servo methods, call the initServo() function.

Author

Jonas Van Der Donckt

Date

16/03/2017

4.12.2 Macro Definition Documentation

4.12.2.1 ANGLE_TO_TICKS

```
#define ANGLE_TO_TICKS(
              ANG ) (US_TO_TICKS(ANGLE_TO_US(ANG)))
```

4.12.2.2 ANGLE_TO_TICKS_INTERP

```
#define ANGLE_TO_TICKS_INTERP(
              ANG ) (((US_TO_TICKS(MAX_PULSE_WIDTH - MIN_PULSE_WIDTH)/180)*ANG))
```

4.12.2.3 ANGLE_TO_US

```
#define ANGLE_TO_US(
              ANG ) (MIN_PULSE_WIDTH + ((MAX_PULSE_WIDTH - MIN_PULSE_WIDTH)/180)*ANG)
```

4.12.2.4 BASE_TIME_WIDTH

```
#define BASE_TIME_WIDTH (PERIOD/NUMB_SERVOS)
```

val in µs

4.12.2.5 CLK_TICKS_US

```
#define CLK_TICKS_US 16
```

the unprescaled clock uses 16 ticks per µs

4.12.2.6 DEFAULT_PULSE_WIDTH

```
#define DEFAULT_PULSE_WIDTH 1500
```

default pulse width when servo is attached

4.12.2.7 INTERPOLLATEINT

```
#define INTERPOLLATEINT 1500
```

refresh inte rval for interpollation

4.12.2.8 INTERPOLLATEVAL

```
#define INTERPOLLATEVAL 1
```

angle change wich each interpollation

4.12.2.9 ISMOVING_INDEX

```
#define ISMOVING_INDEX 7
```

index of the bool isMoving in the data byte

4.12.2.10 MAX_NUMB_SERVOS

```
#define MAX_NUMB_SERVOS 8
```

this is the maximum amount of servos

4.12.2.11 MAX_PULSE_WIDTH

```
#define MAX_PULSE_WIDTH 2400
```

the longest pulse sent to a servo

4.12.2.12 MAX_STATE_ANGLE

```
#define MAX_STATE_ANGLE 110
```

must be smaller than MAXANGLE

4.12.2.13 MAXANGLE

```
#define MAXANGLE 180
```

just informative

4.12.2.14 MIN_PULSE_WIDTH

```
#define MIN_PULSE_WIDTH 600
```

the shortest pulse sent to a servo in µs

4.12.2.15 MIN_STATE_ANGLE

```
#define MIN_STATE_ANGLE 10
```

must be smaller than MAX_STATE_ANGLE

4.12.2.16 NUMB_SERVO_STATES

```
#define NUMB_SERVO_STATES 4
```

4.12.2.17 NUMB_SERVOS

```
#define NUMB_SERVOS 2
```

4.12.2.18 NUMB_SWITCH_STATES

```
#define NUMB_SWITCH_STATES 2
```

4.12.2.19 PERIOD

```
#define PERIOD 20000
```

this is the refresh interval

4.12.2.20 PRESCALER

```
#define PRESCALER 8
```

the prescaler of the clock

4.12.2.21 PULSE

```
#define PULSE 0
```

4.12.2.22 SERVO1

```
#define SERVO1 PORTC0
```

4.12.2.23 SERVO1_DIR

```
#define SERVO1_DIR DDRC
```

will be used as a pointer

4.12.2.24 SERVO1_PORT

```
#define SERVO1_PORT PORTC
```

will be used as a pointer

4.12.2.25 SERVO2

```
#define SERVO2 PORTC1
```

4.12.2.26 SERVO2_DIR

```
#define SERVO2_DIR DDRC
```

will be used as a pointer

4.12.2.27 SERVO2_PORT

```
#define SERVO2_PORT PORTC
```

will be used as a pointer

4.12.2.28 SERVO3

```
#define SERVO3 PORTB1
```

4.12.2.29 SERVO3_DIR

```
#define SERVO3_DIR DDRB
```

will be used as a pointer

4.12.2.30 SERVO3_PORT

```
#define SERVO3_PORT PORTB
