Mach Learn (2011) 85:249–272
DOI 10.1007/s10994-011-5240-0

Ternary Bradley-Terry model-based decoding for multi-class classification and its extensions

Takashi Takenouchi · Shin Ishii

Received: 17 January 2010 / Revised: 15 October 2010 / Accepted: 2 February 2011 /
Published online: 27 February 2011

Abstract A multi-class classifier based on the Bradley-Terry model predicts the multi-class label of an input by combining the outputs from multiple binary classifiers, where the combination should be *a priori* designed as a code word matrix. The code word matrix was originally designed to consist of $+1$ and -1 codes, and was later extended into deal with ternary code $\{+1, 0, -1\}$, that is, allowing 0 codes. This extension has seemed to work effectively but, in fact, contains a problem: a binary classifier forcibly categorizes examples with 0 codes into either $+1$ or -1, but this forcible decision makes the prediction of the multi-class label obscure. In this article, we propose a Boosting algorithm that deals with three categories by allowing a 'don't care' category corresponding to 0 codes, and present a modified decoding method called a 'ternary' Bradley-Terry model. In addition, we propose a couple of fast decoding schemes that reduce the heavy computation by the existing Bradley-Terry model-based decoding.

Keywords Multi-class classification · Bradley-Terry model · Ensemble learning · Decoding

1 Introduction

Development of classification methods is one of the major research topics in the fields of machine learning and pattern recognition (Hastie et al. 2001). While methods for binary classification, such as classical linear discriminant analysis (LDA), support vector machine (SVM) (Vapnik 1995) and AdaBoost (Freund and Schapire 1997), are well established,

Editor: Phil Long.

T. Takenouchi (✉)
Graduate School of Information Science, Nara Institute of Science and Technology, Nara, Japan
e-mail: ttakashi@is.naist.jp

S. Ishii
Graduate School of Informatics, Kyoto University, Kyoto, Japan