Title: Object Detection in Adverse Weather Using Novel Deep Learning and Thermal-Visible Imaging

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Abstract

Object detection is critical for autonomous navigation, surveillance, and remote sensing applications. However, according to studies, the efficacy of object detection systems is significantly reduced by up to 30-40% by adverse weather conditions such as haze, fog, and low light, reducing contrast and obscuring details for visible and thermal infrared (TIR) images. This presents a significant challenge, as traditional object detection models, mainly trained under clear weather conditions, show significant accuracy reduction in performance when dealing with unclear conditions. Current solutions often rely on static algorithms trained on limited datasets that fail to generalize across the diverse scenarios encountered in real-world applications. This thesis aims to develop novel deep learning models, including the Mamba network family, for robust detection of cars, pedestrians, and elephants using visible and thermal imaging and videos in complex weather conditions. To achieve this goal, the following key tasks will be investigated:

1. **Developing EOD-Net:** An innovative object detection framework capable of end-to-end dehazing, enhancing visual perception under challenging conditions using visible images and videos.
2. **Creating a Thermal Image and Video Enhancement Methods:** We are designing a specialized Mamba-based dehazing network for thermal images and videos. This network addresses low contrast, noise, and weak edge detection, incorporating blur-invariant methods to ensure accurate detection across video frames, even in low-light scenarios.
3. **Developing a Thermal Image and Video Recoloring Network:** Enhancing thermal images and videos by recoloring techniques to improve visual representation and detection capabilities.
4. **Evaluation and Validation:** The developed methods will be evaluated using established dehazing benchmark datasets, real-world thermal image datasets, and object detection metrics. Comparisons with state-of-the-art approaches will demonstrate significant improvements. The models will also be deployed in real-world scenarios, such as autonomous vehicles, wildlife monitoring (elephants), and solar panel inspections, to validate their effectiveness and robustness in practical applications.

This thesis will contribute to developing more efficient autonomous systems capable of operating effectively under adverse weather conditions, enhancing safety and efficiency in real-world applications. The proposed research will offer several benefits, including

1. Improvement of detection accuracy of cars, pedestrians, and elephants of the developed models by addressing the challenges posed by adverse weather conditions,
2. Generalized methodology, performing well across various environmental conditions by integrating visible and thermal imaging.
3. Optimized models are designed for near real-time applications, ensuring timely and accurate decision-making in critical scenarios.
4. Advances robust solutions that can be adapted for diverse applications, including solar panel maintenance, wildlife tracking, military operations, and security monitoring.

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