PENGEMBANGAN MODEL *HYBRID CONVOLUTIONAL CAPSULE NETWORK* UNTUK DETEKSI MULTI-OBJEK PADA CITRA TERMAL

SKRIPSI

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Sarjana Teknik (S.T.) pada Program Studi Sistem Telekomunikasi

Oleh:

Muhammad Gelvan Alfiandi

2104425

PROGRAM STUDI SISTEM TELEKOMUNIKASI

KAMPUS UPI DI PURWAKARTA

UNIVERSITAS PENDIDIKAN INDONESIA

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LEMBAR HAK CIPTA

Pengembangan Model *Hybrid Convolutional Capsule Network* Untuk Deteksi Multi-Objek Pada Citra Termal

Oleh:
Muhammad Gelvan Alfiandi

Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Teknik pada Program Studi Sistem Telekomunikasi

LEMBAR PENGESAHAAN

Muhammad Gelvan Alfiandi

2104425

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Disetujui dan Disahkan oleh Pembimbing:

Pembimbing I:

Galura Muhammad Suranegara, S. Pd., M. T.

NIP. 920190219920111101

Pembimbing II:

Endah Setyowati, S.T., M. T.

NIP. 920190219920908201

Mengetahui,

Ketua Program Studi Sistem Telekomunikasi

Galura Muhammad Suranegara, S. Pd., M. T.

NIP. 920190219920111101

ABSTRAK

Pencitraan termal memainkan peran penting dalam berbagai aplikasi, termasuk pengawasan, navigasi otonom, dan pemantauan keselamatan pejalan kaki. Studi ini menyajikan implementasi *Hybrid Convolutional Capsule Network* (HCCN) untuk deteksi multi-objek dalam citra termal, dengan fokus pada klasifikasi objek *human* dan *cyclist*. Model dievaluasi menggunakan metode 6-*Fold Cross-Validation*, yang memastikan distribusi kelas objek yang seimbang di seluruh *subset* validasi. Pendekatan *Stratified K-Fold* digunakan untuk menjaga distribusi ini, sehingga penilaian model tetap adil dan tidak bias. Temuan ini menegaskan bahwa HCCN mampu melakukan generalisasi dengan baik dalam berbagai skenario pencitraan termal, menjadikannya solusi yang andal untuk tugas deteksi multi-objek di dunia nyata. Penelitian di masa depan dapat berfokus pada penanganan ketidakseimbangan kelas melalui teknik augmentasi data atau *class weighting*, guna lebih meningkatkan kinerja deteksi, terutama untuk kelas dengan jumlah data yang lebih sedikit.

Kata Kunci— Citra Thermal, Deteksi Objek, Deteksi Multi-Objek, *Machine Learning*, *Deep LearnIing*

ABSTRACT

Thermal imaging plays a crucial role in various applications, including surveillance, autonomous navigation, and pedestrian safety monitoring. This study presents the implementation of a Hybrid Convolutional Capsule Network (HCCN) for multi-object detection in thermal images, focusing on the classification of human and cyclist objects. The model was evaluated using 6-Fold Cross-Validation, ensuring a balanced distribution of object classes across all validation subsets. A Stratified K-Fold approach preserved this distribution, ensuring fair and unbiased model assessment. These findings highlight HCCN's capability to generalize well across different thermal imaging scenarios, making it a robust solution for real-world multi-object detection tasks. Future research could focus on addressing class imbalance through data augmentation or class weighting strategies to further enhance detection performance, particularly for minority classes.

Keywords— *Thermal Imaging, Object Detection, Multi-Object Detection, Machine Learning, Deep Learning*

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