Siamese Neural Network based Gait Recognition for Human Identification

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1. Introduction

- As the remarkable characteristics of remote accessed, robust and security, gait recognition has gained significant attention in the biometrics based human identification task.
- The existed methods mainly employ the hand-crafted gait features, which cannot well handle the indistinctive inter-class differences and large intra-class variations of human gait in real-world situation.
- To this end, we present one of the first attempts to study the Siamese neural network (SiaNet) based gait recognition framework for human identification with distance metric learning.
- Different from conventional CNN, the Siamese network can employ distance metric learning to drive the similarity metric to be small for pairs of gait from the same person, and large for pairs from different persons.
- In the end-to-end framework, we leverage the competitive Gait Energy Image (GEI) presentation as the input of network while holistically exploit the Siamese neural network to learn effective feature representations for human identification.

2. Conventional CNN based Gait Recognition

- **Approach**
  - We attempt to fine-tune the conventional CNN on the gait database for gait recognition based human identification task. Differently, we change the output of CNN to the number of subjects in the gait database.
- **Problems**
  - **Data limitation.** CNN requires a mass of training data for all categories. For gait recognition, the number of subjects can be large, while with only a few examples per subject in public database.
  - **Domain gap.** Gait recognition for human identification is essentially a search problem but not classification.

3. Siamese Neural Network based Gait Recognition

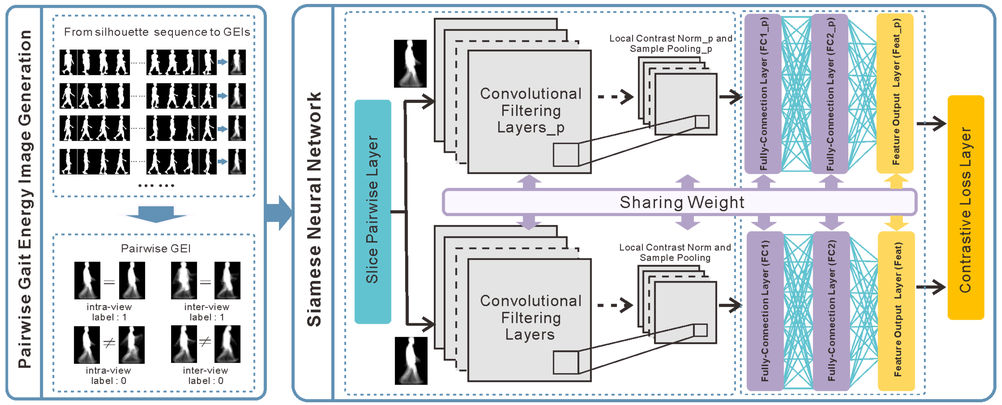

Fig.1 The framework of our proposed gait recognition method.

- **Solutions**
  - To solve the data limitation problem, we use GEI instead of raw sequence of human gait, which can remove most noisy information while keep the major human shapes and body changes during walking.
  - To close the domain gap between recognition and classification, we adopt the Siamese neural network, which can simultaneously minimize the distance between similar subjects and maximize the distance between dissimilar pairs with a distance metric learning architecture.
- **The Structure of the Siamese Neural Network**
  - The Siamese neural network designed for gait recognition contains two parallel CNN architectures sharing the same parameters.
  - The input of the network are pairwise GEIs with similar or dissimilar labels.
  - The output of the CNNs are combined by the contrastive layer to compute the contrastive loss.
- **Training and Learning**
  - The distance $E_W(x_1, x_2)$ between a pair of GEIs can be measured by:

$$E_W(x_1, x_2) = \left\| S_W(x_1) - S_W(x_2) \right\|_2^2$$

  - We can define the contrastive loss function as follows:

$$\mathcal{L}(W) = \sum_{i=1}^{P} L(W, (y, x_1, x_2)^i)$$

$$L(W, (y, x_1, x_2)^i) = (1-y) \cdot \max(m - E_W(x_1, x_2)^i, 0) + y \cdot E_W(x_1, x_2)^i$$

  - The contrastive loss function can be minimized over a set of training pairs using stochastic gradient descent.

4. Experiments

- **OULP-C1V1-A Gait Database**
  - Contains the world's largest number of subjects (3835).
  - Records two sequences for each subject: probe (query) and gallery (source) sequence with 4 observation angles.
- **Pipeline**
  - Foreground segmentation → Periodic identification → GEIs generation → SiaNet training using gallery set → Feature extraction → K-Nearest-Neighbor searching
- **Evaluation on Intra-view Human Identification**

	Rank-1 Identification Rate (%)					Rank-5 Identification Rate (%)				
Method	55°	65°	75°	85°	All	55°	65°	75°	85°	All
HWLD	—	—	—	87.70	95.50	—	—	—	94.70	**98.50**
GEI	84.70	86.63	86.91	85.72	94.24	92.39	92.84	92.78	93.01	97.13
FDF	83.89	85.49	86.59	85.90	94.17	91.53	92.81	92.88	92.83	97.10
CNN.FC1	73.96	76.71	77.87	78.82	86.09	86.64	88.67	89.39	90.09	93.56
SiaNet.FC	**90.12**	**91.14**	**91.18**	**90.43**	**96.02**	**94.98**	**95.90**	**95.92**	**95.97**	98.31

Table.1 Comparison results of different methods in terms of the Rank-1 and Rank-5 Identification Rates

- **Evaluation on Inter-view Human Identification**

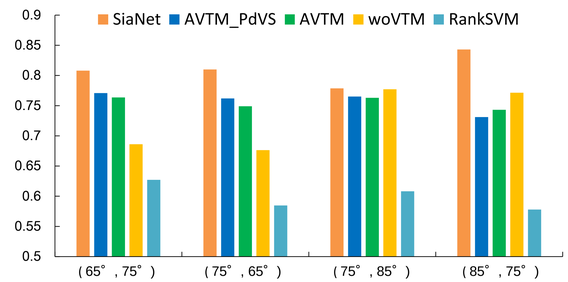

Fig.2 Comparison of the cross-view matching approaches on different types of inter-view test in terms of Rank-1 Id-Rate.

5. Conclusions and Future Works

- We have developed a Siamese neural network based gait recognition framework for human identification with distance metric learning, which outperforms the state-of-the-arts on the world's largest challenge gait database.
- In the future, we will try to train 3-Dimensional Siamese neural network with more training dataset to further improve the performance of the gait recognition.