Automatic collision avoidance algorithm based on improved artificial potential field method

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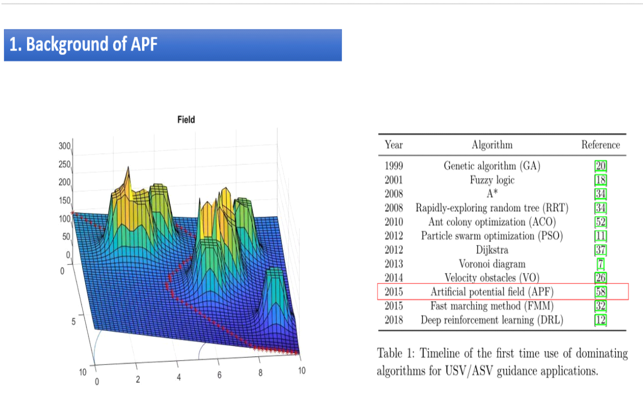
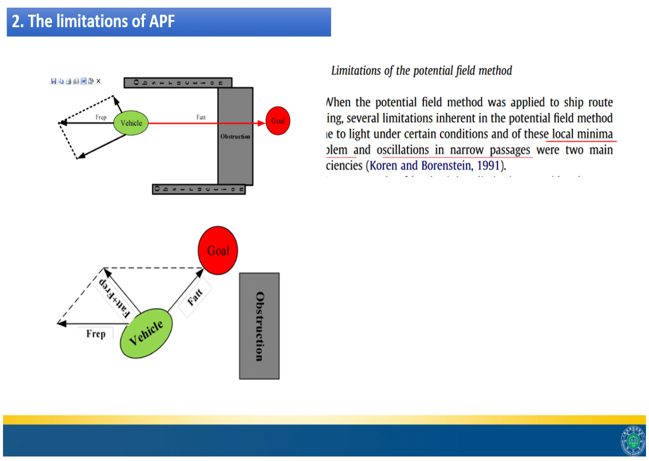
Abstact : *With the development of science and technology, various research on ship collision avoidance has also developed rapidly. The research and development of ship collision avoidance technology has also received high attention from many researchers. This paper proposes a new collision avoidance algorithm for ships based on the artificial force field collision avoidance method. Using the simulation platform, the simulation results show that ships can successfully avoid collision in open water under single ship and multi ship situations, and the research results are relatively ideal.*

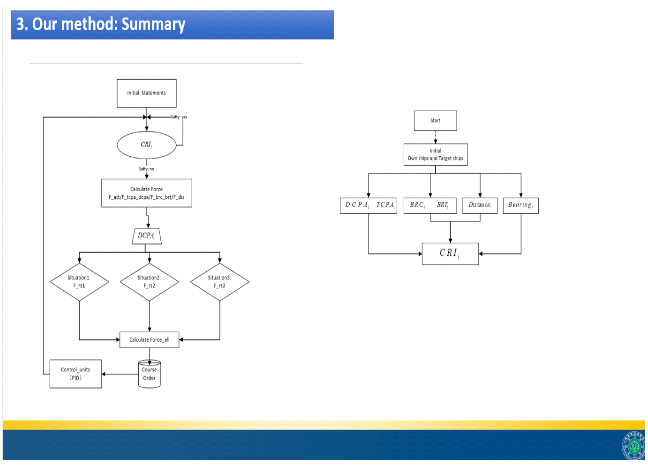
Keywords : *Improved APF, CRI, Automatic collision avoidance, COLREGS*

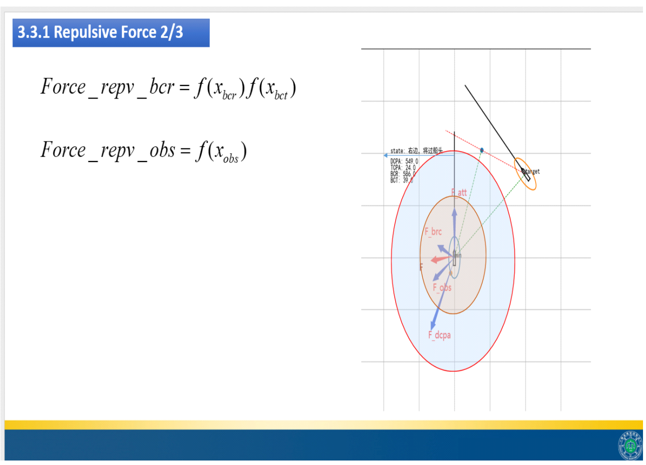


Year	Algorithm	Reference
1999	Genetic algorithm (GA)	[20]
2001	Fuzzy logic	[18]
2008	A*	[34]
2008	Rapidly-exploring random tree (RRT)	[34]
2010	Ant colony optimization (ACO)	[52]
2012	Particle swarm optimization (PSO)	[11]
2012	Dijkstra	[37]
2013	Voronoi diagram	[7]
2014	Velocity obstacles (VO)	[26]
2015	Artificial potential field (APF)	[58]
2015	Fast marching method (FMM)	[32]
2018	Deep reinforcement learning (DRL)	[12]

Table 1: Timeline of the first time use of dominating algorithms for USV/ASV guidance applications.







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3.4 .1Considering states

State 1. Emergency (DCPA<2* d_domain):

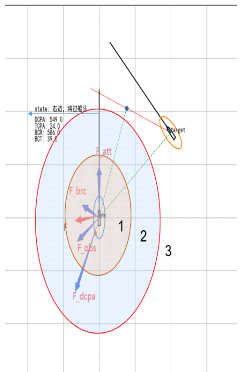
Force=F1+F3

State 2. Negotiation (2* d_domain+safty_distance):

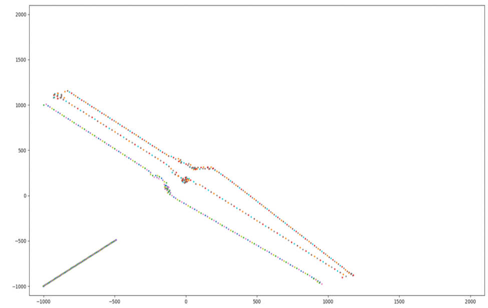
Force=F1+F0

State 3. Negotiation (2* d_domain+safty_distance):

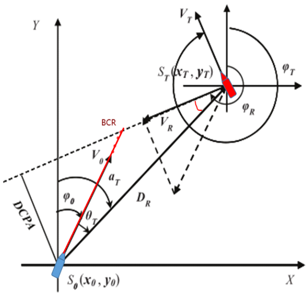
Force=F1+F2+F0



4. Result



3.1 BCR and BCT



$$\theta = \phi_R - \varphi_T - \pi$$

$$BCR = DCPA / \sin(\theta_T + \theta)$$

$$BCT = (BCR \sin \theta_T) / (V_R \sin \theta)$$

3.3.1 Repulsive Force 1

$$f(x_{dcpa}) = \frac{k_1}{\left(\frac{|x_{dcpa}|}{d_{\max}}\right)^n + a_1} + b_1$$

$$f(x_{tcpa}) = \begin{cases} \dfrac{k_2}{\left(\frac{|x_{tcpa}|}{t_{\max}}\right)^n + a_2} + b_2 & x_{tcpa} >= 0 \\ \dfrac{k_2}{\left(\frac{|x_{tcpa}|}{0.1 t_{\max}}\right)^n + a_2} + b_2 & x_{tcpa} < 0 \end{cases}$$

$$Force\_repv = f(x_{dcpa}) f(x_{tcpa})$$