Incorporation of waypoint following logic into ROS publish and subscribe mechanism

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***Abstract*—The waypoint following logic is developed and it is incorporated into ROS publish and subscribe block for 2 wheel mobile platform. Firstly, the waypoint follower in mobile robotics simulation toolbox in simulink is introduced. On the other side of research, platform can be moved through ROS connection. In this presentation, the development of waypoint following logic is experimented with the real mobile robot with ROS connection.**

***Index Terms*—Waypoint following logic, ROS connection**

I. Introduction

The waypoint following logic is developed for decades, see in . For example, pure pursuit is utilized for 2 wheel mobile platform, in 2. In this presentation, we use different way point follow logic using state flow box in Simulink.

New models are often encountered in the agricultural, protection, and precision sectors. Computers, artificial intelligence, and big data technologies have been used to develop intelligent farming systems, particularly for farming robots [1]. With the rapid development of advanced technologies, many new techniques, such as big data, artificial intelligence, the Internet of Things, machine vision, and agricultural robotics, have been applied to agricultural production [2]. Recently, the pure pursuit method has been widely used for the path tracking of outdoor and indoor mobile robots. However, these algorithms and methods are controlled using the vector interval, which causes the mobile platform to vibrate during implementation. Automated navigation technology plays a crucial role in the autonomous navigation of mobile robots in engineering field [3]. The advantage of the pure pursuit algorithm is that the path of the mobile robot follows waypoints. Several methods have been applied to agricultural field operations for robotic localization. Localization systems such as the global positioning system (GPS) [4], real-time kinematic GPS (RTK-GPS) [5], geographic information systems [14], and LiDAR-based systems have been applied to agricultural mobile robotic systems [6]. Recently, linear active disturbance rejection control (LADRC) was designed for the trajectory tracking control problem of a differential-type model [10]. A recursive technique was applied to the path-tracking problem of the differential-type model by composing a chained form of the system [6] [8]. This paper introduces a novel Stateflow algorithm recently introduced by MathWorks. Several researchers [7], [8] have investigated the Stateflow method, namely, its applicability to flight control, hybrid energy control system design, and simulation [9]. The benefit of the waypoint following logic is that the platform is controlled using time interval control rather than vector interval control, in which the vibration of the platform is reduced, on the other hand, the pure pursuit and, Stanley methods have that of the platform. Therefore, we determined that the waypoint following logic is appropriate for the path-tracking problem in an UGV(Unmanned guided vehicle) environment.

Thus, the contribution of this paper can be expressed as

- Despite the various aforementioned control and estimation methods, the experiment was conducted focusing on the waypoint following logic incorporated into ROS publish and subscribe block introduced in MATLAB/SIMULINK recently.
- The actual path is implemented based upon the waypoints from ROS subscribe block.

II. Methods

The waypoint following logic is coded by

First of all, angle and range are extracted using "trackGoal" code. If absolute value of angle is positive, the angular velocity

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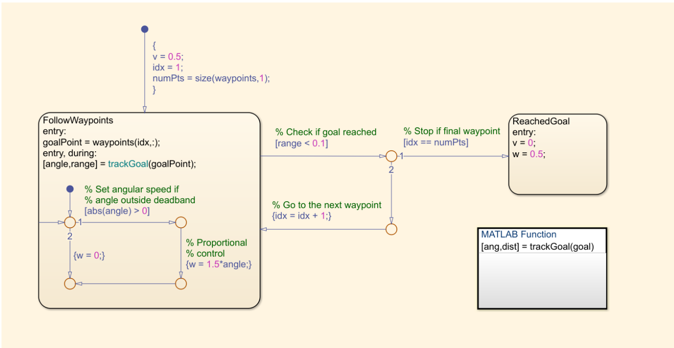

Fig. 1. Waypoint Code

signal is present, otherwise, angular velocity signal is zero. If range approaches zero, the linear velocity is forced to be zero, which means platform stops. The waypoint following logic is incorporated into ROS publish and subscribe blocks in Simulink. The input of the subsystem is longitude,latitude $x(t), y(t)$ and sideslip angle $h(t)$. Furthermore, the output of the subsystem is linear and angular velocity signal $v(t), w(t)$

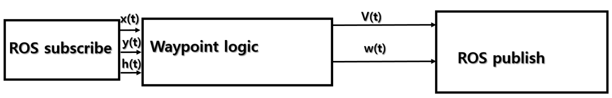

Fig. 2. The overall scheme of waypoint following into ROS subscribe and publish block

