QUALITY ENHANCEMENT FOR DRONE BASED VIDEO

Mini Project report submitted in partial fulfillment of the Requirements for the Award of the Degree of

BACHELOR OF TECHNOLOGY

In

COMPUTER SCIENCE AND ENGINEERING

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in partial fulfillment for the award of the Degree of Bachelor of Technology in Computer Science and Engineering to the Jawaharlal Nehru Technological University, Kakinada is a record of bonafide work carried out under my guidance and supervision.

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DECLARATION

We hereby declare that the dissertation entitled **Quality Enhancement For Drone Based Video** submitted for the B.Tech Degree is our original work and the dissertation has not formed the basis for the award of any degree, associateship, fellowship or any other similar titles.

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ACKNOWLEDGEMENT

Behind every achievement lies an unfathomable sea of gratitude to those who activated it, without whom it would ever have come into existence. To them we lay the words of gratitude imprinted with us.

We would like to thank our respected Principal, **Dr. A.V. Ratna Prasad** and **Dr. D. Rajeswara Rao,** Head of the Department, Computer Science and Engineering for their support throughout our Project.

It is our sincere obligation to thank our guide, **Dr. S Vasavi,** Professor, Department of Computer Science and Engineering, for her timely valuable guidance and suggestions for this Project.

We owe our acknowledgements to an equally long list of people who helped us in this Project. Finally, we wish to thank all the supporting staff who gave us facility in lab for the completion of this Project.

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ABSTRACT

Nowadays Drones are being widely used for surveillance and various other activities. The video stream produced by the drone can be disturbing or can contain noise data which might reduce the quality of the video stream. The video stream can be enhanced so that there is no disturbance in the video stream. The video enhancement can be done in real-time with the help of Field Programmable Gateway Array (FPGA) which reduces the processing time with low energy consumption. Our project mainly focuses on enhancing the quality of the video stream using Enhanced Super Resolution Generative Adversarial Networks (ESRGAN), Contrast Limited Adaptive Histogram Equalization (CLAHE), Gamma Correction and Saturation Adjustment by integrating the image source in the drone with the FPGA.

Keywords: - Image Processing, Quality Enhancement, Field Programmable Gateway Array, Enhanced Super Resolution Generative Adversarial Networks (ESRGAN), Contrast Limited Adaptive Histogram Equalization (CLAHE), Gamma Correction and Saturation Adjustment

1. INTRODUCTION

Video enhancement is improving the quality of a video. Various techniques are available in video enhancing procedure. The fundamental methods are enhancing properties of videos such as brightness, contrast, and color. Also, Noise Reduction, Video De-noising methods are widely used in enhancing videos.

Real-time surveillance and remote monitoring are gaining large importance in a wide range of industries such as Oil and Gas, Power Grid, Industrial Automation, and Smart Buildings. The demand for high-quality real-time video streaming for surveillance applications is higher than ever and this calls for compute-intensive image processing designs and advanced encoding and decoding techniques.

As, Drones are being extensively used around the globe, it is necessary to enhance the quality of the video generated by these drones, to perform different analytics later on the video generated and which will relatively increase the accuracy of the analytics. Since the cameras equipped inside the drones should be cost-effective, the sensors of these cameras are not sharp. Also, there are no sophisticated video enhancing processors built into these cost-effective cameras. Although these cameras are not really good at capturing high detailed videos, they are being widely used.

In most of the cases, these videos need to be monitored in real-time. As an example, border surveillance should be monitored in real-time to protect it from trespassing. If the drone cannot provide sharp videos, it is hard to monitor the area. Also, there might be cases that the observer of the drone video may miss a compulsory scene through the video, which may cause huge damage.

The project will focus on the model used to enhance the drone video using FPGA in real time. It will include various techniques like CLAHE, Saturation Adjustment, Gamma Reduction.

1.1 Basic Concepts

1.1.1. CLAHE

Contrast Limited Adaptive Histogram Equalization (CLAHE) is a variant of Adaptive histogram equalization (AHE) which takes care of over-amplification of the contrast. CLAHE operates on small regions in the image, called tiles, rather than the entire image.

1.1.2. Gamma Correction

Controls the overall brightness of an image. Images which are not properly corrected can look either bleached out, or too dark. ... Varying the amount of gamma correction changes not only the brightness, but also the ratios of red to green to blue.

In image many bits are assigned for the bright tones and few bits for dark tones we remove this using eq(1).

$$O = I^{(1/G)} \quad \text{………… eq(1)}$$

Where I is the input image, G is gamma value, O is output image.

1.1.3. Color Saturation Adjustment

The Method associates with the correlation of light brightness and color saturation that was found by the simulation of light over exposure. When the light brightness varies, the color saturation also changes accordingly. The changes of luminance and color saturation are corresponded to the YCbCr color model.

