# ABSTRAK

Penyajian informasi yang relatif bersamaan tentang titik *impact* dan bentuk *trajectory*/lintasan roket dalam penilaian latihan penembakan *air to ground* oleh pesawat tempur berbasis *computer vision* dinilai penting dan pernah dilakukan dengan *3D-Mixed Reality.* Namun, penerapan kalibrasi *3D View Geometry* di dalamnya belum optimal, khususnya untuk mendapatkan informasi titik ledakan dan bentuk *trajectory* roket secara cepat dan akurat belum tercapai. Algoritme *image processing* yang diterapkan belum mampu secara cepat dan akurat mengolah citra *noise* tak terduga yang berada lebih rendah dari posisi titik ledakan yang sesungguhnya. Ketika citra ledakan roket/bom *explosive* sangat besar serta luasan citranya juga besar maka jumlah koordinat titik citra yang teridentifikasi juga sangat banyak untuk diproses dengan teknik *sort*. Akibatnya, waktu komputasi meningkat ketika mengidentifikasi koordinat titik terbawah sebagai titik ledakan. Penelitian ini mengusulkan metode *Dyna-Mixed Reality* yang terdiri dari dua fase penting yakni algoritme kalibrasi *Target Area Georeference Algorithm* (TAGA) dan metode *motion detection* yang disebut *Clear In Hot* yang menonjolkan teknik *minimum circle* dan *countours* untuk deteksi titik *impact*. TAGA mengunci posisi koordinat target di lingkaran posisi jam 12, jam 3, jam 6, jam 9, dan titik pusat, serta menerapkan seleksi area citra *Region Of Interest (ROI)* di awal proses. Hasilnya, metode yang diusulkan ini berhasil menginformasikan jarak posisi titik *impact* ledakan dengan akurasi 100%, jarak titik *impact* ke titik pusat target (akurasi dari 88,61% menjadi 96,42%), sudut posisi titik *impact* (sebesar 97,02%, visualisasi *window* ledakan, dan visualisasi bentuk lintasan/*trajectory* secara lebih akurat dan *real time* dengan nilai error rata-rata sebesar 3,89% (dibawah 5%). Hasil tersebut menunjukkan kontribusi pengombinasian operasi-operasi teknik *image processing* mampu menggambarkan secara *realtime* bentuk *trajectory* roket meluncur ke target yang diikuti terdeteksinya posisi titik *impact* bom/roket di area target secara berurutan mendekati *realtime* dibandingkan metode sebelumnya.

**Kata Kunci**: *air to ground, calibration, combat training, mixed reality, image processing, weapon scoring system*.

# ABSTRACT

*The simultaneous presentation of impact point information and rocket trajectory shape in air-to-ground firing training assessments for fighter jets based on computer vision is considered crucial and has been previously conducted using 3D-Mixed Reality. However, the application of 3D View Geometry calibration in this process has yet to reach optimal performance, particularly in providing rapid and accurate explosion point and trajectory shape information. The implemented image processing algorithms have not yet been able to swiftly and precisely handle unexpected noise within the image, which appears lower than the actual explosion point. When the explosive rocket/bomb detonation is large and the image area is extensive, the number of identified image coordinate points also significantly increases, requiring sorting techniques for processing. As a result, computational time increases when identifying the lowest coordinate point as the explosion point. This study proposes the Dyna-Mixed Reality method, which consists of two key phases: the Target Area Georeferenced Algorithm (TAGA) for calibration and the motion detection method called Clear In Hot, which emphasizes the minimum circle and contours techniques for impact point detection. TAGA locks the target coordinate positions within a circular arrangement at the 12, 3, 6, and 9 o'clock positions, along with the central point, while implementing Region of Interest (ROI) selection at the initial processing stage. The results show this proposed method successfully provides explosion impact point distance information with 100% accuracy, improves impact point distance accuracy from 88.61% to 96.42%, enhances impact point angle accuracy to 97.02%, enables explosion window visualization, and allows for a real-time visualization of trajectory shape with an average error rate of 3.89% (below 5%). These results demonstrate the contribution of combining image processing techniques, enabling real-time visualization of the rocket trajectory as it launches toward the target, followed by the sequential detection of bomb/rocket impact points in the target area closely to real-time compared to previous methods.*

**Keywords**: *air to ground, calibration, combat training, , image processing, mixed reality, motion detection, weapon scoring system*.