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Hybrid Group Search Optimizer for Plant Leaf Classification

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Abstract: ***The analysis of Big Data is a data mining discipline in which large quantity of unstructured data is analysed which can be challenging to store and also to retrieve efficiently. The classification of plants is based on the identification of leaf that has a very broad application in both agriculture and medicine. In this work, a method which is computerized is used to recognize a plant leaf based on images is proposed. The proposed method extracts features from the image and these are used for classifying the plant leaf. The process of deciding on the subset for all relevant features to be used in the construction of a system is known as feature selection. The Group Search Optimizer (GSO) is a nature-inspired algorithm that possesses all the qualities used effectively to solve feature selection tasks. In this work, there is a GSO-based algorithm of feature selection along with fuzzy logic and the classifier of a Neural Network (NN) is proposed. The results of the experiment prove the proposed method (GSO-NN) was able to achieve a better level of performance compared to the other methods.***

Index Terms: ***Big Data, Group Search Optimizer (GSO), Feature Selection, Fuzzy Logic and Neural Networks (NN), Plant Leaf Classification..***

I. INTRODUCTION

Big Data is a concept that is applied to huge quantity of data which does not ideally conform to the traditional database and its normal structure. For example, the data that is machine-derived will multiply quickly and consist of diverse and rich content which is discovered. The analytics of Big Data will reflect challenges made to data which are vast, unstructured and quite fast moving in order to ensure it is managed by means of employing traditional methods. Considering research institutions, business organizations, governments, and other institutions, data are routinely generated with unprecedented complexity and scope. The gleaning of meaningful information along with competitive advantages from large amounts of such data is now getting increasingly important to global organizations. By attempting to extract meaningful insights from sources of data is very challenging. So, business performance has to increase its market share and the tools have to be made available to be able to handle variety, velocity and volume of Big data. Generally, all these technologies may not always be expensive and most software is the open source [1].

The Hadoop is found to be a new open-source framework that is used to process large data across various clusters of computers that make use of languages of data processing of high levels. The modules will provide languages that are easy to use with graphical interfaces along with tools of administration to handle data of petabytes on many thousands of such computers. The Hadoop and Map Reduce are models that are used widely for the processing of Big Data. The Hadoop is a framework of large-scale processing of data supporting the processing of large data by employing simple models of programming. This Apache Hadoop project contains a Hadoop Distributed File System (HDFS) along with the Hadoop Map Reduce which was in addition to the other modules. This software will be modelled to be able to harvest on the processing for clustered computing at the same time managing node level failures [2]. The plants are the sources that provide fuel, medicine, food, oxygen and so on and thus are an essential aspect of life on earth. There is a need for having a detailed understanding of these plants in order to increase the sustainability and productivity of agriculture. There is an unavoidable growth to the human population with a varying climate that can pose a threat to several ecosystems. So, it becomes vital to be able to identify either a new or a rare species for measuring the scope of geography which is part of a very wide scheme of biodiversity. Thus, there is a need to ensure plant recognition along with its classification. When compared to the other methods like molecule or cell biology, a classification made on the leaf image will be the primary choice for the leaf plant classification. Both sampling and capturing of leaves is very convenient and also inexpensive. This captured leaf image may be easily moved to a computer and all its necessary features can be extracted automatically by means of techniques of image processing [3]. Thus, for the purpose of monitoring plants, the plant database has to be assembled for an effective and speedy grouping or classification which is an important stride. There may be a vast majority of the systems that are dependent on visual components and their extraction such as the hue and also the shape of portrayals for the classification and correlation. Albeit the various parts of a plant such as a blossom, a bud, a root, a seed or any natural produce may be used for making a distinction. There are several visual features and data modelling classifiers or techniques that were proposed for the classification of a plant leaf. There was manifold learning that was based on the features that are found in the leaf images [4]. Feature selection is a major task in the problems of classification. Looking at it in advance, for making discrimination among the classes, the features may not be able to provide the required information.

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It may also be infeasible for us to include the features in this process that classifies both patterns and also the objects.

