Implementation of an Inference System to Classify Persons into Eight Constitutions

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Abstract

Traditional Korean medicine prescribes differently if the patients’ constitutions are different, even if their symptoms are the same. Therefore, correctly determining a patient’s constitution is very important in practice. Traditional Korean medicine doctors classify individuals into constitution classes based on strength and the size of the person’s internal organs. There are eight classes: Pulmotonia, Colonotonia, Renotonia, Vesicotonia, Pancreotonia, Gastrotonia, Hepatonia, and Cholecystonia. However, an objective way of determining an individual’s constitution does not exist. Traditional Korean medicine doctors examine the patient’s appearance, ask several questions, and feel the pulse of the patient in order to determine the patient’s constitution. Therefore, we need an expert system that can assist doctors to determine the patient’s constitution. This paper develops an inference system to classify persons into the eight constitutions.

Keywords: Constitutions, Expert System, Inference Engine, Traditional Korean Medicine

1. Introduction

An expert system is an intelligent system that utilizes the inference procedures and knowledge of the domain to solve problems that require the significant expertise of a person for the solution. Expert systems are widely employed to solve complex problems in multiple domains, such as medicine, disease identification, agriculture, power supply, and oil exploration1.

As depicted in Figure 1, an expert system generally consists of a knowledge base, an inference engine, a man–machine interface, a global database, a knowledge acquisition subsystem and an explanation subsystem2. Human experts input their knowledge into the knowledge base through the knowledge acquisition subsystem. The inference engine derives conclusions or decisions by analyzing the information written in the knowledge base and in the global database, and then displays the derived decisions on the man–machine interface so that customers can read them. If the customer asks, “Why this decision?” then the explanation system provides the reasoning process performed by the inference engine.

Traditional oriental medicine prescribes differently if the patients’ constitutions are different, even if their symptoms are the same. For example, Ayurvedic medicine or Ayurveda (traditional Hindu medicine), prescribes herbal medicines, mineral or metal supplementation, surgical techniques, opium, and the application of oil by massage based on individual differences. Since treatments are based on individual differences, Ayurvedic medicine also provides a set of knowledge to classify individuals3.

Traditional Chinese medicine puts individuals into constitution classes based on body characteristics, common performance, psychological characteristics, disease tendencies and ability to adapt to the external environment. Traditional Chinese medicine treats patients differently if their constitutions are different4.

Traditional Korean medicine also classifies individuals into constitution classes based on strength and the size of the person’s internal organs. There are

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eight classes: Pulmotonia, Colonotonia, Renotonia, Vesicotonia, Pancreotonia, Gastrotonia, Hepatonia, and Cholecystonia. Depending on the patient's constitution, traditional Korean medicine prescribes different medications and treatments for the patient. Therefore, correctly determining a patient's constitution is a traditional Korean medicine doctor's first priority when meeting a patient.

A tool that automatically finds a person's constitution will be helpful to these doctors. Our ultimate goal is to develop an expert system that automatically classifies people by their constitution. As the first step toward the goal, this paper develops an inference system with MATLAB to classify persons into one of the eight constitutions.

2. Related Works

Expert systems, constitutions, and MATLAB are topics related to our work. MYCIN is one of the first expert systems that appeared in the world. It was created in the early 1970s. MYCIN accepts a description of the symptoms and returns the bacteria types that cause the symptoms. MYCIN was followed by many other expert systems. Bilal and Mohsin introduced a cloud-based distributed expert system for the classification of Ahadith (the sayings of the Prophet Muhammad).

An expert system shell is an interface between knowledge engineers and the knowledge base. Through the shell, we can strengthen, refine and maintain the knowledge of an expert system. Islam described ShellAg, which deals with the development procedure of a multi-crop expert system. An example rule we can find in a multi-crop expert system is:

If State is “Haryana” and Sowing Time is “Timely Sown” and condition is “Irrigated” THEN variety is PBW-502.

He et al. designed and implemented an expert-based control system for the Intravenous Medication Preparation Robot. The knowledge base of the expert system consists of a drugs and syringes information base, a dispensing operations information base, and an inference rules information base. An example rule we can find in the inference rules information base is:

IF (Drug Form == Liquid and Heating == No)
Then (Syringe needle = Thin needle)

An expert system is a computer-based information system that uses expert knowledge to attain high-level decision performance in a narrowly defined problem domain. Windriyani et al. built an expert system for detecting mental disorders.

