A NOVEL HYBRID GREY-INTERVAL TYPE-2 FUZZY LOGIC SYSTEM : FORECASTING OF CO_2 EMISSIONS

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This research intends to propose a novel hybrid model of interval type-2 fuzzy logic system (IT2FLS) and grey theory model to produce a sound forecasting method. The proposed model couples an IT2FLS with a grey model theory namely as grey-interval type-2 fuzzy logic system (G-IT2FLS). The G-IT2FLS aims at exploiting the advantages of the two constituent models to the maximum. Yet, the combination between the IT2FLS and grey model require less burden on computational to design a robust hybrid forecasting model. It was significantly improvised and enhanced through parameter identification, model initialization and structure of the model.

The G-IT2FLS was first simulated to forecast the Mackey-Glass equation whereby the results of the simulation encouraged the researcher to further investigate its applicability. Afterwards, data of carbon dioxide (CO_2) emissions in Malaysia from 1971 to 2009

were chosen as the experimental data. Six resources of CO_2 emissions in Malaysia were considered as the experimental variables; gross domestic product, energy use, combustible renewable and waste, population density, transportation and CO_2 intensity.

Comparative study was conducted by employing another five forecasting models. The five forecasting models are the most applied by researchers in forecasting field which were the individual models of the G-IT2FLS; IT2FLS (six parameters), IT2FLS (four parameters) and GM (1,1), while the other two models were adaptive neuro fuzzy inference system (ANFIS) and artificial neural network (ANN). Error analyses based on three statistical indicators: root mean square error (RMSE), mean absolute error (MAE) and mean average percentage error (MAPE) were employed to compare the performance of the hybrid model.

On the basis of the results of the intensive simulation tests, the hybrid model has successfully forecast the CO_2 emissions with a reliable accuracy. In addition, comparison with the individual models showed that the proposed hybrid model provides an improved performance restricted to the conditions within this research. Thus, this thesis hopes to offer an alternative method that is reliable in the forecasting CO_2 emissions framework.

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SISTEM LOGIK SELANG KABUR JENIS-2 HIBRID BARU: PERAMALAN PEMBEBASAN CO$_2$

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Kajian ini bertujuan untuk mencadangkan satu sistem logik selang kabur jenis-2 hibrid baru (IT2FLS) dan teori model kabur untuk menghasilkan model peramalan yang bagus. Model yang dicadangkan menggabungkan sebuah model IT2FLS dengan teori model kabur dinamakan sebagai sistem logik selang kabur jenis-2 (G-IT2FLS). Model G-IT2FLS tersebut mensasarkan untuk mengekploitasi secara maksimum setiap kelebihan yang ada pada kedua-dua model yang telah digabungkan. Malah, kombinasi antara IT2FLS dan model kabur tidak memerlukan pengiraan yang rumit untuk merekabentuk model ramalan hibrid yang teguh. Ia telah diperkukuhkan melalui identifikasi parameter, pengawalan model dan struktur model berkenaan.

Sebagai permulaan, model G-IT2FLS disimulasikan untuk meramal persamaan Mackey-Glass dimana hasil daripada simulasi tersebut telah mendorong penyelidik

untuk mengkaji lebih lanjut kebolehan aplikasi model tersebut. Data pembebasan karbon dioksida (CO_2) bagi tahun 1971 hingga 2009 di Malaysia telah dipilih sebagai data eksperimen. Enam sumber pelepasan CO_2 di Malaysia telah di pilih sebagai pembolehubah eksperimen; keluaran kasar dalam negara, penggunaan tenaga, bahan bakar boleh diperbaharui dan sisa, kepadatan populasi, pengangkutan dan kepekatan CO_2.

Kajian perbandingan telah dijalankan dengan menggunakan lima model peramalan yang lain. Model-model yang dipilih adalah antara model yang paling banyak diaplikasikan oleh penyelidik dalam bidang peramalan iaitu model individu daripada G-IT2FLS; IT2FLS (enam parameter), IT2FLS (empat parameter) and GM (1,1), manakala dua lagi model lain adalah sistem inferens neuro kabur (ANFIS) dan rangkaian neural tiruan (ANN). Analisis ralat berdasarkan tiga petunjuk statistik; ralat min kuasa dua (RMSE), ralat min mutlak (MAE), peratusan ralat min mutlak (MAPE) telah digunakan untuk membandingkan prestasi antara model-model tersebut dengan model hibrid yang telah diusulkan.

Berdasarkan hasil ujian peramalan yang intensif, model hibrid telah berjaya meramal pembebasan CO_2 dengan ketepatan yang boleh disandarkan. Tambahan, perbandingan dengan model induk daripada model hibrid tersebut telah menunjukkan model hibrid yang dicadangkan dapat memberikan prestasi yang memberangsangkan bergantung kepada situasi kajian itu sendiri. Justeru, diharapkan kajian ini dapat memberi kaedah alternatif yang boleh digunapakai dalam rangka kerja peramalan pembebasan CO_2.