AI CLUB PROJECT MEMBER APPLICATION:

- **Nishitha.D, EE23B188**

SECTION A: Managerial Questionnaire:

1. Hi, Im Nishitha.D, EE23B188
    - I'm passionate about AI, learning and exploring it, especially CV, ML,DL, Generative AI.
    - I particularly want to learn Computer Vision as I believe this is a field with a potential for research and growth and can help in a wide variety of tasks and innovations.
    - I'm a quick learner, so as a Project member, I'll learn as much as I can quickly using the internet, watching lectures and discussing with the other project members about any topic.
    - I'm good at meeting deadlines, managing my time and will make sure all my work as a PM of Night vision is done on time. I'll also suggest ideas, help organize and conduct team meets to push the project further by cooperating well with other members of the club.
    - I'm good and interested in Mathematics and **already have a brief knowledge of the basic concepts used in ML like supervised learning, regressions and DL** like neural networks, coding and implementing them.
    - I know Python and C++ and this will help me in writing code and contributing significantly to the projects and explaining any coding related topic. I've also done a project under Sahaay Club of IITM in which I learnt implementation of transfer learning using mobilent, Resnets and some important topics such as improving with validation accuracy, f1 scores, dealing with imbalanced data.
    - **I have good communication skills and will learn relevant skills and innovative ideas** and I will work very hard to understand and improve in any area, even if I find it difficult initially.
    - I will work well with the heads, fellow coordinators, and project members in achieving the club's goals.
    - **I was also a DC in the Ai club and did a mini project on finding the difference between two images using PIL library and SSIMs.**

2. 1. I can weekly commit 2-3 hrs as a Project member.

2. I'm also applying as the coordinator for the AI club and as I will still be a part of the club, I can ensure I do justice to both roles by cooperating with other pms and coords.

Section B: Common Technical Questionnaire:

QUANTILE REGRESSION:

CFI_AI_PM_24-25_NISHITHA.D_EE23B188_Quantile_Regression

SECTION C : PROJECT SPECIFIC QUESTIONS:

1.1 RETINEX

1. Advantages:

- Many image enhancement techniques have been proposed to improve the quality of degraded images captured in varying circumstances, but can lead to contrast over-enhancement and noise amplification
- For example Low-light image enhancement algorithms based on histogram equalization effectively improve image brightness while suppressing image noise. However, these algorithms still suffer from issues such as underexposure, overexposure, or color distortion in certain local regions of the output image.
- Retinex algorithm targets at eliminating the effect of environmental illumination and obtaining the reflection component, thus achieving the goal of enhancing the image.
- It is Easy to implement. Can achieve color constancy and HDR.
- The Retinex algorithms can be applied to multiple tasks like low-light enhancement, dynamic range enlarging, and single image dehazing. But the color distortion, local halo effect, and the high computational cost still leave for further solutions.

2.

- Retinex theory is first introduced by Land and Mc Cann as a model of “Human Visual Perception (HVS)” . They stated that an acquired image is achieved through the combined action of the components of the reflectance and the illumination. Here, the illumination component captures all the types of light sources. Thus, the reflectance component can be isolated by excluding the illumination component from the acquired picture or image.I
- Let image intensity be denoted by I, the reflectance is denoted by R, while L refers to the incident illumination intensity. Consequently, the equation is presented as: $I = R \cdot L$
- The illumination map acts as the "base" lighting in an image. It represents how light is spread across the scene, showing areas that are brighter or darker. For instance, if you take a photo outside on a sunny day, the illumination map might show areas that are well-lit by the sun and others that are in shadow.
- Reflectance Image: This is about the actual objects and their properties in the scene. It captures details like color, texture, and material properties. Imagine you're taking a photo of a red apple on a table. The reflectance image would show the red color of the apple and the texture of the table surface.he

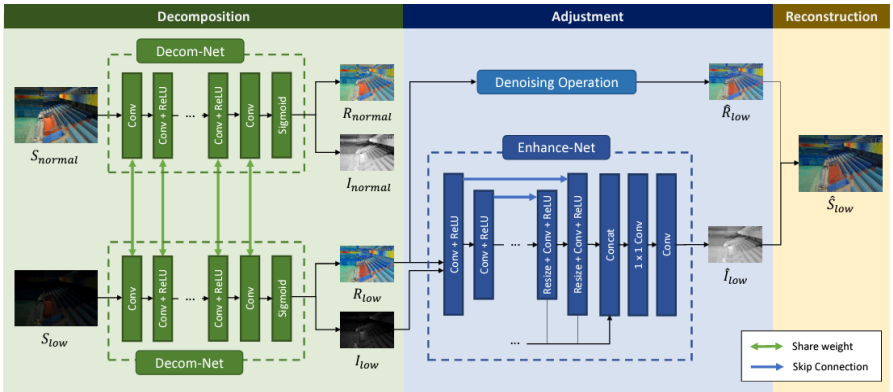
illumination map is obtained through a process called image decomposition, which separates an image into its illumination and reflectance components.

- Corruption: unwanted additions or alterations in the image, like noise or artifacts., corruption can occur in either the illumination map or the reflectance image. This corruption might be due to factors such as sensor noise (from the camera), environmental conditions (like fog or haze), or limitations of the camera system itself
- Examples of corruption in the illumination component include uneven lighting, shadows, glare, and color casts due to lighting conditions.
- Examples of corruption in the reflectance component include color distortion, texture irregularities, and artifacts introduced during image processing.
- These corruptions affect the appearance and characteristics of the objects in the scene, such as color fidelity, texture detail, and surface reflectance.

