Bifurcation of random maps
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English summary

The mathematical formalization of a set of rules describing the time evolution of the state of a given process is called a dynamical system. Examples include the mathematical models that describe the swinging of a pendulum clock, the flow of water in a pipe, climate forecast, financial markets and neural networks. Some dynamical systems can be described as unforced systems - that is, they propagate in isolation from external influences. However, very few systems in the real world are genuinely isolated, and so it is often appropriate to describe dynamical systems as perturbed systems. The random perturbations can be small and irrelevant, or they can be so large as to overwhelm the underlying dynamics. The middle ground is the most interesting: the perturbations can be small, yet contribute non-trivially to the overall dynamics, so that one must consider the interaction of the deterministic dynamics with the stochastic perturbation. This is the approach we take in this thesis. The bad news for this theory comes from the fact that, despite the vigour of the theory, it is usually too complex to derive an explicit expression of the state at a given time, especially when we incorporate random influences. So one may ask what is the usefulness of this theory if it cannot answer the question it was constructed for? The good news is that the dynamics can be analyzed asymptotically through the study of steady states. These are states which do not change over time under the action of the dynamical system. The evolution of a given situation is thus reduced to the analysis of these steady states.

In this thesis perturbed systems are discrete-time random dynamical systems, or random maps, and the steady states are probability measures. We distinguish between stationary probability measures, which carry statistical information, and random invariant measures, which have a closer relation to the dynamics. We investigate stability and bifurcation of these probability measures. We distinguish bifurcations where the density function of a stationary measure varies discontinuously or where the support of a stationary measure varies discontinuously. For random maps on the circle, we give a relationship between bifurcations of stationary measures and bifurcations of random invariant measures. Quantitative descriptions by means of average escape times from sets as functions of the parameter are provided. Further quantitative properties, such as the speed of decay of correlations as function of the bifurcation parameter, are determined. Finally, we investigate numerically two paradigm examples which highlight the influence of random perturbations on deterministic dynamical systems and the complexity of the structure of the random invariant measures.