LwGPS

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CONTENTS

Welcome to the documentation for version 2.1.0.

LwGPS is lightweight, platform independent library to parse NMEA statements from GPS receivers. It is highly optimized for embedded systems.

Download library Getting started Open Github

CHAPTER

ONE

FEATURES

- Written in ANSI C99
- Platform independent, easy to use
- Built-in support for 4 GPS statements
  - `GPGGA` or `GNGGA`: GPS fix data
  - `GPGSA` or `GNGSA`: GPS active satellites and dillusion of position
  - `GPGSV` or `GNGSV`: List of satellites in view zone
  - `GPRMC` or `GNRMC`: Recommended minimum specific GPS/Transit data
- Optional `float` or `double` floating point units
- Low-level layer is separated from application layer, thus allows you to add custom communication with GPS device
- Works with operating systems
- Works with different communication interfaces
- User friendly MIT license

CHAPTER

TWO

REQUIREMENTS

- C compiler
- Driver for receiving data from GPS receiver
- Few *kB* of non-volatile memory

CHAPTER

THREE

CONTRIBUTE

Fresh contributions are always welcome. Simple instructions to proceed:

1. Fork Github repository
2. Respect C style & coding rules used by the library
3. Create a pull request to `develop` branch with new features or bug fixes

Alternatively you may:

1. Report a bug
2. Ask for a feature request

CHAPTER

FOUR

LICENSE

```
MIT License

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SOFTWARE.
```

CHAPTER

FIVE

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5.1 Getting started

5.1.1 Download library

Library is primarly hosted on Github.

- Download latest release from releases area on Github
- Clone *develop* branch for latest development

Download from releases

All releases are available on Github releases area.

Clone from Github

First-time clone

- Download and install `git` if not already
- Open console and navigate to path in the system to clone repository to. Use command `cd your_path`
- Clone repository with one of available `3` options
  - Run `git clone --recurse-submodules https://github.com/MaJerle/lwgps` command to clone entire repository, including submodules
  - Run `git clone --recurse-submodules --branch develop https://github.com/MaJerle/lwgps` to clone *development* branch, including submodules
  - Run `git clone --recurse-submodules --branch master https://github.com/MaJerle/lwgps` to clone *latest stable* branch, including submodules
- Navigate to `examples` directory and run favourite example

Update cloned to latest version

- Open console and navigate to path in the system where your resources repository is. Use command `cd your_path`
- Run `git pull origin master --recurse-submodules` command to pull latest changes and to fetch latest changes from submodules
- Run `git submodule foreach git pull origin master` to update & merge all submodules

Note: This is preferred option to use when you want to evaluate library and run prepared examples. Repository consists of multiple submodules which can be automatically downloaded when cloning and pulling changes from root repository.

5.1.2 Add library to project

At this point it is assumed that you have successfully download library, either cloned it or from releases page.

- Copy `lwgps` folder to your project
- Add `lwgps/src/include` folder to *include path* of your toolchain
- Add source files from `lwgps/src/` folder to toolchain build
- Copy `lwgps/src/include/lwgps/lwgps_opts_template.h` to project folder and rename it to `lwgps_opts.h`
- Build the project

5.1.3 Configuration file

Library comes with template config file, which can be modified according to needs. This file shall be named `lwgps_opts.h` and its default template looks like the one below.

Note: Default configuration template file location: `lwgps/src/include/lwgps/lwgps_opts_template.h`. File must be renamed to `lwgps_opts.h` first and then copied to the project directory (or simply renamed in-place) where compiler include paths have access to it by using `#include "lwgps_opts.h"`.

