

The design of fuzzy collision avoidance expert system implemented by Matlab fuzzy logic toolbox

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Abstract : *In recent years, shipping at the sea has been rapidly grown in marine nations and vessel's collisions are increasing as well. The collision avoidance is one of issues maritime safety. To reduce vessels' collisions, the fuzzy inference system is one of popular algorithms for collision avoidance. In this paper we aim to implement Matlab. Fuzzy logic toolbox software for collision avoidance algorithm.. For this we used an original Matlab fuzzy logic toolbox and customized the toolbox for the collision avoidance algorithm. .*

Keywords : Collision risk, Fuzzy logic toolbox, automatic identification system(AIS), fuzzy expert system

Content

- TCPA/DCPA
- Fuzzy expert system
 - Fuzzy inference
 - Mamdani fuzzy model
 - Fuzzy collision risk
- Matlab fuzzy logic toolbox
- Implementation of Collision Risk in Matlab Fuzzy Logic Toolbox
- Conclusion

Mamdani fuzzy model

- Mamdani applied a set of fuzzy rules supplied by experienced human operators

Fuzzy inference

- Fuzzy logic provides a practical, inexpensive solution for controlling complex or ill-defined system.
- Using fuzzy logic to reach a crisp solution to a specific problem usually involves three steps: fuzzifier, fuzzy inference engine, and defuzzifier.

TCPA/DCPA

- We may use the data from AIS (Automatic identification system) to calculate TCPA and DCPA We need Collision Risk
- TCPA(Time of the Closest Point of Approach)/DCPA(Distance of the Closest Point of Approach)

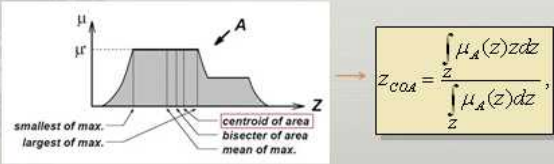
Definition of TCPA and TCPA

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Mamdani fuzzy model

- Defuzzifier-> Converts the **fuzzy output** of the inference engine to **crisp** using membership functions
- We used Mean Of Maximum (MOM) method to illustrate CR.



Fuzzy collision risk

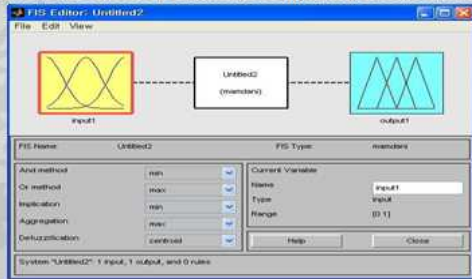
$$CR_{j,k}(i) = f_{fuzzy}\left(\frac{TCPA_{j,k}(i)}{L/V}, \frac{DCPA_{j,k}(i)}{L}\right)$$

$$CR(i) = \frac{\int_{\theta_0}^{\theta_f} CR_k(i) * \omega(\theta_k) d\theta_k}{\int_{\theta_0}^{\theta_f} 1 * \omega(\theta_k) d\theta_k}$$

(Journal of Navigation and Port Research DOI: 10.5394/KINPR.2010.34.10.727- Nam-Sun Son, Sun-Young Kim)

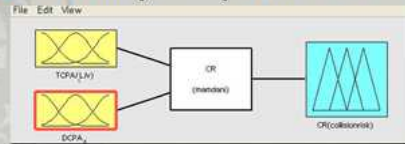
Matlab fuzzy logic toolbox

- Fuzzy Logic Toolbox software is a collection of functions built on the MATLAB technical computing environment

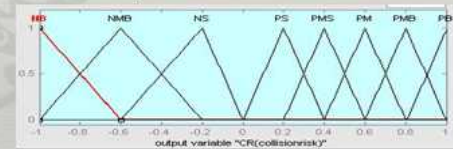


Implementation of Collision Risk in Matlab Fuzzy Logic Toolbox

- Mamdani style fuzzy model in Matlab

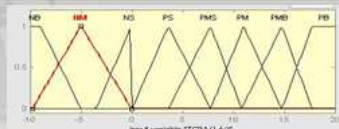


- Membership function of Collision risk



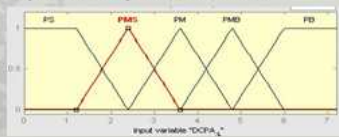
Implementation of Collision Risk in Matlab Fuzzy Logic Toolbox

