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Group 92

ChestGAN: Auxiliary Classifier GAN-based data augmentation for improved Chest Cancer Type Detection

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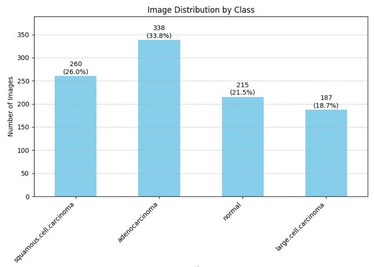
Problem Statement

- Chest cancer type detection requires a substantial amount of labeled datasets for training deep learning models due to diversity in cancerous lesions. Limited availability of positive chest CT-Scan images restricts training efficiency.
- False negatives in cancer diagnosis pose serious risks.
- We propose to utilize Auxiliary Classifier Generative Adversarial Network (ACGAN) to generate synthetic CT-Scan images, enhancing CNN performance on an augmented dataset.

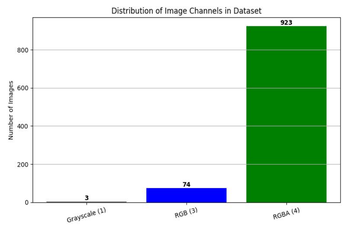
Data

Chest CT-Scan images dataset is used.
The dataset contains CT-Scan images of 3 chest cancer types:

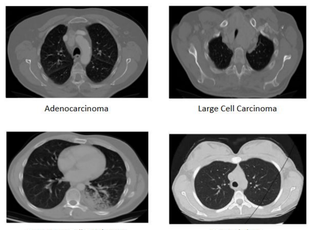
- Adenocarcinoma (C1), Large Cell Carcinoma (C2), Squamous Cell Carcinoma (C3) and normal chest images (C4)

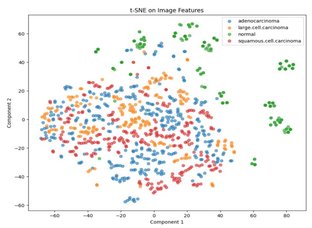


Distribution of image by class



Distribution of channels





t-SNE

Baseline

- The CNN extracts features from RGBA images using convolution and pooling layers, then classifies them through fully connected layers.
- **Training:** Trained over 20 epochs using SGD (lr=0.001), batch size 10, and ReLU activation.
- **Performance:** Weighted Recall of 0.4172
- **Key Insight:** Strong on "Normal", but low recall for "Adeno" and “Large-Cell” Carcinoma

Network Architecture

Layer (type)	Output Shape	Param #
Conv2d-1	[-1, 6, 108, 108]	456
MaxPool2d-2	[-1, 6, 54, 54]	0
Conv2d-3	[-1, 16, 50, 50]	2,416
MaxPool2d-4	[-1, 16, 25, 25]	0
Linear-5	[-1, 120]	1,200,120
Linear-6	[-1, 84]	10,164
Linear-7	[-1, 4]	340

Total params: 1,213,496
Trainable params: 1,213,496

Class-wise Metrics

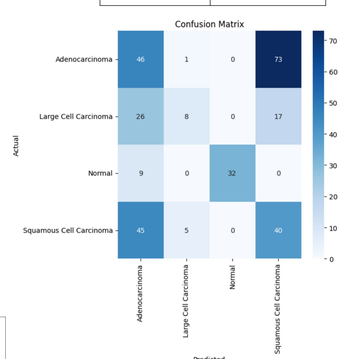
	Accuracy	Precision	Recall	F1-score
Adenocarcinoma	0.3833	0.3651	0.3833	0.3740
Large Cell Carcinoma	0.1569	0.5714	0.1569	0.2462
Squamous Cell Carcinoma	0.4444	0.3077	0.4444	0.3636
Normal	0.7805	1.0000	0.7805	0.8767

Overall Model Performance

Accuracy	Macro Precision	Macro Recall	Macro F1-score	Weighted Precision	Weighted Recall	Weighted F1-score
0.4172	0.5611	0.4413	0.4651	0.4690	0.4172	0.4176

