Journal of Quality Measurement and Analysis *JQMA* 16(2) 2020, 157-170
e-ISSN: 2600-8602 *http://www.ukm.my/jqma*

PERAMALAN TAK LINEAR BAGI SIRI MASA KARBON MONOKSIDA DI KAWASAN DENGAN TABURAN PENDUDUK TINGGI DI SABAH

(Nonlinear Prediction of Carbon Monoxide Time Series in Highly Populated Area in Sabah)

AHMAD BASRI RUSLAN*, NOR ZILA ABD HAMID & KHAIRUNNISA CHE JUSOH

ABSTRAK

Kajian ini bertujuan untuk meramal siri masa CO di kawasan dengan taburan penduduk tinggi di Kota Kinabalu, Sabah melalui pendekatan kalut. Terdapat empat objektif dalam kajian ini, iaitu i) untuk mengesan kehadiran dinamik kalut, ii) untuk meramal, iii) untuk mengaplikasikan kaedah penambahbaikan bagi menentukan nilai jiran terdekat *k* dan iv) untuk mengaplikasikan kaedah *m*-songsang dalam menentukan nilai *m* pada siri masa CO. Sebelum menjalankan proses peramalan, sifat data harus ditentukan terlebih dahulu sama ada bersifat kalut atau tidak. Melalui kaedah plot ruang fasa dan kaedah Cao, sifat kalut hadir dalam siri masa CO. Oleh itu, model peramalan dibina. Bagi proses peramalan, tiga parameter diperlukan, iaitu masa tunda τ, matra pembenaman *m* dan jiran terdekat *k*. Parameter τ ditentukan melalui penetapan $\tau = 1$, parameter *m* ditentukan melalui kaedah *m*-songsang dan parameter *k* ditentukan melalui plot graf pekali korelasi (*pk*) melawan *k*. Nilai *pk* yang maksimum dihasilkan hasil gabungan parameter adalah direkodkan. Dengan menggunakan $\tau = 1, m = 3$ dan $k = 6$, nilai *pk* di antara data sebenar dan data peramalan adalah 0.9641. Tambahan lagi, perbandingan hasil peramalan dengan menggunakan *m*-songsang memberikan hasil peramalan yang lebih cemerlang berbanding dengan nilai *m* yang diperoleh daripada kaedah Cao. Hasil peramalan yang cemerlang ditunjukkan apabila menggunakan parameter *k* daripada kaedah penambaikan dan *m*-songsang. Oleh itu, peramalan melalui pendekatan kalut boleh digunapakai ke atas siri masa CO di Malaysia. Selain itu, diharap peramalan melalui pendekatan kalut ini dapat membantu pihak bertanggungjawab untuk mengawal pencemaran CO di kawasan dengan taburan penduduk tinggi di Malaysia.

Kata kunci: pendekatan kalut; jiran terdekat; peramalan; *m*-songsang

ABSTRACT

This study aims to predict the time series of CO in highly populated area in Kota Kinabalu, Sabah using chaotic approach. There are four main objectives of this study i) to detect the presence of chaotic dynamic, ii) to predict, iii) to apply the improved method of determining the nearest neighbor value *k* and iv) to apply *m*-inverse as the method to determine the value of *m* for CO time series. Before predicting, the nature of the data must be determined whether it is chaotic or not. Through phase space plot and Cao method, chaotic dynamic is presented in the CO time series. Therefore, the prediction model is built. For prediction process, there are there parameters that need to be determined which is delay time τ, the embedding dimension *m* and the nearest neighbor value *k*. The τ parameter is setting of $\tau = 1$, parameter *m* is determined by *m*-inverse method and the parameter *k* is determined through the graph plot of correlation coefficient (*cc*) against *k*. The maximum *cc* value generated as a result of a combined parameters is recorded. Using the $\tau = 1, m = 3$ and $k = 6$, the value of *cc* value between the actual data and predicted data is 0.9641. Furthermore, the comparison of the prediction results by using *m*-inverse gives a better prediction result than *m* from the Cao method. Improved method of the nearest neighbor value *k* and *m*-inverse are used in prediction also gives an excellent result. Therefore, prediction of CO time series can be done through chaotic approach. In addition, it is hoped that chaotic approach can help the authorities to manage CO pollution in highly populated area in Malaysia.

Keywords: chaotic approach; nearest neighbor; prediction; *m*-inverse

Rujukan

Abarbanel H. D. I. 1996. *Analysis of Observed Chaotic Data*. New York: Springer-Verlag.

Abdullah A.M., Samah M.A.A. & Tham Y.J. 2012. An overview of the air pollution trend in Klang Valley, Malaysia. *Open Environmental Sciences* **6**(1): 13–19.

Adenan N.H. & Noorani M.S.M. 2013. River flow prediction using nonlinear prediction method. *World Academy of Science, Engineering and Technology International Journal of Mathematical, Computational, Physical, Electrical and Computer Engineering* **7**(11): 1589-1592.

Adenan N.H. & Noorani M.S.M. 2015. Peramalan data siri masa aliran sungai di dataran banjir dengan menggunakan pendekatan kalut. *Sains Malaysiana* **44**(3): 463-471.

Adnan M.H. 2018. Consumers behavior in Kota Kinabalu: Factors determining their perceptions, habits and actions. *Jurnal Komunikasi Borneo* **8**(6-1): 1-21.

Akinyemi M.L & Usikali M.R. 2013. Investigation of carbon monoxide concentration from anthropogenic sources in Lagos, Nigeria. *Journal of Physical Sciences* **8**(21): 1128-1132.

Ali N.M. & Hamid N.Z.A. 2019. Chaotic analysis for Malaysia west coast sea level: A case study of Kukup, Johor. *IOP Conferences Series: Earth and Environmental Science*, pp. 1-8.

