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(54) **METHOD AND APPARATUS FOR DIAGNOSING AN ALLERGY OF THE UPPER RESPIRATORY TRACT USING A NEURAL NETWORK**

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(57) **ABSTRACT**

The invention relates to a method and means for performing a diagnosis of a medical condition and, in particular, an allergy associated with the upper respiratory tract, using an artificial neural network.

Role of CardiffTELE*form* Information Capture System v8.2

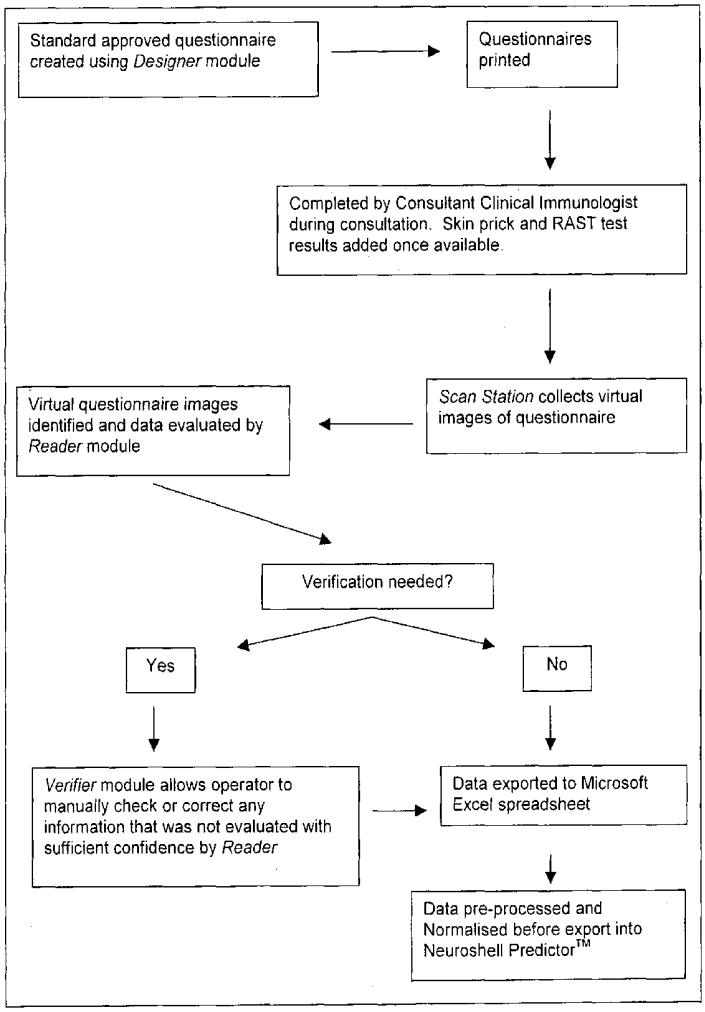
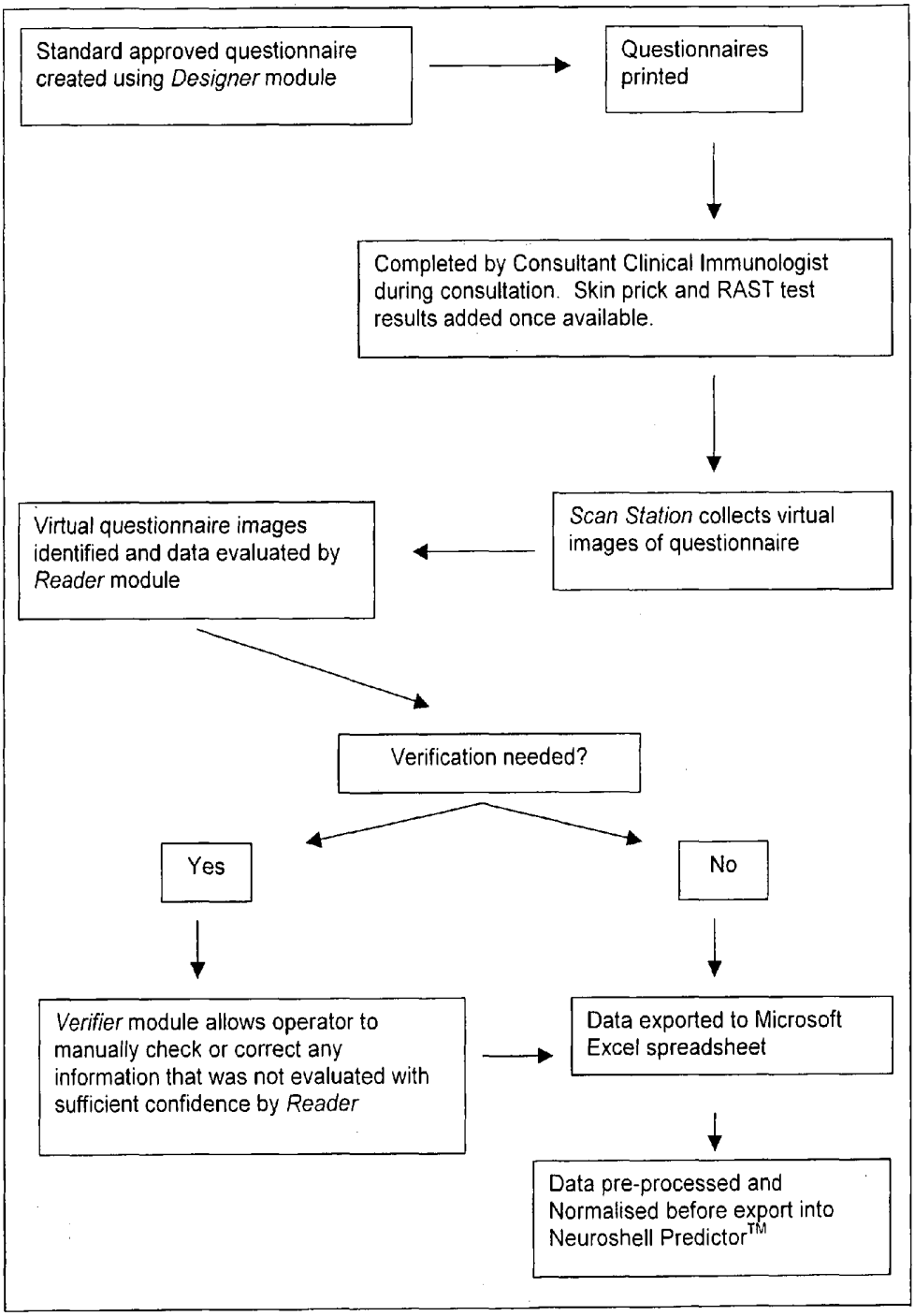
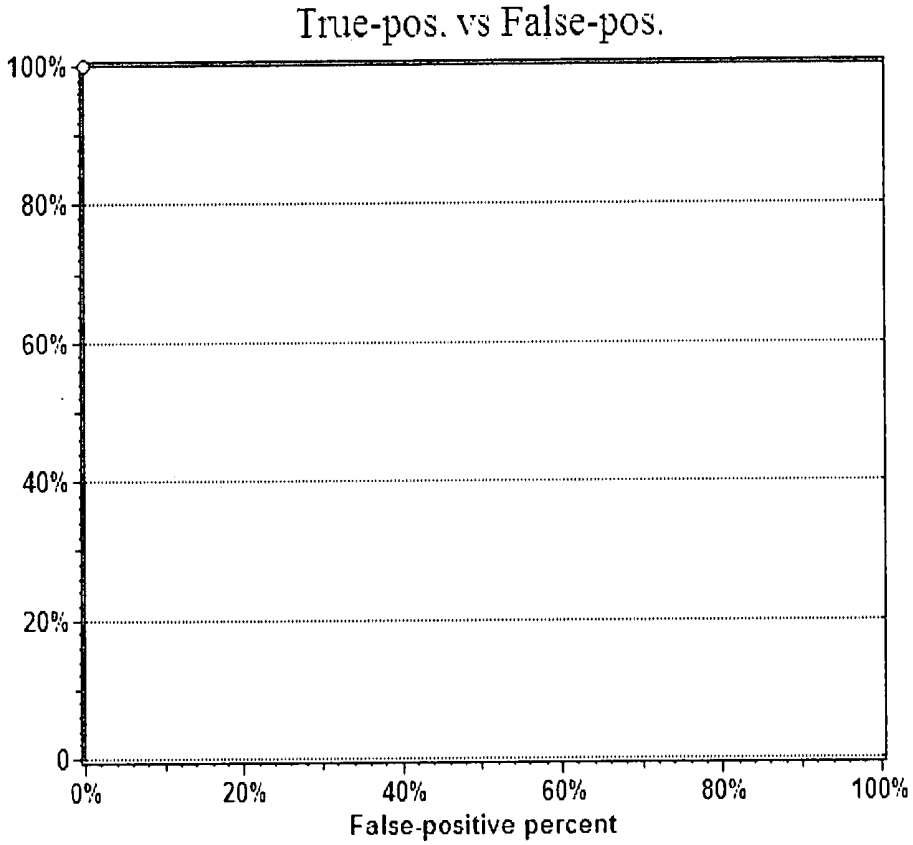


