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Automatic Navigation System Using Collision Prevention Technique

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Abstract-
In this paper, we are going to discuss about the recent technological advancements that has been used in the maritime navigation system. We have used unmanned surface vehicles (USVs) which operates on the surface of the water without any crew. These USVs are made to run along with other manned and unmanned vehicles by using certain obstacle detection technique. This way we can safely avoid collision from other vessels in the sea. A tactical move, or series of moves has to be made to maintain strategic situation. In maritime navigation systems, ships need to follow International Regulation for preventing collision at seas known as COLREGS, for COLlision REGulationS. These rules specify the type of move that has to be taken in the situations where there is a risk of collision.

I. INTRODUCTION

In recent years, uses of Unmanned Surface Vehicles (USVs) have made very good technological development in the marine system. These USVs are made to run along with other manned and unmanned vehicles. To prevent collision from each other and from other hazardous vessels in the sea, the International Maritime Organization (IMO) has created regulation known as COLREGS. In the existing system the person controlling the USVs, control the vehicle in case of velocity obstacles. The major problem in it was that the person may miscalculate the average speed and direction in which the Velocity Obstacle (VO) is moving. The major drawback was that it was difficult to find the average speed of the vehicle.so in the proposed system, we have developed a new way of collision avoiding method by using MATLAB technology and sensor technology. The major advantage was that we could easily find the speed of other vessels in the sea. Moreover the sensors present in it added high accuracy and high reliability to the system.

II. WORKING PRINCIPLE

In the proposed system the velocity obstacles are identified using MATLAB and sensor. A web camera is fixed in front of the USVs and from the input video transmission, a sample of image is taken and it is processed for detecting the position of opposite ship. Namely three positions are detected. The processed output is fetched through UART of Microcontroller which receives and analyzes the processed output over a period of time and intimates the USV about the COLREG decision, whether to give away or cross over. According to that the engine motor is controlled. Also the range finding sensor monitors the obstacles continuously and if any obstacles are detected the motor will stop. In the existing system the manual work is needed and so we have to go for our proposed system. In our proposed system we are going to monitor the opposite ships and obstacles in the path and control the USV automatically.

A wide range of approaches has been made in the past for obeying the COLREGS in the maritime navigation system such as 2-D map grids, fuzzy logic algorithms, interval programming. But these previous approaches were not proper for too many traffic boats and multiple COLREGS rules especially in real time computations on robotics field. There existed some problems such as communication and computational delays and uncertain movement of USVs. To fix these problems, several researchers have adopted the Velocity Obstacle(VO) approach for avoiding collision. In this approach a cone shaped obstacle is generated in the velocity space and it is ensured that no collision occurs in future as long as the robot's velocity vector is outside the VO. In order to identify the collision risk in future, we can predict the position of moving hazard and the position of the USVs for several time steps into the future and perform collision check using their configuration at each time interval. As we have to perform multiple collision check at different time intervals, the computational load becomes very high. On the other side, VO makes a linear prediction, and the collision check is done in the velocity space. Since we are performing only one collision check for all future times, VO can be computed with high speed operations at short reaction time.

III. MOTION PLANNING OF COLREGS

We have to consider the following problems while operating the USV:

- A nearby reference point
- Reference speed
- Moving and static hazards

A. Details about Velocity Obstacles

In this section we will review how the VO will move around the USV for the foundation of the work. The USV will not collide with any obstacles as long as the velocity of the USV lies outside the VO, by considering the velocity vectors constant over time. If it changes over time, then VO will plan itself by using latest information provided by the sensors. When the velocity is inside the VO, the collision time can be obtained by calculating the time it takes for the relative velocity vector to enter the boundary. In this, motion planner is introduced for various types of uncertainties in the sea. The moving hazards are detected and tracking is done by cameras and radars. Another source of uncertainty arises when the moving hazards does not move properly by maintaining constant speed. So for the worst case uncertainty, we are considering it as a boundary set and treat them as constant.

IV. ASSESSMENT OF COLREGS

The work shown in this paper describes the following three COLREGS decisions: crossing, head-on, and overtaking. These rules are shown in the figure. The blue triangle represents the traffic boat and the back triangle represents the USVs. In first case, the traffic boat is travelling from the right direction. For this type of situation USVs should give way to pass the traffic boat and the traffic boat need not to change its path. In second case, we can see that the traffic boat is travelling from left direction. In that case the traffic boat is the give-away vessel and the USVs should maintain its course, In third case, the USVs is overtaking a slow traffic boat. In that case sufficient distance should be maintained between the USVs and traffic boat to provide overtaking. Although COLREGS do not specify that which side of the boat it must overtake, common practices on water indicates that the overtaking boat should pass from the right-hand side of the traffic boat. In fourth case, the USVs and the traffic boat is moving straight towards each other. Here, both the vessels must change their course toward starboard so that they can pass with the other vessel to its left side.

