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Compute-Aware Evaluation of Severity Conditioning and Lightweight Architectures for Real-World Image Deraining

[IIUM Engineering Journal](#) • Article • Open Access • 2026 • DOI: 10.31436/iiumej.v27i3.4689 [Gunawan, Teddy Surya](#)^a ; [Kartiwi, Mira](#)^b^a Department of Electrical and Computer Engineering, Kulliyah of Engineering, International Islamic University Malaysia, Kuala Lumpur, Malaysia[Show all information](#)

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Abstract

Image deraining for embedded perception must balance restoration quality against complete inference cost. Yet density-conditioned methods require annotations unavailable for captured rain, while efficiency studies often omit conditioning-signal cost. This study examines whether label-free severity conditioning justifies its end-to-end cost and whether complexity measures predict realized latency. Under a common L₁ protocol, we compare a PReNet baseline with scalar feature-wise linear modulation, spatial severity modulation (SSM), a matched-capacity constant-map control, and two lightweight architectures. Zero-, shuffled-, and constant-prior interventions test SSM's dependence on prior presence, image correspondence, and spatial structure. Six models were trained for 100 epochs on 10,000 LHP-Rain patches using three seeds and evaluated on the 1,000-image test split. SSM achieved 31.775 ± 0.109 dB, compared with 31.741 ± 0.095 dB for Base and 31.754 ± 0.102 dB under zero-prior replacement. A seed-level equivalence analysis based on paired image differences

supported practical equivalence between SSM and Base (95% CI: -0.026 to 0.094 dB; margin fixed before primary analysis: ± 0.1 dB), consistent with the half-scale experiment. The two-stage model reduced computation from 265.0 to 44.6 GFLOPs and model latency from 20.43 to 4.50 ms, but the prior generation increased total latency to 24.74 ms. CBAM-light required 14.1 GFLOPs yet recorded 33.68 ms. The label-free statistic achieved a cross-scene AUC of 0.772 on RealRain-1k, indicating moderate agreement with density labels. Thus, severity-conditioned and lightweight deraining systems should be assessed through verified prior use and measured end-to-end latency rather than accuracy, parameters, or GFLOPs alone. Copyright (c) 2026 IIUM Press. This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License. <https://creativecommons.org/licenses/by-nc/4.0/>

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End-to-End Latency; Image Deraining; Lightweight Architectures; Real-World Rain; Severity Conditioning

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