```

will be used as a pointer

4.12.2.31 SERVO4

```
#define SERVO4 0
```

4.12.2.32 SERVO4_DIR

```
#define SERVO4_DIR DDRC
```

will be used as a pointer

4.12.2.33 SERVO4_PORT

```
#define SERVO4_PORT PORTC
```

will be used as a pointer

4.12.2.34 SERVO5

```
#define SERVO5 0
```

4.12.2.35 SERVO5_DIR

```
#define SERVO5_DIR DDRC
```

will be used as a pointer

4.12.2.36 SERVO5_PORT

```
#define SERVO5_PORT PORTC
```

will be used as a pointer

4.12.2.37 SERVO6

```
#define SERVO6 0
```

4.12.2.38 SERVO6_DIR

```
#define SERVO6_DIR DDRC
```

will be used as a pointer

4.12.2.39 SERVO6_PORT

```
#define SERVO6_PORT PORTC
```

will be used as a pointer

4.12.2.40 SERVO7

```
#define SERVO7 0
```

4.12.2.41 SERVO7_DIR

```
#define SERVO7_DIR DDRC
```

will be used as a pointer

4.12.2.42 SERVO7_PORT

```
#define SERVO7_PORT PORTC
```

will be used as a pointer

4.12.2.43 SERVO8

```
#define SERVO8 0
```

4.12.2.44 SERVO8_DIR

```
#define SERVO8_DIR DDRC
```

will be used as a pointer

4.12.2.45 SERVO8_PORT

```
#define SERVO8_PORT PORTC
```

will be used as a pointer

4.12.2.46 SERVO_INDEX_NIBBLE

```
#define SERVO_INDEX_NIBBLE 0
```

start index of the nibble that contains the servo index

4.12.2.47 STATE_ANGLE_WIDTH

```
#define STATE_ANGLE_WIDTH ((MAX_STATE_ANGLE - MIN_STATE_ANGLE)/(NUMB_SERVO_STATES - 1))
```

4.12.2.48 STATE_INDEX_POS

```
#define STATE_INDEX_POS 4
```

single bit value that contains the switch state index

4.12.2.49 TICKS_TO_ANGLE

```
#define TICKS_TO_ANGLE(
              TCK ) ((TCK - US_TO_TICKS(MIN_PULSE_WIDTH))/(US_TO_TICKS((MAX_PULSE_WIDTH - MIN↩
_PULSE_WIDTH)/180)))
```

4.12.2.50 US_TO_TICKS

```
#define US_TO_TICKS(
              US ) (US*(CLK_TICKS_US/PRESCALER))
```

4.12.2.51 WAIT

```
#define WAIT 1
```

4.12.3 Function Documentation

4.12.3.1 disableServo()

```
void disableServo (
             int index )
```

This function disables the servo. Writing a position to the servo will have no effect. When you enable the servo, it will go to the last written position.

Parameters

index	the index of the servo that should be disabled

4.12.3.2 enableServo()

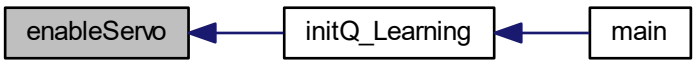
```
void enableServo (
            int index )
```

This function enables the servo. It should be called before writing a position to the servos.

Parameters

index	the index of the servo that should be enabled

Here is the caller graph for this function:



4.12.3.3 initServo()

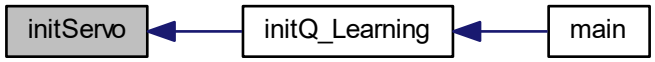
```
void initServo (
            unsigned char restStateArr[NUMB_SERVOS] )
```

Initializes the servo motors. This function sets up the pins and interrupts for the servos. It should be called before you want to use the servos.

