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**Research Article**

# Application of Electronic Tongue in Edible Oil Detection with Cluster Algorithm based on Artificial Fish Swarm Improvement

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**Abstract**: Methods for edible oil quality detection mainly have conductivity and peroxide acid value, but as for currently blending edible detection, the effect of these methods is not satisfied. In this study, we propose a cluster algorithm based on artificial fish swarm improvement to detect edible oil by voltammetric electronic tongue. It can optimize the cluster centers value and the initial value. The results show that this is significant to classification and detection of edible oil using the artificial fish swarm cluster algorithm in voltammetric electronic tongue system.

**Keywords:** Artificial fish swarm algorithm, cluster algorithm, edible oil, electronic tongue

## INTRODUCTION

In the world, the food safety has been a hot topic. Adulterated food can cause serious harm. In the edible oil, the adulterated problem is very prominent. In the restaurant business, edible oil adulteration research method isn't widespread, most of the researches aim on the comprehensive utilization of waste oil. For example, Vlachos and Skopelitis (2006) found that c is double bonds in the hydrocarbon stretching vibration at 3009 $cm^{-1}$ band moves by using Fourier transform infrared spectroscopy detection of olive oil adulteration cheap vegetable oil (sunflower oil, soybean oil, sesame oil, corn oil). R.A. Pandey studied treatment and reuse of the restaurant industry waste grease. Hajimahmoodi *et al*. (2005) found that chromatography fatty acid fingerprints and partial least squares model can be used as the basic measure for the detection of mixed with edible oil. Brodnjak-Voncina *et al*. (2005) classified vegetable oil with fatty acid content and made multivariate data analysis using principal component analysis method and computer nerve network method. Ewa *et al*. (2005) distinguished edible oil using synchronous scanning fluorescence. Pan *et al*. (2003) made determination for waste oil acid value and peroxide value. Liu *et al*. (2005) determinate whether the waste oil contains sodium benzene sulfonate by fluorimetric method.

Electronic tongue (Arunangshu *et al*., 2012; David *et al*., 2012) is new analysis test equipment for qualitative or quantitative analysis using a multi-sensor array to detect the characteristics of the liquid sample response signal and by signal pattern recognition processing and expert system learning identification. Voltammetric electronic tongue system consists of the sensor array, the data signal acquisition system and signal processing systems. The sensor array consists of the working electrode (gold), the auxiliary electrode (platinum) and the reference electrode (calomel). Data signal acquisition system is completed by the electro-chemical workstation that collecting the output data of the sensor and then transferring to the computer to data processing. It is a critical step for managing voltammetric electronic tongue data that obtained by pattern recognition processing in electronic tongue measurements. The cluster analysis is commonly used by voltammetric electronic tongue system and affects the measurement level.

**The composition of system:** Voltammetric electronic tongue system design of this project (Winquist *et al*., 2002) consist of the sensor array, the data signal acquisition system and signal processing systems (Fig. 1). Specifically, we use standard three-electrode system that the working electrode is gold and the reference electrode is calomeland the auxiliary electrode is platinum (Weixin *et al*., 2007). The above three-electrode system are respectively inserted into the three sockets of the rubber stopper in the experiment and connected with electrode of the electrochemical workstation. In the present system, Electrochemical workstation can be used to generate a series of electrical pulses and pick up the response signals, the other end of the workstation is connected to a computer that the set of computer software is match with workstation control the electric pulse types and associated parameters and Store response signal that experiment generated by the computer, then extract feature of response signal, Finally, identify the signal with the pattern recognition algorithm. So we can

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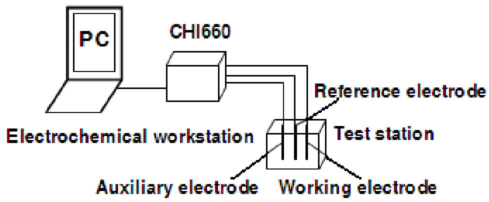


Fig. 1: Voltammetric electronic tongue system

distinguish different substances and draw the taste information of the different substances.