Tip: Check *Configuration* section for possible configuration settings

Listing 1: Template options file

```
1  /**
2   * \file            lwgps_opts_template.h
3   * \brief           LwGPS configuration file
4   */
5
6  /*
7   * Copyright (c) 2020 Tilen MAJERLE
8   *
9   * Permission is hereby granted, free of charge, to any person
```

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```
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 * OTHER DEALINGS IN THE SOFTWARE.
 *
 * This file is part of LwGPS - Lightweight GPS NMEA parser library.
 *
 * Author:          Tilen MAJERLE <tilen@majerle.eu>
 * Version:         v2.1.0
 */
#ifndef LWGPS_HDR_OPTS_H
#define LWGPS_HDR_OPTS_H

/* Rename this file to "lwgps_opts.h" for your application */

/*
 * Open "include/lwgps/lwgps_opt.h" and
 * copy & replace here settings you want to change values
 */

#endif /* LWGPS_HDR_OPTS_H */
```

5.1.4 Minimal example code

Run below example to test and verify library

Listing 2: Test verification code

```
/**
 * This example uses direct processing function
 * to process dummy NMEA data from GPS receiver
 */
#include <string.h>
#include <stdio.h>
#include "lwgps/lwgps.h"

/* GPS handle */
lwgps_t hgps;

/**
 * \brief           Dummy data from GPS receiver
```

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```
 */
const char
gps_rx_data[] = ""
                "$GPRMC,183729,A,3907.356,N,12102.482,W,000.0,360.0,080301,015.5,E*6F\
↪r\n"
                "$GPRMB,A,,,,,,,,,,,V*71\r\n"
                "$GPGGA,183730,3907.356,N,12102.482,W,1,05,1.6,646.4,M,-24.1,M,,*75\r\
↪n"
                "$GPGSA,A,3,02,,,07,,09,24,26,,,,,1.6,1.6,1.0*3D\r\n"
                "$GPGSV,2,1,08,02,43,088,38,04,42,145,00,05,11,291,00,07,60,043,35*71\
↪r\n"
                "$GPGSV,2,2,08,08,02,145,00,09,46,303,47,24,16,178,32,26,18,231,43*77\
↪r\n"
                "$PGRME,22.0,M,52.9,M,51.0,M*14\r\n"
                "$GPGLL,3907.360,N,12102.481,W,183730,A*33\r\n"
                "$PGRMZ,2062,f,3*2D\r\n"
                "$PGRMM,WGS84*06\r\n"
                "$GPBOD,,T,,M,,*47\r\n"
                "$GPRTE,1,1,c,0*07\r\n"
                "$GPRMC,183731,A,3907.482,N,12102.436,W,000.0,360.0,080301,015.5,E*67\
↪r\n"
                "$GPRMB,A,,,,,,,,,,,V*71\r\n";

int
main() {
    /* Init GPS */
    lwgps_init(&hgps);

    /* Process all input data */
    lwgps_process(&hgps, gps_rx_data, strlen(gps_rx_data));

    /* Print messages */
    printf("Valid status: %d\r\n", hgps.is_valid);
    printf("Latitude: %f degrees\r\n", hgps.latitude);
    printf("Longitude: %f degrees\r\n", hgps.longitude);
    printf("Altitude: %f meters\r\n", hgps.altitude);

    return 0;
}
```

5.2 User manual

5.2.1 How it works

LwGPS parses raw data formatted as NMEA 0183 statements from GPS receivers. It supports up to 4 different statements:

- GPGGA or GNGGA: GPS fix data
- GPGSA or GNGSA: GPS active satellites and dillusion of position
- GPGSV or GNGSV: List of satellites in view zone
- GPRMC or GNRMC: Recommended minimum specific GPS/Transit data

Tip: By changing different configuration options, it is possible to disable some statements. Check *Configuration* for more information.

Application must assure to properly receive data from GPS receiver. Usually GPS receivers communicate with host embedded system with UART protocol and output directly formatted NMEA 0183 statements.

Note: Application must take care of properly receive data from GPS.

Application must use `lwgps_process()` function for data processing. Function will:

- Detect statement type, such as *GPGGA* or *GPGSV*
- Parse all the terms of specific statement
- Check valid CRC after each statement

Programmer's model is as following:

- Application receives data from GPS receiver
- Application sends data to `lwgps_process()` function
- Application uses processed data to display altitude, latitude, longitude, and other parameters

Check *Examples and demos* for typical example

5.2.2 Float/double precision

With configuration of `GSM_CFG_DOUBLE`, it is possible to enable `double` floating point precision. All floating point variables are then configured in *double precision*.

When configuration is set to `0`, floating point variables are configured in *single precision* format.