Parameters

restStateArr	these are the restStates of the servos

Here is the caller graph for this function:

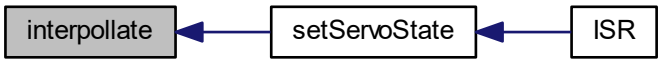


4.12.3.4 interpollate()

```
void interpollate ( )  [inline]
```

Interpollates the movement of the servo's. This function should only be used within this library.

Here is the caller graph for this function:



4.12.3.5 servoWriteAngle()

```
void servoWriteAngle (
            unsigned char angle,
            BYTE servoIndex )
```

This function makes the servo's go to a given angle.

Parameters

angle	this contains the angle the servo needs to go to
servoIndex	this contains the index of the servo

Here is the caller graph for this function:

4.12.3.6 servoWriteAngles()

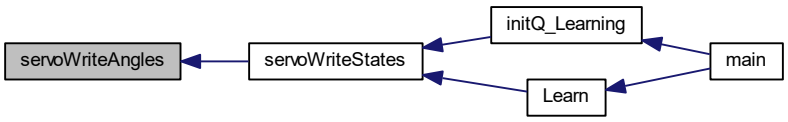
```
void servoWriteAngles (
            unsigned char posArr[] )
```

This function makes the servo's go to a given angle.

Parameters

posArr[]	this contains the angle values of the servo's

Here is the caller graph for this function:



4.12.3.7 servoWriteState()

```
void servoWriteState (
            unsigned char state,
            BYTE servoIndex )
```

This function makes a specific servo go to a given state.

Parameters

state	this contains the state index corresponding servo
servoIndex	this contains the index of the servo

Here is the call graph for this function:

4.12.3.8 servoWriteStates()

```
void servoWriteStates (
            unsigned char stateArr[] )
```

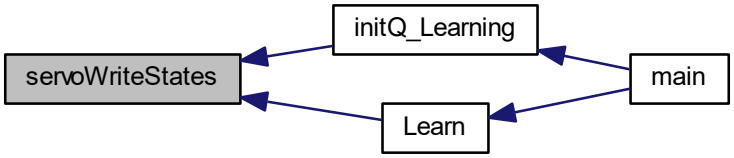
This function makes the servos go to a given state.

Parameters

stateArr[]	this contains the state index corresponding servo

Here is the call graph for this function:

Here is the caller graph for this function:



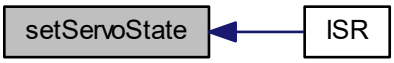
4.12.3.9 setServoState()

```
void setServoState ( )  [inline]
```

This function helps to generate a PWM-signal. This function should only be used by servo timer interrupt (TIME↩R1_COMPA_vect)

Here is the call graph for this function:

Here is the caller graph for this function:

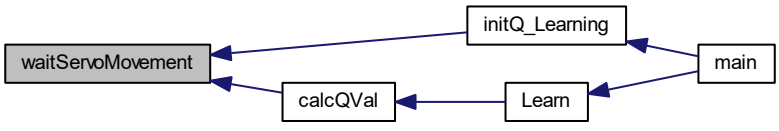


4.12.3.10 waitServoMovement()

```
void waitServoMovement ( )
```

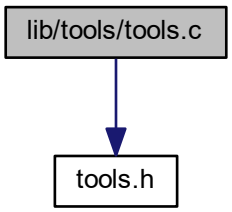
This function waits until the servo reached the goal position.