Suppliers should punctually supply materials and outsourced parts in the appropriate quantities with consistent quality. Manufacturers that have reliable suppliers can reduce inventory costs and also improve product quality. However, supplier evaluation is a complex decision-making process in practice, because there are various aspects that must be considered. Therefore, Wangphanich introduced a web-based expert system for supplier evaluation. The evaluation process is depicted in Figure 3.

An example rule is as follows:

IF Question 1: the supplier is certified by ISO 14000 = YES
AND Question 2: all machines have guards and safety devices = YES
AND Question 3: all employees have personal protective equipment = YES
AND Question 4: all employees receive safety training = YES
THEN

A supplier has high performance in the Safety aspect (Score = 100%)

Over the last decade, fuzzy control technology has been considered an effective method to process uncer-
tain information and to control complicated nonlinear systems. The expression ability of the fuzzy language variable can be used to describe the human experience. An autonomous car is a self-driven car that does not require a human driver. A fuzzy rule-based controller to drive an autonomous car has the capability to make steering decisions by “If, then” rules. A rule is derived from heuristic knowledge expressed linguistically by expert human drivers. A survey on the applicability of an expert system in designing and controlling autonomous vehicles was presented by Khalajzadeh et al.11.

An image can be considered a fuzzy subset of a window. Gopalan et al.12 considered three parameters, such as intensity, the fuzzifier and crossover point, to enhance the image. Oil spills result in significant damage to the ocean. Using adaptively varying membership functions and incorporating fuzzy associative memory with a conventional multilevel median filter, Alli et al.13 proposed a novel system that detects oil spills in Synchronous Aperture Radar images. Bisht and Jangid14 developed river stage discharge models using an adaptive neuro-fuzzy inference system and linear multiple regression methods. Fallahi and Jafari15 presented an automatic system for detection of breast cancer using data preprocessing and a Bayesian network16.

Ayurvedic medicine has a very strong bearing on the concept of Prakriti, which means the nature (natural form) of the build and constitution of the human body. According to Ayurveda, the path to optimal health is different for people depending on their Prakriti. For individuals, the Prakriti is defined as a combination of Vata, Pitta and Kapha. A balanced state of the Prakriti makes a healthy and balanced person (physically and mentally). Diagnosis of the Prakriti offers unique insights into understanding and assessing one’s health. Mendis et al.17 developed an expert system for diagnosis of human constitutions. An example result yielded by the system is shown in Figure 4.

China’s association of Chinese medicine established the “Traditional Chinese medicine constitution classification and decision” standard. There are nine constitutions, as follows18: yin-yang harmony constitution, qi deficiency constitution, yang deficiency constitution, yin deficiency constitution, phlegm dampness constitution, damp heat constitution, blood stasis constitution, qi stagnation constitution, and allergic constitution. Based on human constitution, Liu et al.17 proposed a feasible idea and method for curing immunoglobulin A nephropathy.

MATLAB allows users to implement Mamdani type and Sugeno type fuzzy inference systems. The Sugeno type of fuzzy rules are written in the following format:

![Figure 3. The evaluation process](image)

Your humeral constitutions are in the following percentages:

Vata 10.52632
Pitta 68.42105
Kapha 21.05263

Since your dominancy humeral constitution type is Pitta, you tend to have the following diseases:

#hypertension
#ischaemic_heart_disease
#rheumatoid_arthritis

![Figure 4. A screenshot of the expert system introduced by Mendis et al.](image)
If Input1 = x and Input2 = y, then Output is 
\[ z = ax+by+c. \]  

Where a and b can be zero. Therefore, the Sugeno type is more general than the Mamdani type.

3. Design of the System

3.1 Rules to Determine Constitution

Traditional Korean medicine determines the constitution of a person based on the size and strength of internal organs. Traditional Korean medicine doctors treat patients differently if their constitutions are different. Therefore, determining peoples' constitutions is important. Kim et al. suggested the following rules to determine a patient's constitution.

Cla: prefers an open place to a closed one -> Hepatonia.
Clk: tends to be creative and dislikes imitating -> Pulmotonia.
Clm: has high ambition -> Colonotonia.
Cls: is self-centered -> Vesicotonia.
C4a: tends to be impetuous but not persistent -> Cholecystonia, Pancreotonia.
C4c: is emotionally weak -> Cholecystonia.
C4i: is wicked -> Hepatonia.
C4k: tends to spread what he/she knows to others -> Pancreotonia.
C4l: He/she is a bag of cats and is always in a hurry -> Pancreotonia.
C4m: His/her plans go up like a rocket and come down a stick -> Pancreotonia.
C4n: looks gentle but is actually aggressive -> Gastrotonia.
C4o: is self-righteous -> Pulmotonia.
C4p: exaggerates and boasts what he/she has done -> Pulmotonia.
C4q: is very meticulous and particular when he/she is full of drive -> Pulmotonia.
C4r: He/she does not always live in concord with neighbors -> Pulmotonia.
C4s: is irascible -> Colonotonia.
C4t: is pridelul -> Colonotonia.
C4x: is miserly -> Renotonia.

