

Rule-based AI for acupuncture treatment using micro-computers*

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Abstract

It is shown that acupuncture meridians is an oriented graph. Disease treatment consists in manipulating the acupuncture points. This paper proposes to use artificial intelligence in acupuncture treatment using PROLOG on an IBM-PC-AT.

Key words: Acupuncture, microcomputers, PROLOG, IBM-PC, knowledge-based expert systems.

1. Introduction

A recent application of the area of artificial intelligence is the development of knowledge-based expert systems. These systems are capable of applying rules developed by human experts to the solution of specific problems. While such a system will never surpass the capability of an expert, it does provide an opportunity to simulate the thinking process of an expert when one is not available. Rules are developed by interviewing experts in the application to be automated. A rule interpreter or inference system makes decisions based on these rules and collected data.

It matters very little to the patient which method has been used to treat the disease as long as the disease is treated. Acupuncture treatment has no known side effects and is found to perform with remarkable efficiency in curing a variety of diseases^{1,2}. This method of treatment is found to be statistically valid³. However, it is not an overall cure for all the diseases⁴.

A brief description of the application of artificial intelligence in medicine is presented. A methodology of treatment by acupuncture theory is explained. It has been shown that the oriented graph representation of meridians for acupuncture treatment developed by the authors⁵ lends very well for the application of artificial intelligence.

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2. Artificial intelligence in medicine (AIM)

Following is a brief survey of AIM research carried out at various US universities⁶⁻⁸.

MYCIN system, developed at the Stanford University originally for the diagnosis and treatment of bacterial infections of the blood, was later extended to handle other infectious diseases as well. The fundamental insight of the MYCIN investigators was that the complex behavior of a program which might require a flowchart of hundreds of pages to implement as a clinical algorithm could be reproduced by a few hundred concise rules and a simple recursive algorithm (described in a one-page flowchart) to apply each rule just when it promised to yield information needed by another rule. For example, if the identity of some organism is required to decide whether some rule's conclusion is to be made, all those rules which are capable of concluding about the identities of organisms are automatically brought to bear on the question. The modularity of such a system is obviously advantageous, because each individual rule can be independently created, analyzed by a group of experts, experimentally modified, or discarded, always incrementally modifying the behavior of the overall program in a relatively simple manner. Other advantages of the simple, uniform representation of knowledge which are not as immediately apparent but equally important are that the system can reason not only with the knowledge in the rules but also about them. Thus, it is possible to build up facilities to help acquire new rules from the expert user when the expert and the program disagree, to suggest generalizations of some of the rules based on their similarity to others, and to explain the knowledge of the rules and how they are used to the system's users.

At MIT, a program for advising physicians using the drug, digitalis, for patients with heart disease was developed. The major insight in developing this program was the recognition that therapeutic advice must be based on a patient-specific model which includes, in addition to all relevant factors from the patient's medical history, the goals of therapy and how previous sessions have shed light on the drug's effects on the individual patient.

To effectively formulate any diagnostic problem, the INTERNIST system was developed at the University of Pittsburgh for diagnosis in general internal medicine. INTERNIST-I uses a problem-formulation heuristic to select from among all its known diseases that set which should be considered as competing explanations of the currently known abnormal findings in a case.

The CASNET system, developed at the Rutgers University, in its major incarnation as a diagnostic and therapeutic program for glaucoma and related diseases of the eye, also describes EXPERT, a somewhat simpler and more widely applied system which is being used in the analysis of thyroid disorders and in rheumatology. CASNET identified the fundamental issue of causality as essential in the diagnostic and therapeutic process. Simply put, any abnormal phenomenon must have some causal pathway which can be traced back to an ultimate etiological factor. Conversely, if every possible pathway to a suspected disorder can be ruled out, belief in that disorder is not tenable. CASNET uses these simple observations which permits it to assess the likelihood of a node in the causal

network. CASNET also has the attractive feature that it models the partial or complete failure of treatment with the same mechanisms as the progression of disease.

