# Preface

The images captured by machine vision systems are often degraded due to various atmospheric and surrounding conditions, such as **haze** and **low lighting**. Image dehazing is crucial in computer vision tasks that rely on accurate image processing. Many automated systems struggle to perform effectively on hazy images due to the loss of important visual features. Hence, image dehazing is employed in several machine vision systems to enhance the visibility and clarity of the images captured in hazy conditions. Similarly, low-light image enhancement is crucial for improving the visibility and usability of images captured in dim or poorly illuminated conditions. Automated systems may struggle to process dark and noisy images, leading to errors or misinterpretations. So, low-light image enhancement techniques are helpful in restoring the visibility of the captured images, thereby increasing the information content stored in them.

Existing image dehazing methods suffer from problems such as over-dehazing and over-saturation, which are dealt with using complex post-processing techniques or filters. This affects their processing time and limits their ability to perform in real-time. Further, the processing time of existing low-light image enhancement techniques also suffers due to the large spatial filters and iterations used in image restoration. Platforms such as GPUs and high-end CPUs can handle the high computational requirements of these image enhancement algorithms, but they would significantly increase the cost and power budget of the machine vision systems. Another solution that is suitable for the real-time implementation of these image enhancement techniques is to develop their efficient VLSI architectures and implement them on platforms such as FPGAs and ASICs, which have the capability of parallel processing. This dissertation presents efficient image dehazing and low-light image enhancement techniques and their VLSI architecture suitable for real-time machine vision systems.

This dissertation is organized as follows

**Chapter 1** presents a general flow of the processes involved in a typical real-time image processing system. Some of the key characteristics of a real-time image processing system and the objectives of image enhancement techniques are also discussed in this Chapter. Further, the background of image dehazing and low-light image enhancement methods, along with their applications and challenges, are introduced in a nutshell. The mathematical models for attaining these goals are also introduced in this Chapter.

**Chapter 2** presents a literature survey of the existing state-of-the-art image dehazing and low-light image enhancement techniques. The merits and demerits of all these techniques and existing VLSI architectures for such techniques are also presented in this Chapter. Further, the performance metrics used for the quantitative and qualitative evaluation of the proposed methods are also introduced in this Chapter.

**Chapter 3** presents a saturation-based image dehazing method and its VLSI architecture. In this method, the transmission of a hazy image is estimated pixel-wise using its saturation information. A large patch is used in the proposed method for atmospheric light estimation, preventing the dehazed image from being oversaturated. The proposed method efficiently restores the visibility of the hazy image without introducing any artifacts around the edges. The proposed VLSI architecture is suitable for real-time image dehazing applications.

**In Chapter 4**, an intensity-based video dehazing method and its VLSI architecture are presented. In this method, the atmospheric light for each pixel is dynamically adjusted to prevent oversaturation of the dehazed images. Moreover, a new pixel-wise transmission estimation is also proposed in this Chapter, which suppresses artifacts around depth discontinuities and relaxes the requirement of post-processing enhancement techniques. The proposed VLSI architecture is suitable for real-time video dehazing applications.

**Chapter 5** presents a Retinex-based low-light image enhancement method and its hardware architecture. A low-cost illumination estimation filter is proposed in this method. The proposed method preserves fine details in the decomposed reflectance by preventing the overflow of the values in the reflectance. Further, approximate computing is used to minimize the hardware resource utilization of the proposed method without compromising its performance. The proposed VLSI architecture is suitable for real-time low-light image enhancement applications.

Finally, **Chapter 6** summarizes the main findings of this dissertation and briefly discusses the scope of future work.

I am hopeful that this dissertation will contribute to real-time image dehazing and low-light image enhancement applications in a useful way.