Review 2.1

B.Tech Project (19CCE495)

Batch ID: **031**

DEEP LEARNING BASED IMAGE QUALITY ASSESSMENT FOR INFRARED IMAGES USING NIGHT VISION CAMERAS

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Motivation:

- IR images often suffer from inherent limitations like low contrast, low SNR, and indistinct edges, which make it challenging to accurately identify objects, potentially compromising the safety of autonomous driving systems.

- Current image assessment techniques, primarily designed for visible light, are inadequate for assessing IR images, especially when they are influenced by weather, dirt, or any sensor compromised situations.

- To ensure consistent performance in different weather conditions for perception system of ADAS and autonomous driving systems.

Problem Statement:

To design an overall perception score for IR images captured under various weather conditions for ADAS and AD perception systems.

To categorize the IR images as either high/medium/low quality based on the predicted perception score, using deep learning model which may help to enable ADAS to take appropriate actions.

Objectives:

Infrared Sensors for Various Weather : Investigate how infrared sensors can provide reliable perception in a range of weather conditions

Challenges in Infrared Perception: Identify the limitations in perception caused by factors such as low contrast, high noise levels, and unclear shapes in infrared images

Perception Score Development: Establish a scoring system based on deep learning models that quantifies the perception capabilities of IR images under various weather conditions, classifying them into high, medium, or low perception levels to assist in decision-making processes for autonomous systems.

Algorithm evaluation and validation: Fine-tuning ,evaluate algorithm performance ,validate the algorithm

