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Design of Expert System for Search Allergy and Selection of the Skin Tests using CLIPS

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Abstract— This work presents the design of an expert system that aims in the procurement of patient medial background and in the search for suitable skin test selections. Skin testing is the tool used most widely to diagnose allergies. The language of expert systems CLIPS is used as a tool of designing. Finally, we present the evaluation of the proposed expert system which was achieved with the import of certain medical cases and the system produced with suitable successful skin tests.

Keywords— Artificial Intelligence, Expert System - CLIPS, Allergy and Skin Test

I. Introduction

THE Expert systems are a branch of applied artificial intelligence (AI) and were developed by the AI community in the mind-1960s. The basic idea of the development expert systems is that expertise of domain expert is transferred to a computer. The computer (programming tool CLIPS) can make inferences and arrive at a specific conclusion.

The diagnosis of allergy is an important problem in the medical science. Therefore, the design an automatic control system of diagnosis allergy with the use of robot would be a very basic tool in the service of doctor [3, 4].

The diagnosis of allergic diseases should always begin with the procurement of a patient history and an appropriate physical examination. Skin testing is the tool used most widely to diagnose clinical allergies. In this article is presented the design of an expert system aiming at the search of allergic disease and the selection of suitable skin tests. The medical knowledge of specialized doctor is required for the development of expert system. This knowledge is collected in two phases. In the first phase, the medical background of allergic disease is recorded through the creation of questionnaire in which the patient is called to answer.

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This questionnaire includes: 1) the presented symptoms, 2) the hereditary and family history, 3) search of allergy to inhalants (dusts, pollens etc), 4) search of allergy to foods, drugs, physical agents and 5) habits and hobbies, vaccinations (immunization), rashes from contacts and unusual reaction from insect stings. These answers constitute the facts in the expert system. In the second phase, a set of rules is created wherein each rule contains in IF part the facts and in THEN part the tests that should be realized. The inference engine (forward reasoning) is a mechanism through which rules are selected to be fired. It is based on a pattern matching algorithm whose main purpose is to associate the facts (input data) with applicable rules from the rule base. Finally, the skin tests are produced by the inference engine.

The development of expert system is implemented in CLIPS programming environment (CLIPS 6.22, C Language Integrated Production System) [1]. CLIPS developed in Johnson Space Center NASA. This programming tool is designed to facilitate the development of software to model human knowledge or expertise for medical therapy [5]. CLIPS program is used by reason of the flexibility, the expandability and the low cost. In this study the fact lists and knowledge base are presented. For the evaluation of expert system the results that are produced indicative for two cases are recorded.

The paper is organized as follows. Section II presents the record of the medical history of patient allergy. In section III the overall organization of a production system is discussed. Section IV we present the facts and the rules used for the selection of the skin tests. Simulation results for a test with in particular facts are presented in section V. Conclusions are made in the final section.

II. Medical History of Patient Allergy

The questionnaire that follows constitutes a recording of important data for the doctor that helps in the evaluation of allergic situation of the patient. It will give a clear picture of the allergic aspects of the patient's suffering. So the development of expert system cannot be started without a meticulous history. This information is organised in four groups. The three first groups constitute elements for the allergic evaluation of situation of the patient, while the last group proposes skin tests for the search of allergy [2, 6].

1. Personal data of patient
2. Medical history
    a. Symptoms related with allergy

    b. Hereditary and familial background
    c. Allergy to inhalants
    d. Allergy to foods
    e. Allergy to drugs
    f. Allergy to vaccination
    g. Rashes from contactants
    h. Unusual allergic reaction from insect stings or bites
3. Professional and social habits
    a. Habits and hobbies related with symptoms
4. Medical information of search of allergy and choice of the suitable skin prick test solution
    a. Search allergy to inhalants (Dust, Fungi, Animal dander, Pollen, Miscellaneous inhalants)
    b. Search allergy to foods
    c. Search allergy to animals
    d. Search allergy to insects

Each skin test corresponds in a number that is related with a specific allergen. Skin prick test solutions contain allergens in physiological saline with 50% glycerol preserved with 0.2% phenol. One drop of this solution is enough for this test. This allergen will be administrated intracutaneus. In our study, we used the allergens of Lofarma, Milan, Italy. Thus, number 628 corresponds to the solution which contains allergens of olives, number 25 corresponds to the allergens of cotton. In this study only single allergens had been tested. (Exception: Mixtures of grasses are countered as one allergen).

