

ROOTED TREE LINEAR CASCADES

Why

It is natural to look for a class of structural equation models with favorable identifiability and properties.

Definition

A d-dimensional rooted tree linear cascade is a sequence of four objects: a tree on $\{1, \ldots, d\}$, a vertex of the tree, a family of real numbers indexed by the edges of the tree, and a d-dimensional random vector whose covariance matrix is the identity matrix. The cascade is called "d-dimensional" because we associate it with a random vector (defined as a function of that in the form of its definition) whose codomain is \mathbf{R}^d .

The tree together with the vertex form a rooted tree. The graph associated with the rooted tree and the family of real numbers together form a weighted graph.

The idea is to use the weights and the tree structure to recursively define a random vector in terms of elements of the given random vector. Let C = (T, i, w, e) be a d-dimensional rooted tree linear cascade. So T is a tree on $\{1, \ldots, d\}$, $i \in \{1, \ldots, d\}$ and $w : T \to \mathbf{R}$, and $e : \Omega \to \mathbf{R}^d$ for some probability space $(A, \mathcal{A}, \mathbf{P})$. The random vector associated with C is the random variable $x : \Omega \to \mathbf{R}^d$ defined by

$$x_i = e_i$$
 and $x_j = w_{\{pa j, j\}} x_{pa j} + e_j$ for $j \neq i$.

In other words,

$$e = Ax$$

where A is lower triangle and extremely sparse.¹

Notation

Let $(A, \mathcal{A}, \mathbf{P})$ be a probability space. Let $e: A \to \mathbf{R}^d$ be a random vector, let T be a tree on $\{1, \ldots, d\}$ with $a_{ij} = a_{ji}$ the weight on edge $\{i, j\} \in T$.

¹Future editions will clarify the meaning of the term sparse.