Here is the caller graph for this function:



4.13 lib/tools/tools.c File Reference

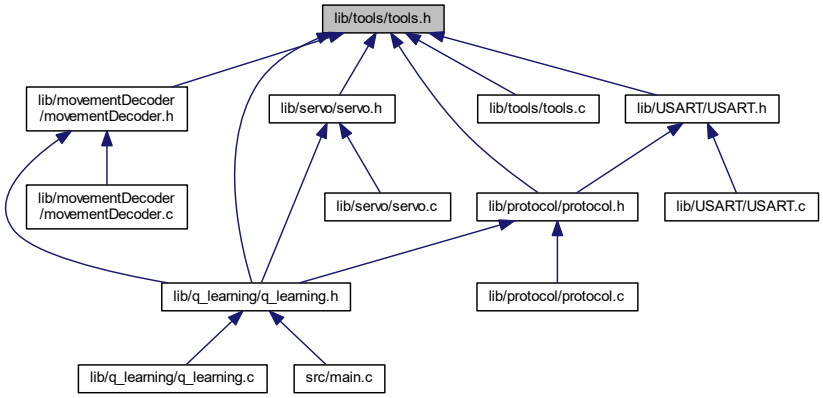
`#include "tools.h"`
Include dependency graph for tools.c:



4.14 lib/tools/tools.h File Reference

This library contains useful MACROS which can be used in other libraries.

This graph shows which files directly or indirectly include this file:



Macros

- #define F_CPU 16000000UL

  adapt this if the CPU has a different frequency
- #define BYTE unsigned char
- #define SET_PIN_HIGH(PORT, PIN) PORT |= (1 << PIN)
- #define SET_PIN_LOW(PORT, PIN) PORT &= ~(1 << PIN)
- #define SET_BIT_HIGH(REG, BIT) REG |= (1 << BIT)
- #define SET_BIT_LOW(REG, BIT) REG &= ~(1 << BIT)

- #define SET_PIN_OUTPUT(DDR, PIN) SET_PIN_HIGH(DDR, PIN)
- #define SET_PIN_INPUT(DDR, PIN) SET_PIN_LOW(DDR, PIN)
- #define TOGGLE_BIT(REG, POS) (REG ^= (1<< POS))
- #define GET_BIT(REG, POS) ((REG & (1<< POS)) > (0) ? (1) : (0))
- #define GET_NIBBLE(REG, LSB_INDEX, D1) (D1 = (REG & (0x0F << LSB_INDEX)))
- #define SET_NIBBLE(REG, LSB_INDEX, D1) (REG |= (D1 << LSB_INDEX))
- #define CLEAR_NIBBLE(REG, LSB_INDEX) (REG &=~(0x0F << LSB_INDEX))

4.14.1 Detailed Description

This library contains useful MACROS which can be used in other libraries.

Author

Jonas Van Der Donckt

Date

14/05/2017

4.14.2 Macro Definition Documentation

4.14.2.1 BYTE

```
#define BYTE unsigned char
```

4.14.2.2 CLEAR_NIBBLE

```
#define CLEAR_NIBBLE(
              REG,
              LSB_INDEX ) (REG &=~(0x0F << LSB_INDEX) )
```

4.14.2.3 F_CPU

```
#define F_CPU 16000000UL
```

adapt this if the CPU has a different frequency

4.14.2.4 GET_BIT

```
#define GET_BIT(
              REG,
              POS ) ((REG & (1<< POS)) > (0) ?  (1) :  (0))
```

4.14.2.5 GET_NIBBLE

```
#define GET_NIBBLE(
              REG,
              LSB_INDEX,
              D1 ) (D1 = (REG & (0x0F << LSB_INDEX)))
```

4.14.2.6 SET_BIT_HIGH

```
#define SET_BIT_HIGH(
              REG,
              BIT ) REG |= (1 << BIT)
```

4.14.2.7 SET_BIT_LOW

```
#define SET_BIT_LOW(
              REG,
              BIT ) REG &= ~(1 << BIT)
```

4.14.2.8 SET_NIBBLE

```
#define SET_NIBBLE(
              REG,
              LSB_INDEX,
              D1 ) (REG |= (D1 << LSB_INDEX))
```

