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Hybrid marked point processes: characterisation, existence and uniqueness

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We introduce the class of hybrid marked point processes which allows one to model a state process that interacts with past-dependent events. For example, similarly to Hawkes processes, events can exhibit cross-excitation effects, but these effects can now be more subtle as they also depend on the state process: events of type A will precipitate events of type B only when they move the state process to some critical region, say. In parallel, as each event occurs, the state process transitions to a new value according to transition probabilities that vary with the event type. We prove that such dynamics are equivalent to an intensity process of a specific product form.

Next, we tackle the existence problem of non-explosive marked point processes with given intensities by studying a well-known Poisson-driven SDE (Poisson embedding). Available strong existence and uniqueness results rely on a Lipschitz condition that the intensity of hybrid marked point processes fails to satisfy. This motivates us to propose a natural pathwise construction that instead only requires a sublinear behaviour for the intensity. Using a domination argument, we are able to check that this construction yields indeed a solution. As we restrict ourselves to non-explosive marked point processes, we manage to prove uniqueness without any specific assumption on the intensity.