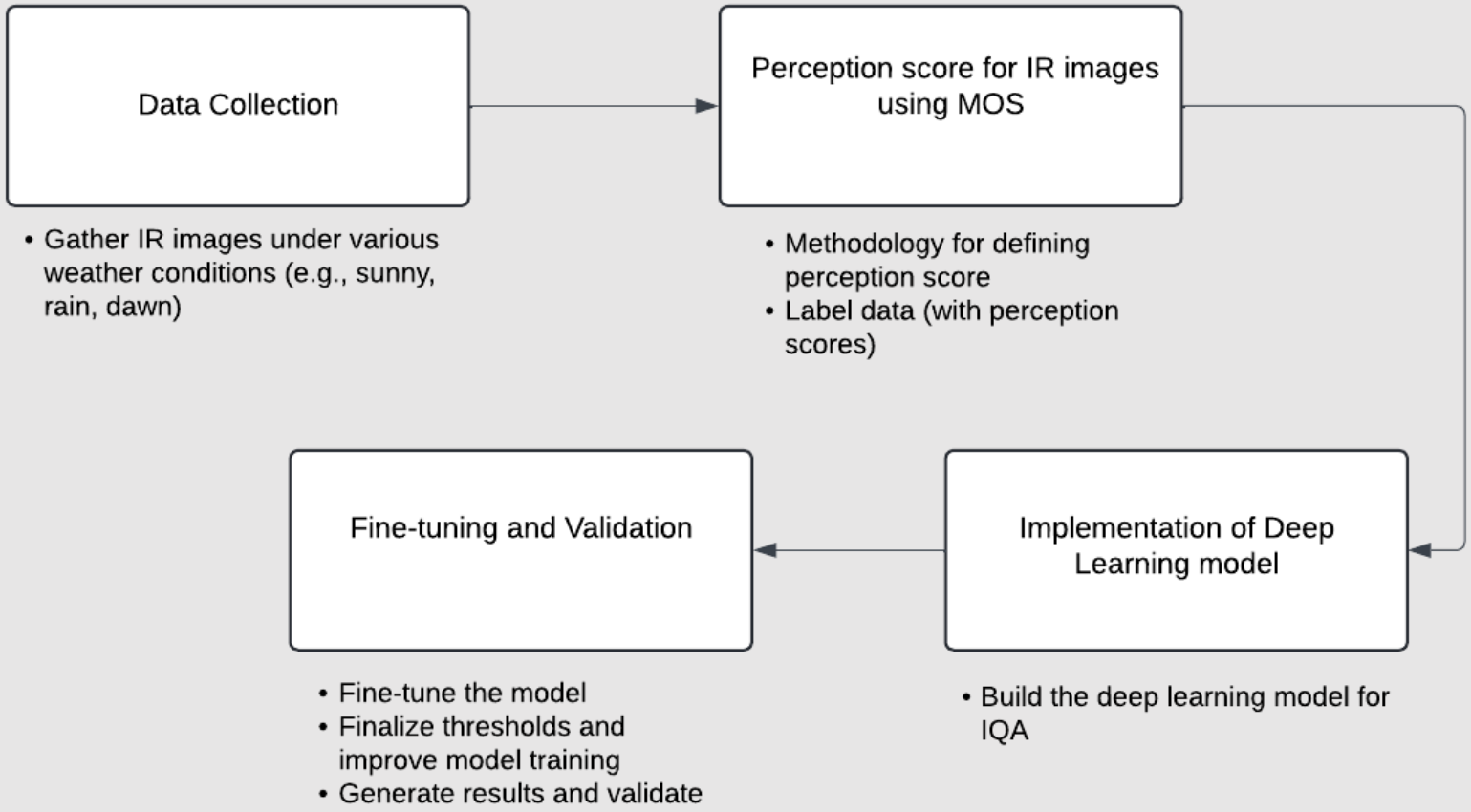
Literature Survey

S.No	Title of the paper	Source	Inferences
1.	KonIQ-10k: An ecologically valid database for deep learning of blind image quality assessment	Journal IEEE Transactions on Image Processing	**Benchmark**: MOS aligns with human perception for image quality assessment. **Crowdsourcing**: Over 1.2M ratings were collected with strict filtering for reliability. **Reliability**: Crowdsourced MOS showed high correlation with expert scores. **BIQA Models**: Used as ground truth for training and testing no-reference BIQA models.
2.	Augmentation of Severe Weather Impact to Far-Infrared Sensor Images to Improve Pedestrian Detection System	MDPI *Electronics* 2021	• MOS reflects human image quality perception. • 1.2M reliable ratings collected via crowdsourcing. • High agreement between crowd and expert scores. • Used to train and test BIQA models.

Literature Survey (contd…)

S.No	Title of the paper	Source	Inferences
3.	NIMA: Neural Image Assessment	IEEE transactions on image processing, (2018)	• CNNs assess image quality like humans. • NIMA uses EMD loss for accuracy. • Enhances denoising and tone adjustment. • Supports real-time, no-reference evaluation.
4.	Infrared Image Super-Resolution Quality Prediction Driven by Frequency-Domain Features	IEEE JOURNAL ON MINIATURIZATION FOR AIR AND SPACE SYSTEMS(2024)	**Feature Extraction**: Extracts key image details. **Neural Network**: Processes features with deep subnetworks. **Training**: Learns to predict quality from examples. **Prediction**: Estimates image quality without an HR version.

Methodology:



Dataset: A collection of IR images (5.5k) captured under various weather conditions (e.g., foggy, rainy, sunny).

Target: Each image is associated with a subjective quality score (MOS) to assess its perceptual quality.

Goal: Train a deep learning model to predict MOS values for IR images to evaluate their quality.

Dataset Collection – Part 1

FLIR ADAS Dataset:

- The FLIR dataset is designed for object detection and segmentation in autonomous vehicle applications, primarily focusing on thermal imaging.

ZUT Dataset:

- The ZUT Dataset is a collection of images specifically designed for computer vision tasks, particularly for training and testing models under various weather conditions.

Correlation Statistics:

Count: 10 unique image types are present.

Mean MOS: The average MOS score across all image types is 52.26.

Standard Deviation (Std): 26.61, showing significant variability in the scores.

Min/Max: The lowest average score is 8.36, while the highest is 86.67.

DATASET	YEAR RELEASED	WEATHER CONDITION	NUMBER OF IMAGES
FLIR	2020	Bright	500
		Low Light	500
		Night	500
		Day	500
ZUT	2020	Drizzle	500
		Cloudy	500
		Heavy Rain	500
		Rain	500
		Frost	1000
		Fog	500