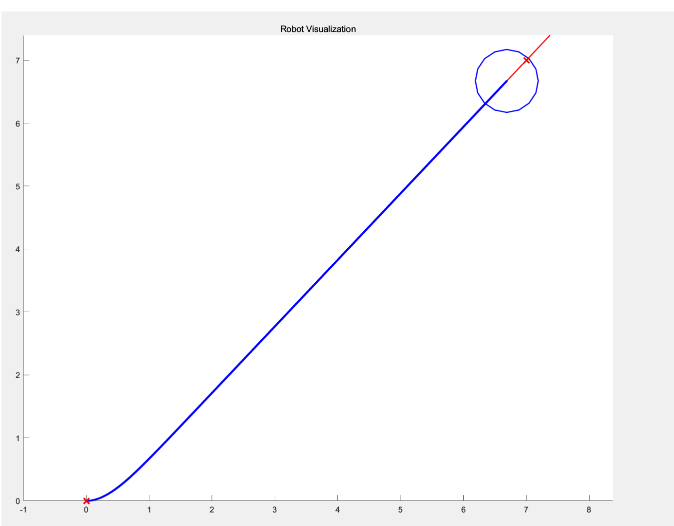

Fig. 3. The actual path using waypoint following logic

A. Maintaining the Integrity of the Specifications

The experimented waypoint condition is given as

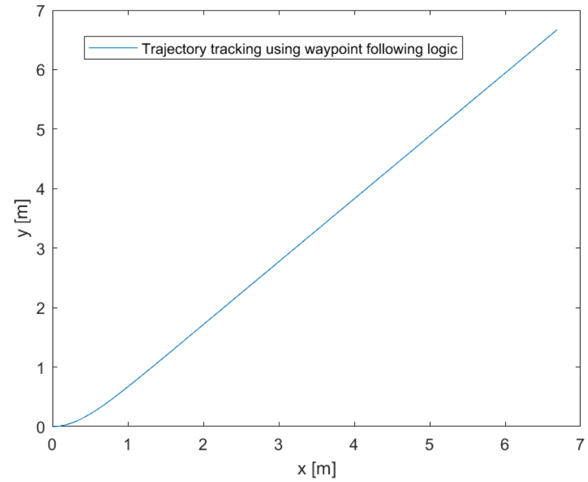

Fig. 4. Plot on MATLAB prompt

TABLE I
WAYPOINT FOLLOWING LOGIC

Table Head	Waypoint following condition		
	Waypoint	***Starting point***	***End point***
a	Predetermined set waypoints	(0,0)	(7,7)

III. EXPERIMENT

The linear and angular velocity signal is automatically calculated using way point code in Fig. 1.

IV. OUTPUT FEEDBACK CONTROL METHOD

The original system modeling have the following relation, given as The above system is MIMO(Multi-input and multi-

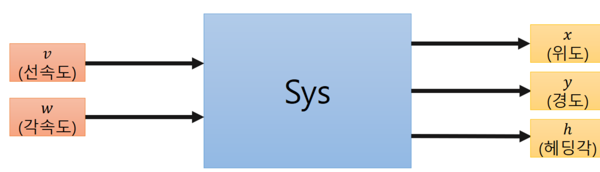

Fig. 5. Original system modeling

output) system. Since linear velocity signal doesn't affect the output signal only by using open-loop experiment, we consider The above system is SISO(Single input and single output) system, so that it is more simplistic for estimating transferfunction. For the system modeling, transfer estimation code "tfest" is used in MATLAB, then "tf2ss" code results in state space model, given as

$$\begin{aligned} \begin{bmatrix} \dot{h}_1'(t) \\ \dot{h}_2'(t) \end{bmatrix} &= \begin{bmatrix} -0.001 & 0 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} h_1'(t) \\ h_2'(t) \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} \\ \begin{bmatrix} h(t) \end{bmatrix} &= \begin{bmatrix} 0.01 & 0 \end{bmatrix} \begin{bmatrix} h_1'(t) \\ h_2'(t) \end{bmatrix} \end{aligned} \quad (1)$$

Fig. 6. Original system modeling

The output feedback control input is given as

$$u(t) = y(t) \tag{2}$$

After that, from workspace block is used with the following code, given as

$$\begin{aligned} &sampleTime = 60/1901; \\ &numSteps = 60; \\ &time = sampleTime * (0 : numSteps - 1); \\ &time = out.t; \\ &simin = [time, out.w2]; \\ &simin = [time * 10^(- 2), out.w2]; \end{aligned} \tag{3}$$

60 is the size of the first experiment, on the other hand, 1901 is the size of the output feedback simulation.Using above code, we can modify the shape of controlled input signals for closed loop experiment by using the input and output data sets from open-loop experiment. The experiments we implemented is described as Originally, the path is deviated from $(7, 7)$ in open loop experiment. By using output feedback inputs $w(t)$, the closed-loop experiment is implemented to target $(7, 7)$, final coordinates.

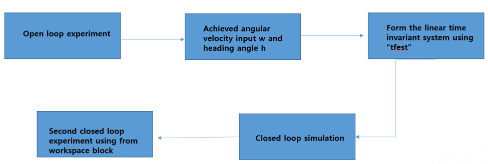

Fig. 7. The description of open-loop, closed-loop experiments

Future Work and Conclusion

In summary, this study demonstrated the successful implementation of a waypoint following with ROS publish and subscribe block using MATLAB/Simulink. Firstly, the waypoint following logic is introduced. Based on the system design, ROS publish and subscribe block is incorporated into waypoint logic. In the future, the interface will be implemented for the 4 wheel independent steering system. Furthermore, the output feedback control is applied to the real experiment using open loop experiment by achieving angular velocity, input and heading angle output.

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