1.1.4. FPGA

Field Programmable Gate Array is an integrated circuit that can be programmed by a user for a specific use after it has been manufactured. FPGAs consist of logical modules connected by routing channels. Each module is made up of a programmable lookup table that is used to control the elements that each cell consists of and to perform logical functions of the elements that make up the cell. FPGAs are mainly used to design application-specific integrated circuits (ASICs).

1.1.5. GAN-Generative Adversarial Networks

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other. A generative adversarial network (GAN) is a machine learning (ML) model in which two neural networks compete with each other to become more accurate in their predictions. GANs typically run unsupervised and use a cooperative zero-sum game framework to learn.

- The model uses Residual-in-Residual block as a basic convolution block instead of a basic residual network.
- The model lacks a batch normalization layer in the generator to prevent smoothing out the artifacts in the images.
- The ESRGAN produces images with a higher approximation of the sharp edges of the image artifacts.
- The ESRGAN uses a Relativistic discriminator to better approximate the probability of an image being real or fake.
- The generator uses a linear combination of Perceptual difference between real and fake images using a pre-trained VGG19 network.

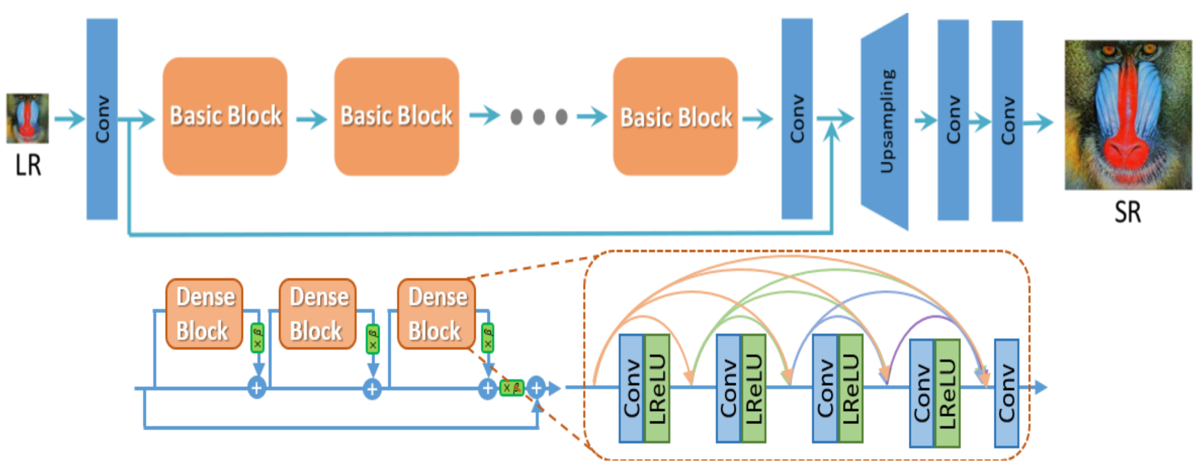

Fig 1.1 ESR GAN [16]

1.2 Motivation

Real-time surveillance and remote monitoring are gaining large importance in a wide range of industries such as Security, Oil and Gas, Power Grid, Industrial Automation, and Smart Buildings. The demand for high-quality real-time video streaming for surveillance applications is higher than ever and this calls for compute-intensive image processing designs and advanced encoding and decoding techniques.

1.3 Problem Statement

Today Surveillance is done using drones, the images or the videos which are collected from the drones may contain the disturbances due to the camera which is attached or due to the network issues. Hence the video stream which is produced by the drone needs to be enhanced before it can be used for any surveillance applications in real time scenarios. The enhancement is done at the drone itself using Field programmable Gateway array (FGPA) rather than enhancing at receiver's end.

1.4 Scope

The scope of the proposed system uses video recorded by drones such as UAV's gliders and from go pros camera's during flight time and can be used for security surveillance for the places where human cannot go and for gaining the information.

1.5 Objective

The objective of the project is to enhance the quality of the video stream and reduce the noise in the stream produced by the drone using FPGA.

2. LITERATURE SURVEY

This chapter describes existing works on internal wave modeling and data assimilation techniques.

2.1. A real-time video de fogging algorithm [1]

In this [1] they proposed a fast and efficient real-time video de fogging algorithm based on pyramid model, which solves the problems existing in the defogging algorithms, such as over-estimation of transmittance, color distortion of sky area, and poor real-time performance. Pyramid subsampling is used to obtain reduced images. The coarse transmittance of the reduced image is obtained by introducing pseudo-defogging image and the confidence of dark primary color as correction factors. The image was returned to the original size, and the texture was refined with the combined bilateral filtering. Finally, the atmospheric light scattering model and the inter-frame video defogging theory were combined to restore the degraded video.