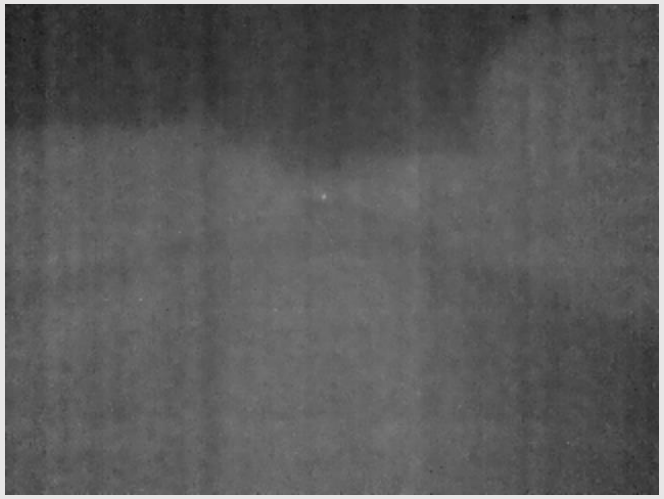
- Finally, it is a total of 5500 images in the dataset that is consolidated.

Examples from dataset :

Bright

Fog

Cloudy



Heavy Rain

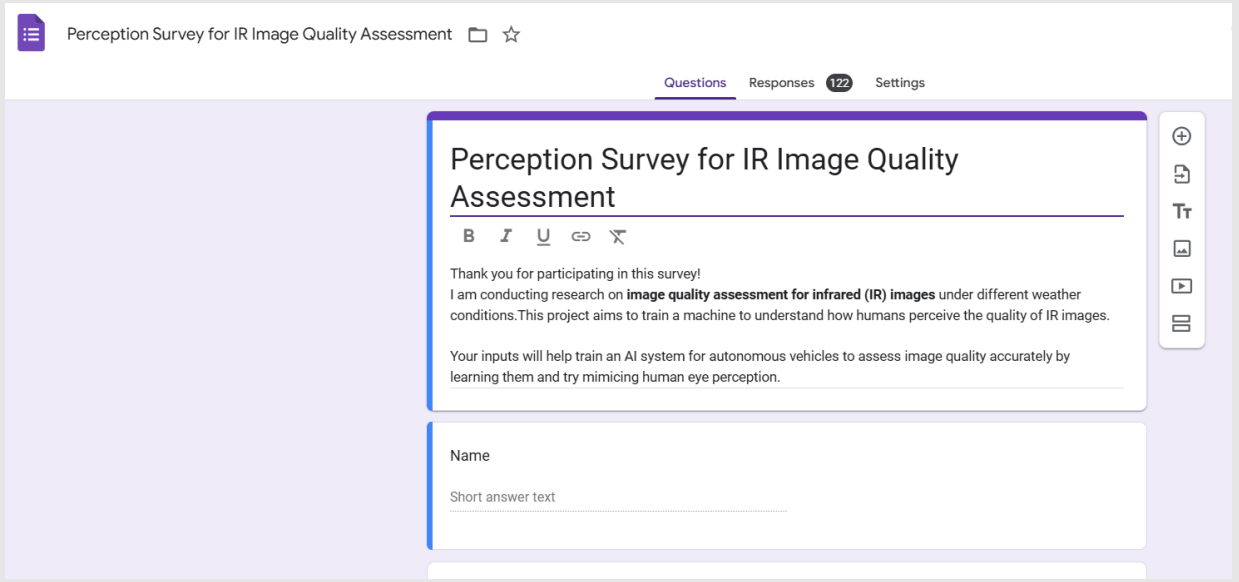
Dataset Collection – Part 2
Crowdsourced Human Perception Data for Image Quality Assessment

Objective:
- Create a Google Form that collects human perception scores for IR images under various weather conditions.

Process:
- Respondents rated the quality of images on a scale of **1 to 100**.
- Quality was based on:
  - How well objects are visible in the IR image.
  - How clear it is to identify objects.

Purpose:
- These values simulate how humans view these images, which is critical for autonomous driving.
- For example, a car driving at night should be able to assess whether the image quality is sufficient for safe navigation.

Outcome:
- The collected scores are averaged to calculate a Mean Opinion Score (MOS) for each image under specific weather conditions.
- These MOS values will help the model detect low-quality images and alert the driver when necessary.



Instruction

Please look at each image carefully and rate their quality on a scale of 1 to 100, where 1 is "Very Poor Quality" and 100 is "Excellent Quality."

Criteria for Scoring:

- How well the objects are visible in the IR image.
- How clear it is to identify objects.

