

Machine Learning-Based Approach for Person Re-Identification

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Abstract—The research develops a time-efficient Re-ID technique that uses manually constructed wavelet transform features for person identification. The approach uses Discrete Wavelet Transform (DWT) to obtain spatial-frequency features from images of persons before reducing dimensions through Principal Component Analysis (PCA). The machine learning models XRT and DRF together with GBM and XGBoost receive training using reduced features extracted with PCA. Testing outcomes indicate the system delivers promising results on accuracy performance through XGBoost as its primary model outcompetes other approaches in both Rank-1 and Rank-5 accuracy standards.

Index Terms—Person re-identification, Fourier transform, Wavelet transform, Principal Component Analysis, Feature extraction, Rank-1 accuracy, XGBoost, Ensemble Learning, Feature Extraction, CMC Curves.

I. INTRODUCTION

Person Re-Identification (Re-ID) functions as an essential capability within intelligent video surveillance systems by identifying people between separate camera viewpoints which might operate at different time periods. The identification process proves to be difficult because multiple factors including lighting conditions and camera viewpoints together with body orientation and occlusion levels and background interference and variations in clothing cause numerous difficulties. Successful and reliable Re-ID systems creation stands as an essential priority for public safety and security together with smart city applications and public safety. Deep learning solutions have proven effective for recent state-of-the-art achievements yet they present important obstacles for implementation. These techniques need vast sets of labeled data together with substantial computational power to conduct training operations and operational phases. Embedded systems and mobile platforms together with developing regions' surveillance operations lack sufficient resources so the requirement exists for lightweight efficient alternatives. This research develops a person Re-ID solution which combines handcrafted features and ensemble models as part of a machine learning approach. The feature extraction process begins with person image processing through Fast Fourier Transform (FFT) and Discrete Wavelet Transform (DWT) signal techniques. The global frequency structure of images is best obtained through FFT analysis yet Wavelet Transform excels at maintaining spatial details at multiple scales of resolution. Thankyou to frequency-domain analysis we obtain features which we enrich through calcula-

tion of each transformed component's statistical measurements including mean variance and energy quantity. After extracting features the system applies PCA for dimensionality reduction to transform high-dimensional feature vectors into a minimal yet informative space which represents maximum variance. The process decreases both computation intensity and improves generalized performance by removing feature noise and redundancy. The ensemble of robust machine learning models receives reduced feature vectors as input for training purposes using XRT in combination with DRF and GBM and XGBoost. The models show superb capabilities in structured tabular data classification tasks because of their specific design for managed data types. The ensemble learning structure enables these models to extract discriminative patterns from handcrafted features regardless of needing end-to-end deep networks because of their error correction capabilities and variance reduction and regularization strengths. The proposed pipeline's performance gets evaluated through standard Re-ID metrics where we analyze both CMC curves together with evaluations of Rank-1 and Rank-5 accuracy scores. The findings indicate this compact implementation matches prevalent performance outcomes thus representing an acceptable substitute for deep learning procedures within surveillance settings with limited resources.



Fig. 1. Sample images from the dataset showing person re-identification scenario.

II. METHODOLOGY

The analysis of person re-identification uses handcrafted feature extraction methods as a starting point which then trains ensemble machine learning models as its conclusion.

A. Dataset

Research tests are proposed for method through evaluation of data obtained specifically for person re-identification tasks. The images within this dataset display all three conditions which provide optimal conditions for testing re-identification methods. The acquired dataset excels at person recognition between different non-overlapping cameras particularly because it aids security together with law enforcement and retail analytics operations.

A total of more than **one million** images are present along with approximately **1250** unique identities. Identical identities contain different numbers of images that show variations in body positions and apparel types as well as environmental contexts. All collected images represent how cameras would capture subjects in actual monitoring conditions. This dataset contains images which have low resolution along with compression format while measuring **128 pixels by 256 pixels**. The images contain multiple light condition types that consist of daytime and nighttime and low-light scenarios and varying brightness levels. The images are in **JPG** format.