Advantages:

- Their method has a complete defogging effect and can efficiently defog a variety of scenes.
- It is fast and stable in operation.

Disadvantages:

- The algorithm still needs to be improved in terms of the processing speed for degraded video with resolution of 1080P.
- The refining process of its coarse transmittance still needs to be improved.

2.2. Image Enhancement using Fuzzy Intensity Measure and Adaptive Clipping Histogram Equalization [2]

Generally, histogram equalization is widely used in image enhancement due to its simplicity and effectiveness; it changes the mean brightness of the enhanced image and introduces a high level of noise and distortion. So, to reduce the noise and the distortion they used fuzzy intensity measure and adaptive clipping histogram equalization. It uses fuzzy intensity measure to first segment the histogram of the original image, and then clip the histogram adaptively in order to prevent excessive image enhancement. They conducted experiments on the Berkeley database and CVF-UGR-Image database to show that proposed model is more efficient histogram equalization-based methods.

Advantage:

- It reduces the noise and distortion caused by the histogram equalization.
- It is more effective than any other histogram equalization.

Disadvantages:

- Adaptive histogram equalization method has the tendency to over-amplify noise in relatively homogeneous regions of an image.

2.3. Video surveillance image enhancement via a convolutional neural network and stacked denoising auto encoder [3]

Authors developed a deep learning image enhancement model which will enhances and reduce the noise in the image. The model consists of two deep learning blocks first block will enhance the image and second block is used to reduce the noise in the image using the stacking denoising auto encoder which consists of three denoising auto encoder layers which helps to enhance the contrast and rescue the noise. Both the deep learning models work parallelly and produces high resolution and noise reduced images. the output of both images is fused using Wavelet fusion.

Advantages:

- The low-resolution images are converted to high resolution images.
- The noise in the image is also eliminated.

Disadvantages:

- The training of autoencoder requires lots of data and processing time.
- The autoencoder is more sensitive to input errors present in the training set.

2.4. An FPGA Based Residual Recurrent Neural Network for Real-Time Video Super-Resolution[4]

In this [4] authors proposed hardware-efficient VSR model ERVSR is built on the residual recurrent convolutional neural network. The hidden state is propagated forward along the temporal dimension. Combining the LR frame with the recurrent input which conveys the temporal information of previous frames, ERVSR reconstructs the HR frame along with the associated hidden state. Specially, residual learning is employed to improve the learning efficiency and prevent from gradient vanishing. Firstly, the model parameters are loaded from the register buffer. The RGB pixels are converted to YCbCr ones. To perform 3×3 convolution for the Y channel, two-line buffers combining with the input stream.

Advantage:

- Less memory is required for enhancement.
- Light weight architecture when compared to any other neural architectures.
- Real-time implementation of super resolution enhancement is done.

Disadvantages:

- Without self-initiation, the recurrent network performs slightly worse than the non-recurrent creating additional load on hardware.

2.5. Proficient Technique for Satellite Image Enhancement Using Hybrid Transformation with FPGA[5]

In this [5] A new approach was described, which improves the picture of the satellite using the SVD DWT concept, the Gaussian transformation DWT and multiwavelet transformation. This suggested approach would convert and approximate the single-color value matrix of the low-flowing sub-band into one low-frequency and 15 high-frequency sub-bands, and then recreate the improved picture using the inverse transformation.Spartan-3E is chosen as FPGA.

Advantages:

- high quality contrast is achieved using hybrid transformation with FPGA.
- noise in image is significantly reduced using the model and smoother edges are achieved.

- real-time enhancement of the image is done using the model.

Disadvantages:

- low signal to noise ratio will affect the quality of the image.

2.6. Implementation of an FPGA Real-Time Configurable System for Enhancement of Lung and Heart Images[6]

The process will first start by reshaping the given image to a binary sequence. Since any hardware device can only work on binary values, the image layers are converted into binary sequence. Various image processing techniques were used like noise reduction, image enhancement, and image restoration. Each image pixel is represented by an 8-bit × 3 RGB values. The entire image is then converted to a sequence of pixels that can be accessed by its row and column values and the method of parallelism enables faster functioning and faster performance.

Advantages:

- faster performance is achieved using the model.
- real-time enhancement is done using the model.
- The model highlights portions of images to make the regions distinct from others.

Disadvantages:

- The model requires more memory for optimal operation.
- The model consumes high power.