Note: Single precision uses less memory in application. As a drawback, application may be a subject of data loss at latter digits.

5.2.3 Thread safety

Library tends to be as simple as possible. No specific features have been implemented for thread safety.

When library is using multi-thread environment and if multi threads tend to access to shared resources, user must resolve it with care, using mutual exclusion.

Tip: When single thread is dedicated for GPS processing, no special mutual exclusion is necessary.

5.2.4 Tests during development

During the development, test check is performed to validate raw NMEA input data vs expected result.

Listing 3: Test code for development

```
/*
 * This example uses direct processing function,
 * to process dummy NMEA data from GPS receiver
 */
#include <string.h>
#include <stdio.h>
#include "lwgps/lwgps.h"
#include "test_common.h"

/* GPS handle */
lwgps_t hgps;

/**
 * \brief           Dummy data from GPS receiver
 */
const char
gps_rx_data[] = ""
                "$GPRMC,183729,A,3907.356,N,12102.482,W,000.0,360.0,080301,015.5,E*6F\r\n"
                "$GPGGA,183730,3907.356,N,12102.482,W,1,05,1.6,646.4,M,-24.1,M,,*75\r\n"
                "$GPGSA,A,3,02,,,07,,09,24,26,,,,,1.6,1.6,1.0*3D\r\n"
                "$GPGSV,2,1,08,02,43,088,38,04,42,145,00,05,11,291,00,07,60,043,35*71\r\n"
                "$GPGSV,2,2,08,08,02,145,00,09,46,303,47,24,16,178,32,26,18,231,43*77\r\n"
                "";

/**
 * \brief           Run the test of raw input data
 */
void
run_tests() {
    lwgps_init(&hgps);                          /* Init GPS */

    /* Process all input data */
    lwgps_process(&hgps, gps_rx_data, strlen(gps_rx_data));

    /* Run the test */
    RUN_TEST(!INT_IS_EQUAL(hgps.is_valid, 0));
    RUN_TEST(INT_IS_EQUAL(hgps.fix, 1));
    RUN_TEST(INT_IS_EQUAL(hgps.fix_mode, 3));
    RUN_TEST(FLT_IS_EQUAL(hgps.latitude, 39.1226000000));
    RUN_TEST(FLT_IS_EQUAL(hgps.longitude, -121.0413666666));
    RUN_TEST(FLT_IS_EQUAL(hgps.altitude, 646.4000000000));
    RUN_TEST(FLT_IS_EQUAL(hgps.course, 360.0000000000));
    RUN_TEST(INT_IS_EQUAL(hgps.dop_p, 1.6000000000));
    RUN_TEST(INT_IS_EQUAL(hgps.dop_h, 1.6000000000));
    RUN_TEST(INT_IS_EQUAL(hgps.dop_v, 1.0000000000));
    RUN_TEST(FLT_IS_EQUAL(hgps.speed, 0.0000000000));
    RUN_TEST(FLT_IS_EQUAL(hgps.geo_sep, -24.100000000));
    RUN_TEST(FLT_IS_EQUAL(hgps.variation, 15.500000000));
```

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```
    RUN_TEST(INT_IS_EQUAL(hgps.sats_in_view, 8));

    RUN_TEST(INT_IS_EQUAL(hgps.sats_in_use, 5));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[0], 2));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[1], 0));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[2], 0));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[3], 7));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[4], 0));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[5], 9));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[6], 24));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[7], 26));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[8], 0));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[9], 0));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[10], 0));
    RUN_TEST(INT_IS_EQUAL(hgps.satellites_ids[11], 0));

