

Multinomial Logistic Regression Model for Predicting Robustness and Evolvability of Biological Networks

Hyobin Kim¹, Stalin Muñoz^{1,2,3}, Carlos Gershenson^{1,3,4}.

(1) Centro de Ciencias de la Complejidad, Universidad Nacional Autónoma de México, 04510 CDMX, hyobin.kim@c3.unam.mx.

(2) Facultad de Ingeniería, Universidad Nacional Autónoma de México, 04510 CDMX, México

(3) Instituto de Investigaciones en Matemáticas Aplicadas y en Sistemas, Universidad Nacional Autónoma de México, 04510 CDMX, México

(4) ITMO University, St. Petersburg, 199034, Russian Federation

Robustness and evolvability are essential properties for biological networks. Robustness allows the existing functions to be conserved against internal perturbations (i.e., mutations), while evolvability enables new functions to be created. In this study, we aim at developing a multinomial logistic regression model to predict robustness and evolvability, using a few simple independent variables. We examined six potential measures likely to be related to robustness and evolvability: diversity, order, complexity before external stress, complexity after external stress, antifragility, and probability of generating antifragile networks. Among them, we selected diversity, order, and probability of generating antifragile networks free from multicollinearity as independent variables. For the dependent variable, we assessed robustness and evolvability by adding structural and functional perturbations to 33 different kinds of biological Boolean networks and then comparing their attractors before and after the perturbations. Our multinomial logistic regression model showed that the properties were predicted with accuracy 46.33 percent. For further study, we plan to develop more sophisticated models to perform improved classification. Our model could be used for various applications from understanding the dynamics of biological networks to designing bio-inspired engineered systems with robustness and evolvability.

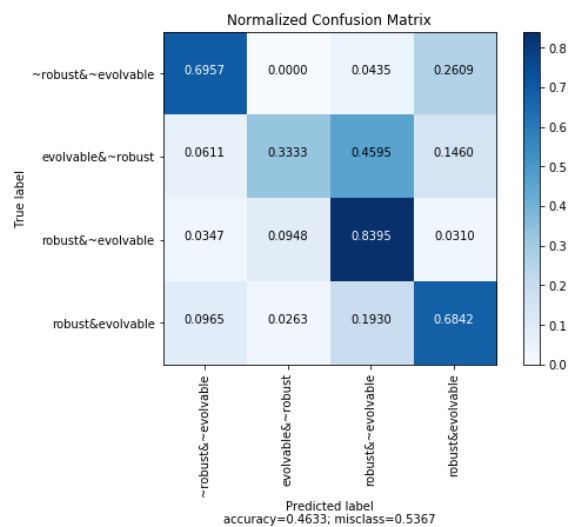


Figure 1: Normalized confusion matrix