2.7. A Low-Cost and High-Throughput FPGA Implementation of the Retinex Algorithm for Real-Time Video Enhancement[7]

In this [7], instead of the traditional retinex algorithm, a low cost and high throughput design of retinex algorithm is implemented for quality enhancement of real-time video stream. Using FPGA, they achieved a throughput of 60 frames/sec for a 1920*1080 image with low latency which can be considered as negligible (0.2 MS). This whole procedure is categorized into seven modules, where each module processes the image enhancement algorithm for the real time video stream.

Advantages:

- This technique is cost friendly and comparatively less complex to implement.
- High throughput can be achieved with negligible latency.

Disadvantages:

- Proper clock frequency should be maintained to obtain the desired throughput while avoiding unnecessary power consumption.

2.8. FPGA-Based Low-Visibility Enhancement Accelerator for Video Sequence by Adaptive Histogram Equalization with Dynamic Clip-Threshold[8]

In this [8] , adaptive histogram equalization with dynamic clip-threshold (AHEwDC) technique is followed for achieving high performance in real-time. They implemented this using FPGA for enhancing low visibility areas of the video sequence. To overcome the noise amplification in the video they proposed a visibility assessment model for achieving best video clip threshold. Intel Cyclone V FPGA hardware was used for implementation. The hardware they described can process 30fps full HD video at a threshold frequency of 75.84 MHz A comparison was made with actual images and enhanced images with different AHEwDC thresholds and optimized clip threshold gave the best enhanced result of the input stream for all inputs.

Advantages:

- Different clip thresholds give different levels of enhancement according to the requirement.
- Support Full HD video enhancement in real-time.

Disadvantages:

- Maximum working frequency of FPGA is 75.84MHz.

2.9. Image Quality Assessment Based on Deep Learning with FPGA Implementation[9]

In this paper, a novel image quality assessment (IQA) algorithm was proposed that rely on an optimized version of convolutional neural network architecture design. This was introduced for the extraction of certain image quality features that are discriminative in the image automatically. For further improvement of the learning ability of the designed CNN model, advanced features like local luminance coefficient normalization were used. The algorithm designed finally implemented using FPGA on two public databases. The notable thing was it outperformed in terms of speed and accuracy compared to many IQA algorithms.

Advantages:

- Modified CNN model increased speed and accuracy.
- Optimized caching design was used for speeding operation rate.

Disadvantages:

- Performance reduced when number of convolutional kernels exceeds 40.

3. ANALYSIS AND DESIGN

This section explains about the software development life cycle used, requirements of the project such as software and hardware requirements which help us to execute our project. Software design diagrams are designed to give a clear view to user through use case diagram, sequence diagram, Activity diagram which tells about the flow of execution, what activities are present, sequence of activities.

3.1. Software Development Lifecycle Model- Incremental waterfall model

Incremental Model is a process of software development where requirements divided into multiple standalone modules of the software development cycle. In this model, each module goes through the requirements, design, implementation, and testing phases. Every subsequent release of the module adds function to the previous release. The process continues until the complete system achieved.

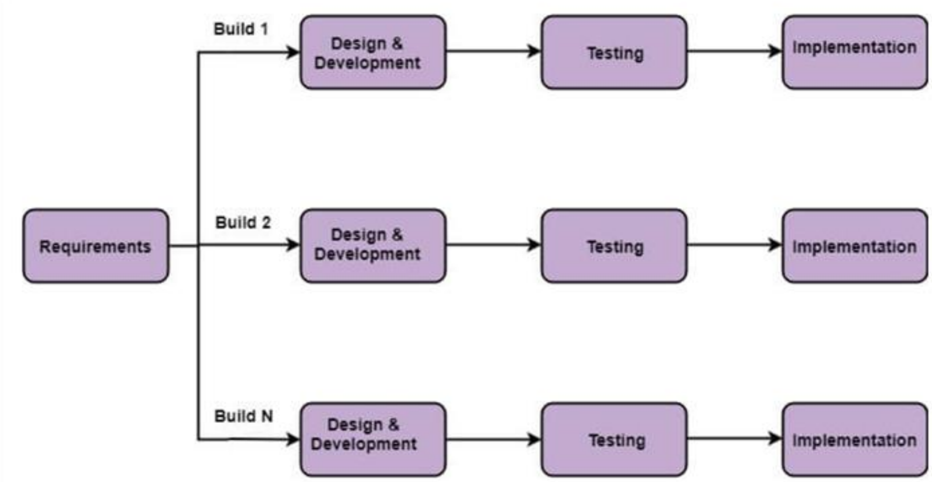

Fig 3.1 Lifecycle model [17]

The various phases of incremental model are as follows:

- **Requirement analysis:** In the first phase of the incremental model, the product analysis expertise identifies the requirements. And the system functional requirements are understood by the requirement analysis team. To develop the software under the incremental model, this phase performs a crucial role.
- **Design & Development:** In this phase of the Incremental model of SDLC, the design of the system functionality and the development method are finished with success. When software develops new practicality, the incremental model uses style and development phase.
- **Testing:** In the incremental model, the testing phase checks the performance of each existing function as well as additional functionality. In the testing phase, the various methods are used to test the behaviour of each task.
- **Implementation:** Implementation phase enables the coding phase of the development system. It involves the final coding that design in the designing and development phase and tests the functionality in the testing phase. After completion of this phase, the number of the product working is enhanced and upgraded up to the final system product

3.2. UML diagrams

3.2.1. Use Case Diagram

A use case diagram summarizes some of the relationships between use cases, actors, and systems. The first step is developer configures the FPGA to the drone. After that, drone is deployed to the site and starts video streaming to the FPGA. CLAHE, Saturation adjustment and Gamma correction is performed for the live feed and then transmitted to the receiver. This model will help us to enhance the video not only in real-time but also at the sender side itself. Here the actor is drone operator and he have to configure the code to FPGA and remove the noise and enhance the frame. The following Fig. 3.2 presents the use case diagram of the proposed system.

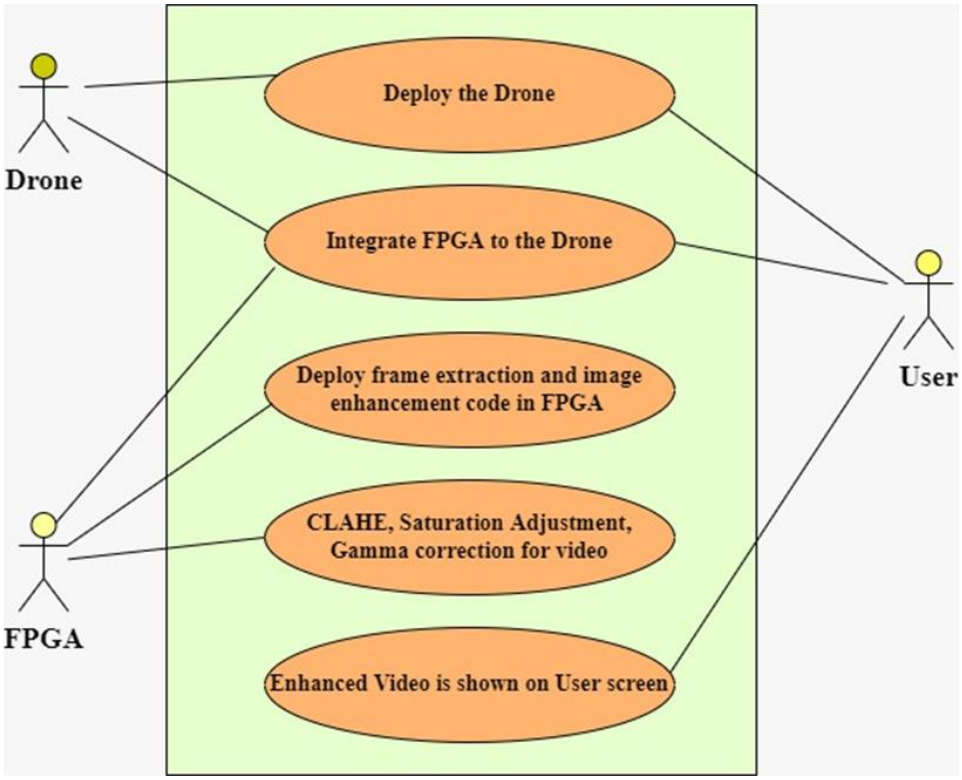

Fig 3.2 Usecase Diagram

3.2.2 Activity Diagram

An activity diagram is a behavioural diagram i.e. it depicts the behaviour of a system. An activity diagram portrays the control flow from a start point to a finish point showing the various decision paths that exist while the activity is being executed. The first step is developer configures the FPGA to the drone. After that, drone is deployed to the site and starts video streaming to the FPGA. CLAHE, Saturation adjustment and Gamma correction is performed for the live feed and then transmitted to the receiver. This model will help us to enhance the video not only in real-time but also at the sender side itself. Here the actor is drone operator and he have to configure the code to FPGA and remove the noise and enhance the frame. The following Fig. 3.3 presents various activities and the flow of the proposed system.

