Hokuyo URG Series Block in Matlab Simulink

Luhur Budi Saesar, Khalid bin Hasnan, and Muhammad Atif Yaqub

***Abstract*—Since simulink has been widely used among engineer and researcher for many aspect of digital signal processing and control theory, then we develop a block that interfaced specific hardware that also has been widely used, a Laser Range Finder (LRF) sensor. Here we interface the LRF sensor from Hokuyo, the URG family series. Hokuyo is famous with the affordable LRF sensor that they built, such as URG-04LX-UG01. This paper presents the structure and the design of block proposed. Moreover, with mathematical calculation we provide the 2D plot graph from the scanned result.**

***Index Terms*—Hokuyo, toolbox, block, simulink, Matlab.**

I. Introduction

Simulink® is an environment for multi domain simulation and Model-Based Design for dynamic and embedded systems. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing [1]. Since the first version of simulink release in 2002, simulink 5.0.2, this tools inside Matlab software has develop and widely used in the world.

Due to easiness and simplicity the use of simulink software, many researchers has developed a block for their simulation or hardware, like Kalagasidis A. S. *et al*. [2] that develop International Building Physics Toolbox (IBPT) for heat, air and moisture system analysis in building physics. And also Kloetzer M. and Pastravanu O. [3] that has develop neural predictive control of non-linear blockset processes. This library allows approaching the neural-net-based identification and predictive control, by simply operating with diagram blocks and circumventing the need for writing MATLAB codes.

Although many researchers has develop simulink block for the simulation, it is rare researcher who develop interface for hardware. Here in this paper, we proposed a block that enabled Hokuyo URG family series LRF to be used directly in simulink block for simulation, Hokuyo URG-04LX-UG01 are used for the example of application.

The rest of this paper is organized as follow. Section II describes Hokuyo URG Series family and URG-04LX-UG01 character for example. C Programming, Library and Legacy Code Tool of the URG block are describes in Section III. Section IV describes experimental procedure from the block proposed. Section V describes the results and discussion. Finally, the summary of our work is described in Section VI.

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II. Hokuyo URG Series

Hokuyo Automatic Co. Ltd. is a Japan company that runs on product manufacturer such as sensors, optical data transmission, laser and automatic door [4]. On the photo sensor areas, Hokuyo has developed so many type of photo sensor, among it there was URG Series family (See Fig.1) that famous with its excellence. The accuracy, the interface, the weight and also the price was the prime advantages if we chose their product. Here, we used the cheapest hokuyo LRF sensor on the market, URG-04LX-UG01 [5] (See Table I).

Fig. 1. URG family, from left to right: UTM-03LX, UHG-08LX, UBG-04LX-F01, URG-04LX, and URG-04LX-UG01.

TABLE I: URG-04LX-UG Specification [5]

Model No.	URG-04LX-UG01
Power source	5VDC ±5%(USB Bus power)
Light source	Semiconductor laser diode(λ =785nm), Laser safety class 1
Measuring area	20 to 5600mm(white paper with 70mm×70mm), 240°
Accuracy	60 to 1,000mm : ±30mm, 1,000 to 4,095mm : ±3% of measurement
Angular resolution	Step angle : approx. 0.36° (360° /1,024 steps)
Scanning time	100ms/scan
Noise	25dB or less
Interface	USB2.0/1.1 [Mini B](Full Speed)
Command System	SCIP Ver.2.0
Ambient illuminance*1	Halogen/mercury lamp: 10,000Lux or less, Florescent: 6000Lux(Max) *1 Thease products are only for indoor applications. Strong sunlight may cause error output.
Ambient temperature/humidity	-10 to +50 degrees C, 85% or less(Not condensing, not icing)
Vibration resistance	10 to 55Hz, double amplitude 1.5mm each 2 hour in X, Y and Z directions
Impact resistance	196m/s^2, Each 10 time in X, Y and Z directions
Weight	Approx. 160g

If we talking about performance and characteristic of Hokuyo URG-04LX-UG01, the author assume that

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performance and characteristic of Hokuyo URG-04LX-UG01 is almost the same with the performance of URG-04LX that has been reviewed its characteristics by [6], [7]. They said, URG-04LX output performance need 90 minutes to stable. They also conclude that the surface reflectance properties, the angle reception, and colors affect the measurement of URG-04LX.

