Dual robot strategy for mission sharing and Processing distribution

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I.ABSTRACT

Our team is developing various underwater robots that are useful in the real world. For example, a seabed resource surveying robot, a pier inspection robot, and a bottom cleaning robot.Taking advantage of that experience, we are working on Robosubmission to further improve our technology.We will participate in this Robosub with 2 AUVs.There are limits to performing large tasks with one robot. In our team, we aim to achieve large tasks in cooperation with multiple robots.Two robots, DaryaBird and YajiroBay, share various missions.This time, we will challenge the image processing mission with the acoustic mission DaryaBird at YajiroBay.

Keywords—

underwater robot, software development, Imane processing, Waypoint Tracking, Acoustic positioning, ROS, MATLAB, Autonomous control

II.COMPETITION STRATEGY

We are planning to share and clear some Robosub missions using two robots this time. (The plan of two robots moving routes in Semi Final and Final is shown in the Fig.1,2. Yellow path is YajiroBay. Red path is DaryaBird.) DaryaBird takes charge of Gate, Follow the Path and Slay Vampires in order. DaryaBird has an image processing and object recognition system with two cameras mounted on the front and bottom. DaryaBird moves near the gate by dead reckoning for Gate mission. Then, with the front camera, grasp the relative positional relationship between the gate and robot, and achieve pass through. In Follow the Path, the camera attached to the bottom grasps the shape of the Path, and adds an operation amount in the direction of movement according to the bending angle of the path. With Slay Vampires, the position of the installed panel is recognized by the camera in front, and touch operation is performed. Following Daryabird, YajiroBay passes through Gate by waypoint tracking and then challenges Pinger Mission (Stake through Heart: Move lever, Expose to Sunlight: Surface in Area). At this time, YajiroBay will be compatible with Random Pinger. At first we recognize Pinger of Stake through Heart and move to the mission point. Contact the body with the lever at the target point and move lever.After that, move to the target Pinger of Expose to Sunlight: Suface in Area, and float on the defined area. In this way, by sharing the mission task with two robots, time saving, battery saving, and load balancing of CPU processing are realized.

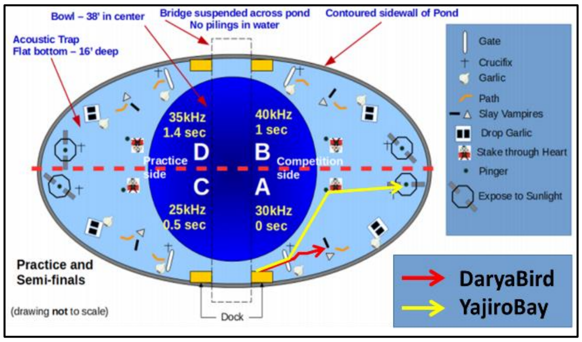

Fig.1 Two robots moving routes in Semi Final

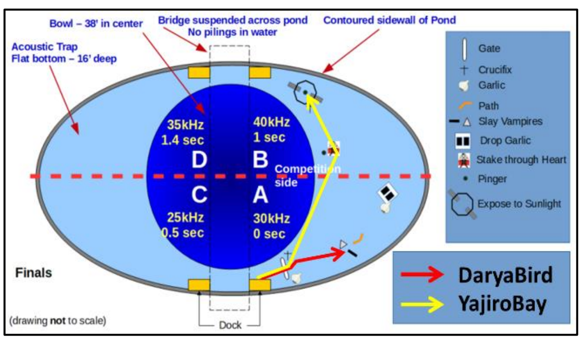

Fig.2 Two robots moving routes in Final

Ⅲ.BEHICLE DESIGN

A. *DaryaBird*

DaryaBird(Fig.3) is an AUV developed at Kyushu Institute of Technology. DaryaBird is controlled using an orientation sensor, depth sensor, DVL, and camera. DaryaBird is a combination of 4 hulls and 6 thrusters in an aluminum frame body. The hulls are the largest main hull installed at the upper part of the robot, the battery hull installed at the lower front, the sensor hull installed at the lower rear, and the camera hull installed below the sensor hull. . The main hull is equipped with a PC and a front camera, the battery hull is equipped with a battery, the sensor hull is equipped with a DVL, and the camera hull is equipped with a downward camera. The thruster is arranged to be capable of omnidirectional movement and yaw rotation. The body can change the combination of the aluminum frame, and has a specification that can change the shape according to the mission.