Such discriminate features are extracted carefully from images and also the extracted features in order to train classifiers [5]. Optimal features subsets are chosen for increasing the accuracy of matching that is based on the classifiers and their performance. A reduction of the dimensions of feature spaces may bring down the complexity of computation and further increase the performance that has been estimated. One more optimal GSO-based approach was employed to choose feature subsets that are forwarded for training the NN and the fuzzy classifier and also for classifying the plant and the leaves of trees.

The scientists and all experts are putting in a lot of effort in the development of advanced approaches to classification and techniques to improve the accuracy of classification. But the classification of the plant leaves has remained a major challenge as there are several factors like leaf pattern complexity, data of the chosen image acquisition and the processing of images there can be some effect on the classification and its success. Even though there has been some research made earlier by the techniques of optimization such as Simulated Annealing (SA), Random Search (RS), Evolution Strategies (ES), Evolutionary Programming (EP) and Genetic Algorithms (GA), there is a comprehensive review of the new techniques made recently and this is valuable to a great extent in choosing a suitable procedure of classification for the diseased plant leaf [6].

The classification of the diseased plant leaf was a task that was multi-objective which had to be handled with great care. The conventional techniques of optimization lime the methods based on the simplex and the SA were not for solving problems that had multiple objectives. In these cases, the multi-objective problems had to be reformulated to be a single objective issue. Here, the evolutionary algorithm like the GA could be applied and the work thus proposed a hybrid GSO-fuzzy logic along with the GSO-NN for the classification of the plant leaf. The rest of this investigation has been organized thus. Section 2 has discussed all related work in literature. The different methods employed were discussed in Section 3. The experimental results were discussed in Section 4 and the conclusion was made in Section 5

II. RELATED WORK

Yang et al., [7] had proposed another new method used for plant classification aiming to recognize various types of leaves from the image set instances that were captured from similar viewpoints. First, for the extraction of features, the work had adopted a two-level wavelet transform that was obtained in seven different features. Next, the leaves had been recognised automatically and then classified using the Back-Propagation Neural Network (BPNN). At the same time, the K-fold cross-validation was employed to test its correctness. The method's accuracy had been achieved at about 90.0%. Furthermore, a comparison was made with that of the other methods and this will arrive at its highest level of accuracy.

The identification of the plant species has been a digitally challenging the object for ensuring better levels of classification like in the problem of taxonomy resources. This is a technique of pre-processing found in data mining that helps in the identification of some of the prominent attributes. For this, there was a relief feature selection algorithm that was employed to improve the Fuzzy K-Nearest Neighbour classification that was based on the shape, the texture and the margins on leaves proposed by Ambarwari et al., [8]. There were best results obtained on a rate of accuracy by about 73.48% for 363 observation data. There was a trend that had been imposed directly on the features and this was considered to be better than the conventional K-NN.

Dhingra et al., [9] had proposed another novel fuzzy set that had extended from a neutrosophic logic based technique of segmentation for evaluation of the Region of Interest (ROI). This segmented neutrosophic image had been distinguished by using three different elements of membership: true, false or intermediate. On the basis of the segmented regions, there were some new feature subsets that employed aspects like diseases, histogram, colour, and texture. Further, there were 9 classifiers used for monitoring and further demonstrating the power of discrimination of the effectiveness of the combined features in which the random forest had dominated all other techniques. The system that was proposed had been validated using 400 cases (200 that were healthy and 200 diseased). This technique was also used to be an efficient tool in the identification of diseases. There was yet another new feature set that was promising with a 98.4% accuracy of classification that was achieved.

Vijayalakshmi and Mohan [10] further proposed another approach that was used for classifying leaf on the basis of colour, shape, and texture. There was another original leaf that was pre-processed in the initial stages by using Cellular Automata (CA) filters for minimizing noise. In order to enhance the quality and the contrast of the image, there was a histogram equalization along with an ROI segmentation that was employed. Gray Level Co-occurrence Matrix (GLCM) with the Local Binary Pattern (LBP) systems had been introduced to extract features. this will bring down the rate of recognition and accuracy. These proposed techniques were able to overcome the challenges that were faced because of the current method. The feature consists of the Haralick texture-based features, the colour features, the shape features, and the Gabor features. Subsequently, kernel-based PSOs were presented for overwhelming the issue of choosing optimum features. Lastly, there was a Fuzzy Relevance Vector Machine (FRVM) that had been employed for characterizing the leaf types. The primary objective of this FRVM classification was to predict the leaf type from the proposed input leaf images. The results of the experiment had proved better outcome in terms of accuracy, sensitivity and its specificity of about 99.87%, 99.5%, and 99.9% respectively, and this was improved values.