3. Introduction to acupuncture treatment

In the recent past there has been considerable interest in acupuncture treatment in the West^{3,4,9-11}. Chan³ lists over 145 references in his recent paper. Acupuncture is a process whose existence has been inferred by its results^{5,12}. It is particularly attractive because it produces no known side effects, as demonstrated in a report on the treatment of tennis elbow¹.

According to Chinese medicine, the vital force (energy) or 'Chi' circulates through the body in channels, which are represented by meridians^{12,13}. Figure 1 is a representation of the human body with these meridians superimposed.

The fundamental knowledge of traditional Chinese medicine mainly includes the theories of Yin-Yang, the five elements and channels. The theory Yin-Yang holds that every object or phenomenon in the universe consists of two opposite aspects, namely, Yin and Yang, which are at once in conflict and in interdependence; further, that this relationship between Yin and Yang is the universal law of the material world, the principle and source of the existence of myriads of things, and the root cause for the flourishing and perishing of things.

The theory of Yin-Yang mainly expounds the opposition, interdepending, inter-consuming-supporting and intertransforming relationship of Yin and Yang. This relationship between Yin and Yang is extensively used in traditional Chinese medicine to explain the physiology and pathology of the human body and serve as a guide to diagnosis and treatment in clinical work. The basic key in the treatment is to restore the imbalance of energy flow in the body and to establish a state of equilibrium. The Chi in the meridians is analogous to current flow in a conductor. The exact anatomical locations of acupuncture points are given by Yang Jiasan¹⁴. The rate of flow of Chi in the meridian can be controlled by the insertion of needles at specific points, analogous to gain control in amplifiers.

A simplified representation of the meridians is shown in fig. 2. There are 12 main meridians and eight extra regulating meridians (not shown in fig.), that are termed reservoirs of energy.

The concept of Yin and Yang is also associated with each one of the principal meridians (fig. 2). For example, heart is Yin meridian and small intestine is Yang meridian. The Chi flow in the regular meridians is continuous, on the other hand, the regulatory channels only flow when stimulated to normalize the excesses and deficiencies caused by a disease. The meridians can also be viewed as a master communication system of life energy, connecting 12 organs with other physiological, sensorial, and emotional aspects of the body. The existence of meridians and the acupuncture points as electrically low-resistance zones, has recently been studied¹⁵⁻¹⁷.

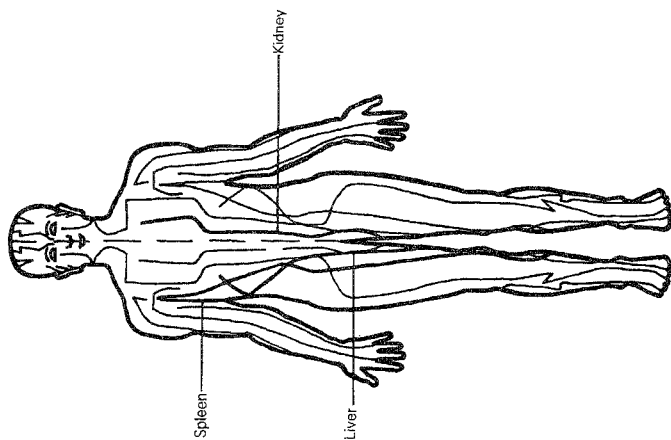


Fig. 1b.

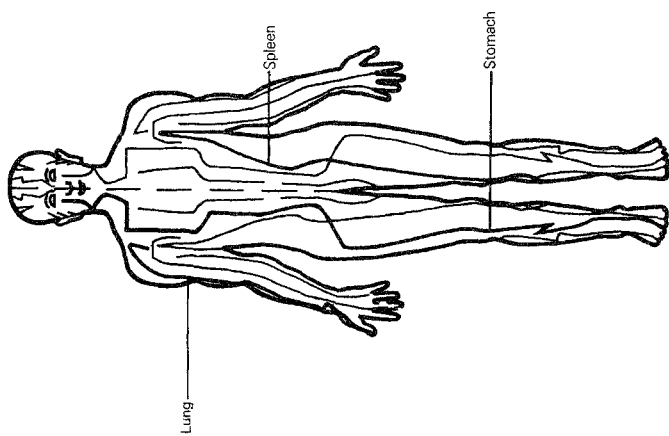


Fig. 1a.