    RUN_TEST(INT_IS_EQUAL(hgps.date, 8));
    RUN_TEST(INT_IS_EQUAL(hgps.month, 3));
    RUN_TEST(INT_IS_EQUAL(hgps.year, 1));
    RUN_TEST(INT_IS_EQUAL(hgps.hours, 18));
    RUN_TEST(INT_IS_EQUAL(hgps.minutes, 37));
    RUN_TEST(INT_IS_EQUAL(hgps.seconds, 30));
}
```

5.3 API reference

List of all the modules:

5.3.1 LwGPS

group **LWGPS**

Lightweight GPS NMEA parser.

Defines

lwgps_is_valid(*_gh*)

Check if current GPS data contain valid signal.

Note *LWGPS_CFG_STATEMENT_GPRMC* must be enabled and `GPRMC` statement must be sent from GPS receiver

Return `1` on success, `0` otherwise

Parameters

- `[in] _gh`: GPS handle

Typedefs

typedef double **lwgps_float_t**
GPS float definition, can be either `float` or `double`

Note Check for *LWGPS_CFG_DOUBLE* configuration

typedef void (***lwgps_process_fn**) (*lwgps_statement_t* res)
Signature for caller-suplied callback function from gps_process.

Parameters

- `[in] res`: statement type of recently parsed statement

Enums

enum lwgps_statement_t
ENUM of possible GPS statements parsed.

Values:

enumerator STAT_UNKNOWN
Unknown NMEA statement

enumerator STAT_GGA
GPGGA statement

enumerator STAT_GSA
GPGSA statement

enumerator STAT_GSV
GPGSV statement

enumerator STAT_RMC
GPRMC statement

enumerator STAT_UBX
UBX statement (uBlox specific)

enumerator STAT_UBX_TIME
UBX TIME statement (uBlox specific)

enumerator STAT_CHECKSUM_FAIL
Special case, used when checksum fails

enum lwgps_speed_t
List of optional speed transformation from GPS values (in knots)

Values:

enumerator lwgps_speed_kps
Kilometers per second

enumerator lwgps_speed_kph
Kilometers per hour

enumerator lwgps_speed_mps
Meters per second

enumerator lwgps_speed_mpm
Meters per minute

enumerator lwgps_speed_mips
Miles per second

enumerator lwgps_speed_mph
Miles per hour

enumerator lwgps_speed_fps
Foots per second

enumerator lwgps_speed_fpm
Foots per minute

enumerator lwgps_speed_mpk
Minutes per kilometer

enumerator lwgps_speed_spk
Seconds per kilometer

enumerator lwgps_speed_sp100m
Seconds per 100 meters

enumerator lwgps_speed_mipm
Minutes per mile

enumerator lwgps_speed_spm
Seconds per mile

enumerator lwgps_speed_sp100y
Seconds per 100 yards

enumerator lwgps_speed_smph
Sea miles per hour

Functions

uint8_t **lwgps_init**(*lwgps_t* *gh)
Init GPS handle.

Return `1` on success, `0` otherwise

Parameters

- `[in]` `gh`: GPS handle structure

uint8_t **lwgps_process**(*lwgps_t* *gh, **const** void *data, size_t len, *lwgps_process_fn* evt_fn)
Process NMEA data from GPS receiver.

Return `1` on success, `0` otherwise

Parameters

- `[in]` `gh`: GPS handle structure
- `[in]` `data`: Received data
- `[in]` `len`: Number of bytes to process
- `[in]` `evt_fn`: Event function to notify application layer. This parameter is available only if *LWGPS_CFG_STATUS* is enabled

uint8_t **lwgps_distance_bearing**(*lwgps_float_t las*, *lwgps_float_t los*, *lwgps_float_t lae*, *lwgps_float_t loe*, *lwgps_float_t *d*, *lwgps_float_t *b*)

Calculate distance and bearing between 2 latitude and longitude coordinates.

Return 1 on success, 0 otherwise

Parameters

- [in] las: Latitude start coordinate, in units of degrees
- [in] los: Longitude start coordinate, in units of degrees
- [in] lae: Latitude end coordinate, in units of degrees
- [in] loe: Longitude end coordinate, in units of degrees
- [out] d: Pointer to output distance in units of meters
- [out] b: Pointer to output bearing between start and end coordinate in relation to north in units of degrees

lwgps_float_t **lwgps_to_speed**(*lwgps_float_t sik*, *lwgps_speed_t ts*)

Convert NMEA GPS speed (in knots = nautical mile per hour) to different speed format.

Return Speed calculated from knots

Parameters

- [in] sik: Speed in knots, received from GPS NMEA statement
- [in] ts: Target speed to convert to from knots

struct lwgps_sat_t

#include <lwgps.h> Satellite descriptor.

Public Members

uint8_t **num**

Satellite number

uint8_t **elevation**

Elevation value

uint16_t **azimuth**

Azimuth in degrees

uint8_t **snr**

Signal-to-noise ratio

struct lwgps_t

#include <lwgps.h> GPS main structure.

Public Members

lwgps_float_t **latitude**
Latitude in units of degrees

