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Software Development for Black Tea's Physical Variable and Quality Class Relationship Analyzing using Correlation Adaptive Visual Pattern Recognition Artificial Neural Network Based Expert System

Proof of Concept of Auto Parameter Choosing Expert System

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***Abstract*— The absence of standard in black tea assessment was one main obstacle in its quality assurance. This research were contains process of black tea assessment software development, software problem solving concept, and the software evaluation made. This paper was a proof of simple concept that an expert system should automatically find and chose relevant parameters from relationship between raw image data and custom customer classification system, not only measuring dictated parameter and calculate the result on it.**

***Keywords*— black tea, expert system, parameter correlation analysis, artificial neural network.**

I. INTRODUCTION

Black tea was one of Indonesia's main export commodities. This was a deluxe export product due to it market acceptance depend on its quality.

Black tea's quality was a composite value, arranged in SNI 01-1902-2000. Black tea's quality evaluation was part of its production chain. One quality parameter measured was black tea's physical particle.

Badan Standardisasi Nasional described physical evaluation as black tea's quality assessment method. The assessor trained by comparing examples. This method gave two drawbacks; black tea's quality assessment was qualitative and subjective. This was explaining why so far there was no data about the relationship between black tea's physical parameter and its quality class.

SNI was not the only classification method used. Everyone can dictate their own sort system, adding the need for system to be able to adapt.

Expert System designer should have been able find method for quantifying their relationship before development process.

One alternative to take was to implement image processing method. This give problem that image processing method was vulnerable to date noise, additional effort needed.

Because relationship between black tea's physical parameter and quality parameter was qualitative, one way to quantify in was by using mathematical equation method that able to adapt to the relationship, such as artificial neural network.

To assure that artificial neural network able to adapt to problem space, pair of system input and output should have been nicely made and the noise should have been eliminated. Correlation analysis method was needed to find physical parameters which have close relationship with the quality parameters.

When choosing artificial neural network to use for black tea's quality evaluation, designer should have been considering each artificial neural network characteristics and its relevance to be implemented.

On implementation stage, the correlation analysis stage have been done by system; hence the user seen that the system automatically adapted to whatever classification system he want.

Four problems have been coped in system development, which physical parameters feasible to be used as system input, which parameter should be used to minimize problem from low correlation to quality parameter, how artificial neural network chosen, and how them implemented as a system, measured from its performance. First and second problem should be handled incognito by system.

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II. LITERATURE REFERENCE

A. Observation Object, Black Tea

Tea was a beverage made from *Camellia sinensis* or *Thea sinensis* infusion in hot water for several minutes. Tea has been known circa 2737 BC in China [1].

Black tea covers 90 % of entire world tea production [2] and cover 90 % of America's tea consumption [2]. Indonesia's tea production was around 133 000 ton per year, value taken in 1995 [2].

As a healthy beverage, tea was rich in catechins (2 %), flavonols, theaflavins, and thearubigins (flavonoids in total 17.4 %), beside caffeine (3.54 %) [1] [3].

Tea production phases were consisting of withering, grinding, enzymes oxidation, drying, and sorting [4]. Every phase was influential to black tea's quality.

Black tea's physical evaluation procedure was standardized in SNI 01-1902-2000, consist of assessment in physical size, colour, shape, odour, ability to retain shape, existence of foreign materials, and tip colour, amount, and looks [5]. The assessment was done using standardized tools [6].

Black tea's classification was divided to classification based on plantation elevation [2], particle size grade [5], and black tea's quality class [5]. Black tea's classification was done to samples taken using standardized methods [5] and done by expert that trained per standard [5].

B. Image Processing

Image was an object made to reproduce things similar to certain object. Image was also considered as array of pixels retain certain colour value in two dimensional dimensions that representing certain object [7].

Image processing was one instance of information processing which input is an image or several images [8].

Pattern recognition was an effort to infer information from raw data and taking action based on data category. Its main objective is to translate raw data to more operate able shape on subject need [8].

In pattern recognition, an image was consists of array of object and background. Every object consists of array of pixel, and every object has array of measurable parameter.

C. Analytical Concept

Correlation or correlation coefficient was represents degree or direction of linear relationship between two random variables, mathematically defined as covariance divided with deviation standard [1], as in (1).

$$r = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2 \sum(x_i-\bar{x})^2}}. \quad (1)$$

Deviation standard was represents how wide variations happen in one clutter of data [10]. Higher deviation standard means weaker correlation between parameters that exist within data [9], as in (2).

$$\sigma = \sqrt{\frac{\sum(x_i-\bar{x})^2}{N}}. \quad (2)$$

D. Expert System

Expert system was a computer system or software deliberately made to do task normally an expert does [11]. Expert system cans either an implementation of artificial intelligence or trainable system.