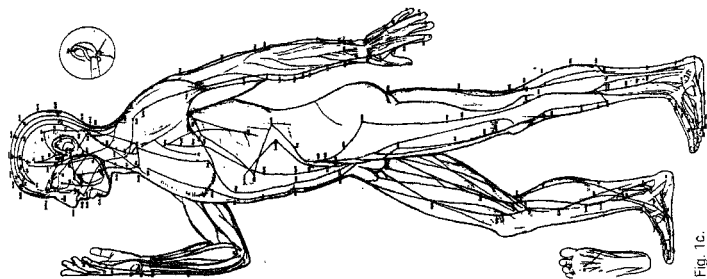


Fig. 1c.

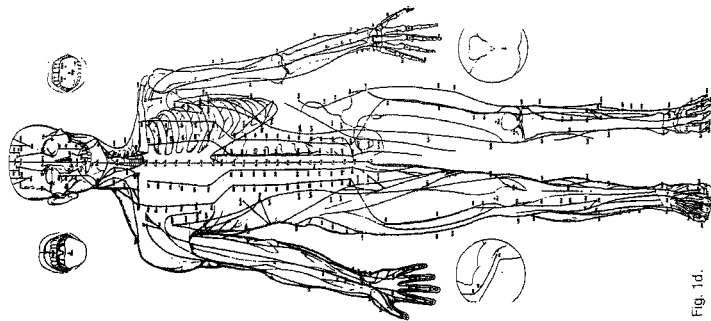


Fig. 1d.

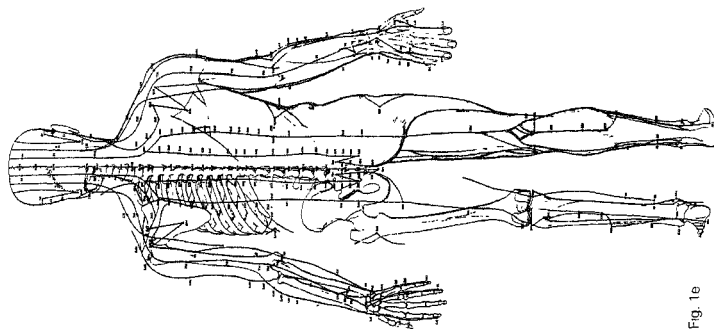


Fig. 1e.

Figs 1a-c. Reproduced with permission from the book *Atlas of acupuncture* by Felix Mann (Heinemann Medical Books, London).

3.1. Five elements and their relationship to disease

Chinese medicine comprehensively relates the physiology and pathology of organs and tissues with natural environmental factors. These factors are classified into five categories corresponding to elements, namely, wood, fire, earth, metal, and water. The interpromoting, interacting and counteracting relationship among the five elements is shown in fig. 3.

'Promoting' here implies growth in the quantity of the elements. The order of promoting is: wood promotes fire, fire promotes earth, earth promotes metal, metal promotes water and water, in turn, promotes wood. 'Acting' connotes bringing the elements under control or restraint. Overacting or interacting takes the form of launching an attack when the counterpart is weak such as water destroying fire. Counteracting implies preying upon such as fire preying on water and is opposite to interacting. The phenomena of overacting and counteracting, caused by excess or insufficiency of any one of the five elements, often manifest themselves simultaneously. For example, if wood is in excess, it not only overacts on earth but also counteracts on metal (fig. 3).

According to the Chinese acupuncture theory, the interpromoting, interacting, overacting, and counteracting relationship of the five elements can be used to explain the interdependent and interrestraining relationship among the organs, tissues, and acupuncture points. When an internal organ is afflicted by a disease, other organs may be affected, or the disease may spread. Acupuncture theory suggests that complex changes that occur in a disease all come from the following conditions: Overacting, counteracting, disorder of the mother affecting the son, and *vice versa* (described below). For example, pulmonary disease may, in some cases, be caused by cardiac disorders; and this can be explained as fire overacting on metal. If the same disease is due to impairment of