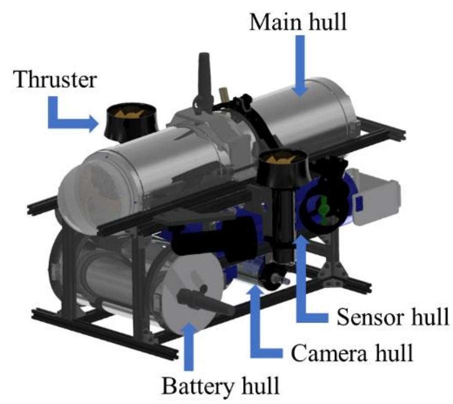

Fig.3 DaryaBird

Next, we show the system configuration of DaryaBird (Fig.4).Simulink 1 communicates with a GNAS sensor, which is an IMU, in Sensor Information. This is an item newly added this year. In the next Simulink 1 (Sensor Information), depth information is acquired from the velocity ground and depth sensors from the DVL, and sensor fusion is performed based on them. Simulink 2 (Thruster Control) controls the thruster from the target value and the current location. Simulink 3 (Image Processing) performs image processing according to the mission. Simulink Sim 4 (Behavior Selection) autonomously determines robot behavior during competition. Simulink 5 (Check the standard problem) is a file that describes calibration data and initial settings.

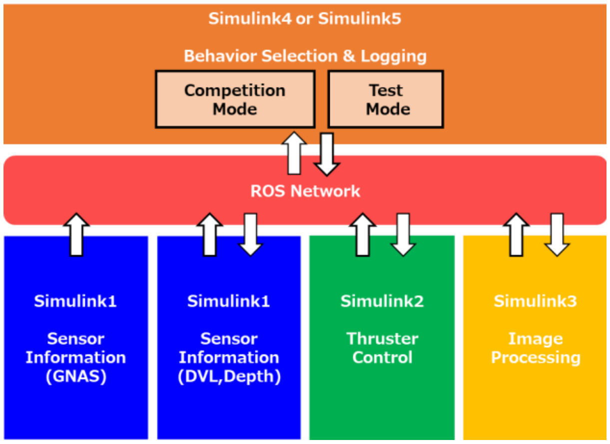

Fig.4 DaryaBird system configuration

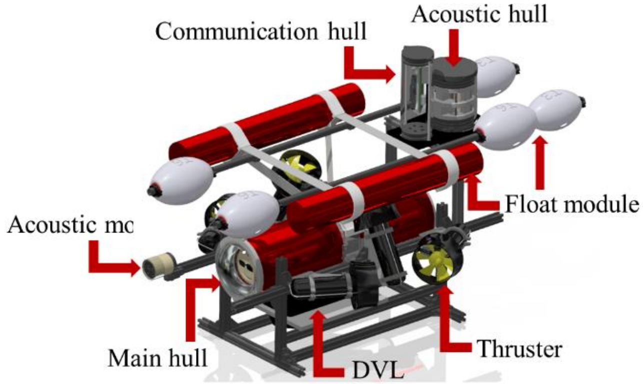

Fig.5 YajiroBay

B. *YajiroBay*

YajiroBay(Fig.5) is an AUV developed at Kyushu Institute of Technology, similar to DaryaBird. YajiroBay is controlled using an orientation sensor, depth sensor, DVL, and acoustic positioning device. The YajiroBay consists of three hulls, six thrusters, a DVL, an acoustic positioning sensor, and a floating body combined with an aluminum frame. The robot's system is integrated into a large red main hull located at the center, and two hulls, a communication hull and an acoustic hull, installed at the top of the robot are connected. The thrusters have the same arrangement as DaryaBird. An acoustic positioning sensor for acoustic measurement is placed in front of the robot. Because of the module configuration that assumes floating is to be changed, the floating position can be easily changed.

Dveloped acoustic positioning device (Fig.6) is an SSBL method that acquires the pinger sound (eg, 40 kHz) of a specific pinger installed in water and calculates the position and orientation from the time difference. The sound from Pinger arrives at the four MEMS microphones in the hydrophone. The distance and direction are estimated from the time difference when the MEMS microphone is reached. The configuration of the acoustic positioning device is as follows.

Hydrophones are used to fix MEMS microphones and to protect them from water. The MEMS microphone uses a jelly-like, water-resistant tough polymer resin called Jellafin, so that the sound impedance (1.48 x 106 [kgm-2s-1]) in water matches. Sound signal processing performs AD conversion with ReSpeaker 4-Mic Array for Raspberry Pi installed in Raspberrypi 3B, and analyzes the data using a program written in python. These are housed in the sound system dedicated hull.

