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Motion Imagery Processing and Exploitation (MIPE)

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Summary

Current military operational needs have driven advances in sensor systems and in the airborne platforms that carry them. In particular, they have brought about the rapid development of motion imagery sensors, including both full-motion video (FMV) and wide-area motion imagery (WAMI)\(^3\) sensors. Moreover, advances in telecommunications now allow raw imagery and other raw intelligence to be transmitted to a worldwide distributed set of military intelligence centers. All these technological advances have led to an “information deluge” that threatens to overwhelm military intelligence analysts.

In this report, we focus on a particular class of tools and technologies (motion imagery processing and exploitation [MIPE]) to help military intelligence analysts take better advantage of the information deluge and to enable them to continue to exploit a wide range of motion imagery collections. We define MIPE as the collection of capabilities and enabling technologies, tools, and systems that aid analysts in the detection, identification, and tracking of objects of interest (OOIs), such as humans and vehicles; in the identification of activities of interest (AOIs);\(^4\) and in the characterization of relationships between and among OOIs and AOIs in live and archival video. We focus on motion imagery collections not only because they are growing so rapidly but also because motion imagery is still a relatively new intelligence, surveillance, and reconnaissance (ISR) capability. As the military services move toward more multi-intelligence (multi-INT)\(^5\) work, it is important to bring new capabilities up to par with the old ones.

Observations and Recommendations

PAF examined the needs of motion imagery analysts, identified MIPE capabilities that could assist in meeting those needs, and assessed the technical readiness of MIPE systems. Major observations and recommendations are as follows.

Use MIPE Systems to Focus Analysts’ Attention

MIPE systems have the potential to greatly alleviate the burden on analysts who follow the current practice of continuously monitoring a video stream in search of OOIs and AOIs. However, the current state of the art is such that MIPE systems cannot completely replace all

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\(^3\) The previously used term was wide-area airborne surveillance (WAAS). It is being replaced by WAMI. We will use the term WAMI throughout this document.

\(^4\) The acronym AOI used in this report for activity of interest is not to be confused with area of interest.

\(^5\) Multi-INT refers to activities that combine multiple intelligence domains (INTs), such as imagery intelligence (IMINT), FMV, and signals intelligence (SIGINT). In this report we consider FMV an intelligence domain separate from IMINT and reserve the latter term for still-imagery intelligence.
human analysts who search for OOIs or AOIs in arbitrary situations.\(^6\) Thus, our first recommendation to military intelligence organizations is to adopt a “focus-of-attention” concept of operations (CONOP) and to invest in the associated enabling MIPE technologies and systems. A focus of attention is a cue from a MIPE system that directs the human operator to examine a particular video frame or subframe in search of an OOI or AOI. This CONOP and associated MIPE system can greatly reduce the amount of archived video footage that an analyst has to sift through in search of an OOI or AOI. We believe that state-of-the-art MIPE systems can achieve the performance levels required for this application.\(^7\) This CONOP may be also leveraged to effectively exploit WAMI data by automatically directing the analyst to examine a smaller part of the wide-area video footage when an OOI or AOI is detected.\(^8\)

**Focus on Specific Target Sets and Environments**

Our second recommendation concerning MIPE hinges on the recognition that current state-of-the-art MIPE systems tend to operate well only in restricted environments and with restricted target sets. We recommend that military intelligence organizations identify which target sets and environments are of most interest to them and direct near-term acquisition toward systems that enable those niche MIPE applications.\(^9\)

**Take Advantage of Multi-INT Tools**

Our third recommendation is for military intelligence organizations to invest in systems that take advantage of many sources of information (e.g., a multi-INT tool) to augment or supplement the capabilities of the not-as-mature MIPE systems. A multi-INT tool, for example, can leverage the capabilities of a mature intelligence discipline (such as SIGINT) to improve a MIPE system’s performance in identifying OOIs and AOIs or in reducing false alarms.

**Standardize MIPE Test Plans**

To be useful to military operations, MIPE systems must be evaluated under conditions that mimic the real world, utilizing a “truthed” data set—that is, a video stream containing real

\(^6\) Consequently, the results from MIPE analysis are heavily dependent on human interpretation.

\(^7\) That is, high confidence in not missing the OOI or AOI (low probability of false negatives) can be achieved, but not necessarily high confidence in not misidentifying another object or action for the OOI or AOI of interest (false positives or false alarms). False positives can be better tolerated than false negatives in these applications since they result in analysts wasting time rather than important OOIs or AOIs being missed. We note, however, that false positives take the analyst’s attention away from the true positives, and this wasted time may be of importance in certain applications.

\(^8\) However, because of the time sensitivity of current operations, automatic analysis of WAMI footage in near-real time requires a very stringent requirement on not missing OOIs and AOIs (very low probability of false negatives), which may be beyond the current state of the art.

\(^9\) Niche applications should have enough operational utility—for example, enough targets of interest—to justify the investment.
targets whose identity, location, and number are known at all times. Thus, our next recommendation is for military intelligence organizations to standardize their MIPE test plans. Metrics for testing these systems should be developed and standardized; in this report, we have suggested several metrics. The test plan should make use of truthed data sets to evaluate the capabilities of candidate technologies and systems.

**Take Advantage of Near-Term MIPE Capabilities, Such as Background Subtraction**

Our last recommendation concerning MIPE is that, in the near term, military intelligence organizations employ MIPE systems based on “low-hanging fruit” technologies,\(^\text{10}\) such as those systems that perform background subtraction. A background subtraction algorithm could automatically indicate whether the foreground of a video feed has changed significantly between frames, thus directing an analyst to return his or her attention to the changing scene. Conversely, if the scene is not changing significantly, the analyst may be free to attend to other tasks. These systems may also assist an analyst in exploring a relatively unpopulated region using a WAMI sensor. The background subtraction algorithm may then direct him or her to focus on areas of the WAMI feed in which there is some activity.

\(^{10}\) By “low-hanging fruit,” we mean technologies that are already mature and are relatively easy to implement.