Predicting the Transit Time of Halo-Coronal Mass Ejections using Machine Learning Techniques

Mohamed Nedal*[1], Heba Shalaby[1], Ayman Mahrous[1,2]

[1]Space Weather Monitoring Center (SWMC), Faculty of Science, Helwan University, Egypt

[2]Institute of Basic and Applied Sciences, Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt

ABSTRACT

In this work, the regression and classification techniques have been applied and the Artificial Neural Networks (ANN) have been employed to estimate the transit time of the Halo-Coronal Mass Ejections (HCME) during the period **1996 – 2018**. The list of events from (Gopalswamy et al., 2010) with **176** CME-ICME pairs have been used as a training set, and the models have been tested on an independent testing set of **48** events obtained from (Michałek et al., 2004). Then, the models have been applied on **494** HCMEs obtained from SOHO/LASCO catalog. For the regression approach, the min. error was **16.98% using the Linear SVM model.** For the classification approach, the accuracy was **96% using the Decision Tree (Ensemble) classifier**.

OBJECTIVES

1. To predict the transit time of CMEs, especially the HCMEs, based on machine learning approaches, such as regression methods and classification methods.
2. To assess the application of neural networks in the CME predictions.
3. To compare the results of the neural network with the previous kinematic models of CMEs transit time prediction.

DATA ANALYSIS & METHODS

For the TEST set	
Model	**Mean Error (%)**
G2000	25.25
G2001	26.90
NN	15.40

Input Parameters:

(Vl, Vf, V20Rs, a)

Min. error of NN model was **4.62** % with a topology of [**2 5**].

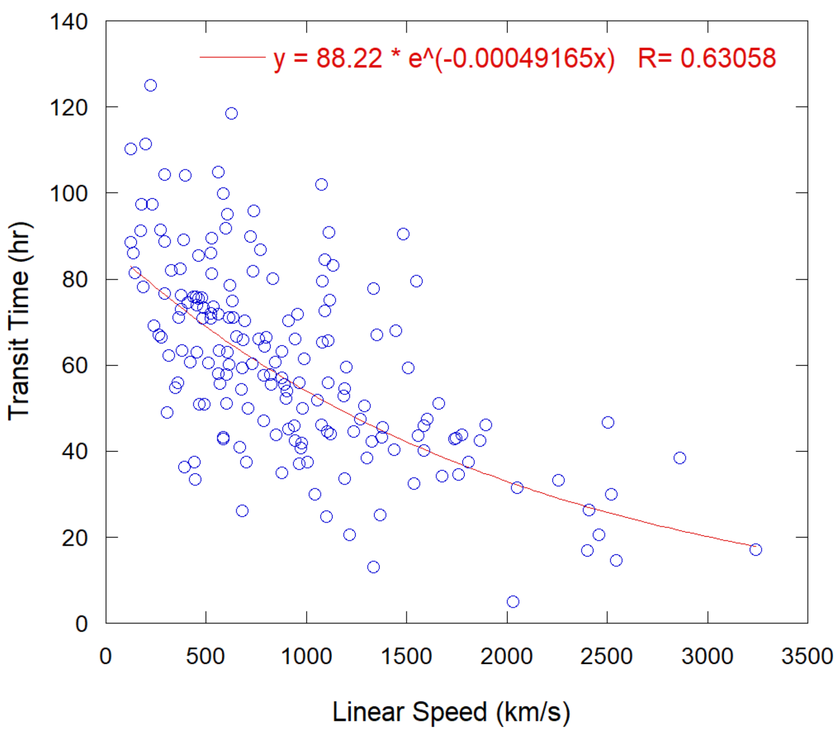

Fig. (1) The correlation of CME speed with its transit time for the **training** data samples.