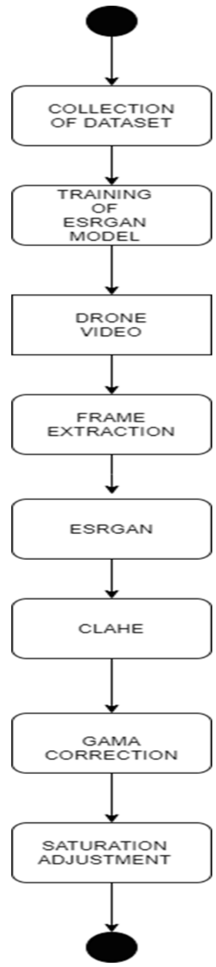

Fig 3.3 Activity Diagram

3.2.3 Sequence Diagram

A sequence diagram simply depicts interaction between objects in a sequential order i.e. the order in which these interactions take place. We can also use the terms event diagrams or event scenarios to refer to a sequence diagram. Here in this the actor is user who interacts with the drone. The video stream generated will be enhanced at drone itself using FPGA and it remove the background noise in the data After that, drone is deployed to the site and starts video streaming to the FPGA. CLAHE, Saturation adjustment and Gamma correction is performed for the live feed and then transmitted to the receiver. This model will help us to enhance the video not only in real-time but also at the sender side itself. The following Fig. 3.4 presents the sequence diagram of our methodology.

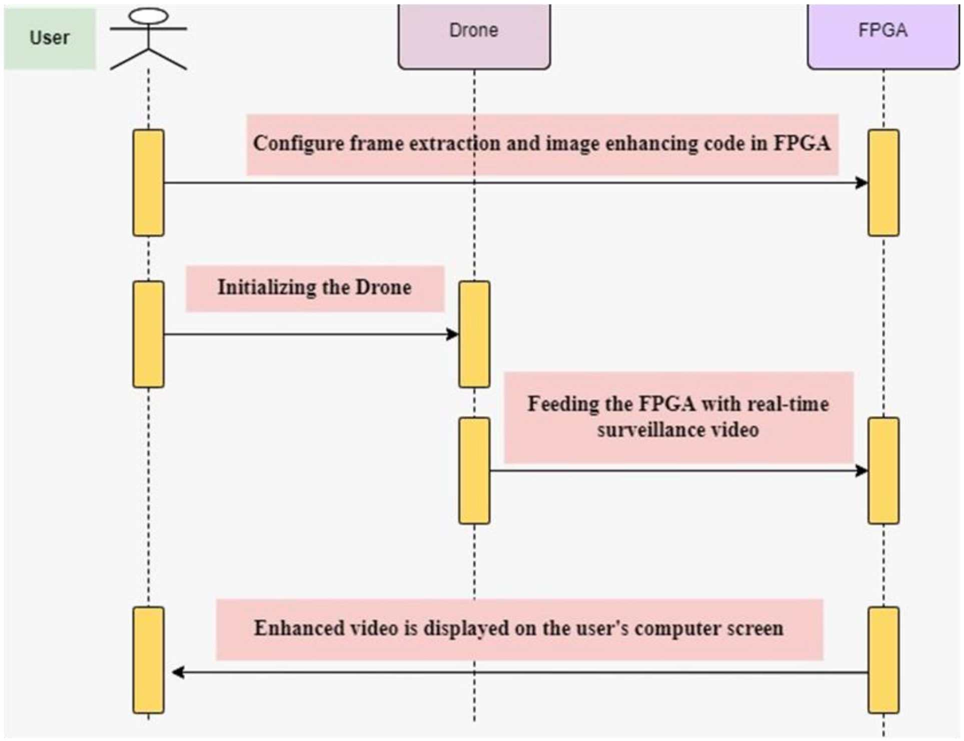

Fig. 3.4 Sequence Diagram

3.3.Software Requirements

3.3.1 Python 3[11]

Python programming language is used that has efficient high-level data structures. Python's elegant syntax and dynamic typing, together with its interpreted nature, make it an ideal language for scripting and rapid application development in many areas on most platforms.

3.3.2 TensorFlow[12]:

TensorFlow is a free and open-source software library for machine learning and artificial intelligence. It can be used across a range of tasks but has a particular focus on training and inference of deep neural networks. TensorFlow is an end-to-end open source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries and community resources that lets researchers push the state-of-the-art in ML and developers easily build and deploy ML powered applications.

3.3.3 OpenCV[13]

OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code. The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc.

3.3.4 Pil (Python Image Library)[14]

Python Imaging Library is a free and open-source additional library for the Python programming language that adds support for opening, manipulating, and saving many different image file formats. The Python Imaging Library adds image processing capabilities to your Python interpreter. This library provides extensive file format support, an efficient internal representation, and fairly powerful image processing capabilities. The core image library is designed for fast access to data stored in a few basic pixel formats. It should provide a solid foundation for a general image processing tool.