III. Programming

There a few step to make the Hokuyo URG series block, to wrapped all in 1 block we need C Programming, Library of C programming and windows and a legacy code tool from simulink, all be discuss on next subsection.

C Programming. C is an imperative (procedural) systems implementation language. It was designed to be compiled using a relatively straightforward compiler, to provide low-level access to memory, to provide language constructs that map efficiently to machine instructions, and to require minimal run-time support. C was therefore useful for many applications that had formerly been coded in assembly language [8]. Here we used a C programming sample from hokuyo [9] (See Fig. 2) for the basic parameter call and defining the function.

Library. In computer science, a library is a collection of resources used to develop software. These may include pre-written code and subroutines, classes, values or type specifications [10]. Shows in Fig. 3 sample of library urg_ctrl.h that has been provided by the hokuyo for the URG Series user.

Legacy Code Tool (LCT). The legacy code function creates a MATLAB structure for registering the specification for existing C or C++ code and the S-function being generated. In addition, the function can generate, compile and link, and create a masked block for the specified S-function [11]. For that we write our own LCT to wrap the C programming and the library into a single block (See Fig. 4. the red block). Shown in Fig. 4 the red block is the URG Series block, it provide the distance measurement and angle given by the LRF sensor. While in Fig. 5. Show the mask editor after the wrapped is done.

```
00057   /* Request for GD data */
00058   ret = urg_requestData(&urg, URG_GD, URG_FIRST, URG_LAST);
00059   if (ret < 0) {
00060     urg_exit(&urg, "urg_requestData()");
00061   }
00062
00063   /* Reception */
00064   n = urg_receiveData(&urg, data, data_max);
00065   printf("# n = %d\n", n);
00066   if (n < 0) {
00067     urg_exit(&urg, "urg_receiveData()");
00068   }
00069
00070   /* Display */
00071   timestamp = urg_recentTimestamp(&urg);
00072   printf("# timestamp: %d\n", timestamp);
00073   for (i = 0; i < n; ++i) {
00074     /*Neglect the distance less than  urg_minDistance()  */
00075     printf("%d %ld, ", i, data[i]);
00076   }
00077   printf("\n");
00078
00079   urg_disconnect(&urg);
00080   free(data);
00081
00082   return 0;
00083 }
```

Fig. 2. Example of GD data scan algorithm from Hokuyo [9].

```
00001 #ifndef C_URG_CTRL_H
00002 #define C_URG_CTRL_H
00003
00015 //#define USE_INTENSITY
00016
00017 #include "urg_t.h"
00018
00019
00023 enum {
00024   UrgLineWidth = 64 + 1 + 1,
00025   UrgInfinityTimes = 0,
00026 };
00027
00028
00032 typedef enum {
00033   URG_GD,
00034   URG_GD_INTENSITY,
00035   URG_GS,
00036   URG_MD,
00037   URG_MD_INTENSITY,
00038   URG_MS,
00039 } urg_request_type;
00040
00041
00045 enum {
00046   URG_FIRST = -1,
00047   URG_LAST = -1,
00049   UrgInvalidTimestamp = -1,
00050 };
00051
00052
00079 extern int urg_connect(urg_t *urg, const char *device, long baudrate);
00080
```

Fig. 3. Example of urg_ctrl.h from Hokuyo [9].

```
close all;
def = legacy_code('initialize');
def.SFunctionName = 'HOKUYO_URG04LXUG01';
def.OutputFcnSpec = 'doubleIt(int32 y1[7260])';
def.HeaderFiles = {'header.h'};
def.SourceFiles = {'urg.c'};

def.IncPaths      = {''};
def.SrcPaths      = {''};

def.SampleTime    = 'parameterized';

legacy_code('sfcn_cmex_generate', def);
legacy_code('compile', def);
legacy_code('generate_for_sim', def);
legacy_code('slblock_generate', def);
legacy_code('sfcn_tlc_generate', def);
legacy_code('rtwmakecfg_generate', def);
```

Fig. 4. Legacy code from Matlab.