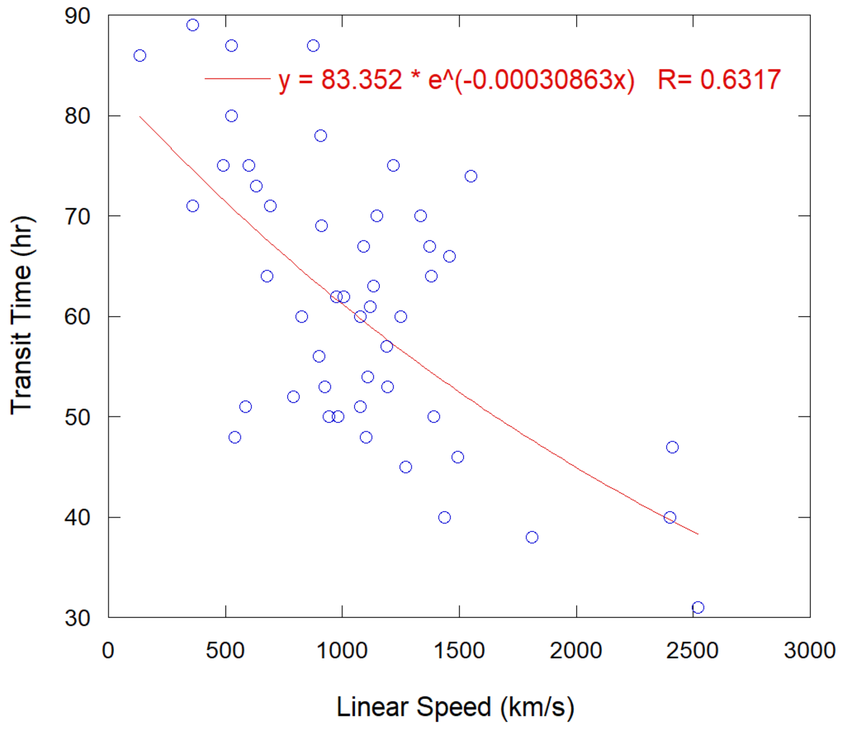

Fig. (2) The correlation of CME speed with its transit time for the **testing** data samples.

HIGHLIGHTS

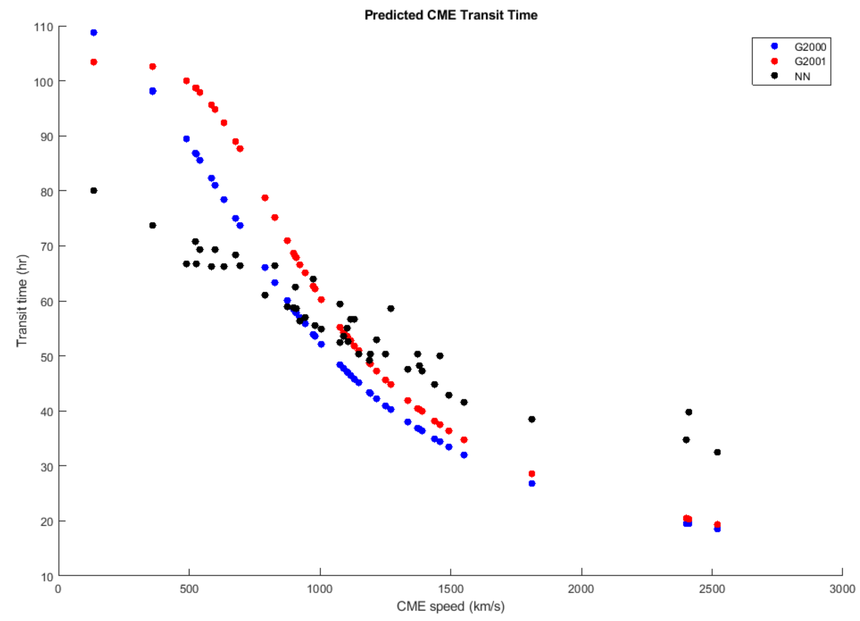

Fig. (3) Comparison between the prediction result for the G2000, G2001, and neural network models for estimating the transit time of CMEs.

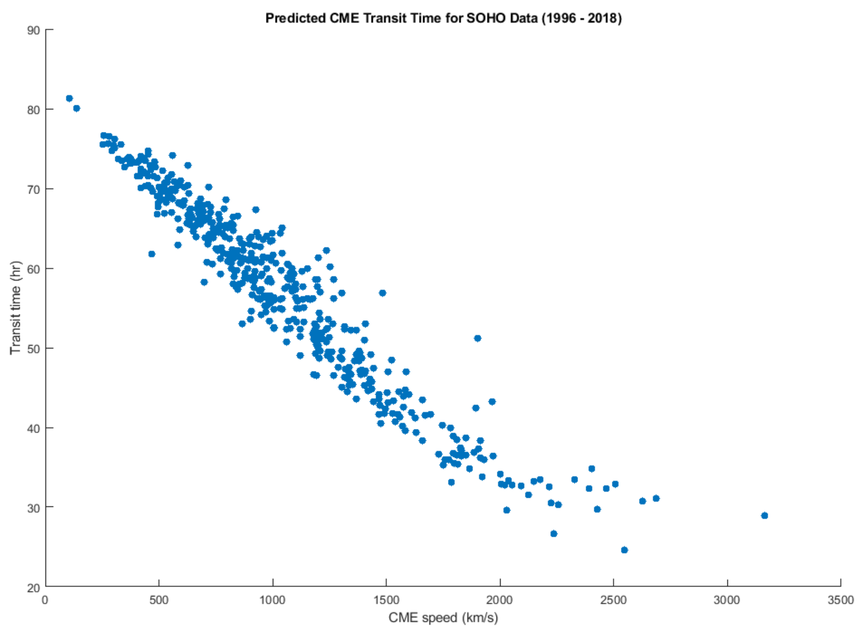

Fig. (4) The predicted values of the CME transit time as a function of the speed.

