Autonomous Groups Particles Swarms Optimisation (AGPSO) to Optimise the Fuzzy Membership Function in the Automatic Watering Plant Case Study

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Abstract. There is still a challenge for efficient watering, considering the exact time and exact watering intervals are unknown. The advances in fuzzy technology and microcontroller technology offer valuable solutions. By using this technology, automatic watering plant based on Humidity and Temperature sensor. However, the application of fuzzy technology requires the optimal determination of membership function. The optimal membership function previously developed using the genetic algorithm. Since the genetic algorithm is time-consuming, many researchers develop optimal membership function using Particles Swarm Optimisation. The modified Particles Swarm Optimisation provides a better solution. Eventually, Autonomous Groups Particles Swarm Optimisation invention offers an optimal solution to search for several mathematical problems. The basic concept of Autonomous Groups Particles Swarm Optimisation algorithm influenced by individuals dissimilarity in bugs swarming or bird flocking. In typical colonies, each insect or bird is not similar in terms of perception and capability, but they all do their commitment as members of the colonies. The Autonomous Groups Particles Swarm Optimisation algorithm discovery has tested for 23 mathematical test functions, but not to the real world. Therefore, the possibility of searching for optimal solutions needs to implement to the real world. In this study, the optimisation applies to fuzzy membership function, so that the automatic plant watering can be more optimal and efficient. Preliminary studies show that optimisation using AGPSO for Gaussian membership function provide a positive result.

Keyword: Autonomous Groups; Particles Swarm Optimisation; automatic watering plant; fuzzy Mamdani; Gaussian membership function

1. Introduction

Watering the plants requires the right amount and time[1]. Problems with the amount and timing of improper watering will result in dead plants and root decay if excessive water[2]. Therefore, one solution for effective and efficient watering is economical and perfect timing[3].

Researcher on water-saving water has been shown to have a positive effect on crop yields compared to traditional watering[4]. The application of careful watering is widely applied; the difference that occurs is only in the form of watering. Among other things in the form of furrow irrigation (groove irrigation), drip-irrigation and sprinkler irrigation (transmitting irrigation)[5].
However, there are still obstacles in the application of efficient watering, namely the difficulty of determining the right time and the appropriate watering interval. This problem occurs because there is no known level of accurate soil moisture. Soil moisture is one indicator to determine wetting and drying[6]. With the advancement of microcontroller technology and fuzzy logic, the problems for efficient watering and the perfect time are easier.

Several studies regarding the automatic watering of plants using fuzzy. Application of MCS51 microcontroller for watering automation[7]. The use of a real-time clock for determining the time and duration of watering on celery plants using humidity and temperature input based on Fuzzy Sugeno [8]. Application of ATMega16 for automatic Fuzzy Logic Controller with input temperature and humidity[9][10]. Development was carried out to make the FLC Multi-Input Multi-Output (MIMO) based on Fuzzy Mamdani. Where output in the form of the duration of watering and spraying of pesticides[11].

In fuzzy logic; a fuzzy variable has a degree of truth in the form of values that exist between values 0 and 1[12]. All values between 0 and one are known as membership functions. The membership function symbolises as \( \mu(x) \). The membership function is usually in the form of a graph that forms a specific line pattern, for example linear, bell, trapezoid, Gaussian and triangle. Each type of membership function has different mathematical equations and characters[13].

Choosing the right MFs requires long effort and time-consuming; however, MFs are generally assign independently based on designer perception, engineering experience, which does not necessarily give optimal performance when used in modelling or control. The genetic algorithm proposed as an optimal fuzzy membership function[14][15][16]. However, this genetic algorithm takes much time to process. The other researcher proposes particle swarm optimisation (PSO) algorithm to optimise the fuzzy membership functions[17][18][19][20]. The proposed method was used to optimise the triangular membership functions of the fuzzy model of a nonlinear system; results show that the optimised fuzzy membership functioned better[21][22][23][24]. A modified PSO algorithm called autonomous groups particles swarms optimisation (AGPSO) is suggested to avoid problems of trapping in local minima and slow convergence rate in solving high-dimensional problems. This method inspires individuals’ diversity in bird flocking[25]. Unfortunately, this method has not implemented in the actual condition. In this paper, we suggest AGPSO optimise the Gaussian fuzzy membership function in the automatic watering plant case study.

2. Method

In this research activity, referring to data from research [11]. The duration test of automatic watering using Arduino was carried out on two polybags. The watering is done twice a day, namely in the morning at 07.00 WIB and afternoon at 17.00 WIB. Testing is carried out for five days. So we get 20 data from the watering. Inputs to control automatic watering are humidity and temperature sensors. Then our research is testing the output in the form of an automatic watering duration using the Gaussian membership function that has been optimised using the AGPSO method. Our test also uses input data in the form of the same humidity and temperature, as in the study [11]. The outputs from our study then compared with research data [11]. Please refer to [11] for a detailed explanation.

2.1. Encoding Scheme of Particle

The process of encoding of the particle-based on the parameter of input, which is the watering factors. The membership function of each linguistics variable uses the Gaussian membership function. The system process two parameters, i.e. humidity, temperature and duration timer of which each has three linguistics variable. Therefore, the total linguistic function process is nine, as shown in Figure 1.
The Gaussian membership function formed by three parameters, namely a, b, and c. Thus the total dimension of each particle is 27 dimensions obtained from 9 linguistic functions with each linguistic function have three parameters. The encoding scheme of particle for this paper, as shown in Figure 2. As an example, for the humidity variable, it has three conditions, which is dry, normal and wet, as shown in Figure 3.

### Figure 1. Gaussian membership function, from left to right, a. Humidity, b. Temperature and c. duration of watering

### Figure 2. The membership function

### Figure 3. The Humidity variable, consist of dry, normal and wet

#### 2.2. Developing Membership Function

According to these points of view, we propose the AGPSO concept as an optimisation of the traditional Gaussian membership function in fuzzy Mamdani. In this method, each membership function tries to search the optimal peak of membership function, based on tuning $c_1$ and $c_2$, for detail explanation see[25].

#### 3. Results and Discussion

The results of the membership function optimisation using AGPSO for the Gaussian type, are shown in Figure 4. In this figure, the peak of Gaussian membership functions, especially for the standard and wet condition after optimisation process shifts to the left side of the red line.
Figure 4. The Humidity variable, consist of dry, normal and wet, before (a) and after (b) optimisation process

The calculation of output for Gaussian membership function without AGPSO optimisation and with AGPSO optimisation, are shown in the form of three-dimensional surface graphs, as shown in Figure 5.

Figure 5. The three-dimensional surface graphs, before (a) and after (b) optimisation process

In Figure 5, the implementation of AGPSO resulting graph is more smooth and sensitive to any changes that occur in the input. This fact, as shown as the red circle and the red arrow.

Figure 6. The calculation of the different membership function, between trapezium MF, triangle MF, Gaussian MF and Gaussian MF optimisation

The difference between each membership function compares to Pratama findings[11] shown in Figure 6. It can see that AGPSO optimisation for gaussian MF showing the smallest value.
4. Conclusion

In this paper, an autonomous groups particles swarms optimisation (AGPSO) apply to optimise the Gaussian membership function for automatic watering plant. In order to evaluate their performance, the results compared with the conventional trapezium, triangle and gaussian membership. The results show that AGPSO is significantly positive. For furthermore studies, it would be challenging to explore membership function optimisation using other technique in automatic watering to evaluate the efficiencies and compare to the other recent modification of PSO to tuning membership function. Enhancing the autonomous groups is also feasible of investigation.

5. References

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