FIGURE 1: Role of CardiffTELE*form* Information Capture System v8.2




True-pos. vs False-pos.
100%
80%
60%
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20%
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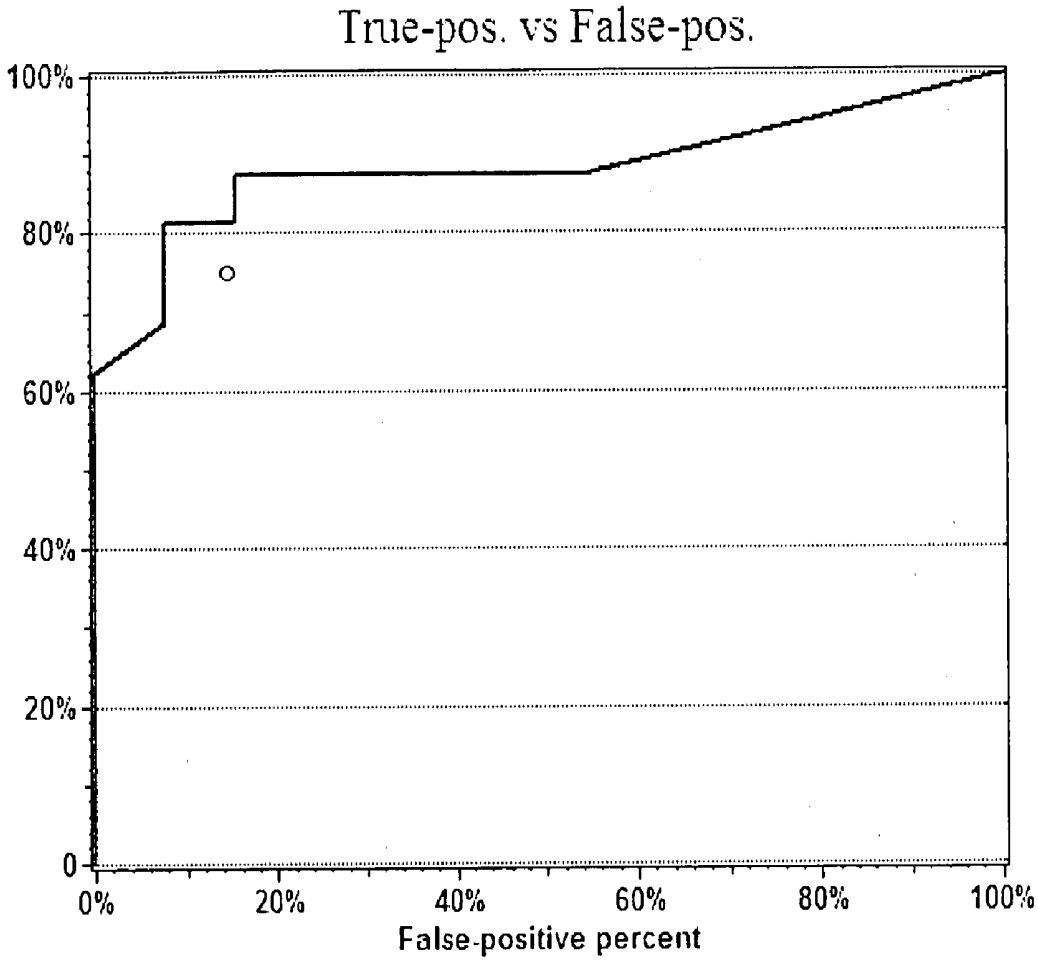
60%
80%
100%
False-positive percent

