Abstract

Adverse climatic conditions—marked by haze, rain, and fluctuating illumination—pose formidable challenges to real-time mobile object tracking by degrading image quality, introducing noise, and increasing computational complexity. In such environments, traditional tracking algorithms struggle with dynamic object appearance, nonrigid deformations, and unpredictable motion, all of which significantly impair performance.

This thesis presents a comprehensive framework that integrates adaptive tracking with advanced image restoration techniques to overcome these challenges. The tracking module fuses the strengths of the Mean Shift algorithm and the Unscented Kalman Filter through an adaptive search region proposal block. A dynamically computed threshold parameter (β), optimized based on factors such as motion blur, high velocity, and nonlinearity, governs the selection between these methods. In addition, a multi-scale template matching strategy anchored by normalized cross-correlation is employed to enhance target localization accuracy while mitigating computational overhead, with a recursive target model update ensuring improved temporal consistency.

To address visibility impairments due to atmospheric aerosols, the framework incorporates a real-time video dehazing pipeline that leverages a novel haze parameter, SATVAL, to selectively process frames based on their saturation-to-value ratios. Complementing this approach, the Light Invariant Dehazing Network (LIDN) employs a Quadruplet loss-trained architecture to achieve consistent dehazing across diverse lighting conditions. Furthermore, a generative adversarial network (GAN) featuring a modified-MobileNet encoder is developed to balance efficiency with high restoration quality, while a wavelet-based deep autoencoder (WAE) simultaneously mitigates both haze and rain effects by exploiting joint spatial and frequency domain features.

Enhancing the practical relevance of this work, the ExtremeTrack dataset is introduced—a synthetic collection of 199 videos that encapsulate a wide range of weather-induced artifacts. Additionally, the ArcTrack algorithm integrates ArcLoss-based similarity matching with an unsupervised detection mechanism to robustly track objects under occlusion and severe visual degradation.

Collectively, the contributions of this thesis advance the state-of-the-art in mobile object tracking and image restoration, offering robust and efficient solutions for computer vision systems operating under challenging adverse climatic conditions.

Keywords: Object tracking, Adverse Climate Condition, Dehazing, De-Rain.