Testing a SAR-based ship classifier with different loss functions

Ch Muhammad Awais[1,2,3]*, Marco Reggiannini[1,3], Davide Moroni[1]
[1]*CNR-Istituto di Scienza e Tecnologie dell'Informazione "Alessandro Faedo" (ISTI), G. Moruzzi 1, 56124 Pisa, Italy*
[2]*University of Pisa, Pisa, Italy*
[3]*NBFC, National Biodiversity Future Center, Palermo 90133, Italy*

*E-mail: *chmuhammad.awais@cnr.it*

***Short summary*: This study investigated the influence of six different loss functions on Synthetic Aperture Radar (SAR) ship classification accuracy across two datasets. Kullback-Leibler Divergence Loss emerged with the highest average accuracy (69.5%), followed by L1 Loss (69.12%) and Focal Loss(68.4%). Interestingly, L1 and Focal Loss exhibited contrasting performance across datasets, suggesting potential data-specific suitability for certain functions. These findings highlight the importance of considering data characteristics and task requirements when selecting loss functions to optimize SAR ship classification performance.**

Keywords: *Loss Functions, Deep Learning, Ship Classification, SAR*

BACKGROUND

Selecting the optimal loss function is crucial for effective image classification, particularly in challenging tasks, like SAR-based object classification. This study aims at investigating the repercussions deriving from different choices of the loss function on the classification of ship targets observed in SAR imagery, across two public SAR datasets (Fusar [1] and Opensarship [2]). Our aim is to assess the influence of loss function choice and explore potential dependencies on data characteristics.

MATERIALS AND METHODS

Both datasets exhibited class imbalance, necessitating an analysis focus on the three prevailing ship categories: Cargo, Fishing and Tanker.

To address imbalances between the considered categories and augment data diversity, random resizing, cropping and flipping were implemented during preprocessing. Six different loss functions were evaluated: KLDivergence (KLDiv), FocalLoss, Mean Squared Error (MSE) loss, L1 Loss, Cross-Entropy Loss (CEL), and Binary Cross-Entropy with Logits Loss (BCEL, one vs all).

A convolutional neural network (CNN) architecture implemented in PyTorch (code available**) was employed for image classification. The hyper-parameters consisted of a learning rate of 0.001, batch size of 64, and 10 epochs. Datasets were divided into training and testing using Random splitting. Classification accuracy was utilized as the primary performance metric to assess the effectiveness of each loss function.

**github.com/cm-awais/loss_fun_SAR

I. RESULTS

The evaluation of loss functions for SAR ship classification revealed distinct performance patterns (Fig. 1). KLDiv Loss achieved the highest average accuracy 69.5%, followed closely by L1 Loss 69.12%, Focal Loss 68.4% and BCEL 67.3%, while CEL and MSE Loss demonstrated moderate performance.

Interestingly, while L1 Loss and Focal Loss achieved similar average accuracy, they exhibited contrasting performance across datasets. L1 Loss excelled on Fusar but underperformed on Opensarship, whereas Focal Loss displayed the opposite trend. This suggests potential dataset-specific suitability for certain loss functions.

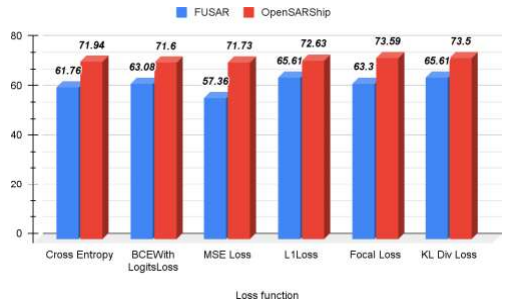

Fig. 1. This figure shows the accuracy of loss functions for each dataset .

III. DISCUSSION AND MAIN CONCLUSIONS

The findings suggest that the choice of loss function can significantly impact performance in SAR ship classification tasks. Notably, L1 and Focal Loss, despite similar average accuracy, exhibited opposing performance trends across datasets, suggesting potential data-specific suitability for certain loss functions. This underscores the need for task-specific evaluation of loss functions to optimize classification accuracy, particularly in scenarios involving diverse datasets or specific performance requirements for certain categories. Further research could explore the underlying factors contributing to the observed performance differences and investigate additional loss functions tailored to the nuances of SAR ship classification.

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REFERENCES

[1] Hou, Xiyue, et al. "FUSAR-Ship: Building a High-Resolution SAR-AIS Matchup Dataset of Gaofen-3 for Ship Detection and Recognition." Science China Information Sciences, vol. 63, 2020

[2] Huang, Lanqing, et al. "OpenSARShip: A dataset dedicated to Sentinel-1 ship interpretation." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 11.1 (2017): 195-208.