lwgps_float_t **longitude**
Longitude in units of degrees

lwgps_float_t **altitude**
Altitude in units of meters

lwgps_float_t **geo_sep**
Geoid separation in units of meters

uint8_t **sats_in_use**
Number of satellites in use

uint8_t **fix**
Fix status. `0` = invalid, `1` = GPS fix, `2` = DGPS fix, `3` = PPS fix

uint8_t **hours**
Hours in UTC

uint8_t **minutes**
Minutes in UTC

uint8_t **seconds**
Seconds in UTC

lwgps_float_t **dop_h**
Dolution of precision, horizontal

lwgps_float_t **dop_v**
Dolution of precision, vertical

lwgps_float_t **dop_p**
Dolution of precision, position

uint8_t **fix_mode**
Fix mode. `1` = NO fix, `2` = 2D fix, `3` = 3D fix

uint8_t **satellites_ids**[12]
List of satellite IDs in use. Valid range is `0` to `sats_in_use`

uint8_t **sats_in_view**
Number of satellites in view

lwgps_sat_t **sats_in_view_desc**[12]

uint8_t **is_valid**
GPS valid status

lwgps_float_t **speed**
Ground speed in knots

lwgps_float_t **course**
Ground coarse

lwgps_float_t **variation**
Magnetic variation

uint8_t **date**
Fix date

uint8_t **month**
Fix month

uint8_t **year**
Fix year

lwgps_float_t **utc_tow**
UTC TimeOfWeek, eg 113851.00

uint16_t **utc_wk**
UTC week number, continues beyond 1023

uint8_t **leap_sec**
UTC leap seconds; UTC + leap_sec = TAI

uint32_t **clk_bias**
Receiver clock bias, eg 1930035

lwgps_float_t **clk_drift**
Receiver clock drift, eg -2660.664

uint32_t **tp_gran**
Time pulse granularity, eg 43

5.3.2 Configuration

This is the default configuration of the middleware. When any of the settings shall be modified, it shall be done in dedicated application config `lwgps_opts.h` file.

Note: Check *Getting started* to create configuration file.

group **LWGPS_OPT**
Default configuration setup.

Defines

LWGPS_CFG_DOUBLE
Enables `1` or disables `0` `double precision` for floating point values such as latitude, longitude, altitude.

`double` is used as variable type when enabled, `float` when disabled.

LWGPS_CFG_STATUS
Enables `1` or disables `0` status reporting callback by *lwgps_process*.

Note This is an extension, so not enabled by default.

LWGPS_CFG_STATEMENT_GPGGA
Enables `1` or disables `0` `GGA` statement parsing.

Note This statement must be enabled to parse:

- Latitude, Longitude, Altitude
- Number of satellites in use, fix (no fix, GPS, DGPS), UTC time

LWGPS_CFG_STATEMENT_GPGSA
Enables `1` or disables `0` `GSA` statement parsing.

Note This statement must be enabled to parse:

- Position/Vertical/Horizontal dilution of precision
- Fix mode (no fix, 2D, 3D fix)
- IDs of satellites in use

LWGPS_CFG_STATEMENT_GPRMC
Enables `1` or disables `0` `RMC` statement parsing.

Note This statement must be enabled to parse:

- Validity of GPS signal
- Ground speed in knots and coarse in degrees
- Magnetic variation
- UTC date

LWGPS_CFG_STATEMENT_GPGSV
Enables `1` or disables `0` `GSV` statement parsing.

Note This statement must be enabled to parse:

- Number of satellites in view
- Optional details of each satellite in view. See *LWGPS_CFG_STATEMENT_GPGSV_SAT_DET*

LWGPS_CFG_STATEMENT_GPGSV_SAT_DET
Enables `1` or disables `0` detailed parsing of each satellite in view for `GSV` statement.

Note When this feature is disabled, only number of "satellites in view" is parsed

LWGPS_CFG_STATEMENT_PUBX
Enables `1` or disables `0` parsing and generation of PUBX (uBlox) messages.

PUBX are a nonstandard ublox-specific extensions, so disabled by default.

LWGPS_CFG_STATEMENT_PUBX_TIME
Enables `1` or disables `0` parsing and generation of PUBX (uBlox) TIME messages.

This is a nonstandard ublox-specific extension, so disabled by default.

Note TIME messages can be used to obtain:

- UTC time of week
- UTC week number
- Leap seconds (allows conversion to eg. TAI)

This configure option requires LWGPS_CFG_STATEMENT_PUBX

5.4 Examples and demos

There are several basic examples provided with the library.

5.4.1 Parse block of data

In this example, block of data is prepared as big string array and sent to processing function in single shot. Application can then check if GPS signal has been detected as valid and use other data accordingly.

Listing 4: Minimum example code

