Project Proposal: **Taxi Visibility System (TVS)**

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Abstract

Air travel safety and operational efficiency are significantly impacted by unfavorable weather conditions. The Taxi Visibility System (TVS) aims to enhance pilots' ground vision during taxiing by integrating advanced image processing techniques. This proposal outlines the project's motivation, objectives, and methodology. Additionally, it outlines the work that has already been done as well as the next work, which is the creation of a pixel-wise transmission detection algorithm for handling heterogeneous fog images.

1 Introduction

Unfavorable weather conditions have a major impact on air travel safety and operational efficiency. Unfavorable weather conditions including fog, smog, and a lot of rain can make it harder to see the runway and taxiway, which can cause delays, higher operating expenses, and in extreme situations, accidents. There is still a significant lack of dependable taxiing help in low visibility, despite the fact that contemporary landing systems like ILS CAT III C allow safe landings in such circumstances. By incorporating cutting-edge image processing techniques, the proposed Taxi Visibility System (TVS) seeks to improve pilots' ground vision when taxiing. This system ensures safer and more effective aircraft ground movement even in inclement weather by providing clear, dehazed visuals and real-time navigation signals.

2 Project Overview

The TVS project focuses on the following key aspects:

- **Safety Enhancement:** Improving situational awareness for pilots during taxiing by providing clear visual information despite low visibility conditions.
- **Economic Benefits:** Reducing flight delays, fuel wastage, and parking costs by enabling efficient ground operations.
- **Technological Innovation:** Utilizing high-resolution, low-light cameras with infrared imaging combined with intelligent image enhancement techniques to offer reliable taxiway guidance.

3 Need Analysis

Pilots' ability to properly navigate taxiways is severely hampered by bad weather. Pilots frequently have to rely on outside direction from air traffic control in situations like fog or intense rain, which raises the possibility of misunderstandings and mishaps. The disastrous effects of diminished situational awareness are brought to light by historical occurrences like the Tenerife Airport tragedy. An independent system that can improve vision and provide pilots more autonomy is desperately needed in order to increase airport efficiency and safety overall.

4 Objectives

4.1 Previously Completed Work

The work completed so far includes:

1. **Analysis of Pre-processing Techniques:** Comparison of various methods for noise reduction, contrast enhancement, and dehazing under low-visibility conditions.
2. **Benchmarking Existing Methods:** Reproduction and evaluation of state-of-the-art image enhancement models in adverse weather conditions.
3. **Zero-Shot Learning Integration:** Initial development and testing of models to adapt to diverse weather and geographical conditions without prior specific training.
4. **Hardware Prototype Development:** Early integration of the imaging system with a hardware device (e.g., Raspberry Pi with compatible cameras) for real-time processing.

4.2 New Work Objectives

The new work planned for the project includes:

1. **Heterogeneous fog image pixel-wise transmission detection:**
    - Create and put into practice a method to identify transmission on a pixel-by-pixel basis.
    - Adapt the detecting technique to efficiently manage a variety of fog circumstances.
2. **Creation of an Integrated Prototype:**
    - Include the new transmission detection module in the pipeline for picture enhancement that already exists.
    - Improve the system's overall performance in inclement weather.

5 Methodology

5.1 Work Already Completed

- **Research and Literature Review:** Comprehensive data collection and review of current image enhancement techniques and real-time processing hardware.
- **Software Development:** Implementation of algorithms for noise reduction, contrast adjustment, dehazing, and initial zero-shot learning model training.
- **Hardware Implementation:** Development of an early prototype using Raspberry Pi and compatible camera systems, with preliminary system integration and testing.

5.2 New Work Methodology

- **Pixel-wise Transmission Detection:**
  - Create a new algorithm optimized for heterogeneous fog photos that calculates transmission values for every pixel.
  - For algorithm calibration and performance assessment, use datasets of both artificial and actual fog images.
- **Integrated System Enhancement:**
  - Integrate the transmission detection module with the existing image enhancement pipeline.
  - Optimize the processing workflow for real-time performance in diverse weather conditions.
- **Testing and Evaluation:**
  - Perform thorough simulation testing in a range of diverse fog circumstances.
  - Measures like processing speed, visual quality, and real time responsiveness are used to assess system performance.

6 Timeline

The following timeline outlines the tasks over a 2-month period, divided into 8 weeks (1 week per task):

Week	Task Description
Week 1	Design the algorithm for pixel-wise transmission detection.
Week 2	Design the algorithm for pixel-wise transmission detection.
Week 3	Create the transmission detection algorithm's initial implementation.
Week 4	Create the transmission detection algorithm's initial implementation.
Week 5	Integrate the transmission detection module with the existing image enhancement pipeline.
Week 6	Conduct system testing under varied heterogeneous fog conditions.
Week 7	Refine the integrated system and debug issues.
Week 8	Final evaluation, documentation, and preparation for demonstration.

7 Conclusion

The Taxi Visibility System (TVS) marks a significant step forward in addressing the issues faced by unfavorable weather conditions in airport operations. By building on the work already achieved and introducing unique technologies such as pixel-wise transmission detection for heterogeneous fog images, TVS hopes to significantly improve safety and operating efficiency. This initiative could open the door for upcoming advancements in aviation technology, which would increase the safety and dependability of air travel.