UNDERGRADUATE THESIS

DETECTION OF THE INDONESIAN SIGN LANGUAGE (BISINDO) ALPHABET USING THE DETECTION TRANSFORMER (DETR)

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ABSTRACT

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Indonesian Sign Language (BISINDO) is the primary language used by the deaf community in Indonesia. However, the communication gap between BISINDO users and the general public remains a challenge that has not yet been fully resolved. This study develops a real-time BISINDO alphabet detection system using the Detection Transformer (DETR) architecture with a ResNet-50 backbone, featuring a single-layer transformer encoder-decoder and 25 object queries, trained to recognize 26 letters (A–Z) and 17 BISINDO words. The research was conducted under two training scenarios: Scenario 1 without on-the-fly augmentation and Scenario 2 with on-the-fly augmentation, which includes spatial and photometric transformations. Evaluation was performed using standard PyCOCOTools metrics, along with real-time robustness testing under three conditions: normal conditions with the same subject, dynamic lighting variations, and subjects different from the training data. PyCOCOTools evaluation results show that Scenario 2 with augmentation outperforms in nearly all key metrics: AP@[IoU=0.50:0.95] of 0.7188 (vs 0.6772), AP@0.75 of 0.9192 (vs 0.8118), AR@maxDets=100 of 0.7949 (vs 0.7219), with the most significant improvements observed for medium-sized objects, where the medium AP increased by 27.6% and the medium AR by 31.7%. In real-time testing, Scenario 2 maintained a 100% detection success rate across all test conditions, while Scenario 1 only achieved 34.9% under the most challenging condition, different subjects with varying lighting. The developed system runs at 30–60 FPS on a GPU and 5–9 FPS on a CPU, and is implemented in a web-based interface using Streamlit. This study concludes that on-the-fly augmentation plays a crucial role in building models that are not only superior in metrics but also reliable and generalize well to real-world conditions.

Keywords: Alphabet, BISINDO, DETR, On-the-Fly Augmentation, Real Time, Streamlit

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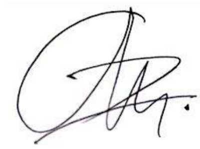

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AP50	:	Average Precision at IoU threshold 0.5
AP75	:	Average Precision at IoU threshold 0.75
AP50-95	:	Average Precision at IoU threshold 0.50–0.95
IoU	:	ntersection over Union, a metric for bounding box overlap
x, y	:	Bounding box center coordinates (horizontal, vertical)
w, h	:	Bounding box width and height
x_{norm}, y_{norm}	:	Normalized bounding box center coordinates (0–1)
H, S, V	:	Hue, Saturation, Value in the HSV color space
α	:	Brightness factor in Color Jitter
β	:	Contrast factor in Color Jitter
γ	:	Saturation factor in Color Jitter
δ	:	Hue factor in Color Jitter
H, W, C	:	Image height, width, and number of channels
d	:	Latent dimension in the feature embedding (256)
N	:	Number of object queries (25 in this study)
C	:	Number of predicted classes (44 = 43 + no-object)
b_{GT}	:	Ground truth bounding box
b^{i}	:	Predicted bounding box from the i-th query
p^i(c)	:	Prediction probability of the i-th query for class c
L_{box}	:	Bounding box loss
λ_{L1}	:	Weight for the L1 loss component
λ_{iou}	:	Weight for the GIoU loss component
L_{GIoU}	:	Generalized IoU loss
L_{cls}	:	Classification loss
L_{match}	:	Matching cost between ground truth and prediction
σ^	:	Optimal pair permutation produced by the Hungarian Algorithm