3. Some of the deep learning models are:

1. **RetinexNet**
    - It works with LOL (LOw-Light dataset)dataset that contains low/normal light image pairs and the network consists of a Decom-Net for decomposition and an Enhance-Net for illumination adjustment.
    - The Decom net decomposes the image into the illuminance and reflectance and has 2 constraints for its learning process— that the pairs have consistent reflectance and that the illumination map should be smooth but maintain structural features of the image.
    - Then the Enhance net improves the lighting of the illumination while denoising on reflectance occurs.
    - Finally the reflectance and illumination are multiplied back together to reconstruct the desired image.

    RESEARCH PAPER : DRDN.pdf



2. **LightenNet :**

- It is a CNN model made of 4 convolutional layers for (i) patch extraction and representation, (ii) feature enhancement, (iii) non-linear mapping, and (iv) reconstruction.
- It is designed to predict the Retinex illumination map component from the original LLI, which is then used to produce the enhanced image (R(x)).
- The network learns through a synthesized dataset obtained by the Retinex model and is guided by the L2 loss function
- The enhanced images are visually pleasing with well restored content.
- But the method shows a degraded performance while applied on low-quality images due to noise or JPG compression resulting in noise and artifacts amplification.

Research Paper: 🗎 lightennet.pdf

There are other deep learning techniques that use Retinex as well:
Research paper: 🗎 all deep learning models.pdf

2. Unets:

1. The purpose is to obtain an image with the same resolution as the original image and sometimes using the encoded data we can generate new images.

2.
   - Skip connections s*kip* some of the layers in the neural network and feeds the output of one layer as the input to the next layers
   - In U nets the skipped connections work through concatenation.
   - The feature information in the encoding path is taken and concatenated with layers in the decoder path.

3. The skip connections are used for feature reusability, helping the U net use finer details to construct an image in the decoder part.
   - U nets have longer skip connections used to pass features from the encoder path to the decoder path in order to recover spatial information lost during downsampling.
   - Whereas in Resnets Short skip connections appear to stabilize gradient updates, prevent vanishing gradients and solve the degradation problem .Here the skip connection is used through addition.

4. An implementation of U-nets in Low Light image Enhancement was presented by the Article : Learning to see in the dark ().
    - The U net is used to enhance low-light images by learning from pairs of raw sensor data and well-lit sRGB images, before which the Raw sampled data is preprocessed without any loss in data as U net works better with 4 smaller channels than 1 larger channel.
    - During training, the model predicts each pixel of the well-lit image from the low-light sensor data.The Training is supervised with the model comparing its predictions to the well lit images to optimize its parameters through backpropagation
    - The encoding or contracting path is used to extract increasingly detailed feature maps. The decoding path to bring the image back to original resolution through repeated upscaling of the concatenation of feature information and other features extracted during encoding via Skip connections.
    - Finally the U-Net provides us with an image at the desired level of brightness.

3. a)

- **Attention mechanisms** in artificial neural networks mimic human cognitive processes, focusing selectively on important information while disregarding irrelevant data.
- They enhance deep learning models by assigning variable weights to different parts of input data, allowing prioritization of relevant information during processing.
- Through attention, models can dynamically "remember" and focus on different segments of input sequences, irrespective of their position, by assigning distinct weights, enabling more effective learning and processing. The attention modules in cv are – Channel attention, Spatial attention, Temporal attention, Branch attention.

b)

1. Calculating attention weights effectively poses a significant challenge, as it requires devising methods to accurately determine the relevance of different parts of the input data.
2. Incorporating attention mechanisms can increase computational complexity, leading to higher resource requirements during both training and inference stages.

3. Balancing the benefits of improved performance with the additional computational cost is another challenge in implementing attention mechanisms effectively.

c)

1. In low-light video enhancement, attention mechanisms could be highly beneficial for selectively enhancing important visual details while suppressing noise and artifacts eg attention module mentioned in KinD++

2. This ensures that the enhancement process remains robust and preserves image quality even in low-light conditions . attention mechanisms is their ability to dynamically adapt to different parts of the input data.

3. Iif a new object enters the frame or if the lighting conditions change suddenly, the network can dynamically shift its attention to prioritize enhancing the relevant areas, ensuring consistent and high-quality enhancement across the entire video sequence.

SECTION D:

1. **Step by step solution pipeline:**
    - Data Collection : Gather a diverse dataset of low-light videos/images for training. This dataset should cover various scenarios, lighting conditions, and environments
    - Preprocessing : Adding augmentation, removing noise, increasing or decreasing brightness can expand and clean the dataset.
    - Choosing the appropriate model: Going through research papers, and choosing the appropriate deep learning model for example one which uses Retinex theory, attention mechanisms, u nets and other convolutional neural networks or gans.
    - Training: Train the selected model on the preprocessed dataset. This step involves optimizing hyperparameters, such as learning rates and batch sizes, to achieve the best performance.
    - Evaluate the trained model on a separate validation dataset to assess its performance in enhancing low-light images/videos
    - Testing and Deployment: Test the model on unseen data and fine-tune as necessary. Deploy the model for real-world applications, such as CCTV surveillance or satellite imaging, ensuring scalability and efficiency.

2.
    - Computer Vision
    - Deep Learning

- Image Processing
- Generative Models
- Unsupervised learning
- Supervised learning
- Feature engineering

3. **PROBLEMS AND SOLUTIONS:**

   1. Insufficient Data: Data augmentation techniques, using GANs to generate data

   2. Real-time Processing: Achieving real-time performance for applications like CCTV surveillance may pose challenges. Solution: Optimize the model for inference speed, possibly using techniques like model compression or hardware acceleration.

4. **APPLICATIONS OF THE PROJECT:**

   a) Surveillance systems: to enhance CCTV footage

   b) Can be used as a augmenter to clean low quality video data for other applications

   c) Autonomous Vehicles: Enhanced vision systems for autonomous vehicles to operate more effectively in low-light conditions, improving safety and reliability.