Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Engineering 15 (2011) 4026 – 4030
Procedia Engineering
www.elsevier.com/locate/procedia
Advanced in Control Engineering and Information Science

A New Evolutionary Computation Based Approach for Learning Bayesian Network

Yungang Zhu[a,b], Dayou Liu[a,b]*, Haiyang Jia[a,b]

[a]College of Computer Science and Technology, Jilin University, Changchun 130012, China
[b]Key Laboratory of Symbolic Computation and Knowledge Engineering of Ministry of Education, Jilin University, Changchun 130012, China

Abstract

Bayesian network is a popular tool for uncertainty process in Artificial Intelligence. In recent years, more and more attention has been paid to learning of Bayesian network. In this paper, we proposed a novel learning algorithm for Bayesian network based on (μ, λ)-Evolution Strategy, we present the encoding scheme and fitness function, designed the evolutionary operators of recombination, mutation and selection. Theoretical analysis and experimental results all demonstrate that the proposed method can learn the Bayesian network from data effectively.

Keywords: Bayesian network; Evolution strategy; Evolutionary computation

1. Introduction

Bayesian network has been a powerful tool for managing uncertainty. It has been successfully applied to expert system, diagnosis system, and decision support system et al. Bayesian network integrates graphical model and probability theory, and it indicates the internal relationship among variables.

In recent years, many researchers pay much attention to the learning algorithm for Bayesian network. Learning the structure of a Bayesian network can be considered a specific example of the general problem of selecting a probabilistic model that explains a given set of data[1].

* Corresponding author.
E-mail address: dyliu@jlu.edu.cn.

1877-7058 © 2011 Published by Elsevier Ltd.
doi:10.1016/j.proeng.2011.08.755

In this paper we proposed a novel learning algorithm for Bayesian network based on Evolution Strategy. In detail, we adopt "(μ, λ)-Evolution Strategy" which is an evolutionary computing method to learn Bayesian network.

The rest of this paper is organized as follows: Section 2 presents brief background knowledge. The method we proposed is described in Section 3. Section 4 presents the experimental results and discussion of the proposed method. Finally, conclusions are summarized in Section 5.

2. Theoretical Background

A Bayesian network (BN) is a graphical model for representing relationships among variables. Let us consider a set of variables $X=\{X_1,X_2,\ldots,X_n\}$, a Bayesian network is a tuple (G , Θ) , where G is a directed acyclic graph (DAG), each node of G represents the variable, and each directed edge represents relationships between variables; and $\Theta=\{ P(X_i \mid \pi_i) ,1\le i\le n \}$ represents the local conditional probability distribution of each node given the values of their parent nodes, where π_i is the parent set of X_i.

Assumed the range of X_i is $\{ x_i^1,\ldots,x_i^{r_i} \}$, the range of π_i is $\{ \pi_i^1,\ldots,\pi_i^{q_i} \}$, the local conditional probability distribution of each node is represented by $\theta_{ijk} = P(X_i = x_i^k \mid \pi_i = \pi_i^j)$, and $\Theta = \bigcup_{i=1}^{n} \bigcup_{j=1}^{q_i} \bigcup_{k=1}^{r_i} \{\theta_{ijk}\}$.

Evolution Strategy (ES) is one of the evolutionary computing methods. ES produces consecutive generations of individual, during a generation a selection method is used to select specific individuals which form the new generation by recombination and mutation [2].

3. Learning Bayesian network based on Evolution Strategy

The problem of learning of Bayesian network can be stated as follows. Assuming that D represent the data, the purpose is to obtain a Bayesian network S that best fit the D.

3.1. Encoding

The Bayesian network structure was encoded into adjacency matrix or adjacency list in previous coding way, but the method will result in a large amount of cyclic graphs which are illegal structures. Based on the coding scheme in [3][4], in this paper, the code is divided into 3 parts.

The 1st part is a sequence of nodes: This order is the reverse of topological sort of the network nodes, so there is no cycle. For example, the sequence of Figure 1 is 54231.

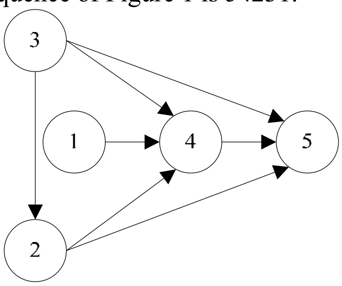

Fig. 1. A simple example of Bayesian network.

The 2nd part has n-1 segments, each segment indicate the parents of each node in the sequence above, the last node has no parent, so only n-1 segments needed. For example, the structure of Figure 1, the second part of code is 1110 111 10 0. segment 1 indicate that for node 5, node 4,2,3 is parent, and Node 1