```
/**
 * This example uses direct processing function
 * to process dummy NMEA data from GPS receiver
 */
#include <string.h>
#include <stdio.h>
#include "lwgps/lwgps.h"

/* GPS handle */
lwgps_t hgps;

/**
 * \brief           Dummy data from GPS receiver
 */
const char
gps_rx_data[] = ""
                "$GPRMC,183729,A,3907.356,N,12102.482,W,000.0,360.0,080301,015.5,E*6F\
↪r\n"
                "$GPRMB,A,,,,,,,,,,,V*71\r\n"
                "$GPGGA,183730,3907.356,N,12102.482,W,1,05,1.6,646.4,M,-24.1,M,,*75\r\
↪n"
                "$GPGSA,A,3,02,,,07,,09,24,26,,,,,1.6,1.6,1.0*3D\r\n"
                "$GPGSV,2,1,08,02,43,088,38,04,42,145,00,05,11,291,00,07,60,043,35*71\
↪r\n"
                "$GPGSV,2,2,08,08,02,145,00,09,46,303,47,24,16,178,32,26,18,231,43*77\
↪r\n"
                "$PGRME,22.0,M,52.9,M,51.0,M*14\r\n"
                "$GPGLL,3907.360,N,12102.481,W,183730,A*33\r\n"
                "$PGRMZ,2062,f,3*2D\r\n"
                "$PGRMM,WGS84*06\r\n"
                "$GPBOD,,T,,M,,*47\r\n"
                "$GPRTE,1,1,c,0*07\r\n"
                "$GPRMC,183731,A,3907.482,N,12102.436,W,000.0,360.0,080301,015.5,E*67\
↪r\n"
                "$GPRMB,A,,,,,,,,,,,V*71\r\n";

int
main() {
    /* Init GPS */
    lwgps_init(&hgps);

    /* Process all input data */
    lwgps_process(&hgps, gps_rx_data, strlen(gps_rx_data));

    /* Print messages */
```

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```
    printf("Valid status: %d\r\n", hgps.is_valid);
    printf("Latitude: %f degrees\r\n", hgps.latitude);
    printf("Longitude: %f degrees\r\n", hgps.longitude);
    printf("Altitude: %f meters\r\n", hgps.altitude);

    return 0;
}
```

5.4.2 Parse received data from interrupt/DMA

Second example is a typical use case with interrupts on embedded systems. For each received character, application uses `ringbuff` as intermediate buffer. Data are later processed outside interrupt context.

Note: For the sake of this example, application *implements* interrupts as function call in *while loop*.