Chouhan et al., [11] had introduced another new method called the Bacterial Foraging Optimization (BFO)

which was based on the Radial Basis Function Neural Network (RBFNN) (BRBFNN) for the classification and identification of the different plant leaf diseases.

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In order to assign an optimal weight to the RBFNN it made use of the BFO that increased the speed and the accuracy of the network that identifies and further classifies all regions that were infected with different diseases of plant leaves. This region growing algorithm had increased the network efficiency by means of searching and then grouping seed points that had common attributes for the process of feature extraction. The authors had worked on the fungal diseases such as common rust, early blight, leaf spot, leaf curl, late blight, and apple rust.

Kour and Arora [12] had presented yet another novel method used for classification and segmentation of different plants such as Arjun, Tomato, Apple, Grapes, Jamun and Guava. For that of its first phase, there were real-time images from that of the crowd-AI database that was collected and then pre-processed for the removal of noise, enhancement of contrast and resizing. In the next phase, there were several other features that were extracted on the basis of colour and also texture. The third had some images of segmentation that made use of the K-Means algorithm. The fourth phase had training the Support Vector Machine (SVM), and in the final phase, there was testing that was performed. The PSO was used to choose its best value for the parameter of initialization found in the process of segmentation and classification. the work proposed had better and higher results with sensitivity = 0.9581, specificity = 0.9676, and finally accuracy = 0.9759, for the segmentation and accuracy of classification = 95.23 on being compared to the other methods.

By aiming at different problems that had several parameters of the new Alex Net model with a single feature scale, Zhang et al., [13] had proposed a new Global Pooling Dilated Convolutional Neural Network (GPDCNN) that was used for the identification of plant diseases by means of combing a dilated convolution along with global pooling. When compared to the classical Convolutional Neural Network (CNN) along with the Alex Net models, there were three different improvements to the GPDCNN which were: (1) a convolution receptive field that were increased without any increase in the complexity of computation without any loss to the formation of discriminants by means of replacing the connected layers along with the global layers of pooling; (2) the dilated convolutional layer which was employed for recovering spatial resolutions that did not increase the parameters of training; (3) The GPDCNN had integrated all the merits of the dilated convolution with global pooling. The results of the experiments of all datasets for the six common diseases of cucumber leaves had demonstrated this proposed model to effectively be able to recognize the cucumber diseases.

III. METHODOLOGY

The GSO is a protocol of optimization that was based on the population that makes use of a producer-scrounger model which was a method of animal scanning. The producer-scrounger was a new design of a scheme of optimal search that owes its inspiration to the behavior of animal search. There were two foraging methods that produce (the search for food) and scrounging (the combination of resources that had been discovered) that had been adopted using the protocol. Thus, it did not have to be forced into the local minimum where the GSO made use of the method of ranger foraging. The GSO protocol population was referred to as the group by the individuals called members.

There were three members in the group: the producer who would search for food, the scrounger who joins the resources of food found by the others and the ranger that used the strategy of random walk for the resource that was spread arbitrarily [14]. For every such iteration, the member that had found the best of resources will remain the producer and except the producers will be the scroungers and the remaining will be rangers. At the time of the process of search in the GSO, the ranger or the scrounger has chances of discovering better locations compared to the current producer or the other members when the producer is not able to find a better location. The ranger or the scrounger is able to identify a location that is better and this will, in turn, be the producer for the subsequent searching session. For the choice of other optimal feature subsets, the data classification becomes very critical. Either a scrounger or ranger had a location that was better for the subsequent session with the producer and the other members. The choice of the optimal feature subsets is important and the features can have other false correlations that can hinder the classification process. there are some features that are redundant as the information added has other features as well. For the purpose of this section, the GSO has a fuzzy classifier with the GSO and the NN classifier that were discussed.

