

Conditional Transformation Models and Non-Proportional Hazards Regression

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In survival analysis, the estimation of patient-specific survivor functions that are conditional on a set of patient characteristics is of special interest. In general, knowledge of the conditional survival probabilities of a patient at all relevant time points allows better assessment of the patient's risk than summary statistics, such as median survival time. Nevertheless, standard methods for analysing survival data seldom estimate the survivor function directly. Therefore, we propose the application of conditional transformation models (CTMs) for the estimation of the conditional distribution function of survival times given a set of patient characteristics. We use the inverse probability of censoring weighting approach to account for right-censored observations. Our proposed modelling approach allows the prediction of patient-specific survivor functions. In addition, CTMs constitute a flexible model class that is able to deal with proportional as well as non-proportional hazards. The well-known Cox model is included in the class of conditional transformation models as a special case. The good performance of CTMs in survival data analysis was investigated in a simulation that included both a proportional and a non-proportional hazards setting. Furthermore, we illustrated model interpretation by means of flexible conditional survivor functions in a re-analysis of a randomised clinical trial comparing busulfan, hydroxyurea, and interferon- α treatment for patients suffering from chronic myelogenous leukaemia. Thereby, we studied the impact of the proportional hazards assumption on previously published results based on a frailty Cox model.