FIGURE 2


True-pos. vs False-pos.
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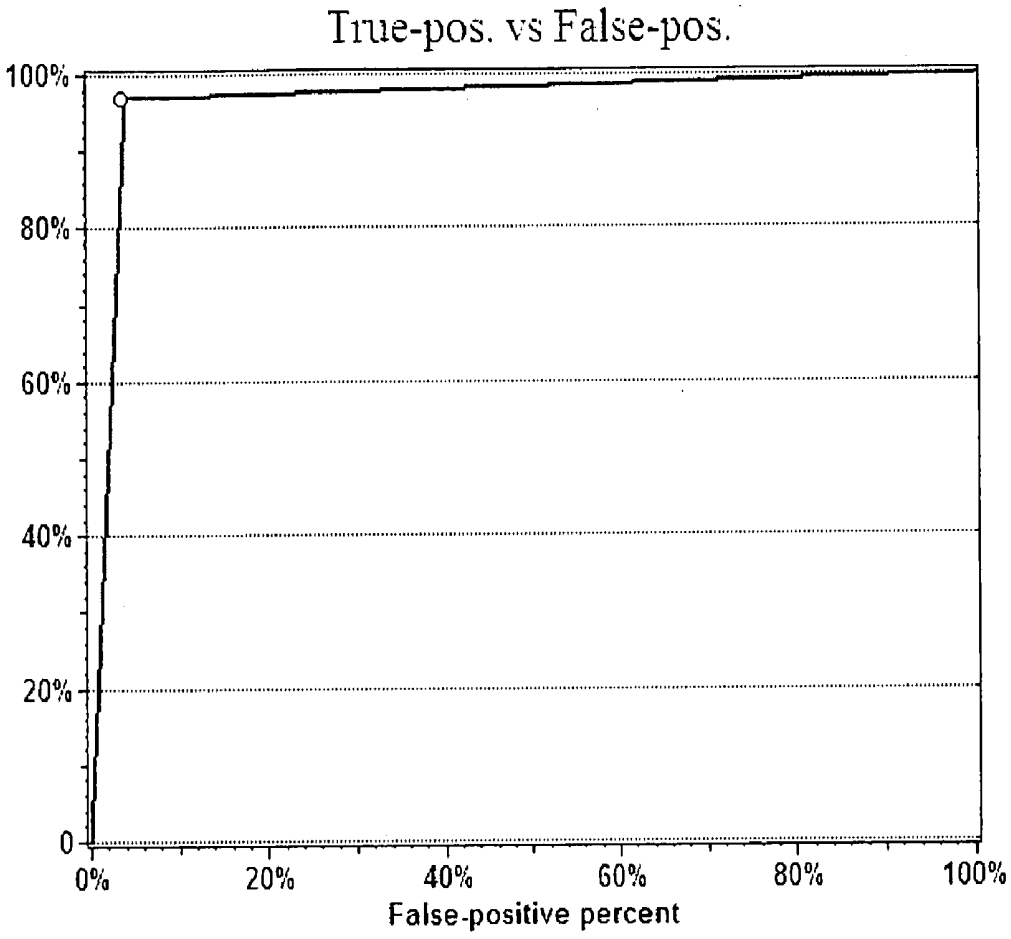
False-positive percent

FIGURE 3


True-pos. vs False-pos.
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False-positive percent

