Integrable Deformations of Discrete Curves and Their Applications

朴, 炯基

（様式６－２）

氏　　名	朴　炯基			
論　文　名	Integrable Deformations of Discrete Curves and Their Applications (可積分系による離散曲線の変形とその応用)			
論文調査委員	主　査	九州大学	教授	梶原　健司
	副　査	筑波大学	教授	井ノ口　順一
	副　査	久留米工業大学	教授	松浦　望
	副　査	ベルリン自由大学	教授	Konrad Polthier

論　文　審　査　の　結　果　の　要　旨

It is well-known that the theory of integrable systems is closely related to differential geometry. Specifically, many integrable equations arise as compatibility conditions of the geometric objects such as curves and surfaces. On the other hand, in view of the relationship between the differential geometry and the integrable systems, discretization of the theory of curves and surfaces preserving the underlying integrable structure has been actively studied by many researchers under the name of discrete differential geometry.

In this thesis, the connection between the deformations of curves and the integrable systems is studied with particular emphasis. This connection has been first pointed out by Hasimoto(1972) and then studied further by Lamb(1976) and Goldstein-Petrich(1991). In these researches, it has been clarified that certain deformations of curves in the Euclidean geometry are governed by the integrable systems. Then, the discretization of these theories, which means to construct the frameworks of discrete curves governed by the discrete integrable systems, has been studied (for example, Inoguchi, Kajiwara, Matsuura and Ohta(2014)). Besides the Euclidean geometry, integrable deformations of curves in various Klein geometries also have been studied (for example, the works by Chou and Qu, 2002-2004).

This thesis aims to develop the theory of discrete differential geometry and present applications of it. This thesis consists of three works: deformations of smooth/discrete plane curves governed by integrable equations in some Klein geometries are investigated in the first work. In the second work, a mathematical model of linkage mechanisms by using integrable deformations of discrete space curves is considered. In the third work, a new figure, which is called the spherical Kaleidocycles, is introduced.

In the first part of this thesis, he considers a certain deformation of smooth plane curves in the centroaffine geometry, governed by the defocusing mKdV equation. Then, he constructs a framework of discrete plane curves in the centroaffine geometry, and a deformation of discrete plane curves governed by the Lotka-Volterra equation. On the other hand, it is known that the KdV equation and its semi-discrete analog arise from deformations of smooth/discrete plane curves in the equicentroaffine geometry. It is also known that a solution to the KdV equation can be constructed from a solution to the (defocusing) mKdV equation by the Miura transformation. He constructs correspondences between the deformations of smooth/discrete

plane curves in the centroaffine and the equicentroaffine geometries using the Miura transformation.

In the next part of this thesis, he considers a mathematical model of a particular class of linkage mechanisms called the Kaleidocycles by using the theory of discrete space curves. A linkage is a mechanical system consisting of rigid bodies joined together by joints. In particular, linkages consisting of hinge joints are considered in this thesis. He presents how to identify hinged linkages by using discrete space curves. Then he investigates specific configuration spaces of the Kaleidocycles governed by the semi-discrete mKdV and the semi-discrete sine-Gordon equations.

In the last part of this thesis, he introduces a figure called the spherical Kaleidocycles, defined on the standard unit 3-sphere. It has a similar shape as the Kaleidocycles when we see it in via the stereographic projection. Moreover, a particular rotation of them exhibits the turning-over motion, which is reminiscent of the motion of Kaleidocycles. He presents an algorithm to construct spherical Kaleidocycles and visualize them by using the software Javaview.

We admit that the results of this thesis are valuable performances in the field of integrable systems and discrete differential geometry. Therefore, we acknowledge that he deserves to be awarded a Doctor of Functional Mathematics.