Listing 5: Example of buffer

```
#include "lwgps/lwgps.h"
#include "lwrb/lwrb.h"
#include <string.h>

/* GPS handle */
lwgps_t hgps;

/* GPS buffer */
lwrb_t hgps_buff;
uint8_t hgps_buff_data[12];

/**
 * \brief           Dummy data from GPS receiver
 * \note            This data are used to fake UART receive event on microcontroller
 */
const char
gps_rx_data[] = ""
                "$GPRMC,183729,A,3907.356,N,12102.482,W,000.0,360.0,080301,015.5,E*6F\
↪\r\n"
                "$GPRMB,A,,,,,,,,,,,V*71\r\n"
                "$GPGGA,183730,3907.356,N,12102.482,W,1,05,1.6,646.4,M,-24.1,M,,*75\r\
↪n"
                "$GPGSA,A,3,02,,,07,,09,24,26,,,,,1.6,1.6,1.0*3D\r\n"
                "$GPGSV,2,1,08,02,43,088,38,04,42,145,00,05,11,291,00,07,60,043,35*71\
↪\r\n"
                "$GPGSV,2,2,08,08,02,145,00,09,46,303,47,24,16,178,32,26,18,231,43*77\
↪\r\n"
                "$PGRME,22.0,M,52.9,M,51.0,M*14\r\n"
                "$GPGLL,3907.360,N,12102.481,W,183730,A*33\r\n"
                "$PGRMZ,2062,f,3*2D\r\n"
                "$PGRMM,WGS84*06\r\n"
                "$GPBOD,,T,,M,,*47\r\n"
                "$GPRTE,1,1,c,0*07\r\n"
                "$GPRMC,183731,A,3907.482,N,12102.436,W,000.0,360.0,080301,015.5,E*67\
↪\r\n"
                "$GPRMB,A,,,,,,,,,,,V*71\r\n";
```

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```c
static size_t write_ptr;
static void uart_irqhandler(void);

int
main() {
    uint8_t rx;

    /* Init GPS */
    lwgps_init(&hgps);

    /* Create buffer for received data */
    lwrb_init(&hgps_buff, hgps_buff_data, sizeof(hgps_buff_data));

    while (1) {
        /* Add new character to buffer */
        /* Fake UART interrupt handler on host microcontroller */
        uart_irqhandler();

        /* Process all input data */
        /* Read from buffer byte-by-byte and call processing function */
        if (lwrb_get_full(&hgps_buff)) {        /* Check if anything in buffer now */
            while (lwrb_read(&hgps_buff, &rx, 1) == 1) {
                lwgps_process(&hgps, &rx, 1);   /* Process byte-by-byte */
            }
        } else {
            /* Print all data after successful processing */
            printf("Latitude: %f degrees\r\n", hgps.latitude);
            printf("Longitude: %f degrees\r\n", hgps.longitude);
            printf("Altitude: %f meters\r\n", hgps.altitude);
            break;
        }
    }

    return 0;
}

/**
 * \brief           Interrupt handler routing for UART received character
 * \note            This is not real MCU, it is software method, called from main
 */
static void
uart_irqhandler(void) {
    /* Make interrupt handler as fast as possible */
    /* Only write to received buffer and process later */
    if (write_ptr < strlen(gps_rx_data)) {
        /* Write to buffer only */
        lwrb_write(&hgps_buff, &gps_rx_data[write_ptr], 1);
        ++write_ptr;
    }
}
```

5.4.3 Distance and bearing

Library provides calculation of distance and bearing between 2 coordinates on earth. This is useful if used with autonomnous devices to understand in which direction device has to move to reach end point while knowing start coordinate.

Listing 6: Distance and bearing calculation

```
#include "lwgps/lwgps.h"

/* Distance and bearing results */
lwgps_float_t dist, bear;

/* New York coordinates */
lwgps_float_t lat1 = 40.685721;
lwgps_float_t lon1 = -73.820465;

/* Munich coordinates */
lwgps_float_t lat2 = 48.150906;
lwgps_float_t lon2 = 11.554176;

/* Go from New York to Munich */
/* Calculate distance and bearing related to north */
lwgps_distance_bearing(lat1, lon1, lat2, lon2, &dist, &bear);
printf("Distance: %f meters\r\n", (float)dist);
printf("Initial bearing: %f degrees\r\n", (float)bear);

/* Go from Munich to New York */
/* Calculate distance and bearing related to north */
lwgps_distance_bearing(lat2, lon2, lat1, lon1, &dist, &bear);
printf("Distance: %f meters\r\n", (float)dist);
printf("Initial bearing: %f degrees\r\n", (float)bear);
```

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