Expert system was also be considered as an agent, something that percept its environment using perception tools and done action using actuator [12].

Designer should have been assuring input, consistence, and completeness of knowledge base to make system that can do thing like the expert that simulated [11]. The system should have been tested using Turing test [12].

E. Artificial Neural Network

Artificial neural network was a computer program that operates by imitating how human natural neural network works [11]. One kind of artificial neural network widely used for science research was back propagation network [13].

One attribute of artificial neural network was that knowledge has been distributed to its entire network, not by explicitly written in program. The network was able to learn something by directly interacting with them [11].

Artificial neural network was classified by its learning paradigm [14], how it operates the inputs, or training pattern [11].

Known artificial neural network e.g. straight forward neural network [11] [15], self organizing network [11], recurrent network [16] [17], modular network, and advanced types like spiking neural network [18] and cascading neural network [19]. Much of them are a relationship based network, except non statistical Hopfield neural network [20].

F. Related Works

Borah and Bhuyan already done several research in black tea, consist of finding black tea's optimal enzymatic oxidation time during oxidation process from its pixel deviation based on its hue [21], research in finding optimal black tea's colour during oxidation process by extracting its hue and saturation, and measuring black tea's size grade from its texture and measuring size grade of black tea's from its volatile compound [22].

III. PROBLEM SOLVING METHODS

A. Standard Model

In simple artificial neural network expert system (ANN system), solution designer have been using predetermined parameter to be mined from data, and used the parameters as basis for solution creation, disregarding correlation between chosen parameters and target values, as in Fig. 1. This model often usable, but when the correlation from chosen parameters is minimal, system performance was low. One method to

alleviate correlation problem was using principal component analysis, but it wouldn't work when the parameters correlations were low to begin with.

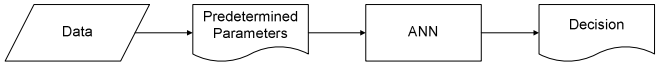

Figure 1. Standard model.

B. *Auto Parameter Choosing Model*

New system was proposed where the system understand the data pattern and adjust the parameter mining module accordingly, as in Fig. 2. The system was mining as many parameters possible (4761 parameters in this case), and automatically calculate the parameters correlation to sort system used, and auto generate new miner to mine only appropriate parameters.

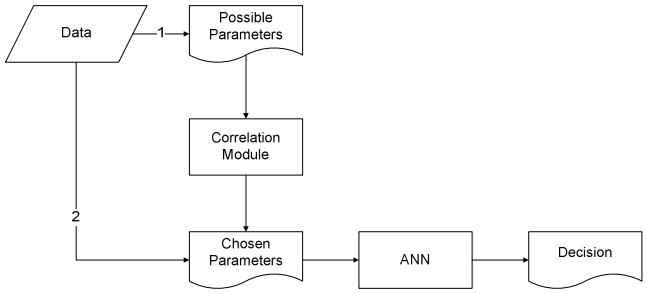

Figure 2. Proposed model.

C. *Testing Model*

Simple test were made to measure new system performance. The correlation module was modified so the user chosen his desired parameters as opposed to automatically done by the system. The modification was made to enable tester generate three sets of parameters, good (pick best correlation parameters), bad (pick worst correlation parameters, and standard (pick normally chosen parameters).

Two kinds of samples used for testing, stacked black tea samples to emulate normal ways for tea testers test and scattered samples for better insight, although this never done manually in real world.

Three kind of artificial neural network structure used for testing, two input one output model (the lightest possible models), ten input one output model, and ten input five output models.

IV. SOFTWARE DEVELOPMENT

A. *Problem Scope*

Software was made in stages. Both stages are individual software, described in Fig. 3. Both stages are implemented into system to emulate an auto parameter choosing expert system.

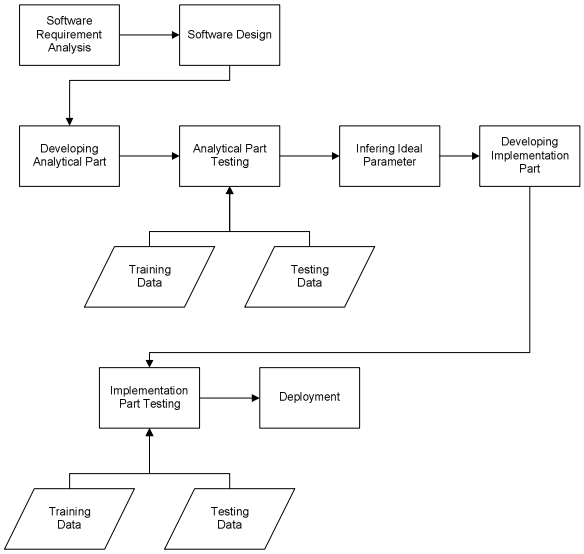

Figure 3. Software development phases.