3.4. Hardware Requirements

The hardware requirements for the project are

- Drone
- FPGA- ALTERA FPGA Cyclone II

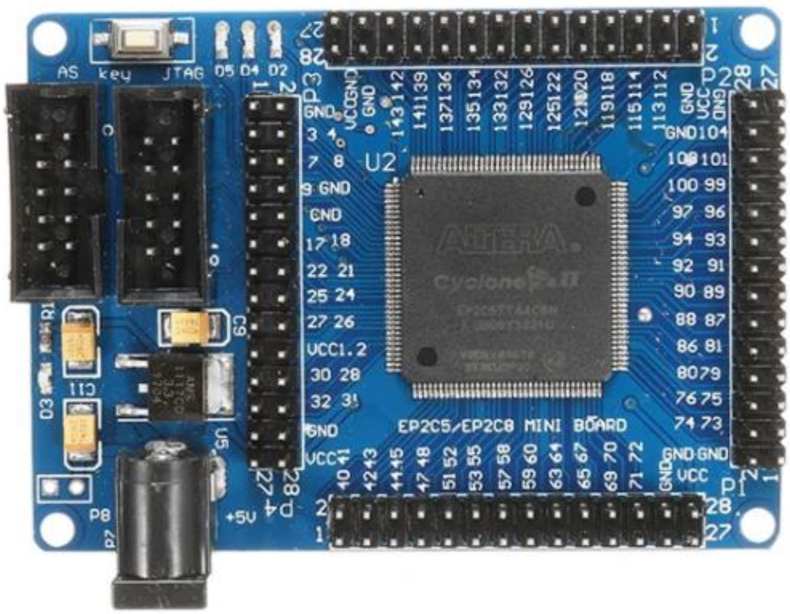

Fig 3.5 ALTERA FPGA Cyclone II [18]

4. PROPOSED SYSTEM

This chapter describes the architecture of the proposed system, methodology implemented, and the dataset used.

4.1. Architecture

The Fig. 4.1 presents various steps involved in the proposed system

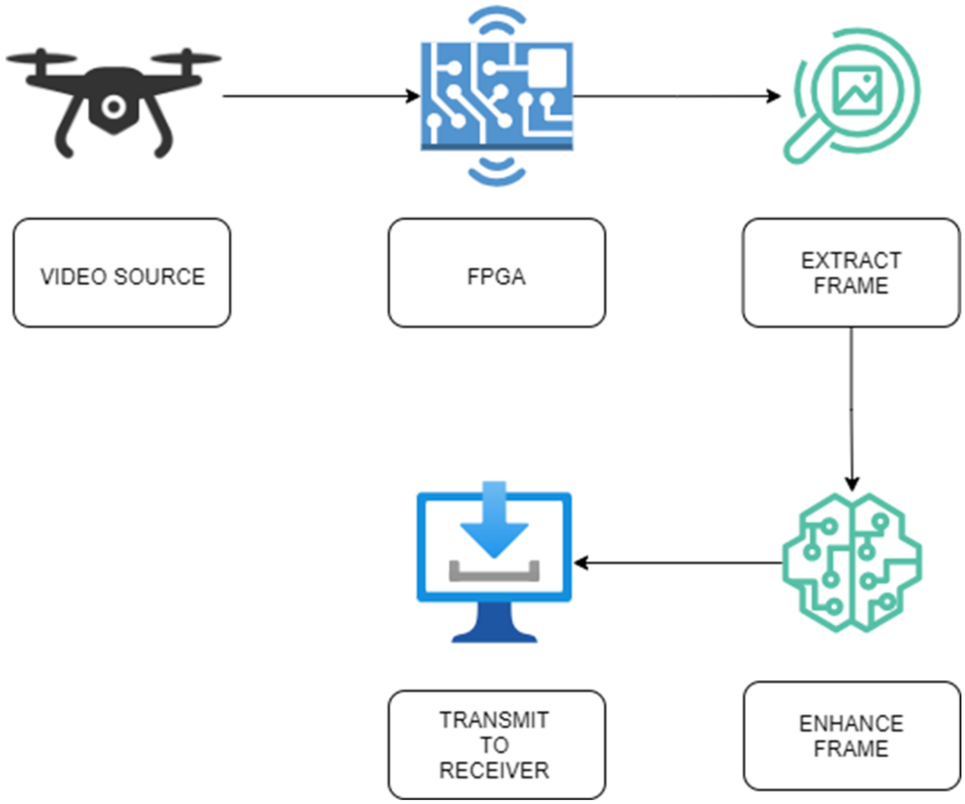

Fig. 4.1 System Architecture

The proposed system will enhance the drone video and send it back to the receiver.

4.2.**Methodology**

Various modules of our project are described in this section which include Frame extraction, Enhancing the frame..