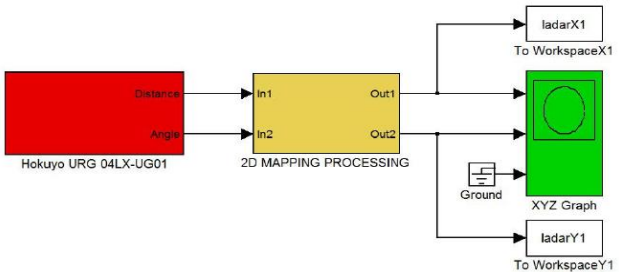

Fig. 5. Hokuyo block plot system.

To plot LRF scanned result, mathematical calculation has been done to get coordinate data of point that being scanned. Since LRF only gives distance (S) and angle data (α). Mathematical calculation must be done to get coordinate from it. First, the coordinate LRF itself must be register, x=0 and y=0 as point distance reference. Trigonometric function is used to get coordinate point the data from ladar scan as shown in Eq. 1 and Eq. 2. Moreover this calculation was wrapped into 2D mapping processing (See Fig. 6).

$$x_{n\ \ angle} = x_{\mathrm{LRF}} + (S.\cos\alpha) \quad (1)$$

$$y_{n\ \ angle} = y_{\mathrm{LRF}} + (S.\sin\alpha) \quad (2)$$

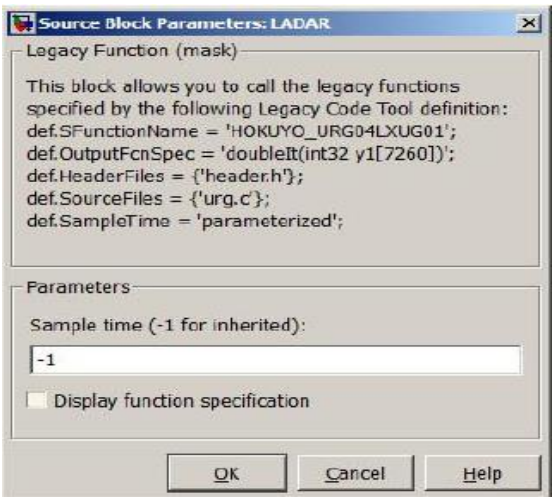

Fig. 6. Ladar maskin simulink.

IV. Experimental Procedure

First, you must install the LRF driver from the Hokuyo URG Series, connect the LRF to the laptop if it has. Shown in Fig. 7 here, we test the Hokuyo URG-04LX-UG01 with rectangle and circle shape for the obstacle of laser scanner.

Fig. 7. Rectangle and circle shape obstacle.

V. Results and Discussion

Shown in Fig. 8, the 2D mapping scan result from Hokuyo URG-04LX-UG01 interfaced in Matlab/Simulink [1], [11] software. The result shows the shape of obstacle in front of the LRF sensor which has rectangle and circular shape. The result shows 1 second scanned data from URG-04LX-UG01. 6820 measurement data in millimeter were received and collected during the scan, since URG-04LX-UG01 has capability of 10Hz frequency of scanning.

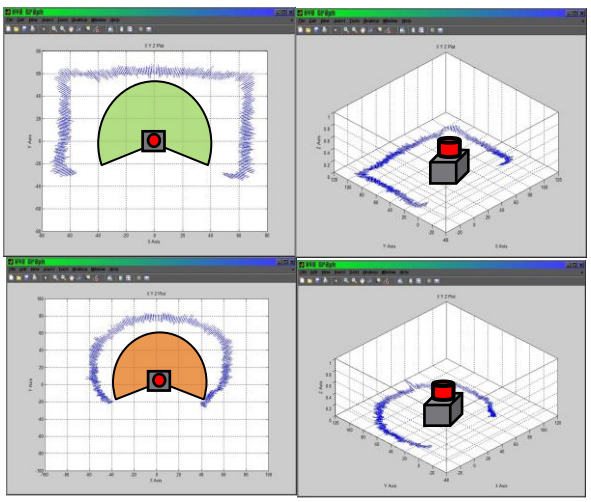
Fig. 8. Pattern result scanned from rectangle obstacle and circle obstacle.

VI. Summary

In this paper we successfully suggest a block in simulink to interface with hardware. With help of C programming, Library from C and windows and also Legacy Code Tool (LCT) from MATLAB/simulink, the block could be built. The scanning result shows the success of mathematical calculation to plot the measurement data from Laser Range Sensor (LRF). Finally, the approach of interfacing LRF sensor from Hokuyo Series in simulink finally achieved.

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