Analytical phase software was used to find black tea's parameter that highly correlated to its quality parameters. Implementation phase software was made as implementation of parameters found in analytical phase in real evaluation process. These phases build to maintain processor and memory usages efficacy.

B. *Software Requirement Specification*

The system was generally act as a simple agent, it percept input from user and giving expected outputs (known as simple reflex agent), as Fig. 4.

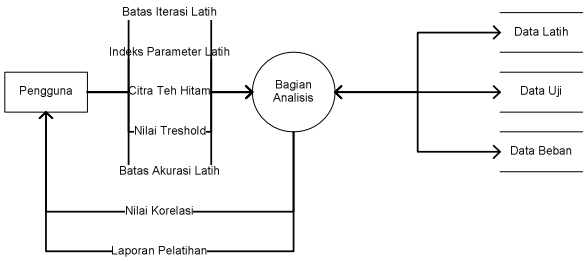

Figure 4. Expert system structure.

System was designed to extract black tea's parameters data from its images, and does correlation analysis to give the entire data to user. User was able to choose several parameters based on the information provided as inputs for artificial neural network (the artificial neural network changes shape based on inputs). User can train the system and used it for real black tea's evaluation, as Fig. 5.

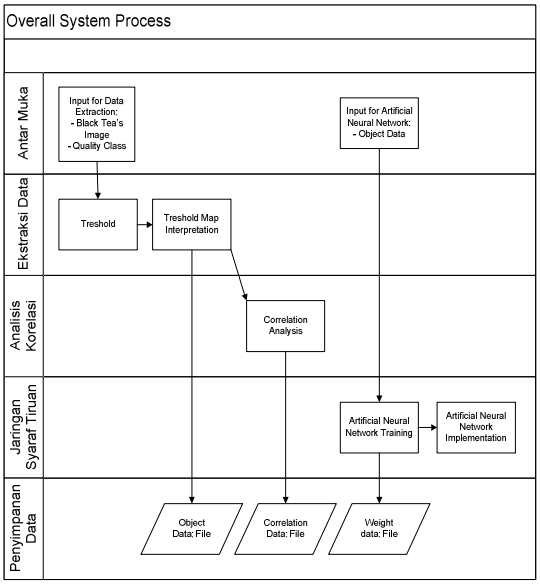

Figure 5. Entire system process.

C. *Analytical Model*

Based on the requirement specification, software composed from array of component such as user system interface, artificial neural network component, data extraction control, correlation analysis component, and data repository, as Fig. 6.

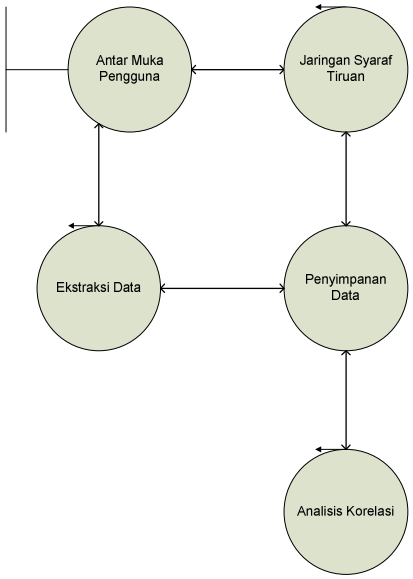

Figure 6. Analytical model.

D. *Design Model*

When implementing the analytical model to design model, the interface divided to four interfaces based on usage. The correlation analysis component was used as helper class for repository data, divided to two classes, as Fig. 7. The data repository was divided to seven classes as the image hierarchy, image is an array of object, object is an array of pixels, and both objects and pixel have their array of parameters, as Fig. 8.

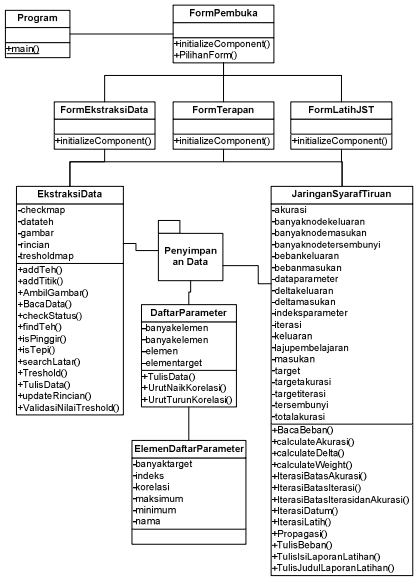

Figure 7. Design model.