## EXPERIMENTAL MATERIALS AND METHODS

**Pretreatment method:** Because edible oil is a non-conductive material, its voltammetric electronic tongue detection should be the first to pretreatment, pretreatment methods have two ways (Liji, 2009):

- Each oil sample takes 20 mL, the amount of petroleum ether is 50 mL with 2.5 multiple of oil. Petroleum ether needs to be dissolved. The amount of ionized water is 40 mL with 2 multiple of oil. We uses ultrasound the oscillation method to be mixed the above three substances with 5 min and rests till stratification, separating the aqueous phase to be measured.
- Taking the oil sample with about 5.0 g in 100 mL beaker, we add deionized water with 20.0 mL, then shaking about 10 min, when after shake layered oil-water mixture in the separatory funnel, we take the lower invasion of the solution to measure.

These two methods is the main method for the pretreatment of the edible oil.

**Materials and procedure of experimental:** Preparation of blend inferior oil: selected Jilongyu soybean oil and the repeated frying old oil A were blended with a certain percentage. The proportions of Jilongyu soybean oil are: 0, 20, 40, 60, 80 and 100%, respectively. The above-mentioned low-grade oil will be detected by electronic tongue. Prepared blending ratio: 10, 30, 50, 70 and 90%, respectively of a blend of edible oil, tagging the number and disrupting their orders, the prediction accuracy of the results for edible oil will be identified.

Different types of edible oils, as well as to a certain blend ratio (0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100%, respectively) of soybean oil and old oil A blend made of low-grade oil to be tested by voltammetry electronic tongue. Specific steps:

- Beaker with deionized water and cleaned to be set aside
- The three-electrode regards alcohol soak for 5 min, followed by deionized water rinse and dry with filter paper, the electrode mount is fixed with the electrochemical workstation connection
- The samples were pretreated
- Remove the three samples from each of the edible oil in the sample and wait for the measurement after the solution was prepared
- Open electrochemical workstation switch, technology and related parameters required to set a good experiment and then the three electrodes are inserted into the liquid and to start measuring
- In each group in each sample is measured with 10 times and obtain a total of 100 sets of data

When measured with cyclic voltammetry, a set of parameters that a first test of the pretreatment method are set: the initial voltage is 2.0V, the end voltage is -2.0V, the maximum voltage is 2.0V and the scanning speed was 0.005V/s, sampling interval 0.001s, standing time of 2s. The parameters are set in the second preprocessing method measurement: initial voltage of 1.0V, the end voltage is -1.0V, the maximum voltage is 1.0V, the scanning speed for 0.005V/s sampling interval 0.001s, standing time 2s.

**Hierarchical cluster method:**

**Hierarchical cluster method steps:** Cluster (Serena *et al*., 2012; Manuela and Teresa, 2011) refers to the data object which divided into multiple classes of higher similarity. Different classes of objects have large difference. The general description of the clustering problem is: $X = (X_1, X_2,\dots, X_N)$ is the collection of N data sets, $C = (C_1, C_2,\dots, C_K)$ $[C_1 \cup C_2 \cup \dots \cup C_k = XC_i \cap C_j = \emptyset\ (i \neq j),\ C_i \neq \emptyset\ (I = 1,\dots, K)]$ is the collection of K data objects. By cluster analysis, N data objects compose respectively K data sets. Each data set include at least one data object, which belongs to only one data set. The clustering mathematical model can be described as follows: Model sample {X} has n samples and k model classifications. $\{S_j, j = 1, 2, \dots, K\}$. The mathematical model $min \sum_{j=1}^{K} \sum_{X \in sj} \|X - m_j\|$ represents the distance of each model sample to the cluster center (k equals the cluster number; m equals the mean vector of the samples. If model sample i is assigned to the j cluster centers, $y_{ij} = 1$, or else $y_{ij} = 0$. Therefore the cluster mode is:

$$\min \sum_{i=1}^{n} \sum_{j=1}^{K} (y_{ij} \|X_i - m_j\|)$$

$$\text{s.t.} \sum_{j=1}^{K} y_{ij} = 1, i = 1,2,\dots,n$$

$$m_j = \frac{1}{\sum_{i=1}^{n} y_{ij}} \sum_{i=1}^{n} y_{ij} X_i, \quad j = 1,2,\dots,K \quad y_{ij} = 0,1$$