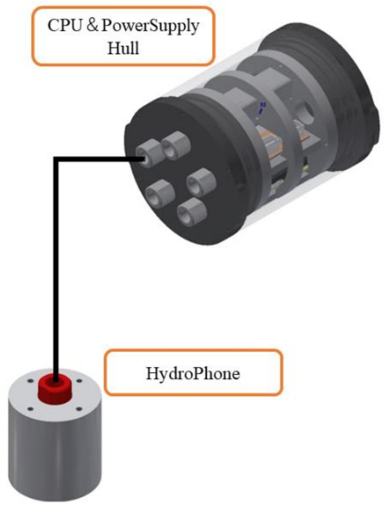

Fig.6 Our created the acoustic positioning device

IV.RIMENTAL RESULTS

We conducted multiple movement control experiments for both DaryaBird and YajiroBay in the simple swimming pool at the Kyutech Wakamatsu Campus and the 25 m swimming pool at the Kyutech Iizuka Campus.For DaryaBird, please refer to the test results of TDR up to last year, since there has been no significant change in mobility control algorithm since last year. For YajiroBay, we newly built a self-location calculation program for movement control with ROS. And in the experiment, the calculated 3D information was recorded as LOG. By combining Yaw calculated from a 9-axis sensor, X, Y plane position calculated from the velocity of DVL, and Z height information, it was confirmed that values could be acquired in real time as three-dimensional Odometry. The following Fig.7 is a view showing odometry in Rviz. We plan to use this 3D odometry as the current value to control the position. Evaluation experiments on acoustic positioning and image processing have not been performed sufficiently.

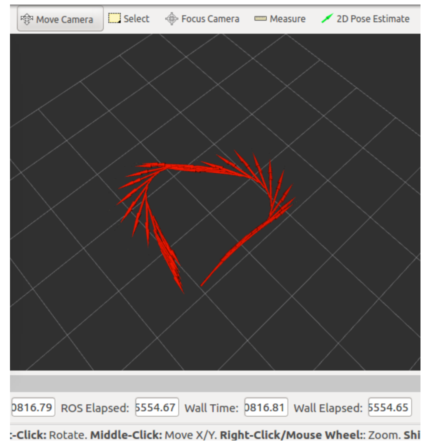

Fig.7 Odometry display in Rviz

V.CKNOWLEDGEMENTS

We would like to thank professor Ishii, assistant professor Nishida, associate professor Yasukawa, and associate professor Sonoda. We especially would like to thank assistant professor Nishida, who gave us various advice, and supported by experiment in pool. This team supported by Kyutech・Meisenkai student project grant.

VI. References

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[3] R. Nakanishi, J. Ahn, K. Suzuki, Y. Soejima, K. Masuda and Y. Nishida, "System Design and Hardware Development of Autonomous Underwater Robot “DaryaBird”," AUVSI&ONR’ s 19th Annual RoboSub Competition Journal Paper, 2016.

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AppendixA

Subjective Measures			
	Maximum Points	Expected Points	Points Scored
Utility of team website	50	50	
Technical Merit (from journal paper)	150	150	
Written Style (from journal paper)	50	50	
Capability for Autonomous Behavior (static judging)	100	100	
Creativity in System Design (static judging)	100	100	
Team Uniform (static judging)	10	10	
Team Video	50	50	
Pre-Qualifying Video	100	0	
Discretionary points (static judging)	40	40	
Total	650	550	
Performance Measures			
	Maximum Points	4591.36	
Weight	See Table 1 / Vehicle	(DB)1.76	(YB)39.6
Marker/Torpedo over weight or size by <10%	minus 500 / marker	0	
Gate: Pass through	100	100	
Gate: Maintain fixed heading	150	150	
Gate: Coin Flip	300	0	
Gate: Pass through 60% section	200	0	
Gate: Pass through 40% section	400	400(DB/YB)	
Gate: Style	+100 (8x max)	0	
Collect Pickup: Crucifix, Garlic	400 / object	0	
Follow the "Path" (2 total)	100 / segment	200	
Slay Vampires: Any, Called	300, 600	300	
Drop Garlic: Open, Closed	700, 1000 / marker (2 + pickup)	0	
Drop Garlic: Move Arm	400	0	
Stake through Heart: Open Oval, Cover Oval, Sm Heart	800, 1000, 1200 / torpedo (max 2)	0	
Stake through Heart: Move lever	400	400	
Stake through Heart: Bonus - Cover Oval, Sm Heart	500	0	
Expose to Sunlight: Surface in Area	1000	1000	
Expose to Sunlight: Surface with object	400 / object	0	
Expose to Sunlight: Open coffin	400	0	
Expose to Sunlight: Drop Pickup	200 / object (Crucifix only)	0	
Random Pinger first task	500	500	
Random Pinger second task	1500	1500	
Inter-vehicle Communication	1000	0	
Finish the mission with T minutes (whole + factional)	Tx100	Undecided	

