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Application of Sign Depth to Point Process Models

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An important task in reliability studies is the lifetime testing of systems consisting of dependent or interacting components. Since the fatigue of a composite material is largely determined by the failure of its components, its risk of breakdown can be linked to the observable component failure times. These failure times form a simple point process that has numerous applications also in econometrics and epidemiology, among others.
A powerful tool for modeling simple point processes is the stochastic intensity, which can be thought of as the instantaneous average rate for the occurance of an event. Here, this event represents the failure of a system component. Under a random time change based on the cumulative intensity, any such point process can be transformed into a unit-rate Poisson process with exponential interarrival times. If we consider a parametric model for the stochastic intensity, we can perform this transformation for each parameter to obtain so-called hazard transforms. As soon as the parameter deviates from its true value, these transforms will generally no longer follow a standard exponential distribution. At this point, familiar goodness-of-fit tests such as the Kolmogorov-Smirnov test can be applied.
However, viewing the transforms as "residuals", data depth approaches commonly encountered in the regression context can be considered as an alternative. In particular, the consistent 3-sign depth test provides a much more powerful generalization of the classical sign test. The major benefit of data depth methods lies in their inherent robustness, for instance in the presence of contaminated data due to measurement errors or unexpected external influences. This robustness often entails a drop in power of the associated test. In a simulation study, we therefore compare the 3-sign depth test with competing approaches in terms of power and robustness, and find that satisfactory results can still be achieved even if almost half of the data is contaminated.
Finally, we apply our depth-based method to real data from a civil engineering experiment conducted at TU Dortmund University. We assess whether these robust approaches are suitable for predicting the lifetimes of prestressed concrete beams exposed to different cyclic loading and investigate if there is evidence of a statistically significant accumulation of damage over the course of the experiment.

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Primary author: JAKUBZIK, Mirko (TU Dortmund University)

Presenter: JAKUBZIK, Mirko (TU Dortmund University)

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