Meromorphic Vector Fields and Circle Packings

The objective of the Ph.D. project is to initiate a classification of bifurcations of meromorphic vector fields and to clarify their relation to circle packings. Technological applications are to image analysis and to effective grid generation using discrete conformal mappings. The two branches of dynamical systems, continuous and discrete, correspond to the study of differential equations (vector fields) and iteration of mappings respectively. In holomorphic dynamics, the systems studied are restricted to those described by holomorphic (complex analytic) functions or meromorphic (allowing poles as singularities) functions. There already exists a well-developed theory for iterative holomorphic dynamical systems, and successful relations found between iteration theory and flows of vector fields have been one of the main motivations for the recent interest in holomorphic vector fields. Restricting to structurally stable vector fields, there is an underlying dynamically defined triangulation of the plane. Circle packings are a means to realize such a given combinatorial structure. About 20 years ago, W. Thurston suggested applying circle packings to obtain approximations to Riemann mappings. This gave rise to the development of a theory of discrete analytic functions, which is a new tool in conformal geometry that can be used to implement many of the classical tools from complex analysis. Circle packing is a relatively new subject that has a great potential for technological applications, specifically for imaging problems. Since the class of complex polynomial vector fields in the plane is natural to consider, it is remarkable that its study has only begun very recently. There are numerous fundamental questions that are still open, both in the general classification of these vector fields, the decomposition of parameter spaces into structurally stable domains, and a description of the bifurcations. The same holds true for questions related to vector fields on the Riemann sphere and Riemann surfaces of higher genus. The overall objectives of this Ph.D.-study are to characterize the decomposition of parameter spaces of meromorphic vector fields on Riemann surfaces of low genus and a description of the bifurcations and to implement characteristic vector fields on such surfaces using circle packings. Furthermore, when the implementations using circle packings have been established, applications in conformal geometry and image analysis will be investigated in collaboration with faculty members at MAT and IMM.

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