

Introduction

This paper addresses the task of classifying galaxy clusters, which are the largest known objects in the Universe. Galaxy clusters can be categorized as cool-core (CC), weak-cool-core (WCC), and non-cool-core (NCC), depending on their central cooling times.

Challenges

Traditional classification approaches used in astrophysics are inaccurate and rely on measuring surface brightness concentrations or central gas densities.

Approach

In this work, we propose a multi-branch attention network that uses spatial attention to classify a given cluster. To evaluate our network, we use a database of simulated X-ray emissivity images, which contains 954 projections of 318 clusters.

Results

Experimental results show that our network outperforms several strong baseline methods and achieves a macro-averaged F1 score of 0.83. We highlight the value of our proposed spatial attention module through an ablation study.

Architecture

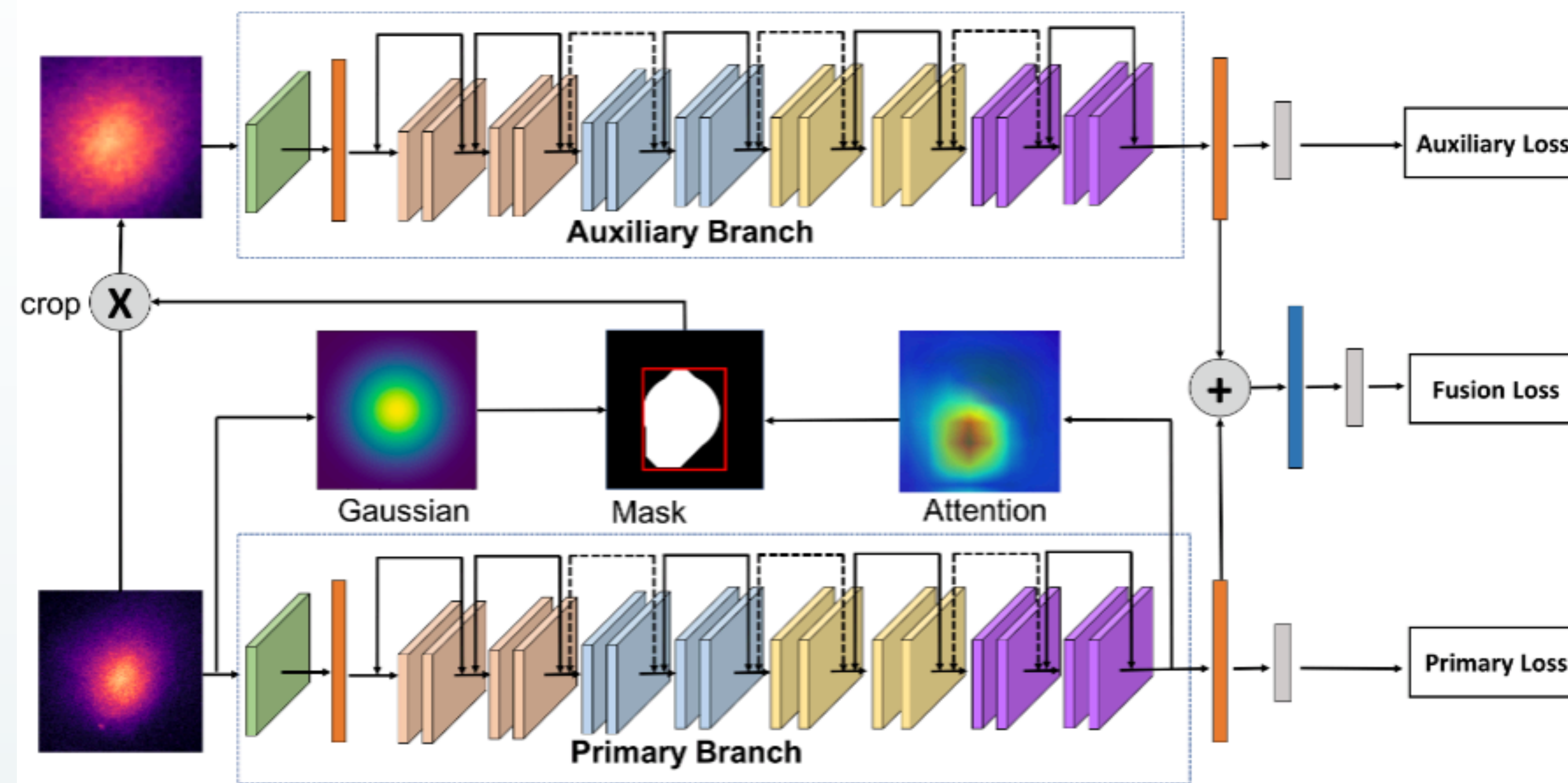


Fig. 1: Overview for the Architecture

Dataset

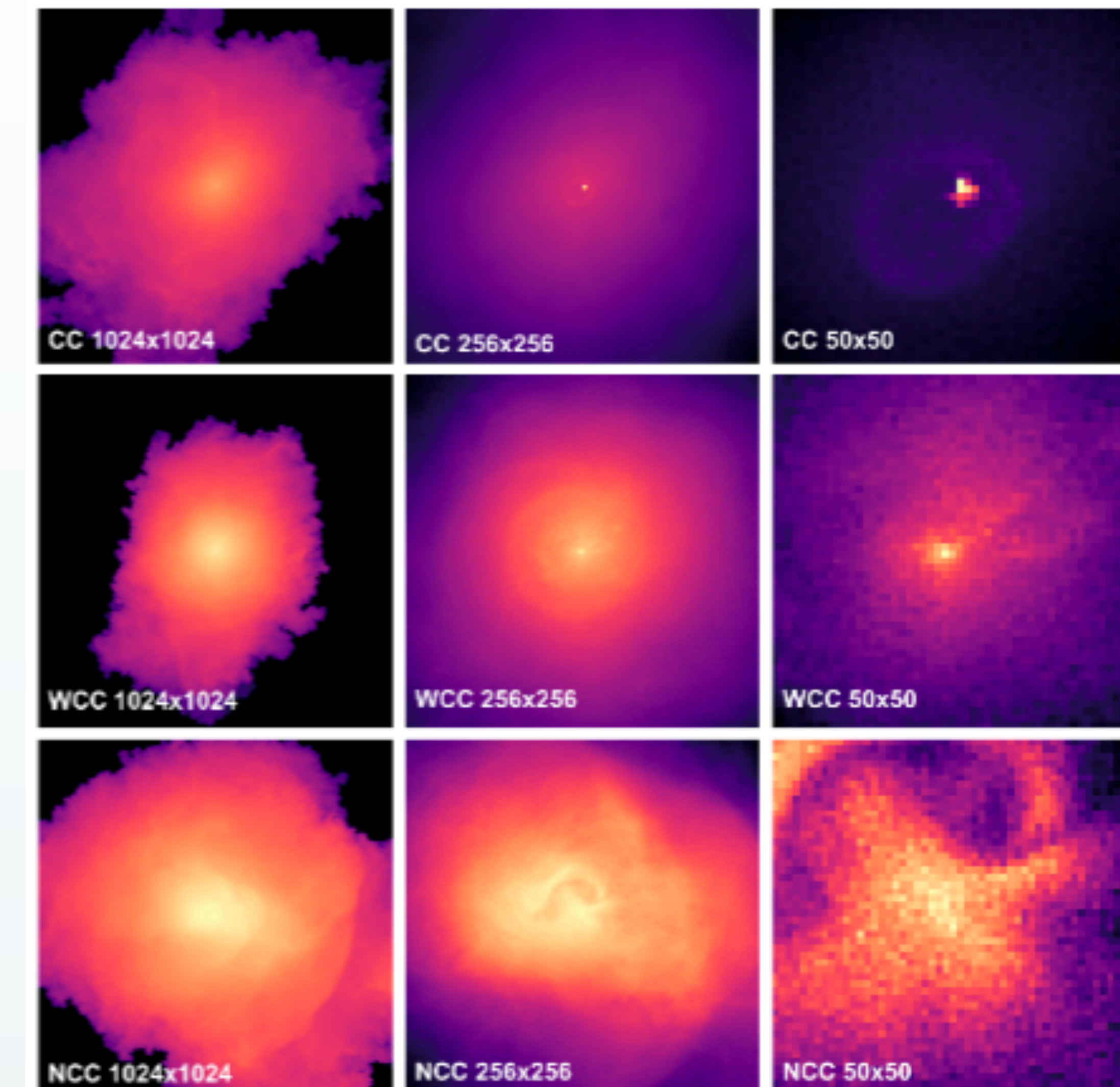


Fig. 2: Simulated X-ray Emissivity Images

