ABSTRAK

Rip current merupakan salah satu penyebab utama kecelakaan laut di pantai yang sulit dikenali secara visual oleh masyarakat umum. Fenomena ini seringkali tidak tampak jelas di permukaan air sehingga menyulitkan pengunjung untuk mengidentifikasinya secara langsung. Minimnya sistem peringatan dini dan pengawasan visual yang efektif memperbesar risiko kecelakaan. Berbagai penelitian telah mengembangkan metode deteksi rip current, namun sebagian besar masih berbasis citra statis yang tidak memperhitungkan pergerakan arus secara kontinu, sehingga kurang efektif untuk deteksi *real-time* di kondisi nyata.

Penelitian ini mengusulkan metode deteksi rip current berbasis algoritma YOLO11 yang dikombinasikan dengan Axis-Aligned Bounding Box (AABB) Collision Detection untuk mendeteksi dan memantau risiko keberadaan manusia secara *real-time*. Data penelitian diperoleh dari perekaman video di Pantai Drini dan dataset sekunder, kemudian dilakukan proses anotasi dengan bantuan pakar. Model dilatih menggunakan citra berukuran 640x640 piksel selama 300 epoch. Evaluasi model dilakukan dengan metrik precision, recall, dan mAP50, serta divalidasi menggunakan data tambahan berupa video berdurasi dua menit pada berbagai kondisi visual pantai. *Post-processing* menggunakan algoritma AABB Collision Detection diterapkan untuk memantau potensi tumpang tindih antara objek manusia dan rip current.

Hasil penelitian menunjukkan bahwa model mencapai mAP50 sebesar 95,8%, *precision* sebesar 94,9%, dan *recall* sebesar 92%. Validasi model menggunakan data tambahan menunjukkan performa terbaik pada Pantai Nglolang, dengan presisi 89,42%, recall 92,08%, dan akurasi sebesar 83,04% sedangkan performa menurun pada pengujian di Pantai Kukup, dengan nilai presisi 69,14%, recall 77,41%, dan akurasi 66,03%. Hasil pengujian *post-processing* menunjukkan bahwa AABB Collision Detection dapat bekerja dengan akurat tanpa menambah beban signifikan. Berdasarkan hasil ini, deteksi dan pemantauan yang dikembangkan terbukti mampu mendeteksi rip current dan memantau risikonya terhadap manusia secara *real-time* dengan performa yang baik, selama digunakan dengan konfigurasi kamera yang sesuai, yakni menghadap langsung ke laut. Penelitian ini memberikan kontribusi dalam pengembangan peringatan dini keselamatan pantai yang dapat membantu mitigasi kecelakaan akibat rip current.

Kata Kunci: rip current, deteksi objek, YOLO11, AABB Collision Detection

ABSTRACT

Rip currents are one of the leading causes of coastal drowning incidents and are difficult to recognize visually by the general public. This phenomenon often does not appear clearly on the water surface, making it challenging for beach visitors to identify it directly. The lack of effective early warning systems and visual monitoring further increases the risk of accidents. Various studies have proposed rip current detection methods; however, most are still based on static images that do not account for continuous water movement, making them less effective for real-time detection in real-world conditions.

This study proposes a rip current detection method based on the YOLO11 algorithm, combined with Axis-Aligned Bounding Box (AABB) Collision Detection to detect and monitor the presence of humans in rip current zones in real-time. The data used in this research were obtained from video recordings at Drini Beach and secondary datasets, followed by annotation with the assistance of experts. The model was trained using images resized to 640x640 pixels over 300 epochs. The model was evaluated using precision, recall, and mAP50 metrics, and validated with additional two-minute video data under varying visual beach conditions. Post-processing using AABB Collision Detection was applied to monitor potential overlaps between human objects and rip currents.

The results show that the model achieved an mAP50 of 95.8%, precision of 94.9%, and recall of 92%. Validation using additional data demonstrated the best performance at Nglolang Beach, with a precision of 89.42%, recall of 92.08%, and accuracy of 83.04%, while performance decreased during tests at Kukup Beach, with precision of 69.14%, recall of 77.41%, and accuracy of 66.03%. Post-processing evaluation indicated that AABB Collision Detection could accurately detect object overlaps without adding significant computational load. Based on these findings, the developed detection and monitoring system proved capable of identifying rip currents and assessing their risk to humans in real-time with good performance, provided the camera configuration faces directly toward the sea. This research contributes to the development of computer vision-based coastal safety systems that can assist in mitigating accidents caused by rip currents.

Keywords: *rip current, object detection, YOLO11, AABB Collision Detection*