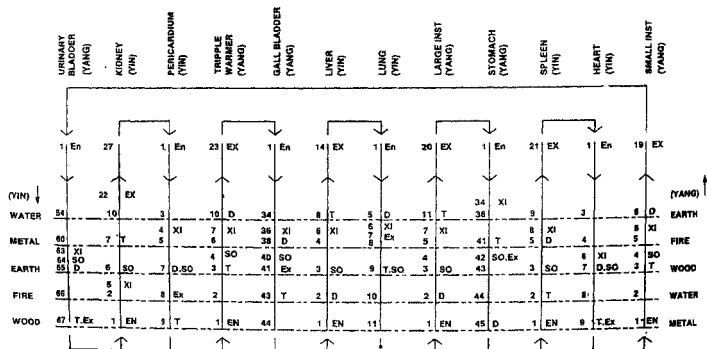


FIG. 2. Relation between five elements and the principal meridians.

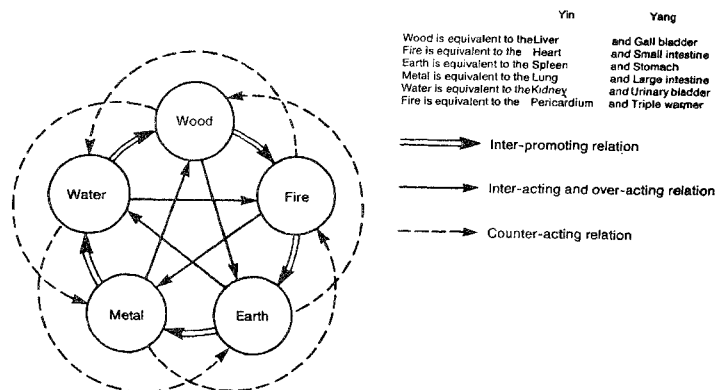


FIG. 3. Interpromoting, interacting, overacting and counteracting relations among the five elements: wood, fire, earth, metal and water.

the liver, it is explained as wood counteracting on metal. The above correlation of the disease with the five elements forms a basis for the treatment by acupuncture.

3.2. Conceptual visualisation of energy or Chi flow

In this section the Chi flow in the principal meridians is represented as an oriented graph. The five elements, along with the other significant points, are mapped on the graph (fig. 2). The arrows indicate the direction of energy, or Chi flow. It is important to understand that these meridians internally connect the organs in the body to the surface of the skin. The points marked on the meridians are located at specific locations on the surface of the skin.

Acupuncture points located on the principle meridians can be classified into seven categories, according to their specific properties as:

- a) Five shu points: The five shu points are attributed, respectively, to the five elements, their order being, in the Yin channels wood, fire, earth, metal and water and in the Yang channels metal, water, wood, fire and earth. These points correspond to the intersections of the lines of the five elements and the principal meridians. According to the inter-promoting relationship of the five elements, each channel has a mother point and a son point. The mother point has a tonifying (reinforcing) effect and is denoted by 'T' on the graph. The son point has dispersing (reducing or sedating) effect and is represented by 'D'.
- b) Source points (SO): Each of the 12 channels has a source point where the Chi is retained.

c) Connecting point (C): Each of the 12 regular channels has a point connecting a definite pair of meridians. These points are particularly used to treat diseases which involve more than two meridians and also for diseases in the area supplied by the respective channels.

d) Cleft points (XI): The cleft point is the site where the Chi of the channel is deeply converged. These points are used in treating acute disorders and pain in the areas supplied by the channels.

e) Back-shu points: Back-shu points are located on either side of the vertebral column and are located on the urinary-bladder channel. These points represent the disease in a particular organ.

f) Front-mu points: These points are located on the chest and abdomen. Like back-shu points, these are significant in diagnosis and treatment of the organs they represent.

g) Crossing points: These points denote the intersection of two more channels. They are mainly distributed on the head, face, and trunk. They reflect symptoms regarding the disease involving several channels.

The points of e, f and g are not shown in fig. 4 to avoid congestion. 'En' represents entry point and 'Ex' is the exit point on each channel.

The specific properties of the points described above are important to determine the particular acupuncture treatment. For example, the heart meridian is a fire meridian. The fire point of the heart meridian is H-8. According to the theory of five elements, wood (interpromotes fire) is the mother of fire. Therefore, if the wood element in the fire (heart) meridian is stimulated, the son fire would be tonified (reinforced). Therefore the point of tonification of the heart meridian is H-9 (wood).