Results

Approach	Attention	Gaussian	Regression	macro-avg. f1	class	precision	recall	f1
Baseline	✗	✗	✗	0.803	CC	0.59	0.79	0.68
					WCC	0.92	0.85	0.88
					NCC	0.84	0.86	0.85
Ours(Att)	✓	✗	✗	0.823	CC	0.62	0.81	0.70
					WCC	0.93	0.86	0.89
					NCC	0.86	0.90	0.88
Ours(Gauss)	✗	✓	✗	0.813	CC	0.58	0.79	0.67
					WCC	0.93	0.85	0.89
					NCC	0.86	0.90	0.88
Ours(Att+Gauss)	✓	✓	✗	0.827	CC	0.67	0.79	0.73
					WCC	0.91	0.86	0.89
					NCC	0.84	0.88	0.86
Ours(all)	✓	✓	✓	0.830	CC	0.65	0.86	0.74
					WCC	0.94	0.85	0.89
					NCC	0.83	0.90	0.86

Table 1: Evaluation results of our approaches trained on different settings vs. baseline

Evaluation

We compare our complete architecture with three variants as well as the baseline method. Ours (Att) represents the method that only uses attention maps to generate the binary masks. Ours (Gauss) shows the results obtained by using bivariate Gaussian distribution to generate binary masks. Ours (Att+Gauss) represents that we generate binary masks by taking the union of Gaussian and attention. Ours (all) achieves the highest macro-averaged F1 score (0.830) among all experiments.