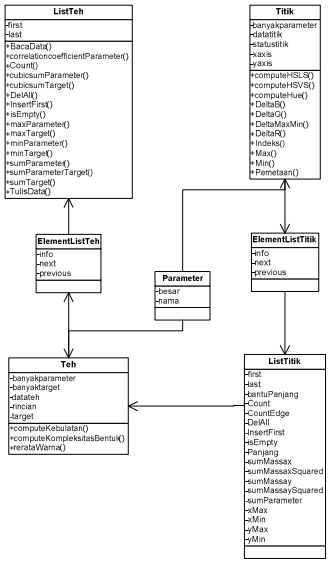

Figure 8. Data repository structure.

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V. RESEARCH METHODS

Research done in two places, Laboratorium Tesis Sekolah Teknik Elektro dan Informatika Institut Teknologi Bandung and Laboratorium Manajemen dan Mekanisasi Pertanian, Institut Pertanian Bogor.

Software was written in Java. Hardware used consists of a PC and a controlled image retrieving tools. Black tea's sample

used was the expert prepared samples divided to two evaluation categories (observed stacked as whole or observed pieces by pieces scattered), five quality classes (A to E), and three artificial neural network models.

Research phases were consisting of image retrieval, black tea's parameter correlation analysis, and software performance testing.

VI. RESULT

A. Parameter Analysis

Parameter analysis show that in two sample cases, black tea's parameters which has high correlation to its quality parameters is described in TABLE I and TABLE II. The correlation was made to SNI 01-1902-2000 Standard.

TABLE I. CHOSEN PARAMETER FOR STACKED SAMPLES

Name	Correlation Value to Quality Class	Minimum Value	Maximum Value
Mean HSL-L / Mean RGB-G	0.8058	0.9231	0.9606
Mean YIQ-Q / Mean RGB-IG	0.7655	1.3446	1.4157
Mean HSV-S / Mean HSL-IS	0.7578	1.1141	1.2869
Mean CMYK-Y / Mean HSL-S	0.7544	0.6787	0.8439
Mean CMYK-CV / Mean HSV-IH	0.6729	0.0014	0.0278
Mean HSL-S / Mean CMYK-Y	-0.7499	1.1850	1.4735
Mean RGB-IG / Mean YIQ-Q	-0.7672	0.7064	0.7437
Mean HSL-IS / Mean HSV-S	-0.7675	0.7771	0.8976
Mean RGB-G / Mean HSL-L	-0.8075	1.0411	1.0832
Mean RGB-IG	-0.8692	0.3444	0.3533

TABLE II. CHOSEN PARAMETER FOR SCATTERED SAMPLES

Name	Correlation Value to Quality Class	Minimum Value	Maximum Value
Mean CIE XYZ-IX / Mean YIQ-II	0.5046	0.6967	0.9233
Mean RGB-IR / Mean YUV-IV	0.5016	0.5452	1.1114
Mean RGB-IR / Mean YIQ-II	0.4981	0.5378	1.1411
Mean RGB-IR / Mean YDbDr-IDr	0.4852	0.5175	1.2690
Mean CIE XYZ-IX / Mean YDbDr-IDr	0.4851	0.6704	1.0267
Luas / Mean HSL-S	-0.5305	3.0488	20078
Tinggi / Mean HSL-S	-0.5257	0.0000	721.22
Luas / Mean CMYK-M	-0.5194	1.0000	838181
Luas / Mean CMYK-IM	-0.5168	1.0000	817114
Keliling / Mean HSL-S	-0.5163	3.0488	3197

B. Expert System Testing Result

Testing shows that by implementing the founded parameters on 18 testing cases, implemented system shows better training speed or training accuracy that other cases. On the other hand, implemented system giving better implementation accuracy in 50 % cases, as TABLE III. Parameter group was classified on normally used pattern recognition parameters (Standard), best parameters found (Good), and worst parameters found (Bad). The target accuracy was added to show whether the result is satisfying, based on observation.

TABLE III. LEARNING AND IMPLEMENTATION ACCURACY

Sample	ANN Structure	Parameter Group	Learning Accuracy	Implementation Accuracy	Target Accuracy
Stacked	3 - 5 - 1	Standard	0.0162	0.87	0.80
		Good	0.0128	0.56	
		Bad	0.0483	0.20	
	11 - 21 - 1	Standard	0.0033	0.73	0.80
		Good	0.0028	0.77	
		Bad	0.0483	0.20	
	11 - 21 - 5	Standard	0.0346	0.75	0.80
		Good	0.0200	0.72	
		Bad	0.0400	0.76	
Scattered	3 - 5 - 1	Standard	0.0134	0.26	0.10
		Good	0.0121	0.22	
		Bad	0.0141	0.21	
	11 - 21 - 1	Standard	0.0116	0.23	0.10
		Good	0.0087	0.27	
		Bad	0.0120	0.18	
	11 - 21 - 5	Standard	0.0385	0.31	0.10
		Good	0.0307	0.39	
		Bad	0.0373	0.34	

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