B. Feature Extraction using Fourier Transform

Each image underwent simulation using Fast Fourier Transform (FFT) which transformed its spatial data to frequency domain. The Fast Fourier Transform identifies overall patterns of frequencies to extract the structural aspects of edges and contours. The transformed frequency domain enabled calculation of statistical indicators for mean and variance and energy to effectively represent each image content.

C. Feature Extraction using Wavelet Transform

Multi-resolution analysis used Discrete Wavelet Transform (DWT) as its processing method. The spatial characteristics together with frequency information captured by DWT set it apart from FFT thus making it effective for detail preservation. The resolution analysis of each image generated four sub-bands comprising approximation (cA) and horizontal (cH) and vertical (cV) as well as diagonal (cD). A complete and localized feature representation emerged from these extracted statistical features of every sub-band.

D. Dimensionality Reduction using PCA

PCA was employed to decrease computational complexity and eliminate redundant features in the extracted features. PCA conducted a dimensionality reduction that shifted the feature vectors into a lower space which maintained the most vital variance. The reduction of dimensions through this step improved model training performance and protected from overfitting issues caused by noisy or irrelevant features.

E. Model Training

The principal component analysis reduced the extracted feature vector dimensionality which generated a compact set for training and evaluation of ensemble machine learning models. Structured data benefits most from ensemble models because

these models enhance predictive performance outcomes by leveraging multiple base learners.

We choose Extremely Randomized Trees (XRT) Distribute Random Forest (DRF) Gradient Boosting Machine (GBM) and XGBoost as our four main ensemble algorithms for model training.

Ensemble Learning Models:

Extremely Randomized Trees (XRT): Induction of XRT stems from standard random forest models. XRT adds more randomness through selecting both random subsets of features and performing random threshold selection rather than finding optimal splits. The approach generates diverse tree collections which decreases both modeling errors and data overfitting. The training conducted by XRT becomes more efficient due to its capability of skipping time-intensive split optimization procedures.

Distributed Random Forest (DRF): As a classical bagging-based algorithm DRF creates multiple decision trees from randomly sampled subsets of input data. Decision trees are trained separately so their predictions unite through majority voting in classification to enhance generalization results. DRF excels at parallel processing and demonstrates reliable performance on large datasets because of its scalability together with its resistant nature towards noise.

Gradient Boosting Machine (GBM): GBM trains its sequential ensemble through a method that deploys new trees to tackle the remaining errors which result from previous trees. The each iteration of gradient-based optimization concentrates on hard-to-classify examples for enhancing model accuracy incrementally. GBM produces exceptional predictive results when professionals apply proper adjustment strategies.

XGBoost (Extreme Gradient Boosting): The advanced XGBoost system represents an improved version of gradient boosting which includes various new algorithmic features. Multipurpose features such as regularization (L1 and L2) together with shrinkage (learning rate) and column subsampling alongside tree pruning serve to stop overfitting while ensuring better model generality. XGBoost operates with exceptional speed and parallel processing ability which outperforms conventional boosting protocols regarding performance and scalability.

Evaluation Metrics: The evaluation methodology included established metrics that allowed assessment of model effectiveness within person re-identification systems. Authentication of the targeted identity became possible through the analysis of Cumulative Matching Characteristic (CMC) curves which evaluated system retrieval performance. The assessment included Rank-1 crucial statistics determining first place and Rank-5 accuracy statistics measuring correct identification within the first five results. These measurement methods provide both an extensive view and a simple understanding about the model's precision along with its suitability for real-world security operations.

III. DISCUSSION

Wavelet-based features present an ideal representation solution for person re-identification because of their powerful yet comprehensible characteristics. The localized pattern detection of DWT at various resolution levels makes this method better than global descriptors such as FFT for distinguishing people in different situations. The PCA step maintains essential variations in the data by ensuring computational efficiency of the system. Ensemble classifiers obtain exceptional results on structured data by employing XGBoost because this algorithm reduces overfitting with its integrated regularization functions. The proposed method stands out because of its ease of implementation and operational effectiveness thus becoming suitable for practical deployment in locations with inadequate hardware or limited data.

IV. RESULTS

V. CONCLUSION

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