FIGURE 4

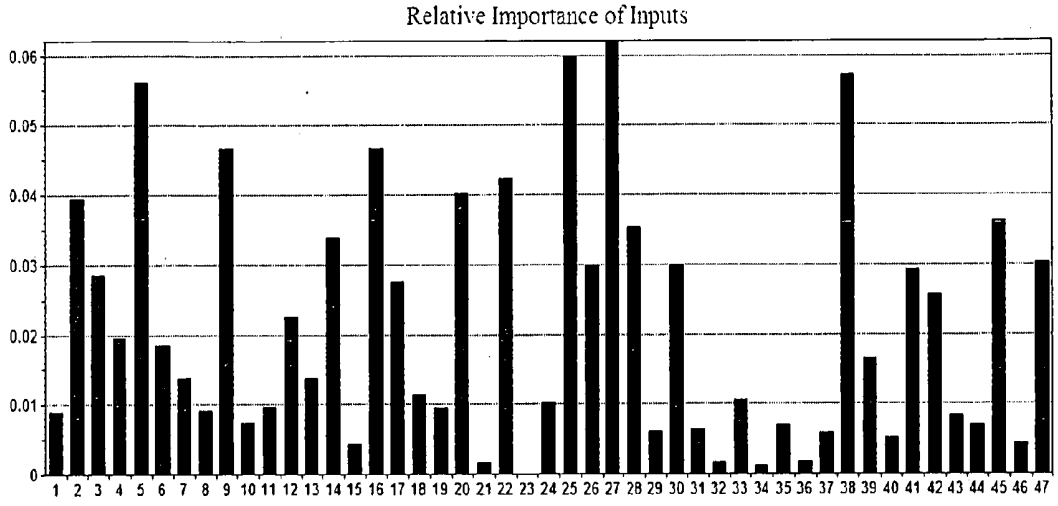
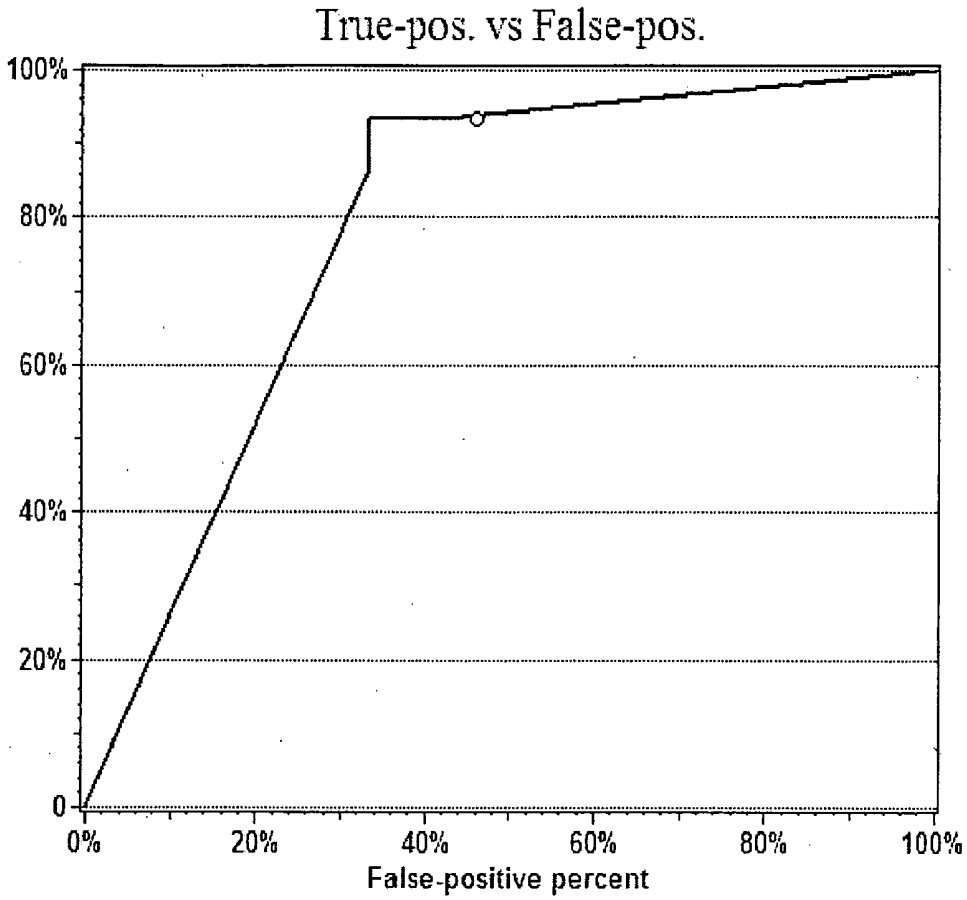