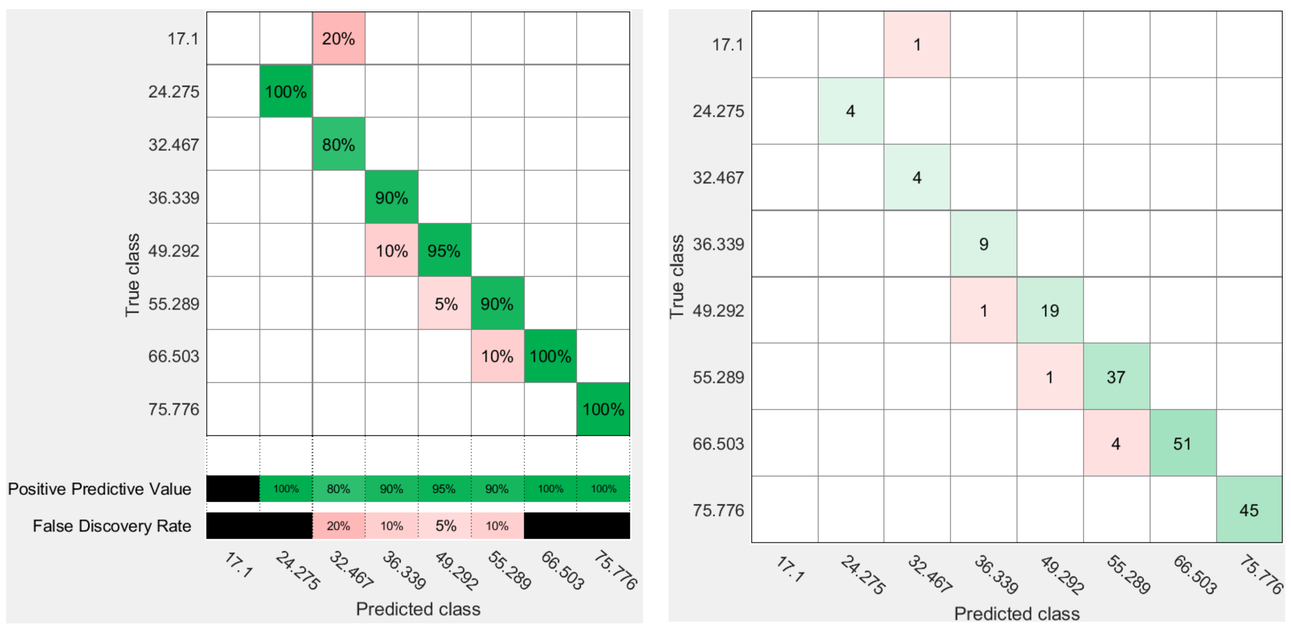

Fig. (5) Confusion matrices for the classification model.

REFERENCES

- Gopalswamy, N., Xie, H., Mäkelä, P., Akiyama, S., Yashiro, S., Kaiser, M. L., … Bougeret, J.-L. (2010). Interplanetary shocks lacking type II radio bursts. *The Astrophysical Journal*, *710*(2), 1111.
- Michałek, G., Gopalswamy, N., Lara, A., & Manoharan, P. K. (2004). Arrival time of halo coronal mass ejections in the vicinity of the Earth. *Astronomy & Astrophysics*, *423*(2), 729–736.
- Gopalswamy, N., Lara, A., Lepping, R. P., Kaiser, M. L., Berdichevsky, D., & St. Cyr, O. C. (2000). Interplanetary acceleration of coronal mass ejections. *Geophysical Research Letters*, *27*(2), 145–148.
- Gopalswamy, N., Lara, A., Yashiro, S., Kaiser, M. L., & Howard, R. A. (2001). Predicting the 1-AU arrival times of coronal mass ejections. *Journal of Geophysical Research: Space Physics*, *106*(A12), 29207–29217.
- Owens, M., & Cargill, P. (2004). Predictions of the arrival time of Coronal Mass Ejections at 1AU: an analysis of the causes of errors. *Annales Geophysicae*, *22*(2), 661–671.

CONTACT

Emails: Mohamed_Nedal@science.helwan.edu.eg | mohamed.nedal.solar@gmail.com

Websites:

http://spaceweather.edu.eg/members.html

https://www.researchgate.net/profile/Mohamed_Nedal

https://www.linkedin.com/in/mohamednedal/