3.3. Use of the oriented graph

The theory of channels and circulation of Chi is used as a guide to treatment by acupuncture. As disease in the human body is due to the imbalance of Chi flow, treatment is

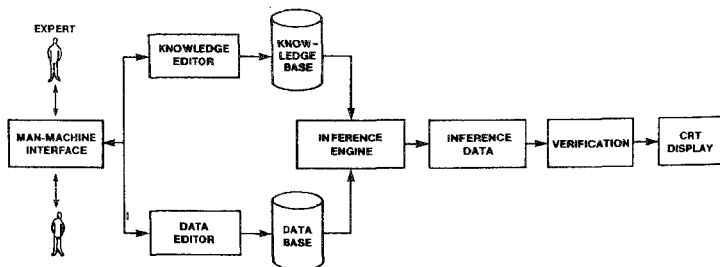


FIG. 4. Expert system shell for acupuncture treatment.

effected by insertion of needles at specific locations on the corresponding principal meridians. By this method, an overall equilibrium of energy can be attained and the disease cured. This method of treatment can also be termed as reinforcing the deficiency and reducing the excess. In the case of illness, the affected organ and the corresponding channels are first identified.

- a) Summarize the cause of effects of the disease according to the theory of five elements. Then correlate them with the principal meridians, considering the constitution of the individual and environmental conditions to locate and diagnose the disease.
- b) After identifying the affected organ and the channel, investigate further the mechanism of the disease and determine the essential and secondary symptoms, so as to decide whether reinforcing methods are to be applied.
- c) Having identified the nature of the disease, the next step is to select specific points for treatment. The choice of acupuncture points for treatment of a particular disease can be determined by correlating the cause of the disease to the properties of the acupuncture points (see example below).
- d) The last step is the determination of specific locations of the points selected for treatment. Standard acupuncture charts are available for locating specific points on the human body¹⁶.

Figure 2 may be used to evaluate the status of the disease and its response to the treatment. The graph provides a conceptual visualisation to the energy or Chi flow and can help in formulating the treatment. The following example illustrates the acupuncture treatment for headache.

Example

Treatment for headache

In the absence of definitive anatomical-pathological change, tension headaches are an important warning signal of stress. They serve as a safety valve to signal our attention to the various imbalances. Most of the available pain-killer drugs simply repress the symptoms, instead of dealing with the cause.

The head is where all channels of hand and feet meet (fig. 1). Headache can be caused by physical effects, *i.e.* vascular and muscular tension, which may also be brought about by emotional stress. According to the acupuncture theory, the cause for headache is the derangement of Chi and circulation of blood in the head, and the retardation of circulation of Chi in the channels that traverse the head. Tension in the head is related to the meridians that flow over it. For example, the commonest complaints, caused by a disfunction of the liver, are headaches and dizziness. The condition is called 'liver fire ascending'. Thus wood and fire will increase their activity, causing headache and dizziness. In this case, the disease is in liver and has not affected other organs. It is sufficient

to treat the liver alone by sedating its excessive fire. The treatment for this case is best achieved by dispersing (sedating) the fire in liver (LIV-2) and activating the water in gall bladder (GB-43).

Therefore, the prescription for this type of headache is to stimulate LIV-2 (disperse the fire) and GB-43 (activate water). The theory of five elements combined with the properties of acupuncture points can be applied for treating other types of headaches and diseases. Figure 2 provides a conceptual visualisation for the treatment. The points on the graph are determined from the standard acupuncture charts^{13,14}. The direction of Chi flow and the Yin & Yang nature are also indicated on each meridian.

4. Artificial intelligence in acupuncture

As noted earlier, acupuncture treatment is basically to harmonise the Chi flow in the meridians. This is achieved by needling (or injecting electric currents) specific acupuncture points.