AppendixB_DaryaBird

Component	Vendor	Model/Type	Specs	Cost(if new)
Buoyancy Control		VINICON T2 * 5		
Frame	MISUMI	HFSB5－2020	Aluminum	
Waterproof Housing			Aluminum Acrylic Max. Depth: 50[m]	
Waterproof Connectors	Fischer Connectors			
Thrusters	Seabotix/RoboPlusHIBIKINO	BRD150/HIBIKINO Thruster	110[W]/90[W]	
Motor Control	Dimension Engineering	Sabertooth		
High Level Control	INNINGS	ix-5050	Intel i7 RAM16GB SSD 128GB	
Actuators				
Propellers				
Battery	SHORAI	LFX09A2-BS12/LFX14A2-BS12	LiFePO4(12[V]9[Ah]/12[V]14[Ah])	
Converter				
Regulator				
CPU	Intel	i7 IvyBridge		
Internal Comm Network	Ethernet			
External Comm Interface	Buffalo	BMC-GT-S10K/WB	Optical communication(IEEE802.3ah)	
Programming Language 1	MathWorks	Matlab Simulink		
Programming Language 2	ROS	ROS(Python)		
Compass	PNI	TCM-XB		
Inertial Measurment Unit(IMU)	TKK	GNAS CSM-MG100		
Doppler Velocity Log(DVL)	Teledyne Explorer			
Camera(s)	Logicool	Logicool HD Pro Webcam C920	Full HD 1080p	
Hydrophones				
Manipulator				
Algorithms:vision		Matlab Simulink		
Algorithms:acoustics				
Algorithms:localization and mapping		Matlab Simulink		
Algorithms:autonomy		Matlab Simulink		
Open source software				
Team size (number of people)	Kyutech underwater Robotics	16		
HW/SW expertise ratio	Kyutech underwater Robotics	7:5		
Testing time: simulation				
Testing time: in-water				

AppendixB_YajiroBay

Component	Vendor	Model/Type	Specs	Cost(if new)
Buoyancy Control		VINICON T3 +T6		
Frame	MISUMI	HFSB5－2020	Aluminum	
Waterproof Housing			Aluminum Acrylic Max. Depth: 50[m]	
Waterproof Connectors	Fischer Connectors			
Thrusters	RoboPlusHIBIKINO	HIBIKINO Thruster	90[W]	
Motor Control	Dimension Engineering	Sabertooth Dual 25A*3	25[A] 6~24[V]	
High Level Control	LattePanda	LattePanda	Atom x5-Z8300 RAM4GB eMMC64GB	
Actuators				
Propellers				
Battery	IMPACT POWER	IMPACT POWER NI-MH 4200mA	NI-MH 4200[mA]	
Converter	Vicor	VE-JV0-CZ/V28A24T200BG	5[V]25[W]/24[V]400[W]	
Regulator				
CPU	Intel	Intel Cherry Trail Z8350	4core 1.8[GHz]	
Internal Comm Network	Ethernet			
External Comm Interface	ELECOM	WRH-300WH3-S	IEEE802.11n/g/b	
Programming Language 1		Python		
Programming Language 2		C++		
Compass				
Inertial Measurment Unit(IMU)	InvenSense	MPU-9250		
Doppler Velocity Log(DVL)	Teledyne Explorer	PATHFINDER 600 KHZ		
Camera(s)				
Hydrophones	Knowles Electronics	SPU0414HR5H-SB*4		$10
Manipulator				
Algorithms:vision				
Algorithms:acoustics		SSBL		
Algorithms:localization and mapping		ROS(Dead Reckoning/Waypoint Tracking)		
Algorithms:autonomy		ROS		
Open source software		ROS		
Team size (number of people)	Kyutech underwater Robotics	16		
HW/SW expertise ratio	Kyutech underwater Robotics	7:5		
Testing time: simulation				
Testing time: in-water				