- Fuzzy membership function of TCPA



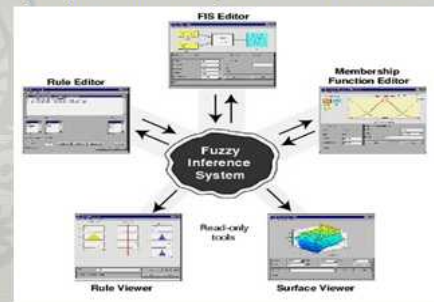
S: Small M: Medium
P: Positive N: Negative
B: Big

- Fuzzy membership function of DCPA



Matlab fuzzy logic toolbox

- Fuzzy Logic Toolbox Graphical User Interface Tools



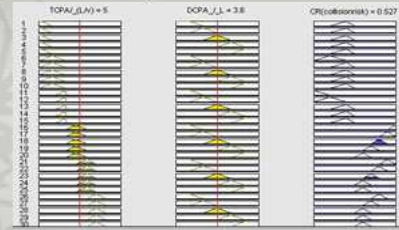
Implementation of Collision Risk in Matlab Fuzzy Logic Toolbox

Inference laws of Collision risk

		TCPA							
		NB	NM	NS	PS	PMS	PM	PMB	PB
D C P A	PS	NS	NMB	NB	PB	PMB	PM	PMS	PS
	PMS	NS	NS	NMB	PMB	PM	PMS	PS	PS
	PM	NS	NS	NS	PM	PMS	PS	PS	PS
	PMB	NS	NS	NS	PMS	PS	PS	PS	PS
	PB	NS	NS	NS	PS	PS	PS	PS	PS

Implementation of Collision Risk in Matlab Fuzzy Logic Toolbox

Implementation of fuzzy rules in Matlab

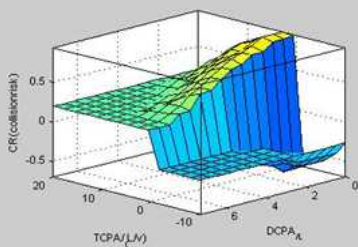


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1. If (TCPA(L/V) is NB) and (DCPA(L) is PS) then (CR(CollisionRisk) is NS) (1)
2. If (TCPA(L/V) is NB) and (DCPA(L) is NM) then (CR(CollisionRisk) is NS) (1)
3. If (TCPA(L/V) is NB) and (DCPA(L) is NS) then (CR(CollisionRisk) is NS) (1)
4. If (TCPA(L/V) is NB) and (DCPA(L) is PM) then (CR(CollisionRisk) is NS) (1)
5. If (TCPA(L/V) is NB) and (DCPA(L) is PS) then (CR(CollisionRisk) is NS) (1)
6. If (TCPA(L/V) is NM) and (DCPA(L) is PS) then (CR(CollisionRisk) is NS) (1)
7. If (TCPA(L/V) is NM) and (DCPA(L) is PM) then (CR(CollisionRisk) is NS) (1)
8. If (TCPA(L/V) is NM) and (DCPA(L) is NM) then (CR(CollisionRisk) is NS) (1)
9. If (TCPA(L/V) is NM) and (DCPA(L) is PS) then (CR(CollisionRisk) is NS) (1)
10. If (TCPA(L/V) is NS) and (DCPA(L) is PS) then (CR(CollisionRisk) is NS) (1)
11. If (TCPA(L/V) is NS) and (DCPA(L) is PS) then (CR(CollisionRisk) is NS) (1)
    
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Implementation of Collision Risk in Matlab Fuzzy Logic Toolbox

Surface view of Collision Risk



Conclusions and Future study

- Fuzzy collision avoidance system will advise a proper avoidance action to resolve the risk
- Matlab fuzzy logic toolbox is very efficient to create fuzzy expert system and plots.
- We will compare fuzzy inference system with other collision avoidance algorithm