	Timestam	Name	Age	1. Image	2. Image	3. Image	4. Image	5. Image	6. Image	7. Image	8. Image	9. Image	10. Image
2	2024/11/2	Neha	21	100	30	1	30	35	100	40	70	100	40
3	2024/11/2	Yazhini R	20	90	15	1	30	30	95	30	65	85	25
4	2024/11/2	Saran J Na	21	75	15	5	45	45	95	45	75	90	30
5	2024/11/2	Divya	21	75	10	20	40	30	100	50	70	100	35
6	2024/11/2	Srinithi	21	100	30	3	40	50	100	50	80	90	20
7	2024/11/2	Abishek S	20	80	30	5	40	35	90	50	65	85	30
8	2024/11/2	Hehe	20	60	20	1	30	30	90	40	75	90	30
9	2024/11/2	Aswathy J	21	90	20	1	40	30	100	60	80	80	30
10	2024/11/2	Thanusha	20	100	35	0	30	30	95	40	75	100	30
11	2024/11/2	Aarushi Gu	21	100	25	5	40	35	100	38	80	100	37
12	2024/11/2	Greeshma	20	95	45	1	35	30	100	55	75	98	40
13	2024/11/2	Hariesh	20	80	20	3	40	35	90	36	75	85	25

1. Image Quality Assessment - NIGHT

Look at the image below taken at night. Rate it on a scale of 1 to 100 based on how clear or good it looks for the human eye.

Your answer should be within this range : (50-100)

Short answer text

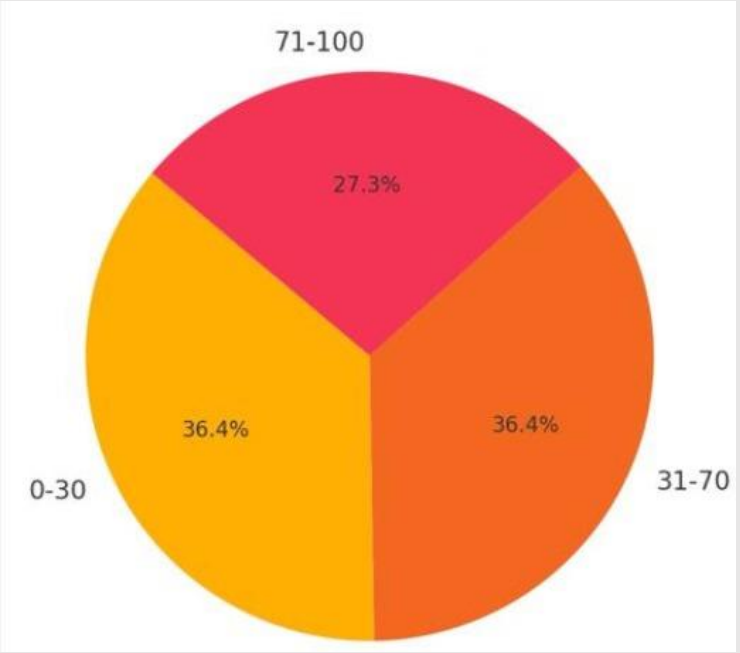
	A	B	C
1	image	MOS	set
2	night301.png	62.1582	training
3	night498.png	62.1582	training
4	night473.png	62.1582	training
5	night64.png	62.1582	training
6	night398.png	62.1582	training
7	night282.png	62.1582	training
8	night220.png	62.1582	training
9	night278.png	62.1582	training
10	night387.png	62.1582	training
11	night76.png	62.1582	training
12	night201.png	62.1582	training
13	night464.png	62.1582	training

Mean Opinion Score (MOS)

Why MOS?

- Mean Opinion Score (MOS) is a reliable subjective measure for image quality, widely used in IQA to align models with human perception. It aggregates human ratings, offering consistent benchmarks for comparing IQA methods.

Participants: 122 people rated the images.
Weather Conditions: 10 types, including Night, Rain, Fog, and Day.
Sequential Rating: Average score calculated for each condition.
MOS: The average score assigned as the final MOS for each batch.



Distribution of MOS in Low, Medium and High quality

Deep Learning Model Workflow

1. **Input:**
   - A dataset consisting of 5.5k images gathered from ZUT and FLIR, with a CSV file consisting of MOS scores and train-test splits corresponding to each image.

2. **Preprocessing:**
   - Resizing and Normalization of data.