A.Proposed GSO-Fuzzy Logic

There is fuzzy logic that was applied to solving problems in classification among classes that were not defined. There are some more fuzzy classifiers containing interpretable types of if-then rules that have fuzzy antecedents along with class labels. These antecedents (the if-parts) of that of rules partition with an input space within the fuzzy regions had the consequents (the then-parts) that described the classifier output for the regions. The formation of all fuzzy if-then rules with membership functions were critical issues that were found in the designing of the fuzzy classifier system. Generally, the membership function rules were formed by human experts and the increase in the number of such variables increased the rules exponentially that made it challenging for the experts to set an ideal system performance [15].

All approaches that were data-driven were proposed for the development of the fuzzy system that had numerical data without employing domain experts. They were found to be weak in the determination of all the fuzzy if-then rules. There was a new design of the system of fuzzy classifiers that were formulated in the high dimensional space that represents the rule set, the corresponding system and its behavior and the membership function.

There had been some performance criteria, where the system and its performance had formed a hyper-surface. This developed an optimal fuzzy system and made the swarm intelligence or the evolutionary algorithms better candidates for the design of fuzzy classifiers.

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For the purpose of this work, there was another method based on the GSO that was implemented for choosing a suitable system of fuzzy classification. In approaches based on the GSO, every individual within the population was taken to be a part of the system of fuzzy classification. After this, there was a fitness function that was implemented for guiding the process of search to choose a suitable system like the fuzzy rules and the patterns classified incorrectly that were minimized simultaneously.

The work further presented the GSO approach to make optimal designs for the fuzzy classifier to evolve rule sets with the rules and their membership functions. The GSO-fuzzy proposed can increase the speed of convergence and also improve the solution quality for the fuzzy classifier system in the GA. The proposed GSO based classifier system was simple and had produced a compact set of rules [16].

While designing the fuzzy classifier with the GSO, the issues below had to be addressed which are: the representation and the fitness function. The very first consideration at the time of designing the fuzzy system with the PSO was the strategy of representation that was followed. The fuzzy system had been specified with a rule set and its membership function that was associated. The floating point numbers had been used for representing their membership functions with the rule set that was represented with discrete numbers. For designing another compact rule set there was only the 'nR' rules that were shown in its population. In the 'nR' rules for choosing all optimal rules, there were a rule selection bit that was used. The membership functions that were trapezoidal and triangular had been used for representing an input fuzzy set.

Another important consideration that follows the representation of the fitness function. The evaluation of all groups found within the population that was accomplished by means of computing an objective function value for its parameter set. The objective function calculation and its results had been used for computing the individual's fitness value. In this problem, there was the need to correctly maximize the data classified or for minimizing any difference existing between the total of such data and also the data that was classified for minimizing the rules. This was represented mathematically as in (1),

$$Min\ f = (S - Cc) + (k \times nR) \tag{1}$$

Here the S, Cc, nR and the k denote the actual number of these samples, the actual number of class and the number of rules and their constant.

In the GSO run, the GSO will search for the solution that has maximum fitness value. So, a minimization objective function has been given by (1) and this was transformed for the fitness function that had been maximized as in (2):

$$Fitness = \frac{K}{f} \tag{2}$$

Where K was another constant. This was for amplifying (1/f), a value of this is small; that its fitness value for the chromosome that is in a range that was wider.

B. Proposed GSO-Neural Network

Artificial Neural Networks (ANN) had a problem in weight training that is a hard and continuous problem of optimization owing to its search space that is high-dimensional and multi-modal and this will be polluted by the missing data and their noises. So, it will be logically applied to the GSO for ANN weight training. This objective of the process of ANN weight training was to bring down the error function. But, it is pointed out that this minimizing its error function was different from its maximizing generalization. So, in order to be able to improve the generalization performance of the ANN, there was a scheme of early stopping that was introduced. Error rates of the validation sets had been monitored at the time of training. At the time of a validation error, there is an increase of the number of these iterations and for this, the training will stop. For the purpose of this work, the GSO and its early stopping scheme will be applied to the ANN and its training [17].

