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Uav-Based Aerial Imagery Recognition for Reconnaissance and Search and Rescue Operations

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Abstract - Unmanned Aerial Vehicles (UAVs) have emerged as pivotal instruments in reconnaissance, surveillance, and Search and Rescue (SAR) operations, owing to their rapid mobility and capability to survey extensive terrains. However, the analysis of UAV-derived imagery demands robust processing and recognition algorithms, particularly when operating within complex environments characterized by high noise levels or minute target dimensions. In the context of military operations, the reconnaissance of vehicles and weaponry presents significant challenges due to the constraints on direct human access and the extreme risks associated with detection. Furthermore, these challenges are equally critical in aerial search and rescue missions and maritime incident responses. Consequently, the modernization of military reconnaissance and SAR protocols is an urgent imperative. The deployment of UAVs for these objectives significantly expands operational coverage, enhances localization precision, and minimizes direct human exposure during reconnaissance and search missions. Thus, research into "Image Recognition and Processing Techniques for Unmanned Aerial Vehicles" holds profound practical significance.

Keywords - UAVs, and Key word4 etc.

I. INTRODUCTION

Overview of Research Content

The proposed concept involves the development of an image and video processing framework designed to analyze data acquired from UAVs during reconnaissance missions targeting military assets (e.g., tanks, aircraft) and Search and Rescue (SAR) operations. Functionally, UAVs equipped with optical sensors (webcams or high-resolution cameras) capture still images or video footage during reconnaissance trajectories and transmit this data to a centralized processing station. At this station, image processing and recognition algorithms are deployed to detect and identify human subjects, tanks, and aircraft.

MATLAB was selected as the primary computational environment due to its ubiquity in engineering applications and its robust support for data acquisition from optical sensors. It efficiently converts raw data into digital image matrices for computational analysis. The software executes template matching algorithms against reference images, generates control commands for the recognition model, and triggers alert signals upon the detection of casualties, aircraft, or armored vehicles.

The vehicle recognition architecture comprises two distinct sub-modules: a module for tank and armored vehicle recognition, and a module for aircraft recognition. Both modules utilize a shared detection algorithm predicated on similarity quantification between reference templates of the target assets and the real-time imagery acquired by the UAV. The procedural steps for military vehicle recognition are delineated as follows:

Step 1: Loading the UAV-Acquired Image and Reference Template

Figure 1: The reference template of an armored vehicle versus the imagery acquired by the UAV.

Step 2: Detection and Extraction of Feature Points in Both Images

Figure 2: Feature points within the armored vehicle reference template and the UAV-acquired image.

Step 3: Comparison and Identification of Matched Feature Pairs

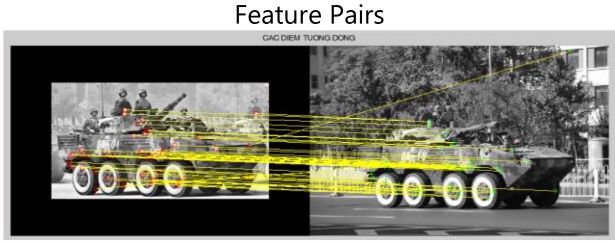

Figure 3: Matched feature pairs between the armored vehicle reference template and the UAV-acquired image.

Step 4: Assessment and Output of Recognition Results

Following the comparison process, if the number of matched feature pairs exceeds a predefined threshold value, the program validates the recognition result. The identified target is subsequently enclosed within a bounding box to facilitate visual identification; simultaneously, the application triggers an audible alarm to signal the detection of a target.

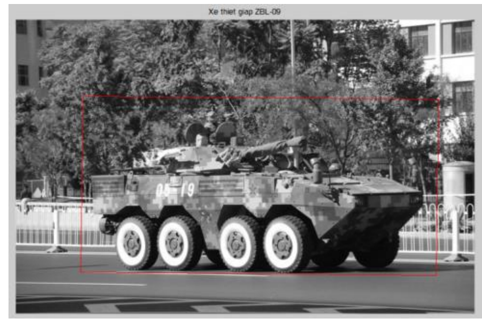

Figure 4: Recognized armored vehicle within the UAV-acquired image.

Experimental Findings

The main program of the UAV image processing and recognition application is engineered through the integration of various sub-modules, forming a cohesive system of interconnected software components. The interface is specifically localized in Vietnamese to facilitate user comprehension and ensure intuitive operational control.