4.14.2.9 SET_PIN_HIGH

```
#define SET_PIN_HIGH(
              PORT,
              PIN ) PORT |= (1 << PIN)
```

4.14.2.10 SET_PIN_INPUT

```
#define SET_PIN_INPUT(
              DDR,
              PIN ) SET_PIN_LOW(DDR, PIN)
```

4.14.2.11 SET_PIN_LOW

```
#define SET_PIN_LOW(
              PORT,
              PIN ) PORT &= ~(1 << PIN)
```

4.14.2.12 SET_PIN_OUTPUT

```
#define SET_PIN_OUTPUT(
              DDR,
              PIN ) SET_PIN_HIGH(DDR, PIN)
```

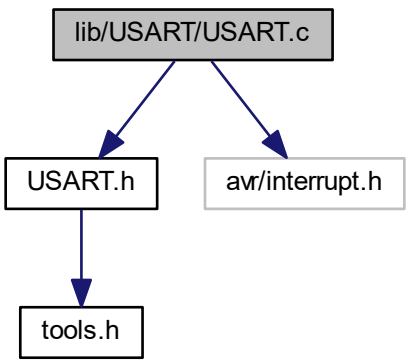
4.14.2.13 TOGGLE_BIT

```
#define TOGGLE_BIT(
              REG,
              POS ) (REG ^= (1<< POS))
```

4.15 lib/USART/USART.c File Reference

```
#include "USART.h"
#include <avr/interrupt.h>
```

Include dependency graph for USART.c:



Functions

- void initUSART ()

  Initializes the USART protocol and configures the frame format. This function should be called before using any of the other methods within this library.
- void transmit_USART (BYTE data)

  Transmits data with the USART protocol.
- unsigned char Receive_USART ()

  Receives data with the USART protocol.

4.15.1 Function Documentation

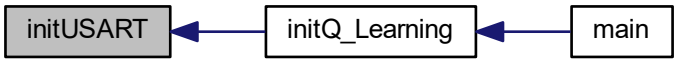
4.15.1.1 initUSART()

```
void initUSART ( )
```

Initializes the USART protocol and configures the frame format. This function should be called before using any of the other methods within this library.

USART.c

Created on: May 14, 2017 Author: Jonas Van Der Donckt Here is the caller graph for this function:



4.15.1.2 Receive_USART()

```
unsigned char Receive_USART ( )
```

Receives data with the USART protocol.

4.15.1.3 transmit_USART()

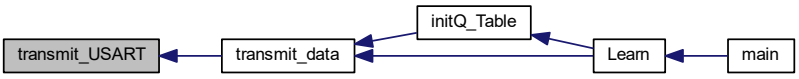
```
void transmit_USART (
            BYTE data )
```

Transmits data with the USART protocol.

Parameters

data	this is the data that will be transmitted.

Here is the caller graph for this function:

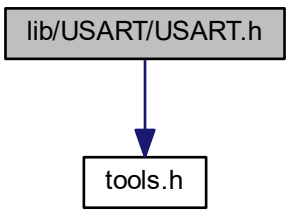


4.16 lib/USART/USART.h File Reference

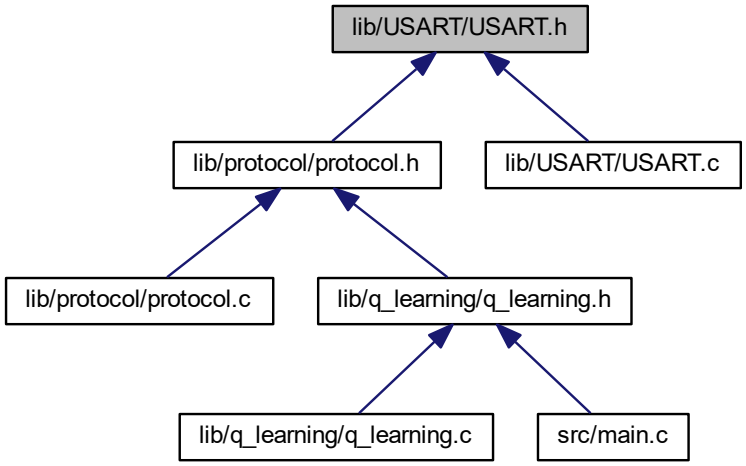
This library contains functions to transmit data with the USART protocol. Before using the USART's methods, call the initUSART() function.

```
#include "tools.h"
```