The ANN will contain three layers, the input, the hidden and the output. The nodes found in each layer will have input signals from the earlier layer and will pass it to the subsequent layer. These nodes in its input layer will supply all the other elements for the pattern of activation (the input vector) and this contain input signals obtained from the outside system that was applied to nodes within the hidden layer using weighted links. Output signals for the nodes in an output layer contains the response to the network for the pattern of activation that was supplied by source nodes. Subscripts n, h, and k are the node in the input, the hidden and the output layers. This net input u has been defined to be the weighted sum for the signal which was incoming minus the bias term. There was also a net input for the node h, u_h, within the hidden layer as shown in (3):

$$u_h = \sum_n w_{hn} x_n - \theta_h \tag{3}$$

Wherein x_n was the input of that of the node n in its input layer, w_{hn} which represents a connection weight which is from the node n in that of the input layer to node h in a hidden layer and the θ_h will be the bias of the node h found in its hidden layer. There was an activation function that was used in its proposed ANN which is a sigmoid function. Thus, for the hidden layer, output y_h for node h, is shown as in (4):

$$y_h = f_h(u_h) = \frac{1}{1+e^{u_h}} \tag{4}$$

The node k and its output were in its output layer shown as in (5 and 6):

$$y_k = f_k(u_k) = \frac{1}{1+e^{u_k}} \tag{5}$$

Wherein,

$$u_k = \sum_h w_{kh} y_h - \theta_k \tag{6}$$

Wherein θ_k denotes the bias of the node k found in its output layer:

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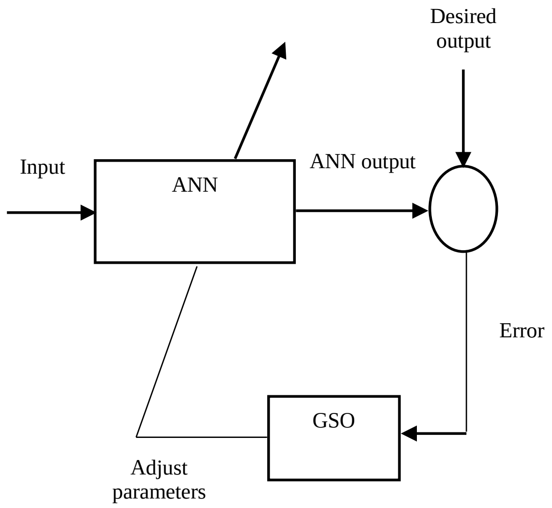

Fig 1 Schematic diagram of GSO-based ANN

These parameters (the connection weights along with the bias terms) were tuned with the GSO algorithm as per figure 1. In this GSO-based training algorithm, every member will be a vector that consists of connection weights along with the bias terms [18]. Without any loss of generality, it has been denoted that the W_1 which is the connection weight matrix that is between an input layer and a hidden layer, Θ_1 these bias terms to their hidden layer, the W_2 of its connection weight matrix that is between hidden layers and output layers, and Θ_2 are the bias terms to an output layer. This ith member found in this population is represented as in (7):

$$X_i = \left[W_1^i \ \Theta_1^i \ W_2^i \ \Theta_2^i \right] \quad (7)$$

A fitness function has been assigned to that of the ith individual which will be its least-squared error function that is defined as in (8):

$$F_i = \frac{1}{2} \sum_{p=1}^{P} \sum_{k=1}^{K} (d_{kp} - y_{kp}^i)^2 \quad (8)$$

Wherein the y_{kp}^i will be its kth computed output as per n equation (6) for ANN that is for the pth sample vector and this is of the ith member; P now denotes the sample vectors; and d_{kp} was its desired output for that of the kth output node

IV. Results And Discussion

Nine species (Bamboo, Chinese horse chestnut, true indigo, maple, castor aralia, Chinese cinnamon, cheesewood, Don Deodar and Ginkgo) with each 20 samples are considered for experiments. 5000 images are evaluated. The algorithms were run using Matlab and Weka tools. The features extracted are used to train the classification algorithms. The GSO-fuzzy logic and GSO-NN methods are used. The accuracy, precision and recall as shown in tables 1 to 3 and Fig 2 to 4.