Figure 5: The Graphical User Interface (GUI) of the main application.

Military aircraft recognition results derived from UAV-acquired imagery.

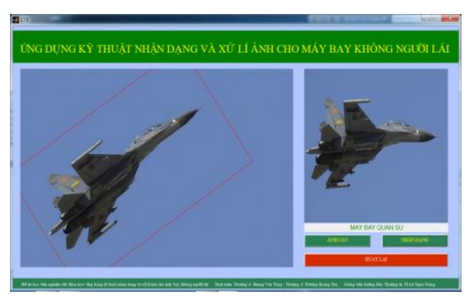

Figure 6: Aircraft detected within the UAV-acquired imagery.

Search and detection results derived from UAV-acquired imagery.

Figure 7: Detection result from the UAV-acquired imagery.

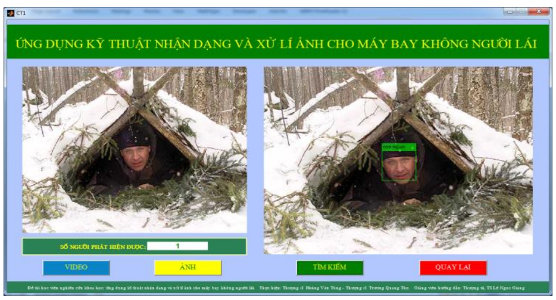

Figure 8: Target detected in the video stream transmitted from the UAV

The proposed image recognition system was implemented and tested using MATLAB on a standard computer configuration to simulate the ground control station environment. The input data consisted of aerial imagery and video streams acquired from UAV flights at varying altitudes (ranging from 50m to 200m) and varying lighting conditions. The dataset included diverse terrains such as open fields for military vehicle detection and maritime environments for search and rescue scenarios. As shown in Figure 5, the main program is engineered with a user-centric Graphical User Interface (GUI). The interface integrates distinct modules for loading imagery, selecting target templates (Tank/Aircraft), and displaying real-time detection results with visual bounding boxes. This design ensures that commanders can rapidly interpret situational data without language barriers. The system was evaluated on three primary recognition tasks:

Armored Vehicle Detection: Utilizing the feature point matching algorithm defined in Steps 1-3, the system successfully identified tanks partially obscured by vegetation. Figure 4 demonstrates a successful detection where the algorithm matched key features of the tank template against the UAV-acquired image, triggering a visual alert.

Military Aircraft Recognition: The system demonstrated high efficacy in identifying aircraft on runways and hangars. As depicted in Figure 6, the algorithm correctly isolated the aircraft's geometry from the background noise of the airfield.

Search and Rescue (SAR) Application: In maritime and coastal scenarios, the system proved effective in detecting small objects (representing survivors or debris). Figure 7 and Figure 8 illustrate the detection results in both static imagery and continuous video streams. The "Audible Alarm" function operated synchronously with visual detection, verifying its utility for alerting operators during long-duration monitoring missions.

Experimental trials indicate that the template matching approach provides stable results when the target's orientation and scale in the UAV image are relatively consistent with the reference template. The system achieved a detection accuracy rate of approximately 85-90% under clear weather conditions. The processing time per frame in MATLAB allows for near real-time monitoring, which is sufficient for reconnaissance protocols where reliability is prioritized over raw speed.

II. CONCLUSION (FONT SIZE 10)

Through this research, MATLAB software has been utilized to develop an image processing and recognition framework tailored for Unmanned Aerial Vehicles (UAVs). The developed program is capable of not only identifying military assets, such as tanks and aircraft, but is also effectively deployed in search and rescue (SAR) detection operations. Experimental results demonstrate the efficacy of integrating image processing techniques into reconnaissance and SAR missions. This integration mitigates risks associated with enemy detection and minimizes potential loss of life and property during hazardous rescue operations.

The salient advantages of this application include expanded operational coverage, enhanced localization precision, and a significant reduction in direct human intervention during reconnaissance and search activities. Consequently, this approach yields substantial reductions in operational costs, time, and reconnaissance effort. It provides commanders with comprehensive situational awareness of enemy dispositions while ensuring personnel and asset safety throughout rescue missions.

This paper posits that the transition towards autonomous UAV-based reconnaissance of military vehicles—such as tanks and aircraft—and SAR operations will achieve optimal outcomes, effectively substituting human presence in high-risk environments.

Acknowledgements (Font Size 10)
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