V. ON WATER OUTCOMES

A. Setup

The COLREGS algorithms was coordinated within the Jet Propulsion Laboratory's (JPL) self-controlled suite called Control Architecture for Robotic Agent Command and Sensing (CARACaS). CARACas can command the USV through an integrated Controller Area Network(CAN) bus. The traffic boats used for the tests are two 7-m rigid –hulled inflatable boat(RHIBs) and one 12-m craft. The picture of stereo cameras are shown. Two pairs of stereo cameras are used, where one pair is placed at right side and the other pair is placed at left. These JPL stereo systems provides the speed and position of the traffic boats but not their

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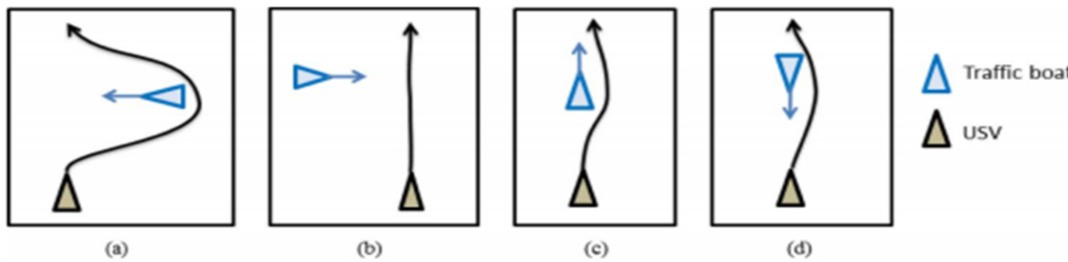
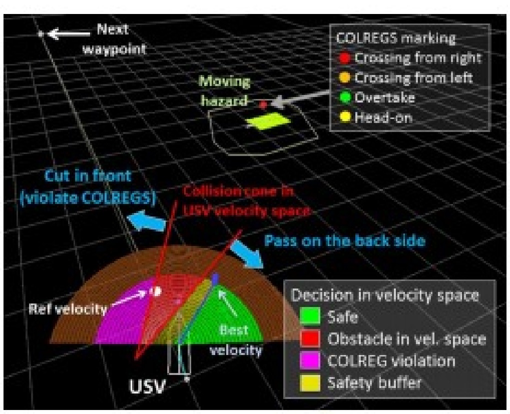


Maneuvers required for various COLREGS situations (a) Crossing from right. (b) Crossing from left. (c) Overtaking. (d) Head-on.

orientation. The traffic boats that moves slower are treated as stationary hazards and the COLREGS rules are not applied.

B. Testing of four vessels with COLREGS

In this test, we are involving four traffic vessels for on-water COLREGS test. Same traffic boats are used which was mentioned earlier. In all the cases the USVs was provided with a waypoint that was 1000 m away in front and commands were provided to reach the waypoint by obeying COLREGS with traffic vessels.In first head-on and crossing case: The USVs has to overtake a traffic boat. As it starts making a move, the other vessels start moving towards the USVs by creating a head on situation. This is shown in the figure.In the left side of the



A snapshot of a simulation run (the USV is in a crossing situation).

figure, there are two images at the top which are captured from right looking and left looking cameras, and the image below them shows the USV, the detected objects and decision space of the COLREGS. And on the right side, there are plots in the frame, the position and path of the USV, the field view of stereo cameras and the detected objects from the stereo system. In first image, we can see that the USV is provided with a travel space with other vessels in the water. The USV detects a 7-m RHIBs at a far distance. Since the speed of the vessel was very slow the USV considers it as a stationary hazard and no COLREGS is applied. As the vessel approaches near, the USV finds out the head-on situation and COLREGS rule is applied. In second image, the COLREGS forces the head-on maneuver to turn right by reducing the speed to the left. And the top of the detected vessel is marked with a yellow sign for thehead-on situation. In third image, thevessel approaching from the front side is detected by the USV and recognizes it to be in head-on COLREGS situation with both vessels. During this time, although the 12-m craft is visible in the image, the stereo system will not detect it. In fourth image, the 12-m craft is detected and all the three vessels are avoided by USV by changing its path. As the orientation of the USV is changed, the heading difference is changed from almost perpendicular to almost opposite. The USV and the 12-m craft are both considered in crossing situation and head-on situation. The fifth image shows the successful avoidance of 12-m craft. Overall, the traffic vessels are obtained based on the output of the stereo system and the information generated from it allows the USV to make a smart move in the sea. In second Overtake, Head-on and crossing case: The USV identifies a overtake situation and starts making smart moves towards starboard. This act emerges from the COLREGS forces the USV to overtake from the starboard side. While overtaking, the USV detects another vessel in the head-on situation. The USV identifies that other vessel in in head-on situation as well as overtaking situation. This way the USV changes its path away from its normal while avoiding the head-on vessel. In the next image the head-on vessel is avoided by the USV. Soon after we are able to see the image of another vessel in the stereo image coming from the right direction. The USV is in both head-on situation as well as overtaking, after successfully avoiding the head-on vessel. The 12 m craft is allowed to maintain its course because that craft is the stand-on vessel in this situation. In next figure the 12 m craft is avoided and the7-m RHIB comes in the view again. Since it is very far, the USV does not consider this situation to be overtaking. But avoidance of hazard is always active, as shown in the left cone of the left plot.

VI. CONCLUSION

In this paper we have used the navigational algorithms to avoid hazards and follow COLREGS using Velocity Obstacles(VOs). Since we are using the Sensor technologies, the system is highly reliable and there is safe and proper navigation. In this, the algorithms were coordinated with the CARACaS and it was successfully operated on water by using stereo sensors.

REFERENCES

[1.] *Senior Member,* Yoshiaki Kuwata, Michael T. Wolf, Dimitri Zarzhitsky, and Terrance L. Huntsberger, "Safe Maritime Autonomous Navigation With COLREGS, Using Velocity Obstacles".