**Hierarchical cluster method results:** Soybean oil, corn oil, peanut oil, sesame oil and sunflower oil, which

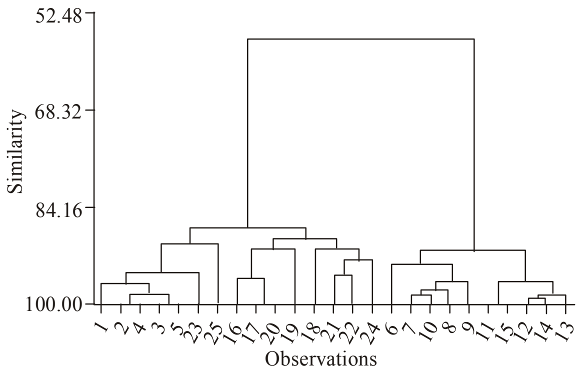


Fig. 2: Edible oil types dendrogram

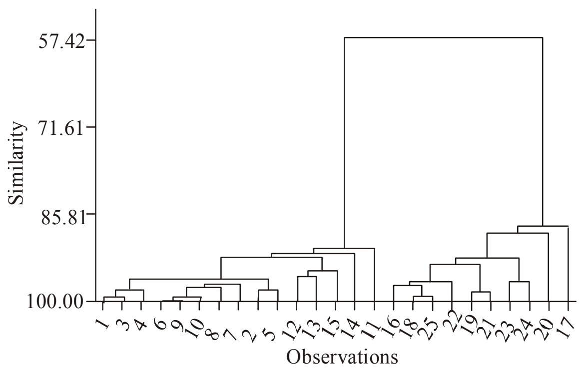


Fig. 3: Blended edible oil dendrogram

in numeric order, is in Fig. 2 of hierarchical cluster result. Each kind of oil has five experimental samples. In this figure, we can clearly find that the hierarchical cluster method cannot distinguish each kind of oil. For example, 23, 25 on behalf of sunflower oil are incorrectly assigned to soybean oil, so hierarchical cluster method is not very ideal and easy to fall into local minimum.

For blended edible oil hierarchical cluster results are as follows (Fig. 3). In this figure can also clear to see that the classification of the hierarchical cluster method for blended edible oil (blend ratio are 20, 40, 60, 80, 100%, respectively each of five samples) also exists the possibility of misclassification, even cannot distinguish five kinds of blend ratio. Therefore, hierarchical cluster method needs to be improved. Two methods are used in this subject, artificial fish and hybrid leapfrog.

## ARTIFICIAL FISH SWARM ALGORITHM

Artificial fish swarm algorithm, (Artificial Fish Swarm Algorithm, ASFA) which studied from the fish behavior (Xiao-Lei *et al*., 2002; Xiaolei and Jixin, 2003), was put forward for the first time by Xiao-Lei (2002). It applied to animal commune model and proposed a new type of bottom-up optimization model-artificial fish algorithm. Summarized and extracted fish swarm algorithm applied to several typical behavior: foraging behavior and the behavior of cluster and rear-end behavior. Artificial fish swarm algorithm is an effective optimization algorithm, parallelism, simple and quickly jump out of local minim, optimization fast.