3. **Modified ResNet-50 Architecture:**

Input Layer:

Pre-trained ResNet-50 directly accepts RGB-converted IR images as input (3 channels).

Fully Connected (FC) Layer:

Outputs a single perception score (MOS)

4. **Training Process:**
   - Train and validation datasets split as per the provided data in CSV.
   - MOS scores serve as ground truth for quality assessment.
   - Trains the model over multiple epochs and computes loss, back propagates gradients, and updates model weights.

set	Count of image
test	550
training	4400
validation	550

Loss Function:

- Mean Squared Error (MSE)

Optimizer:

- Adam

5. Validation Process:

- Comparing the model's predicted perception scores with ground truth MOS scores using validation metrics such as Mean Absolute Error (MAE)

6. Output:

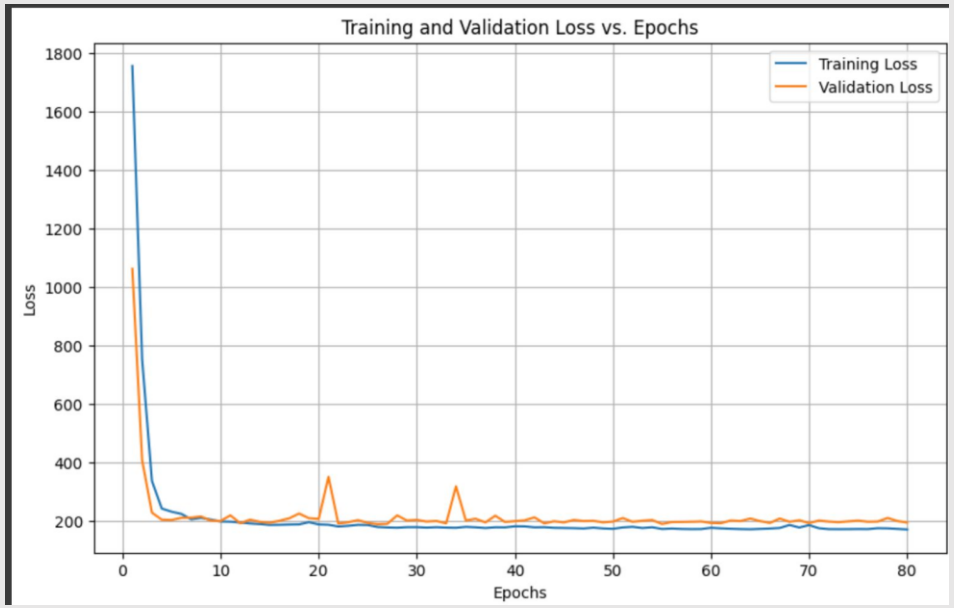
Perception Score:

- Numeric values (MOS) representing the predicted image quality.

Image Names	Predicted MOS	Ground Truth MOS
bright364.png	88.17	86.6667
fog341.png	50.47	47.1731
heavyrain28.png	21.1	8.3612
frost899.png	29.64	24.9671

Predicted MOS

Results :



