氏名	YEOH TZE WEI
学位の種類	博士（工学）
学位記番号	甲第 692 号
学位授与の日付	平成３０年３月２０日
学位授与の要件	信州大学学位規程第５条第１項該当
学位論文題目	Covariate-invariant gait analysis for human identification （人識別を目的とする共変量不変歩行解析）
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論 文 内 容 の 要 旨

Gait recognition has been an active research topic in recent years. It has attracted increasing attention as it is an unobtrusive biometric that can be captured from distance and without the need of interaction with the subject. As a result, gait has become one of the latest promising biometric. However, the practical deployment in real-time surveillance and security access control applications are still considered a challenging task because of the presence of covariate factors such as different clothing types, carrying conditions, walking surfaces, camera viewpoint and walking speed with respect to the subject. This is mainly because of the variations will alter an individual's appearance and increase the difficulty of gait recognition.

The goal of this thesis is addressing the problem of covariate factors that affect gait recognition performance. In particular, we aim to extract the gait characteristics of the human for recognition under variable covariate conditions. For this purpose, an efficient covariate factor mitigation framework is proposed. First, we propose a feature extraction method for robust gait recognition against different covariate factors. We then adapt feature selection methods to select a subset of the most relevant gait features which further reduces the effect of covariate factors of gait recognition, and hence improves the overall performance. Furthermore, we are also interested in exploring the use of deep learning techniques to extract gait signatures for recognition. Therefore, the contributions of this thesis are divided in three parts.

In the first part, we focus on modelling gait dynamics and eliminating the effect of the covariates by designing a simple yet efficient model-based gait recognition system. The proposed approach can handle occluded silhouette either from self-occluded or those by objects which usually present significant challenges for other conventional approaches. Hence, it shows robust performance against various covariate factors in SOTON covariate database and also outperforms other state-of-the-art algorithms.

However, the recognition task can become complicated due to the existence of challenging covariate factors. For instance, clothing type has been demonstrated to be the most challenging one. This is because it can occlude a significant amount of gait features and combined with the location of occlusion, which may differ for different covariate factors, relevant gait features may become irrelevant when the covariate factor changes, and exploiting them can hinder the recognition performance. Therefore, feature selection has become an important step to make gait analysis more manageable and to extract useful information for the classification task. In the second part of the thesis, we present an empirical approach to evaluate the degree of consistency among the performance of different selection algorithms in the context of gait identification under the effect of various covariate factors. In addition, we systematically compare the feature subsets selected by six

popular selection methods and the computational cost of different selection approaches. We present a performance measure method via statistical and mixed-model analysis to examine the feature selection across different classifiers and covariates. Then, we investigate the effectiveness of feature selection approaches through extensive experiments on two well-known benchmark databases: the SOTON covariate database and the CASIA-B dataset. Our experimental results show that feature selection approaches significantly improve the overall performance of gait recognition, also obtains results that are comparable to other state-of-the-art recognition approaches.

In recent years, deep learning has gained significant attention from the computer vision community. This is because deep learning models are capable of learning multiple layers of feature hierarchies by constructing high-level features from low-level features. Hence, they are more generic since the feature construction is fully automated. Specifically, many recent studies have shown promising results for applying deep learning approaches to a variety of applications (e.g. image classification, text classification, natural language processing, scene labeling, etc.). Therefore, in the last part of the thesis, we propose the use of convolutional neural network (CNN) for gait recognition task. Inspired by the great success of CNNs in image classification tasks, we feed in the most widely used gait representation, that is, the gait energy image (GEI), as the input to the CNN. More specifically, the network structure contains six layers, with three convolutional layers, two fully connected layers and followed by a softmax layer. We conduct our experiments on the CASIA-B dataset and OU-ISIR Treadmill B dataset which includes the largest variations of view angles and clothing of combinations types. The experiment results show that our method can achieve far better performance compared to hand-crafted features in conventional methods with minimal knowledge of the problem required. For clothing variation, we also employ a stacked progressive auto-encoders model to extract clothing-invariant gait feature for recognition. The proposed method is evaluated on the same clothing dataset, the results show that the proposed method can yield good recognition accuracy even when the combination of clothing types get more complicated.

The thesis concludes with a summary of our contributions. Last but not least, we also suggest promising directions for future work related to gait recognition system.