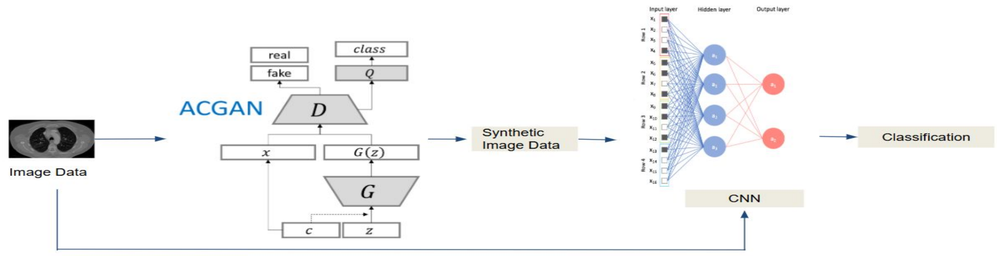
Baseline Hyperparameters

Parameter	Value
Epochs	20
Batch Size	10
Loss Function	Cross-entropy loss
Optimizer	SGD
Learning Rate	0.001
Activation Function	ReLU



Confusion metrics

Network Architecture



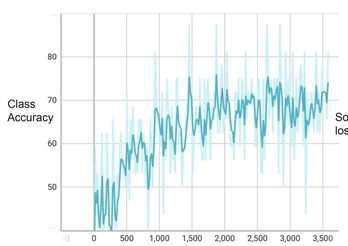
- **ACGAN** takes noise and class labels to generate synthetic images, while its discriminator learns to distinguish real vs. fake and predict image classes.
- The generator produces class-conditioned synthetic images, which are combined with real data to enrich the training dataset by **Data Augmentation**.
- **CNN** is trained on this augmented dataset to perform multi-class classification, benefiting from improved diversity and quantity of training samples.

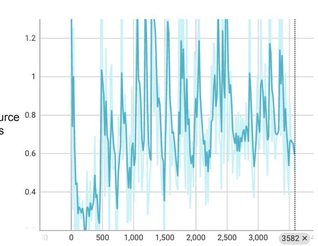
Evaluation Plan and Results

AC-GAN Model

- Accuracy improved steadily, reaching around 91%.
- Discriminator and generator losses decreased overall.
- Training shows stable adversarial learning behavior.
- Model effectively learns class distinctions over time.

ACGAN generated synthetic images





Optuna Hyper-Parameter Optimization

Parameter	Type	Search Space / Range	Best Value
ngf	Categorical	[32, 64, 128]	32
ndf	Categorical	[32, 64, 128]	32
lambda_class	Float	[0.5, 3.0]	1.30555015
label_smooth_real	Float	[0.7, 1.0]	0.93780963
nz	Categorical	[64, 100, 128, 256]	100
batch_size	Categorical	[16, 32, 64]	32

Overall Recall Metrics Comparison

Metric	Baseline Model (CNN)	CNN with aug data (unbal)	CNN with aug data (bal)
Macro Recall	0.4413	0.5627	0.5426
Weighted Recall	0.4172	0.5099	0.4669

	Adeno	Large Cell	Normal	Squamous
Original (Baseline)	189	111	108	149
After Aug (unbal = 50)	239	161	158	199
After Aug (bal)	189	189	189	189

Class-wise Metrics Comparison

Class	Baseline Model			Baseline Model ACGAN with Augmented data (Unbalanced)			ACGAN with Augmented data (balanced)		
	Recall	Prec	F1	Recall	Prec	F1	Recall	Prec	F1
Adeno	0.3833	0.3651	0.3740	0.3167	0.5429	0.4000	0.2417	0.5273	0.3314
Large Cell	0.1569	0.5714	0.2462	0.2941	0.3125	0.3030	0.3529	0.2647	0.3025
Squamous	0.4444	0.3077	0.3636	0.6889	0.43666	0.9398	0.6000	0.6000	0.5243
Normal	0.7805	1.0000	0.8767	0.9512	0.9286	0.5345	0.9756	0.9756	0.7692

Main References

- [1] Hany, M. (2020). Chest CT-Scan images Dataset. Kaggle.com. https://www.kaggle.com/datasets/mohamedhanyyy/chest-ctscan-images/data
- [2] Odena, A., Olah, C., & Shlens, J. (2016). Conditional image synthesis with auxiliary classifier GANs. arXiv. https://arxiv.org/abs/1610.09585