Loss Graph

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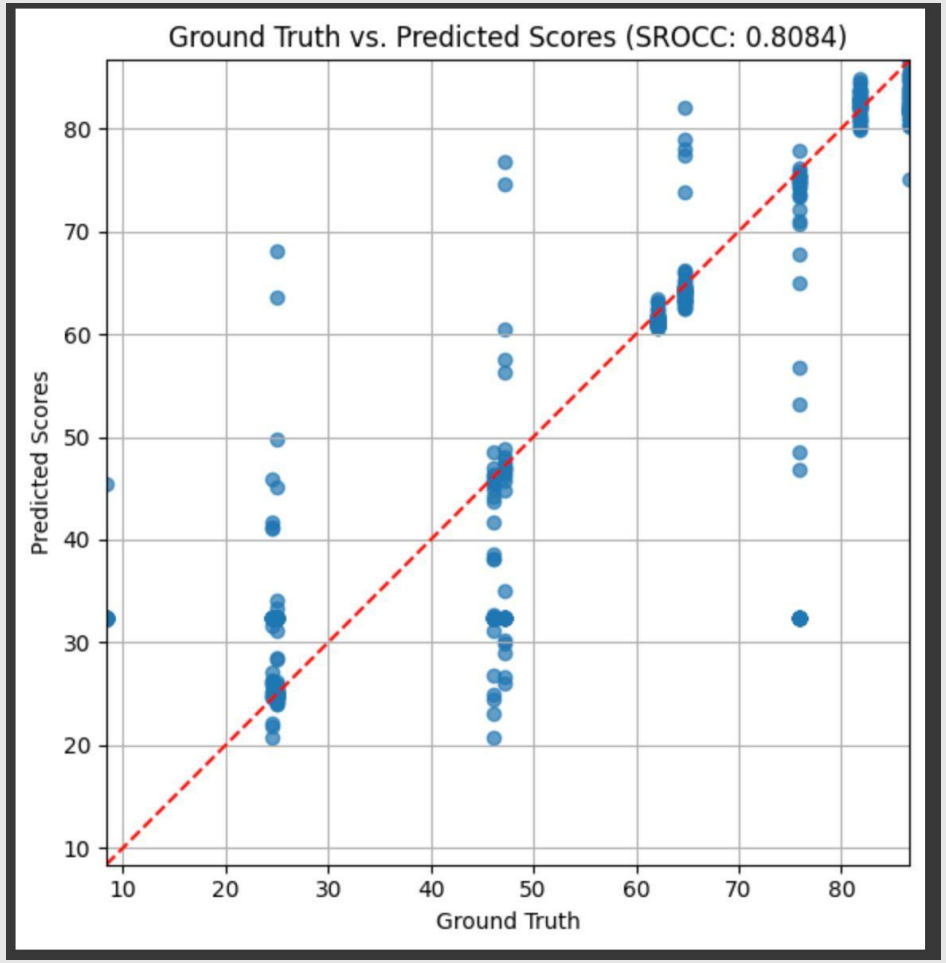
Mean Absolute Error (MAE): 8.8617
Root Mean Squared Error (RMSE): 13.8880
```



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Deliverables:

- **Dataset :** Created a dataset with various weather conditions with respective mean opinion scores.
- **Literature Review document**: A comprehensive review of existing perception metrics and their limitations in the context of autonomous driving under various weather condition.
- **Deep Learning Model**: A deep learning model designed to generate reliable perception score for IR images. This model will analyze IR images captured under various weather and lighting conditions supporting safe decision-making for autonomous driving systems.

Timeline:

Month	Milestone
Aug 2024	• Literature review on techniques to generate/simulate the dataset • Literature review on perception scores using deep learning model • Gather the dataset • Dataset generation
Sep 2024	• Finalize the concept/approach to generate perception score • Finalize on the dataset • Identify a deep learning model for IQA
Nov 2024	• Define perception score • Create own dataset • Implementation of deep learning models
Jan 2025	• Identify the desired DL model for the project • Fine tuning of the algorithm • Improvements on the model training
Feb 2025	• Results generation for paper draft
March 2025 (External Review)	• Project Report / Dissertation

Summary:

- To design a perception score (MOS) for infrared (IR) images under various weather conditions using a deep learning model.
- A deep learning model is built to predict a score that is used in image quality assessment.
- Aimed at supporting the performance of the perception system for Advanced Driver Assistance Systems (ADAS) and autonomous driving (AD) systems.

References:

[1] V. Hosu, H. Lin, T. Sziranyi, and D. Saupe, “KonIQ-10k: An Ecologically Valid Database for Deep Learning of Blind Image Quality Assessment,” IEEE Transactions on Image Processing,vol.29,pp.4041–4056,2020.

[2] Z. Song et al., "Synthetic Datasets for Autonomous Driving: A Survey," in IEEE Transactions on Intelligent Vehicles, vol. 9, no. 1, pp. 1847-1864, Jan. 2024, doi: 10.1109/TIV.2023.3331024.

[3] H. Talebi and P. Milanfar, “NIMA: Neural Image Assessment,” IEEE Transactions on ImageProcessing,vol.27,no.8,pp.39984011,Aug.2018.

[4] B. Feng, Y. Chen, Y. Wu, Q. Ye and L. Li, "Infrared Image Super-Resolution Quality Prediction Driven by Frequency-Domain Features," in *IEEE Journal on Miniaturization for Air and Space Systems*, vol. 5, no. 2, pp. 79-84, June 2024, doi: 10.1109/JMASS.2024.3355545.

Thank You