Chapter 5
Conclusion

Ensembles of IT2FNN models and the optimization of their fuzzy integrators using the GA and PSO algorithms for time series prediction, was proposed in this book.

We design the Ensemble of IT2FNN architectures for time series prediction. Three modules were used in each experiment of the Ensembles architectures. In module 1 the training was with the IT2FNN-1 model, in module 2 the training was with the IT2FNN-2 model and in module 3 the training was with the IT2FNN-3 model.

Genetic Algorithm and Particle swarm optimization were used to optimization the parameters of the membership functions of fuzzy integrators. We used type-1 (Gaussian, Generalized Bell and Triangular) and interval Type-2 (igaussmtype-2, igbelltype2 and itritrype2) MFs.

Gaussian membership functions in type-1 and type-2 fuzzy systems produced better results in predicting time series that were tested in the fuzzy integrators on this proposed model. I think that behave better with the kind of values that are represent in the time series.

Based on the statistical *Z-scores* results, we can make the conclusion that the results obtained of the optimization of fuzzy integrators with GAs are better than the PSO for the Mackey-Glass ($\tau = 13, 17, 30, 34, 68, 100, 136$) time series show in Table 4.10.

The results of ensemble of the IT2FNN architectures for Mackey-Glass ($\tau = 13, 17, 30, 34, 68, 100, 136$), Mexican Stock Exchange, Dow Jones and NASDAQ time series showed efficient results in the prediction error and the performance obtained of proposed method is good for this research.

Prediction errors obtained in this book are evaluated by the following metrics: Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Percentage Error (MPE) and Mean Absolute Percentage Error (MAPE). Therefore according to the results obtained by these metrics it can be concluded that the proposed model provides good performance in solving problems of time series.

The objectives and goals in this book were achieved satisfactorily, because the results reported from experiments are efficient prediction errors because they are very small.

Future works
We envision applying others fuzzy integrator methods for the ensemble of IT2FNN models, like Sugeno fuzzy integration or the Choquet integral.

Apply other methods to optimize of fuzzy integrators, like the Gravitational Search Algorithm (GSA), Differential Evolution (DE), Cuckoo Search (CS), Firefly, Bat algorithms (BAT) and other ones metaheuristic algorithms for optimization.

Apply the proposed method to problems of control systems.

Apply the proposed method to problems pattern recognition.

Apply the method for obtain data prediction of another time series, like the, Dollar exchange series and Political elections.

Apply the proposed method to problems clustering, classification and control systems.