**Artificial fish algorithm clustering principle:** Artificial fish swarm algorithm optimization method is based on Autonomous mimic fish behavior. It is a new cluster of smart thinking. It tells us that, from life experience, when we planted food somewhere in waters, fish will gather near the food. This is the fish of the foraging behavior. In the mean time, fish in the longer distance will approach to the stock of food. This is the cluster of behavior and tailgating behavior. The cluster method is to gather similar data domain data objects. In this way, the gathering place of the waters fish stock has rich nutrients. The cluster method is to gather similar data domain data objects. And cluster method is more similar to the gathering data field data object. This is the clustering algorithm based on artificial fish which we used to solve the clustering problems. According to clustering algorithm, Artificial fish swarm algorithm in the data field of evenly placed n artificial fish, as a the search proxy agent to calculate different state food concentration (the data object concentration), cluster behavior, foraging behavior, following behavior behaviors and promptly update the bulletin board, bulletin board information is stored the k optimal artificial fish and subprime artificial fish information input as the initial cluster centers clustering algorithm.

**Algorithm steps:** Cluster mining use artificial fish swarm algorithm based on the description of the model of the artificial fish and related definitions fish school algorithm-based clustering method. Steps of the algorithm (Mingyan and Dongfeng, 2006; Jinqi *et al*., 2009):

1. **Initialization:** Set fish school algorithm parameters, including the size of the schools of fish scale, the maximum number of iterations, the perception of artificial fish range visual, artificial fish crowded degree factor moving step biggest temptation number of cycles. Current iteration Gen = 0, the fish randomly generated in the feasible region, the formation of the initial fish stocks.
2. The use of the formula the initial artificial fish individual, the current position of the food concentration and compare their size, to find the global maximum current into the bulletin board that determine the initial cluster centers and save its state. The bulletin board has some characteristics of the memory, when encountered or erected clusters, this group feature information and location information recorded.
3. Artificial fish were simulated to perform the following behavior and cluster behavior, the behavior of the actual execution of food

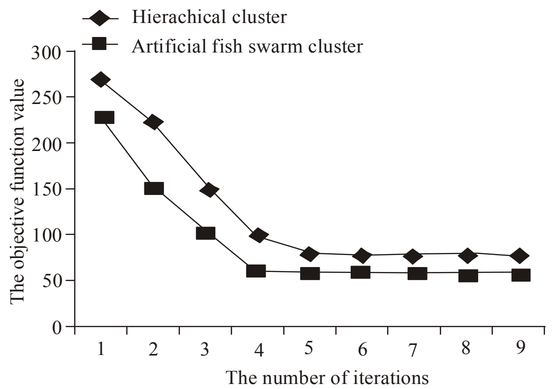


Fig. 4: Edible oil comparison chart of the number of iterations

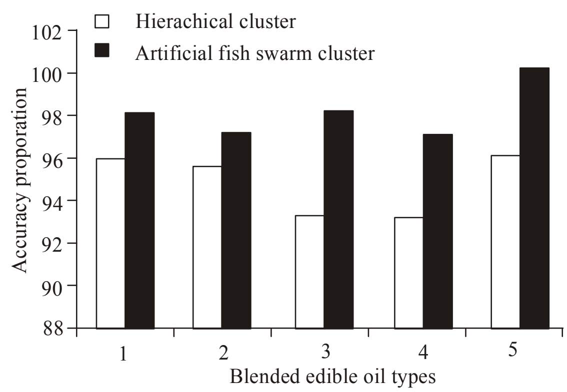


Fig. 5: Edible oil cluster accuracy rate comparison chart

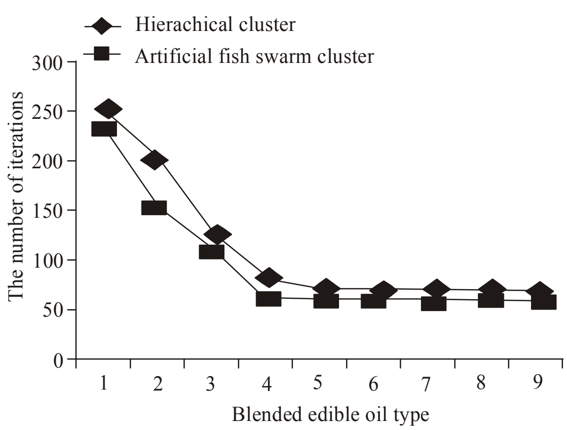


Fig. 6: Blended oil comparison chart of the number of iterations

concentration value is greater choice of action, the default behavior of foraging behavior. Artificial fish every action, test their own state and bulletin board state, if the state of the bulletin board is better than by its own state replaced.

