

# 신경 손상과 전기 뇌 자극에 의한 흰쥐의 뇌 섬유 경로 변화에 대한 기계학습 판별

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## Classification of Fiber Tracts Changed by Nerve Injury and Electrical Brain Stimulation Using Machine Learning Algorithm in the Rat Brain

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### ● 요약 ●

The purpose of the study was to identify fiber changes induced by electrical stimulation of a certain neural substrate in the rat brain. In the stimulation group, the peripheral nerve was injured and the brain area associated to inhibit sensory information was electrically stimulated. There were sham and sham stimulation groups as controls. Then high-field diffusion tensor imaging (DTI) was acquired. 35 features were taken from the DTI measures from 7 different brain pathways. To compare the efficacy of the classification for 3 animal groups, the linear regression analysis (LDA) and the machine learning technique (MLP) were applied. It was found that the testing accuracy by MLP was about 77%, but that of accuracy by LDA was much higher than MLP. In conclusion, machine learning algorithm could be used to identify and predict the changes of the brain white matter in some situations. The limits of this study will be discussed.

**키워드:** machine learning (기계학습), multi-layer perceptron (다층퍼셉트론),  
linear discriminant analysis (선형판별분석), rat (흰쥐), diffusion tensor image (확산텐서영상)

## I. Introduction

Diffusion tensor imaging (DTI) is a non-invasive method for visualizing white matter fiber tracts in the brain. It is possible to observe fiber changes due to nerve development or degeneration through white matter fiber tracking or tractography [1]. However, there are few studies methods of discrimination using DTI. As a pilot study, the study attempted to establish the way of classifying DTI data using machine learning. For this, the study was to identify fiber changes induced by electrical stimulation of a certain neural substrate in the rat brain with multi-layer perceptron (MLP).

## II. Method

### 1. Subjects

Sprague-Dawley rats were used in this study. Groups were divided into three groups; 1) sham peripheral nerve in with sham stimulation (sham), 2) the peripheral nerve injury with sham stimulation (sham stimulation), and 3) peripheral nerve injury with a specific brain region stimulation (stimulation).

## 2. Imaging acquisition

DTI data were acquired on a 9.4 T high-field MRI scanner developed for imaging of small animals (Bruker Biospin, Ettlingen, Germany). The following parameter was used: TR/TE = 12,500/0.512 msec, in-plane resolution = 0.134 mm, 30 directions, b-value = 3,063.4 s/mm<sup>2</sup>, diffusion time/encoding duration = 20/4 msec. The data were reconstructed in the Waxholm Space atlas of the Sprague Dawley rat brain using q-space diffeomorphic reconstruction [2] to obtain the spin distribution function [3].

## 3. Feature Selection and Classification

Thirty-five features were extracted from 5 DTI measures in each of 7 pathways of interest, were extracted and used as feature vectors. Two classifiers, the linear discriminant analysis (LDA) and the multi-layer perceptron (MLP), were applied to classify the brain pathways among 3 groups.

## III. Results

Results of LDA showed 100.0% classification of 3 groups (Table 1).

Table 1. Confusion matrix for classification using LDA

		Predicted			Total
		Group 1	Group 2	Group 3	
Original	Group 1	100%	-	-	100%
	Group 2	-	100%	-	100%
	Group 3	-	-	100%	100%

For applying the MLP, the data was randomly assigned into 70% subjects as the training set and 30% the testing set. The classification accuracy of testing was as high as was 77.8% (Table 2).

Table 2. Confusion matrix for classification using MLP

Set	Observed	Predicted			% Correct
		Group 1	Group 2	Group 3	
Training	Group 1	100%	-	-	100%
	Group 2	-	100%	-	100%
	Group 3	-	-	100%	100%
Testing	Group 1	100%	-	-	100%
	Group 2	-	75%	50%	75%
	Group 3	-	25%	50%	50%

The average accuracy of testing set: 77.8%

## IV. Conclusions

Results showed that features of fibers obtained by DTI on rat brain could be useful for classifying changes of nerve fibers induced by nerve injury and brain stimulation with MLP. But LDA seemed to be more effective in discriminating nerve changes. We will try to find the difference between the two methods in the future. Also, we will seek out more useful features from 35 ones to get better classification.

We suggest that DTI is a useful technique to find out the changes of nerve fibers in the brain. The machine learning would be also useful method for identifying changes of brain fibers.

## ACKNOWLEDGEMENT

This study was supported by the National Research Foundation of Korea (NRF) grants funded by the Korean government (MSIT) (2020R1A2C3008481).

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