Azeez O., Shafri H.M. & Pradhan B. 2018. Vehicular CO emission prediction using support vector regression model and GIS. *Sustainability* **10**(10): 1-18.

Bahari M. & Hamid N.Z.A. 2019. Analisis peramalan siri masa suhu menggunakan pendekatan kalut. *Journal of Quality Measurement and Analysis* **15**(1): 43-52.

Cao L. 1997. Practical method for determining the minimum embedding dimension of a scalar time series. *Physica D: Nonlinear Phenomena* **110**(1-2): 43-50.

Hamid N.Z.A., Noorani M.S.M, Juneng L. & Latif M.T. 2013. Prediction of ozone concentration using nonlinear prediction method. *Proceedings of the 20th National Symposium on Mathematical Sciences*, pp. 125-131.

Hamid N.Z.A. & Noorani.M.S.M. 2013. An improved prediction model of ozone concentration time series based on chaotic approach. *International Journal of Mathematical and Computational Sciences* **7**(11):1593-1598.

Hamid N.Z.A., Noorani.M.S.M. & Adenan N.H. 2017. Chaotic analysis and short-term prediction of ozone pollution in Malaysian urban area. *IOP Conference Journal of Physics*, pp. 1-5.

Hamid N.Z.A. 2018. Application of chaotic approach in forecasting highland's temperature time series. *IOP Conference Series Earth and Environmental Science*, pp. 1-9.

Janet C., Neidellff M. & Schimieder J.F. 2009. Air pollution and infant health: lesson from New Jersey. *Journal of Health Economic* **28**: 688-703.

Jabatan Statistik Malaysia. 2019. Kependudukan Negeri Sabah. Jabatan Perdana Menteri.

Kantz H. & Schreiber T. 2004. *Nonlinear Time Series Analysis.* Cambridge: Cambridge University Press.

Kayode S.J & Feyisayo K. 2013. Air pollution by carbon monoxide (CO) piosonous gas in Lagos Area Southwestern Nigeria. *Atmospheric and Climate Science* **3**: 510-514.

Lakshmi S. & Tiwari R.K. 2009. Model dissection from earthquake time series: A comparative analysis using modern non-linear forecasting and artificial neural network approaches. *Computers & Geosciences* **35**(2): 191–204.

Liebert W. & Schuster H. 1989. Proper choice of time delay for the analysis of chaotic time series. *Physics Letter A* **142**(2): 107-111.

Mashuri A., Adenan N.H. & Hamid N.Z.A. 2019. Determining the chaotic dynamics of hydrological data in flood-prone area. *Civil Engineering and Architecture* **7***(*6A): 71-76.

Peter A., Jack A. & Maureen A. 2015. Healthy Home Issues: Carbon Monoxide Version 3. U.S Department of Housing and Urban Development.

Regonda S., Rajagopalan B., Lall U., Clark M., & Moon Y.-I. 2005. Local polynomial method for ensemble forecast of time series. *Nonlinear Processes in Geophysics* **12**(3): 397-406.

Ruslan A.B. & Hamid N.Z.A. 2019. Application of improved chaotic method in determining number of *k*-nearest neighbor for CO data series. *International Journal of Engineering and Advanced Technology* **8**(6S3): 10-14.

Ruslan A.B., Hamid N.Z.A. & Jusoh K.C. 2020a. Peramalan aplikasi pendekatan kalut bahan pencemar siri masa CO menggunakan kaedah penambahbaikan dalam penentuan parameter bilangan *k*-jiran terdekat. *Borneo International Journal* **2**(4): 11-16.

Ruslan A.B., Hamid N.Z.A. & Jusoh K.C. 2020b. Kajian rintis peramalan siri masa SO_2 melalui pendekatan kalut di kawasan bandar. *Journal of Quality Measurement and Analysis* **16**(1): 17-27.

Shafie S. H. M., Mahmud M., Mohamad S., Rameli N.L.F., Ismail K.M., Mohamed A.F. & Abdullah R. 2018. Pengaruh penduduk terhadap pencemaran udara bandar di Lembah Klang dengan mengaplikasi Sistem Maklumat Geografi (GIS). *The 2nd International Conference on Social and Economic Development*, pp. 1-13.

Sivakumar B. 2002. A phase-space reconstruction approach to prediction of suspended sediment concentration in rivers. *Journal of Hydrology* **258**: 149-162.

Sprott C. 2003. *Chaos and Time Series Analysis*. Oxford: Oxford University Press.

Ul-Saufie A.Z., Yahaya A.S., Ramli N.A. & Hamid H.A. 2012. Performance of multiple linear regression model for long-term PM10 concentration prediction based on gaseous and meteorological parameters. *Journal of Applied Sciences* **12**: 1488-1494.

Zaim W.N.A.W.M. & Hamid N.Z.A. 2017. Peramalan bahan pencemar ozon (O_3) di Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak, Malaysia mengikut monsun dengan menggunakan pendekatan kalut. *Sains Malaysiana* **46**(12): 2523-2528.

Zaim W.N.A.W.M. 2018. Peramalan siri masa ozon mengikut monsun di kawasan Pendidikan Tinggi Malaysia melalui pendekatan kalut. Tesis SSn. Universiti Pendidikan Sultan Idris, Malaysia.

Jabatan Matematik
Fakulti Sains dan Matematik
Universiti Pendidikan Sultan Idris
Proton City, Tanjong Malim
35900 Perak, MALAYSIA
E-mel: ahmadbasriruslan@gmail.com[*], *nor.zila@fsmt.upsi.edu.my, nisachejusoh@gmail.com*

Diserahkan: 22 Ogos 2020
Diterima: 15 Oktober 2020

[*]Pengarang penghubung