Figure 4 provides our proposal for expert system in acupuncture. The language used will be PROLOG⁸. 'Knowledge base' consists of facts and heuristics about acupuncture diagnosis and treatment. This base is provided by the expert. Data editor is the working memory of a case under study. In our case 'inference engine' uses modus ponens and backward chaining. Our expert system conceptualizes the world by means of a hierarchy, which describes all types of diseases and where they occur within the body. The top link in the hierarchy is any disease; the next level down divides diseases among the different body systems. Lower still are branches for diseases of the heart, the liver, and so forth.

5. Conclusions

Acupuncture treatment lends itself very easily for rule-based artificial intelligence. PROLOG language is well suited for implementation on an IBM-PC AT.

We hope that our program will be of assistance to practicing acupuncturist.

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Appendix I

PROLOG

A popular programming language used in the field of artificial intelligence is PROLOG. PROLOG gained momentum when it was chosen by the Japanese as the language of their fifth-generation computer project. A program written in PROLOG is mainly a descriptive data base of facts and rules that can be executed to solve a problem. Facts are represented in a predicate-logic style, and can be added and deleted very easily. Typical facts appear like this:

```
greater_than (100 99)
equal_to (2 2).
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Rules are written in a slight variation of the popular IF-THEN statement. They state that a resultant condition is true provided that all parts of the conditional clause are true. A rule might appear like this:

_A less than B if greater-than (B A) and NOT equal to (B A).

The execution is then triggered by posing a query about the data base. The reasoning mechanism, or inference engine, searches through the rules and facts until a solution is found. For instance, the query:

which (A:A less_than 100)

would produce A = 99 since there is a fact stating that 100 is greater than 99 and no fact that states 100 is equal to 99. In a similar manner, answers can be inferred by an expert system by searching through a data base consisting of hundred, or even thousands, of facts and rules.

Appendix II

Following sample taken from the program developed indicates methods of regulating Chi energy. The excess or deficiency of the Chi energy can be corrected in a meridian under study.

Methods of regulating energy

HERE ARE SHOWN SEVERAL REGULATING METHODS

METHOD No. 6: Tonification-sedation chosen in function with the law
 <mother-son> with no regard to the actual season.

METHOD No. 7: Tonification-sedation based on the actual season and the law
 of <mother-son>.

METHOD No. 8: Based on the law <entraver-ecouler>, or <aller a
 l'encontre-suivre>.

METHOD No. 9: Based on the hour of treatment and the law of the five
 elements.

METHOD No.13: Law of the five elements.

WHAT METHOD HAVE YOU CHOSEN? (1-20)

Point(s) to treat

Which one of these meridians is unbalanced?

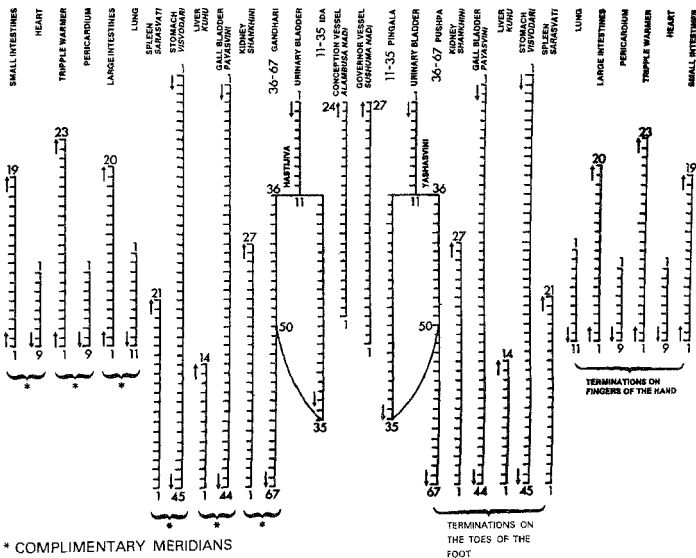


Insert abbreviation in bracket

heart (h)
 kidney (k)
 lung (lg)
 liver (lr)
 spleen (sn)
 small intestine (si)
 bladder (b)
 large intestine (li)
 gall bladder (gb)
 stomach (sk)
 pericardium (p)
 triple warmer (tw)

Appendix III

The conceptual visualisation of principal meridians and their identification with nadis



TERMINATIONS ON FINGERS OF THE HAND