III. EXPERT SYSTEM

A literature review of the last decade for the recording of development methodologies of expert systems surveys and classifies these methodologies using eleven categories [7]:

1. Rule-based systems
2. Knowledge-based systems
3. Neural networks
4. Fuzzy ES
5. Object-Oriented methodology
6. Case-Based Reasoning (CBR)
7. System architecture development
8. Intelligent agent (IA)
9. Modeling
10. Ontology
11. Database methodology

The methodologies constitute the second generation of expert systems and they have the tendency to be developed to the direction of on one side directed also specialised knowledge (expertise orientation) and on the other hand in the development of applications in specialised problems (problem - oriented). In the present article the problem of the search allergy is implemented by methodology in the first category of rule based systems.

One of the well-know methods of representation of knowledge in the expert systems is the productive representation as the CLIPS (production system). The basic structure of a rule-based system with forward chaining is described by the following algorithmic equations:

Rule-based systems = Expert system

Expert system = Knowledge base + Inference

Knowledge base = Facts + Procedural knowledge

Procedural knowledge = Linguistic rules

The 4th group contributes in the creation of the linguistic rules and facts that constitute the knowledge base of the expert system.

The overall organization of a production system can be explained with the help of Figure 1. The three basic components of a production system are: a *working memory* for data (facts), a *production memory* for rules and an *inference engine,* whose function is to infer new facts from existing facts and rules, to assert the new facts into the working memory and then to continue this procedure of discovering new facts via the rules through the new store of facts in the working memory until no further facts can be inferred.

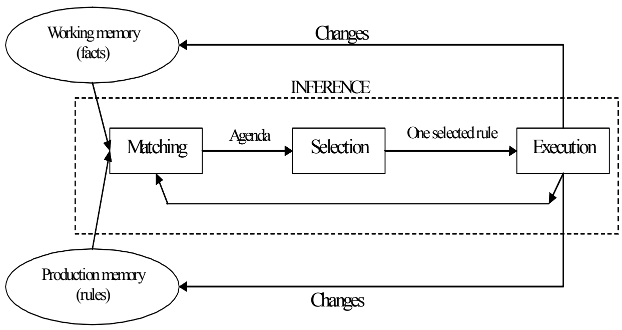

Fig.1 Structure of a production system (CLIPS) [8]

IV. FACTS – RULES IN CLIPS

CLIPS keeps in memory a fact list, a rule list, and an agenda with activations of rules. Facts in CLIPS are simple expressions consisting of fields in parentheses. For example a fact to express that a patient named Jim has allergy, could be coded in CLIPS as: *(Jim symptom allergy)*. Groups of facts in CLIPS, usually follow a fact-template, so that to be easy to organize them and thus design simple rules that apply to them.

Below, we present fact templates for facts concerning the search of allergy to inhalants and foods:

(<inhalant> <question keywords> <answer>)
(<food> <question keywords> <answer>)

For example, one of the questions to patients in the survey is: “Do you live in a city?” This question is to search potential of patient’s allergy to inhalants, and specifically to dust. Supposing a patient answers “yes”, this fact in CLIPS would be coded as: *(dust live-in-city yes)*. Each fact is added to the fact list that CLIPS keeps in working memory.

Rules in CLIPS consist of patterns (usually related to facts) and actions. Actions are actually functions which typically have no return value and may perform insertion or deletion of facts to the fact list, printing of messages in an output device, etc. A rule is activated and put on the agenda, when all of its patterns match with facts in the fact list.