Include dependency graph for USART.h:



This graph shows which files directly or indirectly include this file:



Macros

- #define BAUDRATE (long)9600

  adapt to change BAUDRATE
- #define UBBRVAL (F_CPU/(16∗BAUDRATE) - 1)

Functions

- void initUSART ()

  Initializes the USART protocol and configures the frame format. This function should be called before using any of the other methods within this library.
- void transmit_USART (BYTE data)

  Transmits data with the USART protocol.
- unsigned char Receive_USART ()

  Receives data with the USART protocol.

4.16.1 Detailed Description

This library contains functions to transmit data with the USART protocol. Before using the USART's methods, call the initUSART() function.

Author

Jonas Van Der Donckt

Date

14/05/2017

4.16.2 Macro Definition Documentation

4.16.2.1 BAUDRATE

```
#define BAUDRATE (long)9600
```

adapt to change BAUDRATE

4.16.2.2 UBBRVAL

```
#define UBBRVAL (F_CPU/(16*BAUDRATE) - 1)
```

4.16.3 Function Documentation

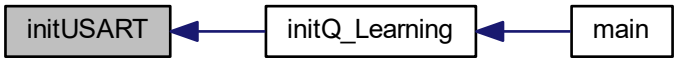
4.16.3.1 initUSART()

```
void initUSART ( )
```

Initializes the USART protocol and configures the frame format. This function should be called before using any of the other methods within this library.

USART.c

Created on: May 14, 2017 Author: Jonas Van Der Donckt Here is the caller graph for this function:



4.16.3.2 Receive_USART()

```
unsigned char Receive_USART ( )
```

Receives data with the USART protocol.

4.16.3.3 transmit_USART()

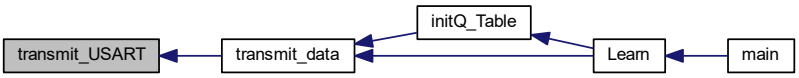
```
void transmit_USART (
            BYTE data )
```

Transmits data with the USART protocol.

Parameters

data	this is the data that will be transmitted.

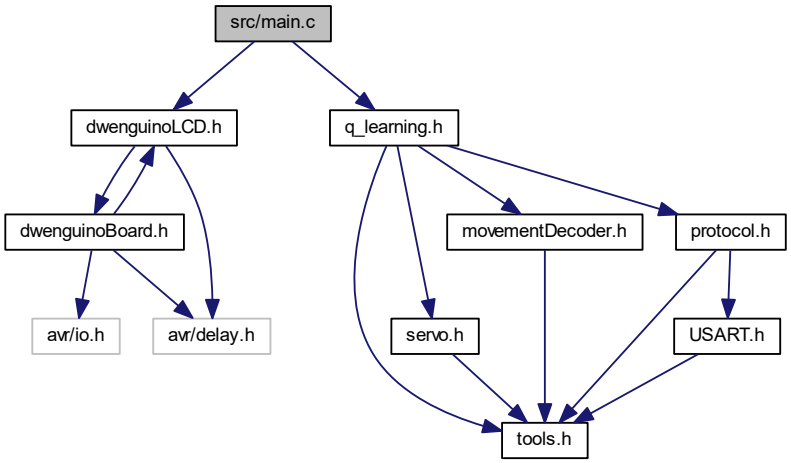
Here is the caller graph for this function:



4.17 src/main.c File Reference

```
#include "dwenguinoLCD.h"
#include "q_learning.h"
```

Include dependency graph for main.c:



Functions

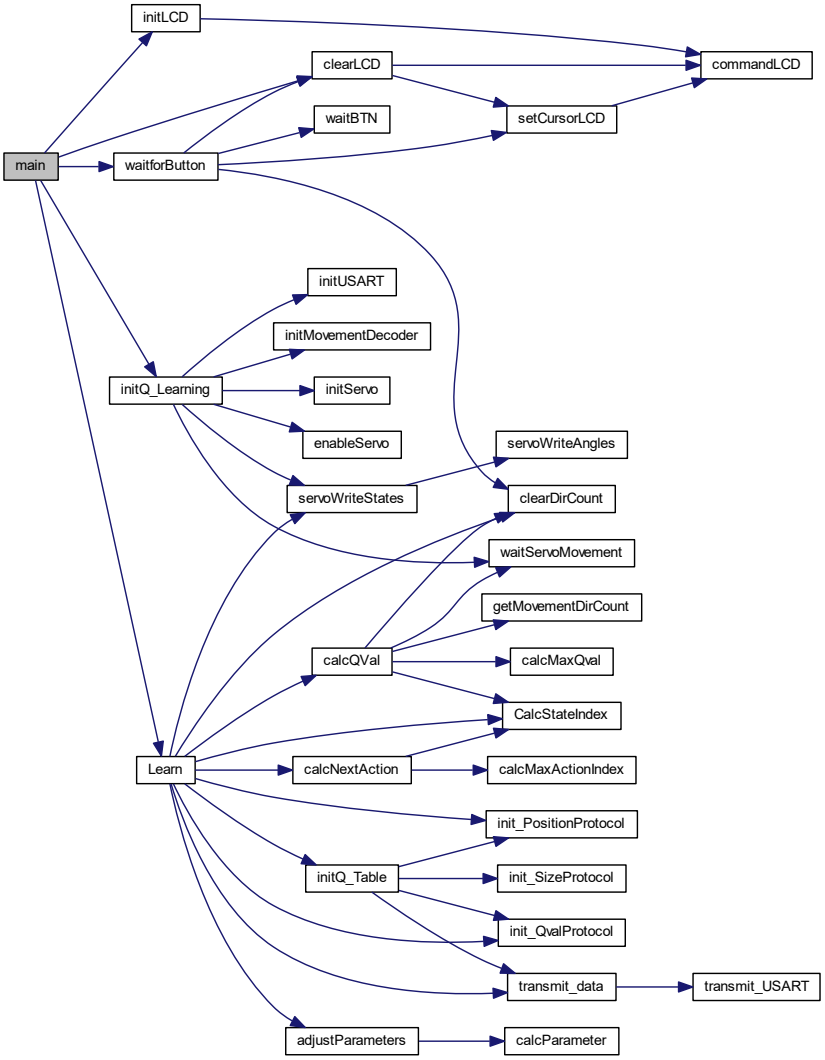
- void waitforButton ()
- int main ()

4.17.1 Function Documentation

4.17.1.1 main()

```
int main ( )
```

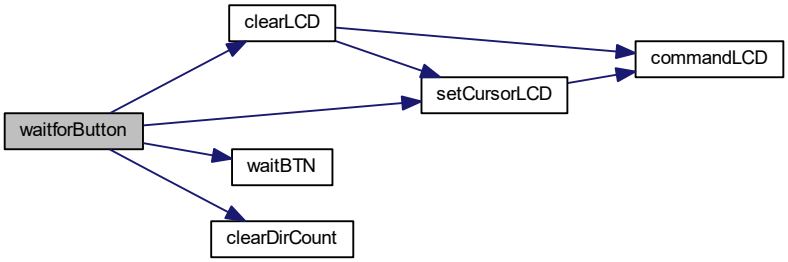
< waits until the user has pressed BTN_S Here is the call graph for this function:



4.17.1.2 waitforButton()

```
void waitforButton ( )
```

Here is the call graph for this function:



Here is the caller graph for this function: