Chapter 2
Evolutionary Algorithms for Multisensor Data Fusion

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ABSTRACT

The aim of Multisensor Data Fusion (MDF) is to eliminate redundant, noisy or irrelevant information and thus find an optimal subset from an array of high dimensionality. An important feature of MDF is that the signals are constantly evolving instead of being static. This provides an opportunity for Evolutionary Computation (EC) algorithms to be developed to solve MDF tasks. This chapter describes the application of three EC algorithms to widely used datasets. Comparative studies were performed so that relative advantage and disadvantages of the different approaches could be investigated. From this study, authros found that ECs performed in the feature selection stage can greatly reduce the dataset dimensionality and

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hence enhance the MDF system performance; when being used in a way to represent knowledge, ECs can dramatically increase rules when input data are not clustered.

INTRODUCTION

The emergence of new sensors, coupled with advanced processing techniques and improved processing hardware has meant that Multisensor Data Fusion (MDF) technology has undergone rapid growth since the late 1980s (Huang, Lan, Hoffmann, & Lacey, 2007); nevertheless, the field is still in its infancy. In general, MDF is a technique by which data from a number of sensors are combined through a centralized data processor to provide comprehensive and accurate information. Sensors can be located in different ways (collocated, distributed, mobile) producing measurements of the same or of different type. Among these, the fusion of passive sensor data (for example from an electronic nose or EN), especially in the context of defence and security, is of particular importance.

Usually a sensor element operates by measuring a physical or (bio-) chemical property and outputting an analog signal which is amplified, filtered and then converted to a digital signal by the analog-to-digital (*A/D*) unit (Mitchell, 2007). As a result, sensor responses do not provide information on the nature of the physical property under investigation, but only give a ‘digital fingerprint’, which can be subsequently investigated by means of data processing methods. Another feature of MDF is that, due to recent advances in sensor developments, feature extraction, and data processing techniques, users are always provided with an increased amount of information using multi-sensor arrays. However, even if each sensor is linked to specific classes of compounds, not all the sensors contribute to the characterisation being analysed, as some may contain irrelevant or noisy data (Ballabio, Cosio, Mannino, & Todeschini, 2006). Furthermore, not all sensor responses are equally relevant to the particular Pattern Recognition (PR) classification task. An associated problem with the increased amount of data is known as the curse of high dimensionality (Bishop, 2006; Gardner, Boilot, & Hines, 2005; Scott, James, & Ali, 2006), meaning that increasing the dimensionality rapidly leads to the point where there may not be enough training patterns, in which case a very poor representation of the input/output mapping may be provided.

The aim of MDF is to eliminate redundant, noisy or irrelevant information and thus find an optimal subset from an array of high dimensionality. By optimising the array size, the overall system performance can potentially be increased by maximising the information content and hence increasing the predictive accuracy. Hall and Llinas (2008) have identified three basic alternatives that can be used for multisensor data: (1) direct fusion of sensor data; (2) representation of sensor data via feature vectors, with subsequent fusion of the feature vectors; or (3) processing

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