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## Chapter VIII

# Recognition of Gait Patterns Using Support Vector Machines

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## ABSTRACT

*Automated gait pattern recognition capability has many advantages. For example, it can be used for the detection of at-risk or faulty gait, or for monitoring the progress of treatment effects. In this chapter, we first provide an overview of the major automated techniques for detecting gait patterns. This is followed by a description of a gait pattern recognition technique based on a relatively new machine-learning tool, support vector machines (SVM). Finally, we show how SVM technique can be applied to detect changes in the gait characteristics as a result of the ageing process and discuss their suitability as an automated gait classifier.*

# INTRODUCTION

Human walking is a complex process involving numerous interactions of the various elements of the musculoskeletal and neural systems. Gait analysis is a recognized procedure that is conducted to diagnose disability and to assess the effectiveness of a particular rehabilitation procedure. There are mainly two approaches adopted while analysing gait-related data: statistical techniques and machine-learning approaches (e.g., neural networks, fuzzy logic, evolutionary technique (e.g., genetic algorithm) or support vector machine). There have been also some attempts to combine more than one of the machine-learning techniques (to work in a hybrid model) so that these techniques can complement each other to deliver better outcomes. The vast majority of the works in gait analysis have been based on traditional statistical techniques because of their clear advantage of providing much greater insight into the models and the ease of studying the effects of various variables. However, machine-learning approaches are increasingly becoming widespread in recent times, especially because of their non-linear modelling capabilities. Another advantage of a machine-learning approach is that the predictive models can be built without much *prior* knowledge about the distribution of the data, which makes it particularly suitable for modelling complex motions such as those involved in the dynamics of human gait.

In this chapter, a relatively new machine-learning technique based on statistical learning theory (Vapnik, 1995), support vector machine (SVM), is described and then we apply it to the task of automated recognition of gait pattern changes due to ageing. The SVM technology has been shown to have a much better ability in building superior predictive models. This is due to the fact that in SVM techniques, an optimal separating hyperplane is determined that is expected to result in superior generalization performance on unseen data. It is also very effective in situations when the dimension of the input data is relatively high and the number of observations available for developing and training the models is limited (c.f., Zavaljevski et al., 2002).

# BACKGROUND

## Swing Phase and the MFC During Gait

The swing phase is an important phase of the gait and its analysis can offer much useful information, especially when studying the gait characteristics related to trips and related falls. Tripping during walking has been identified to account for >50% of all falls (Owings et al., 1999). Minimum foot clearance (MFC) during walking (see Figure 1), which occurs during the mid-swing phase of the gait cycle is defined as the minimum vertical distance between the lowest point on the shoe and the ground. The MFC has been identified as an important gait parameter in the successful negotiation of the walking environment, including obstacles and uneven surfaces. There are two main reasons for this. First, it has been estimated that the mean MFC value is quite low in magnitude (1.11 - 1.29 cm) in both young and older adults. Second, during this MFC event the foot travels at its maximum velocity (Winter, 1991). This small mean MFC value combined with the variability in MFC data (.5-.62cm) has the potential to cause tripping during walking, especially for unseen obstacles or obstructions. The literature relating to the MFC event

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