4. Samples to each mode according to the formula $d_{ij} = ||X_i - M_j||$, calculate the new cluster centers calculated the distance of the new cluster centers cluster quality is satisfactory, calculated according to Eq. (3), updating the bulletin board. The main cluster process will encounter clustering or objects, subject itself to distinguish between these two different situations, which take different actions to be treated differently.
5. Gen←Gen+1, if Gen<Genmax and cluster to achieve satisfactory results, according to the food concentration selected from the current artificial fish school cluster to achieve satisfactory written to the bulletin board, the output value of the bulletin board that is the best solution; Otherwise go to 2.

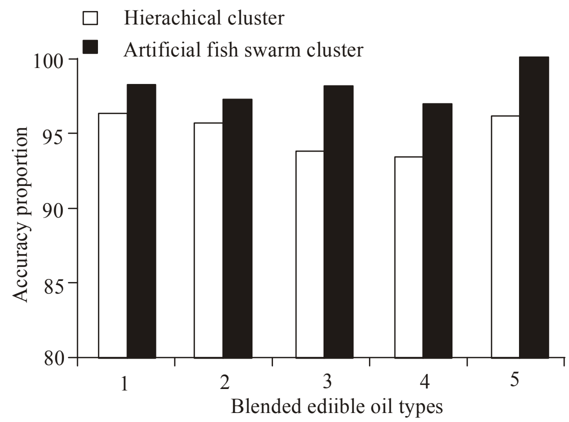


Fig. 7: Blended oil cluster accuracy comparison chart

## RESULTS AND DISCUSSION

The simulation data obtained by voltammetric electronic tongue blended inferior oil and the blending ratio in accordance with the division of the old oils are 20, 40, 60, 80 and 100%, respectively. The parameters are set as follows: maximum number of iterations is 100 artificial fish population size Total = 30, Step = 0.7, the horizons Visual = 2.5 crowding factor $\delta = 8$, the number of attempts of artificial fish Try_number = 50, cluster centers a number CN = 5 fuzzy index FI = 2, the implementation of the swallowing behavior threshold value T_value = 250. Comparison chart, as shown in Fig. 4 for the first pretreatment method to get the number of iterations can be artificial fish swarm algorithm is less than simple clustering algorithm the number of iterations, the correct rate increase. Figure 5 pretreatment methods to get the edible oil in the first cluster algorithm and artificial fish swarm clustering accuracy contrast, Figure can get high accuracy of artificial fish swarm cluster algorithm for various edible oils.

For the data obtained by the second preprocessing method, various parameters are set as follows: the maximum number of iterations is 100, the number of artificial fish populations Total = 30, Step = 0.7, Visual = 2.2, congestion degree factor = 8, the artificial fish attempts Try_number = 51, the number of cluster centers CN = 5 the fuzzy exponential FI = 2, the threshold value of execution swallowed behavior T_value = 240. Figure 6 for the second pretreatment method, the number of iterations comparison chart, as shown in the artificial fish swarm algorithm can get less than simple clustering algorithm the number of iterations, the correct rate. Figure 7 for the second pretreatment edible oil clustering algorithms and artificial fish swarm clustering accuracy contrast, Figure artificial fish swarm clustering algorithm for the accuracy of various edible oils relative hierarchical clustering method can be improvements.

## CONCLUSION

Artificial fish algorithm is based on the simulation of the behavior of the random search optimization algorithm. It is a kind of global optimization algorithm, which is used in solving large-scale combinatorial optimization problem. This method not only keeps the basic AFSA simple and easy to achieve, but also to improve the operating efficiency of the algorithm and solution quality. This study, which is based on electronic tongue edible oil detection data cluster algorithm improved artificial fish swarm clustering of edible oil samples. The result shows that the algorithm based on artificial fish electronic tongue edible oil detection is feasible and effective.

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