When multiple activations are on the agenda, CLIPS automatically assigns to each of the activations a salience, according to which the corresponding rule will fire and thus its actions will be executed. Below we present the rules used for the selection of the skin tests:

```
(defrule food-meat
  (food ? y|yes)
  =>
  (assert (tests 216) (tests 244) (tests 242) (tests 188) (tests
240)
        (tests 239) (tests 215) (tests 241) (tests 224) (tests
224A)
        (tests 189) (tests 217) (tests 208) (tests 238) (tests 237)
        (tests 243) (tests 193) (tests 213) (tests 206) (tests 245)
        (tests 183) (tests 182) (tests 211) (tests 196) (tests 204)
        (tests 200) (tests 199) (tests 195) (tests 185) (tests 202)
        (tests 209) (tests 198) (tests 212) (tests 246) (tests 214)
        (tests 184)))

(defrule food-vegetables
  (food ? y|yes)
  =>
  (assert (tests 153) (tests 143)  (tests 85)   (tests 82)  (tests
135)
        (tests 115) (tests 152L) (tests 152M) (tests 110) (tests
164)
        (tests 174) (tests 113)  (tests 105)  (tests 130) (tests
114)
        (tests 166) (tests 151A) (tests 142)  (tests 168) (tests
180)
        (tests 81)  (tests 152D) (tests 167)  (tests 148) (tests
152C)
        (tests 143) (tests 176)  (tests 104)  (tests 100) (tests
116)
        (tests 89)  (tests 127)  (tests 103)  (tests 160) (tests 144)
        (tests 128) (tests 109)  (tests 139)  (tests 163) (tests
131)
        (tests 108) (tests 152I) (tests 121)  (tests 146) (tests
137)
        (tests 136) (tests 129)  (tests 147)  (tests 126) (tests
171)
        (tests 138) (tests 141)  (tests 124)  (tests 170) (tests
112)
        (tests 86)  (tests 133)  (tests 84)   (tests 102) (tests 88)
        (tests 120A)(tests 152H) (tests 101)  (tests 152B)(tests
106)
        (tests 178) (tests 83)   (tests 118)  (tests 119) (tests 165)
        (tests 152E)(tests 107)  (tests 122)  (tests 152A)))

(defrule sniff_general
  (sniff-general cotton-makes-worse y|yes)
  =>
  (assert (tests 25)))

(defrule gyris
  (pollen ? y|yes)
  =>
  (assert (tests 531) (tests 564) (tests 543) (tests 518) (tests
594)
        (tests 511) (tests 561) (tests 515) (tests 510) (tests 547)
        (tests 506) (tests 613) (tests 533) (tests 661) (tests 517)
        (tests 655) (tests 514) (tests 562) (tests 610) (tests 653)
        (tests 559) (tests 542) (tests 513) (tests 563) (tests 540)
        (tests 538) (tests 606) (tests 684) (tests 591) (tests 628)
        (tests 504) (tests 581B)(tests 581A)(tests 611) (tests
636)
        (tests 572) (tests 539) (tests 903) (tests 503) (tests 516)
        (tests 505) (tests 641) (tests 537) (tests 677) (tests 502)
        (tests 509) (tests 574) (tests 508) (tests 512) (tests
507)))

(defrule pets
  (pets ? y|yes)
  =>
  (assert (tests 49) (tests 54) (tests 60) (tests 48) (tests 53)
        (tests 47) (tests 43) (tests 61) (tests 44) (tests 59)
        (tests 50) (tests 45)))

(defrule fungi
  (fungi ? y|yes)
  =>
  (assert (tests 257) (tests 260) (tests 263) (tests 267) (tests
269)
        (tests 262) (tests 266) (tests 264) (tests 280) (tests 265)
        (tests 284B)(tests 272) (tests 258) (tests 274) (tests
273)
        (tests 276) (tests 277) (tests 284C)(tests 278) (tests
279)))

(defrule dust
  (dust ? y|yes)
  =>
  (assert (tests 25) (tests 7) (tests 1) (tests 2B) (tests 22) (tests
2)
       (tests 2A) (tests 21)(tests 31)(tests 28) (tests 82) (tests
75)))

(defrule conclusion
  (conclusion)
  =>
  (printout t crlf crlf "The following skin tests are proposed:"
crlf))

(defrule proposed-tests
  (tests ?code)
```

```
  =>
  (printout t ?code "-"))

(defrule fin
  =>
 (printout t "." crlf))
```

V. Simulation Results

Here we present the results, for a test with the following facts (the facts are created with the *deffacts* command and loaded in memory with the *reset* command):

```
(defacts answers
 (dust house-worse no)
 (dust live-in-city yes)
 (dust improper-heat no)
 (dust house-older-25y no)
 (dust carpets yes)
 (dust wallpaper no)
 (dust improper-furniture yes)
 (dust basement-useful no)
 (dust dusty-work no)
 (fungi worse-wet no)
 (fungi worse-touch-dry-plants no)
 (fungi worse-basement-store no)
 (fungi worse-yoghurt-etc no)
 (pets worse-touch no)
 (pets house-close-to-stables no)
 (pollen annoying-plants-around yes)
 (sniff-general perfumes-makes-worse no)
 (sniff-general chemicals-makes-worse no)
 (sniff-general cotton-makes-worse yes)
 (sniff-general newspaper-makes-worse yes)
 (food vegetables-from-list-cause-symptoms no)
 (food meat-from-list-causes-symptoms no)
 (conclusion))
```

The following skin tests are proposed:

25-531-564-543-518-594-511-561-515-510-547-506-613-533-661-517-655-514-562-610-653-559-542-513-563-540-538-606-684-591-628-504-581B-581A-611-636-572-539-903-503-516-505-641-537-677-502-509-574-508-512- 507-7-1-2B-2

VI. Conclusions

The application of expert systems in the medicine is very interesting and has created considerable importance systems of diagnosis. In the present work became a first step of design of an expert system for the search of allergy in patient and the suitable selection skin tests. The proposed system constitutes part of intelligent robotic system of diagnosis of allergies. In the article is presented the evaluation of expert system through concrete medical cases. As future work will constitute the utilization of fuzzy logic in order to is faced the ambiguity or the imprecision of measurements that are recorded as fuzzy facts and fuzzy rules in expert system.

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