ASYMPTOTIC PROPERTIES OF SEVERAL NONPARAMETRIC MULTIVARIATE DISTRIBUTION FUNCTION ESTIMATORS UNDER RANDOM CENSORING

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1. Introduction

The problem of nonparametric estimation of a multivariate distribution function in the presence of random censoring is considered. The multivariate lifetimes could represent the times to death of animals in fixed-sized litters, the failure times of components in a multicomponent system, the observations of participants of a matched triples study, or the onset times to stages of a disease in a patient. In the special bivariate case, there are the numerous examples of paired data on eyes, lungs, kidneys, twins or married couples. It is possible that the censoring is univariate or multivariate. Whereas the censoring of times to death of animals in litters born at random times yet truncated at a fixed time is an example of univariate censoring, the truncation at a fixed time of measures on the participants in a matched triple study would provide trivariate independent censoring. The study of lifelengths of twins and married couples would provide an example of bivariate censoring with possible dependence between the two censoring variables.

The estimation of one-dimensional distribution function estimators with randomly censored data has been extensively developed. The product-limit estimator was proposed by Kaplan and Meier (1958). Under suitable conditions, asymptotic normality and weak convergence of this estimator was established by Breslow and Crowley (1974) and strong uniform almost sure convergence was proved by Földes and Rejtö (1981).