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# Computational intelligence methods of a safe ship control

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**Abstract**

The paper describes the application of selected methods of optimal control theory, game theory and artificial neural networks with the aim of computer support for a safe ship control in collision situations. It shows the structure of the control system and defines the task of safe control. Also presented are methodologies and models for collision avoidance strategies. Using Matlab software, positional game, risk game and dynamic optimal trajectory algorithms have been developed to provide computer support of navigator for collision avoidance at sea. A computer simulations showing safe trajectory through eighteen met ships at sea illustrates this.


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## 1. Safe ship control process

In order to ensure the safety of navigation the ships are obliged to comply with the International Regulations for Preventing Collisions at Sea (COLREG). However, these Rules refer only to two ships and under the conditions of good visibility [6]. In the case of a restricted visibility the Rules only specify recommendations of a general nature and are not able to consider all the necessary conditions which determine the passing course. Consequently, the actual process of a ship passing other objects very often occurs in conditions of uncertainty and conflict accompanied by an inadequate co-operation of the ships with regard to the COLREG Rules. It is, therefore, reasonable to investigate, develop and represent the methods of a ship's safe handling using the rules of theory based on differential game and computational intelligence[1,2,3,4].

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While formulating the model of the process it is essential to take into consideration both the kinematics and the dynamics of the ship's movement, the disturbances, the strategy of the encountered ships and the formula assumed as the goal of the ship's handling[5,6,7,8].

Having regard to a high complexity of the basic model in the form of the differential game for the practical synthesis of safe steering algorithms various approximated models are formulated, such as for example: multi-stage positional game and multi-step matrix game[9,10,11,12,13].

An obvious contribution in increasing safety of shipping has been the development of ARPA (Automatic Radar Plotting Aids) anti-collision system, which presents important part of safe ship control system (Fig. 1).

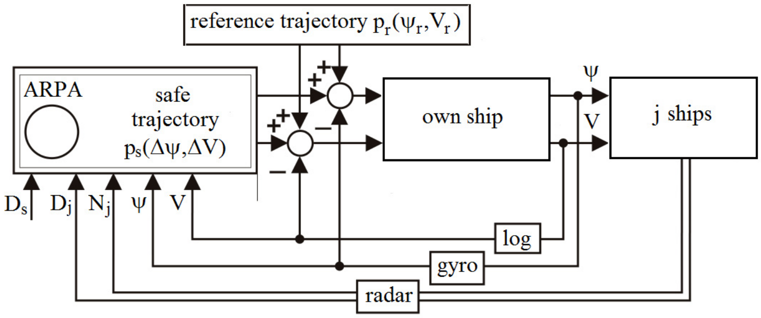


Fig. 1. The structure of safe ship control in collision situations

The ARPA system enables to track automatically at least 20 encountered *j* ships, determination of their movement parameters (speed $V_j$, course $\psi_j$) and elements of approach to the own ship ( $D^j_{\min} = DCPA_j$ - Distance of the Closest Point of Approach, $T^j_{\min} = TCPA_j$ - Time to the Closest Point of Approach) and also the assessment of the collision risk. (Fig. 2).

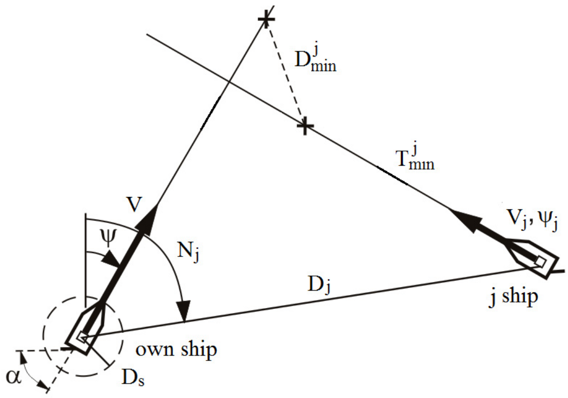


Fig. 2. Situation of passing of the own ship with the *j*-th met ship

The functional scope of standard ARPA system ends with the simulation of the safe manoeuvre, providing a safe distance passing $D_s$, by altering the course $\pm\Delta\psi$ or the ship's speed $\pm\Delta V$ selected by the navigator[14,15].