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| Algorithm 1 Pseudo code of the hybrid MCICNet-LightGBM model |
| **Require:** Retinal fundus image dataset $D=\{(X\_{i},y\_{i})\}\_{i=1}^{N}$, where $X\_{i}$ represents the input image and $y\_{i}$ the corresponding label |
| **Ensure:** Trained MCICNet-LightGBM model |
| 1: | **Feature Extraction with MCICNet** |
| 2: | Initialize MCICNet with input $X\in R^{96×96×3}$ |
| 3: | Apply Residual Multi-scale Feature Fusion Module: $X\leftarrow RMFFM(X)$ |
| 4: | **for** each $k$ in {32, 64, 128, 256} **do** |
| 5: |  Configure involution parameters: group number, kernel size, stride, reduction ratio |
| 6: |  Apply Residual Hybrid Convolutional-Involutional Module: $X\leftarrow RHCIM(X, k)$ |
| 7: | **end for** |
| 8: | Extract feature tensor $F=Flatten(X)$ |
| 9: | **Train LightGBM Classifier** |
| 10: | Prepare training set: $F\_{train}=extract\\_features(MCICNet, X\_{train})$ |
| 11: | Prepare validation set:$F\_{val}=extract\\_features(MCICNet, X\_{val})$ |
| 12: | Prepare test set:$F\_{test}=extract\\_features(MCICNet, X\_{test})$ |
| 13: | Convert to LightGBM dataset: |
| 14: |  $D\_{train}=\{(F\_{i},y\_{i})|i\in train set\}$ |
| 15: |  $D\_{val}=\{(F\_{i},y\_{i})|i\in val set\}$ |
| 16: | Train LightGBM model: |
| 17: |  $LGBM\leftarrow lgb.train(D\_{train},D\_{val})$ |
| 18:  | **Evaluate Model Performance** |
| 19: | Predict on test set |
| 20: | Compute metrics |
| 21: | **return** Trained MCICNet-LightGBM model |