Table 1 Accuracy for GSO-NN

GSO- Fuzzy Logic	GSO-NN
0.8097	0.8457

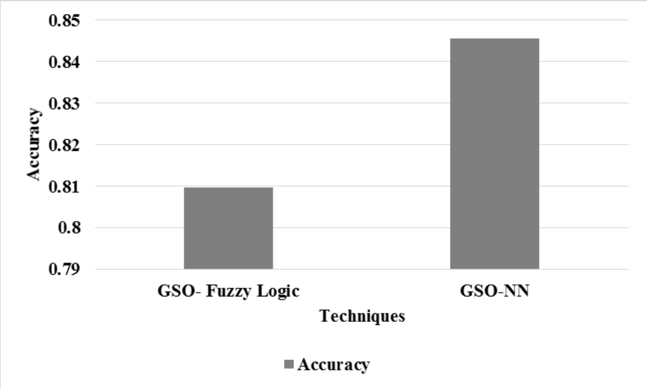

Fig 2 Accuracy for GSO-NN

From the Fig 2, it can be observed that the GSO-NN has higher accuracy by 4.34% compared for GSO-fuzzy logic.

Table 2 Precision for GSO-NN

Species	GSO- Fuzzy Logic	GSO-NN
a	0.7608	0.835
b	0.8442	0.8382
c	0.8455	0.852
d	0.7925	0.8699
e	0.8186	0.8294
f	0.7687	0.8445
g	0.8323	0.8446
h	0.8122	0.8789
i	0.8128	0.8193

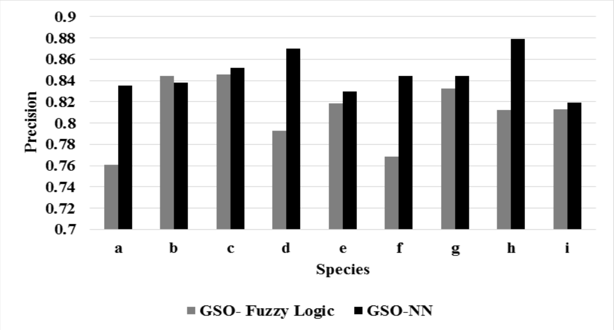

Fig 3 Precision for GSO-NN

From the Fig 3, it can be observed that the GSO-NN has higher average precision by 4.35% compared for GSO-fuzzy logic.

Table 3 Recall for GSO-NN

Species	GSO- Fuzzy Logic	GSO-NN
a	0.8721	0.8773
b	0.8396	0.857
c	0.7797	0.8457
d	0.841	0.844
e	0.8393	0.8374
f	0.7444	0.8546
g	0.8275	0.8542
h	0.7297	0.7973

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i	0.8391	0.8514

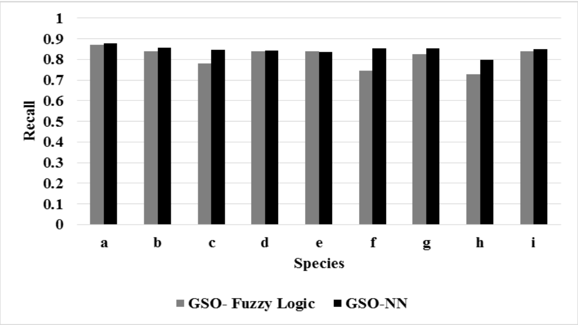

Fig 4 Recall for GSO-NN

From the Fig 4, it can be observed that the GSO-NN has higher average recall by 4.1% compared for GSO-fuzzy logic

V.CONCLUSION

Big Data analysis is an emerging data paradigm of science for the multi-dimensional information mining in business analytics and scientific discovery. The choice of optimal features subsets is a very important methodology in plant leaf classification. There have been several other approaches for the selection of optimal feature subsets and leaf classification like the Bee Optimization, the Ant Colony Optimization, and the Swarm Optimization. In this work, an optimal deterministic subset is chosen by the GSO technique. The subsets will be forwarded for training fuzzy logic with the NN classifier. This fuzzy system which is based on the rules given by an expert, the rules have been optimized with the GSO for obtaining the ideal number of rules for classifiers that have the lowest errors. For the purpose of this work, the NN that is trained using the GSO that is a novel algorithm based on population which has been inspired by the animal social foraging behaviour. The results have proved that the accuracy of the GSO-NN is higher by about 4.34% compared for the GSO-fuzzy logic.

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