4.2.1 Frame Extraction

The video is a combination of different frames or images so for enhancing the video we need to first extract the frames which are present in the video and then we will enhance it and then all the enhanced frames are joined together to form a new enhanced video.

4.2.2 Enhancing the Frame

The frame enhancement will be done using ESRGAN, CLAHE, gamma correction, saturation adjustment. The frame which we extracted will be sent to the ESRGAN model which will produce the high-quality image then the frame will be sent to CLAHE which is a variant of Adaptive histogram equalization which helps us in improving the level of visibility in foggy environment and also helps in reducing the noise while doing the histogram equalization. Then the frame will be sent for Gamma Correction which helps in correcting the brightness in the frame. Then the frame will be sent to the Saturation Adjustment will enhances the image by spreading the bits uniformly in the image such as when we have high colored images the bit concentration will be more at that point it will reduce so that the color contrast will be uniform throughout the frame.

4.3.**Dataset Collection[15]**

The datasets which we used are UG2 Dataset and UAV Dataset. UG2 Dataset consists of videos collected from UAV, Glider, and Ground videos. It consists of 684 videos at 30 fps frame rate. It was published in IEEE Winter Conference on Applications of Computer Vision 2018. UAV Dataset consists of videos collected from different UAV's. It consists of 50 video sequences of 70250 frames with 30 fps frame rate.

4.4.**Algorithm**

4.4.1 Enhancing the Frame

The following is the pseudo code for enhancing the frame extracted from the video.

Step 1: Enhance the image using pre trained ESRGAN model.

Step 2: Contrast limiting adaptive histogram equalization is applied on the enhanced frame from ESRGAN to adjusts the global contrast of an image by updating the image histogram's pixel intensity distribution.

Step 3: Gamma Correction is applied on the Frame to the overall brightness of an image using eq(1).

$$O = I^{(1/G)} \quad \text{……..eq(1)}$$

Where I is input image, G is gamma value, O is output image.

Step 4: Saturation Adjustment is applied to the frame to make it more vibrant and colorful using eq(2) and eq(3)

$$cb' = ((cb-128) \times saturation) + 128 \quad \text{………eq(2)}$$

$$cr' = ((cr-128) \times saturation) + 128 \quad \text{……..eq(3)}$$

Where

$$Y=0.2989\times R+0.5866\times G+0.1145* B$$

$$cb =-0.1688\times R-0.3312\times G+0.5000\times B$$

$$cr=0.5000\times R-0.4184\times G-0.0816\times B$$

5. IMPLEMENTATION

This chapter presents the output and results of the proposed system.

Fig 5.1 represents the original un enhanced Frame from the Drone video from UG2 Dataset.

Fig.5.1. Unenhanced drone video frame from UG2 Dataset [15]

Fig. 5.2 is the result of the enhancement after applying the proposed system.

Fig. 5.2. Enhanced Drone video frame from UG2 Dataset

Results and Analysis:

The below figure represents the difference between the original frame extracted from the drone and enhanced frame from the drone.

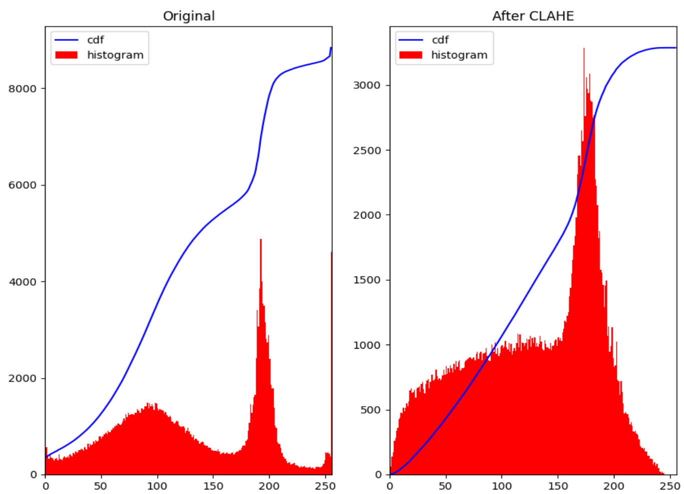

Fig 5.3 Original vs Enhanced frame

6. CONCLUSION AND FUTURE WORK

The proposed system can be used to enhance the drone video which can be used for many purposes, as the drone are being widely used for many purposes the proposed system will be helpful in enhancing the quality of video collected by the drones which have lower camera quality, the proposed system also reduces the noise in the video which is being recorded from the drone.

Future work involves in implementation of enhancement in the drone itself before sending the video to the user. This can be done by integrating an FPGA to the drone which acts as a computational device for enhancing the video at the drone.

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