3.2 Fuzzy Logic Designer

The first step in building a fuzzy inference system is to type the following command at the MATLAB prompt: 

```matlab
>>> fuzzyLogicDesigner
```

Then we will have a graphical user interface similar to Figure 5. The submenu of the File menu includes New FIS..., Import, Export, Print, and Close. By selecting New FIS ..., we can create either a Mamdani or Sugeno fuzzy inference system (FIS). The Export submenu allows us to save the FIS we are working on.

The general format for FIS rules is “If antecedent then consequent.” An antecedent is in the form “clause1 connect1 clause2 connect2 … clause k”. A consequent is in the form “clause1 clause2 … clause n”. A clause is in the form “a variable is a ‘linguistic value defined by a fuzzy set’.” A variable can be either input or output. An example rule can be “If C4a is high, then Cholecyston is positive or Pancreotonia is positive.” Where C4a is an input variable, high is a linguistic value defined by a fuzzy set.

In the beginning, there are two variables: one input and one output. In order to add an input variable, we select

Edit > Add Variable > input

Since there are 18 input variables, we select input 18 times to get the result seen in Figure 6. For each input variable, we change its name. For example, we change input1 to Cla.

Now, we save our work by selecting “File > Export.” We named our work EightConstitutions because there are eight constitutions. Therefore, we repeated the following operation eight times to obtain the result seen in Figure 7. The name of the first output variable is “Pulmotonia.”

Edit > Add variable … > Output

Now, we select “Edit > Membership Functions …” in order to move to the “Membership Function Editor” page shown in Figure 8. For each of the variables, three membership functions are provided. The default name of a membership function can be mf1. We can change the name, type, range, display range, and parameters of membership functions with the editor. For example, we can change mf1, mf2, and mf3 to low, average, and high, respectively, as shown in Figure 8.

Then, we designate the function type for each of the membership functions. There are 11 membership function types: trimf (triangular membership function), trapmf (trapezoidal), gbellmf (generalized bell), gaussmf, gauss2mf, sigmf (sigmoidal), dsigmf (difference between
two sigmoidals), psigmf (product of two sigmoidals), pimf, smf, and zmf. Typical forms for each of these types are shown in Figure 9.

Now, we move to the Rule Editor page, shown in Figure 10, by selecting Edit > Rules …. For each rule, we specify an antecedent and a consequent. An antecedent can have up to 18 clauses because we defined 18 input variables. If a certain input variable is irrelevant to the rule, then we should select none. Otherwise, we need to select one of the three fuzzy sets (low, average, or high). Similarly, we specify a consequent for the rule. Then, we click the “Add rule” button.

4. Experiments

The purpose of this paper is to build an inference system that determines users’ constitutions. In order to see how our system works, we select “View > Rules”. Then we move to a window like the one shown in Figure 11. Here, we can specify the user’s characteristics. For example, if the user highly prefers open places to closed ones, then we drag the red line in the first column to the right hand side. Then the probability for the user to be Hepatonia increases. When the user highly prefers open places and is highly wicked, then the probability for the user to be Hepatonia would be 0.869, as shown in Figure 11.

5. Conclusions

Traditional Korean medicine treats patients with herbs and acupuncture. It also emphasizes preventive medicine and contributes to health. When traditional Korean medicine doctors prescribe for patients, they first determine the patient's constitution. Depending on the constitution, the prescriptions are changed. However, an objective method of determining a person's constitution does not exist. Therefore, we need an expert system that automatically classifies persons by constitution. This paper developed an inference system with MATLAB to classify persons into eight constitutions. An inference system is one of the most important parts of an expert system. For further study, we plan to add more rules to the inference system and implement a knowledge acquisition system and an explanation system.

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Figure 7. There are 18 input and eight output variables.

Figure 8. The Membership Function Editor page.
Figure 9.  Typical forms for membership functions.

Figure 10.  The rule editor page.

Figure 11.  The Rule Viewer page.
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