# 論 文 の 内 容 の 要 旨

論文題目　Machine Learning over Space Forms
（空間形上の機械学習）

氏　名　鈴木 惇

Machine learning can be interpreted as dissimilarity learning using a program. The class of dissimilarity measures given by space forms is considered an appropriate class because it describes an adequate range of dissimilarity measures and provides simple optimization and implementation. Limited research has been conducted on the applications of space forms in terms of fundamental elements of machine learning that include modelling, optimization, and evaluation. Specifically, (i) the models for learning dissimilarity measures in the data domain using ordinal data or multi-relational graph data have not been studied; (ii) the two major optimization methods (i.e., the natural gradient and the Riemannian gradient methods) have not been compared; (iii) evaluation methods for machine learning over space forms have not been discussed. This study is aimed at solving these issues by (a) proposing methods for dissimilarity learning over (non-Euclidean) space forms applicable for ordinal data or multi-relational graph data, utilizing the distance function and the exponential map, (b) drawing theoretical comparisons among first-order stochastic optimization methods using the traditional Euclidean metric, the natural gradient method, and the Riemannian gradient method in the machine-learning setting, and (c) proposing a model evaluation method based on the minimax regret principle that is a primitive evaluation principle that does not require any statistical data-distribution assumptions. These three solutions provide the foundations for machine learning over space forms.