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CSE 498A: Literature Review Records

Student's Id and Name	22234103382, Umma Sumaiya Riya
Capstone Project Title	High-Efficiency Micro-Expression Recognition for Automated Human Behavior Analysis Systems.
Supervisor Name & Designation	Md. Mijanur Rahman, Assistant Professor
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Aspects	Paper # 24 HMRM: A Hybrid Motion and Region-Fused Mamba Network for Micro-Expression Recognition) [Published Year: 2025 Publisher: Elsevier (Digital Signal Processing)]
Problem Statement	Micro-expression recognition (MER) is extremely difficult because facial micro-expressions are low-intensity, short-duration, and easily affected by noise and low motion amplitude. Existing MER models struggle to capture subtle motion, handle limited datasets, and model long-range temporal dependencies efficiently. The authors aim to build a lightweight but highly accurate MER framework that can capture fine motion, enhance data diversity, and fuse region-specific features effectively..
Key Contributions	The core contributions of this paper are: (i) a Hybrid Motion Feature Augmentation (HMFA) module combining a GRU-Attention Optical Flow Estimator and MotionMix augmentation,

	<p>(ii) a Grained Mamba Encoder for efficient sequence modeling with low computational cost,</p> <p>(iii) a Region Feature Fusion Strategy (RFFS) that fuses multi-scale regions for better discrimination, and</p> <p>(iv) achieving state-of-the-art performance on multiple MER benchmark datasets.</p>
Methodology/Theory/Framework	<p>The authors proposed the HMRM framework, consisting of a GRU-Attention Optical Flow Estimator to generate clean and high-quality motion features, followed by MotionMix augmentation for region-level motion mixing. The processed flow maps are then encoded using a Grained Mamba Encoder, which models long-range dependencies efficiently. Finally, a Region Feature Fusion Strategy integrates coarse and fine region-level features using multi-head attention, and classification is performed with a Multi-Scale Weighted Cross-Entropy loss.</p>
SoftwareTools/Setup Details	<p>Ubuntu 20.04.1 operating system, Intel Xeon Gold 6271C CPU, NVIDIA RTX 4090 GPU, Python, PyTorch framework, Dlib for landmark extraction, and MTCNN for face alignment. GRU-AOFE was pretrained on FlyingChairs and FlyingThings datasets</p>
Test/Experiment Analysis	<p>Experiments were conducted using the Leave-One-Subject-Out (LOSO) protocol on CASME II, SMIC-HS, SAMM, and the Composite Dataset. Evaluation metrics included UF1 and UAR.</p> <p>Training used AdamW optimizer, learning rate 0.0005 with dynamic scheduling, weight decay 0.01, 1000 epochs, and Mamba settings: embedding dimension 192, depth 4, state dimension 16. Region-based analysis was performed using coarse (4-region) and fine (16-region) partitions. GRU-AOFE and MotionMix showed strong improvements in ablation experiments.</p> <p>Accuracy:</p> <ul style="list-style-type: none"> • CASME II: 0.9561 UF1, 0.9588 UAR • SAMM: 0.8909 UF1, 0.9017 UAR • Composite: 0.8788 UF1, 0.8906 UAR • SMIC-HS: 0.7491 UF1, 0.7759 UAR

Test Data/Dataset Source	<p>CASME II: 247 samples (200 fps, 280×340) SMIC-HS: 164 samples (100 fps, 150×190) SAMM: 159 samples (high-resolution 2040×1088) Composite Dataset: MEGC2019-based merged dataset with 442 samples (Negative, Positive, Surprise classes)</p>
Final Result (Assessment Criteria Wise)	<ul style="list-style-type: none"> • The model achieved state-of-the-art performance in MER using motion enhancement (GRU-AOFE, MotionMix), efficient sequence modeling (Mamba), region-aware fusion (RFFS), and multi-scale loss design. The framework demonstrated strong accuracy, robust region-based discrimination, improved motion quality, and computational efficiency across all datasets.
Limitations (List the limitations the authors mentioned in the article)	<ul style="list-style-type: none"> • The model performs poorly on low-resolution datasets, relies on accurate face alignment and apex frame detection, and uses fixed region partitions. It has no explainability module, limited real-world evaluation, and relies on landmark accuracy.
Final Summary	<p>S. Guo et al. proposed HMRM, a motion-enhanced and region-fused micro-expression recognition model combining GRU-Attention optical flow, MotionMix augmentation, and a Grained Mamba Encoder. The framework efficiently captures subtle facial motions while maintaining low computational cost. Using LOSO evaluation, the model achieved state-of-the-art accuracy on CASME II, SAMM, and the Composite dataset. Region Feature Fusion further improved fine-grained discrimination, and ablation studies verified the importance of each module. However, performance decreases on low-resolution data, and the model relies heavily on accurate apex frame detection and landmarks. The system lacks explainability and real-world testing. Overall, HMRM is a highly effective and efficient MER framework offering strong motion modeling and region-based learning.</p>