Relative Importance of Inputs
0.06
0.05
0.04
0.03
0.02
0.01
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47

FIGURE 5


True-pos. vs False-pos.
100%
80%
60%
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20%
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0%
20%
40%
60%
80%
100%
False-positive percent

FIGURE 6

METHOD AND APPARATUS FOR DIAGNOSING AN ALLERGY OF THE UPPER RESPIRATORY TRACT USING A NEURAL NETWORK

FIELD OF THE INVENTION

[0001] This invention relates to a method and means, including parts thereof, for diagnosing a medical condition, in particular an allergy associated with the upper respiratory tract, using an artificial neural network (ANN). The invention involves obtaining information about a patient, based on asking the patient a series of selected questions and carrying out a number of selected tests, inputting this information into a neural network, and obtaining a preliminary diagnosis. The invention applies equally to adults and children.

BACKGROUND OF THE INVENTION

[0002] Allergies currently affect approximately 34% of the general population (Linneberg 2000). Whilst at one extreme serious conditions such as anaphylaxis can be life threatening, most allergic disorders pose little risk of death. However, diseases such as rhinitis, eczema and urticaria cause distress and misery for millions of patents, often at times in their lives when they should be most active (Holgate and Broide 2003). Allergic diseases are a significant cause of morbidity in modern society, adversely affecting sleep, intellectual functioning and recreational activities; food allergy may lead to considerable anxieties for fear of inadvertently ingesting the offending allergen (Holgate 1999). Furthermore, allergic diseases exert a profoundly negative impact on occupational performance and have major public health costs.

[0003] Across the United Kingdom, waiting times for specialist allergy consultations following referral from primary care are long.

[0004] The rising prevalence of allergies and the associated demand for specialist services suggest that waiting times will inevitably lengthen over the course of the next decade. Given that there is currently an acute shortage of Immunologists and Allergists in the UK and worldwide, it seems unlikely that sufficient medical manpower will emerge in the foreseeable future to deal with this increasing demand.

[0005] Recent in-house research has centred on the role of the Allergy Nurse Practitioner in the diagnosis and management of allergic disease. Increasing use of the Nurse Practitioner in a diagnostic role would enable waiting times to be shortened and new patient referrals to be seen without the presence of the Consultant Clinical Immunologist. Whilst Nurse Practitioner-based diagnosis and management strategies should, in time, ameliorate the critical situation, a parallel increase in demand for allergy services will, without doubt, limit the positive effects on waiting times. There therefore remains a need to develop further innovative methods to facilitate access of patients to clinical diagnostic services.

[0006] However, as one would expect, it is extremely important that any new methods of diagnosis are accurate if they are to be adopted by the medical community at large. These methods must be able to replicate, it not exceed, the accuracy of an experienced Clinical Immunologist. This is a difficult task to achieve because a Clinical Immunologist uses information from a vast number of sources when reaching a diagnosis.

[0007] Typically, when diagnosing a condition, a medical practitioner will integrate information from several sources, such as a medical history, a physical examination, the results of clinical tests, and by asking the patient about his/her condition. The medical practitioner will use judgement based on experience and intuition, both when deciding what to look for and in analysing the information, in order to come to a particular diagnosis.

[0008] Thus, the process of diagnosis involves a combination of knowledge, intuition and experience that leads a medical practitioner to ask certain questions and carry out particular clinical tests, and the validity of the diagnosis is very dependent upon these factors.

[0009] Given the predictive and intuitive nature of medical diagnosis, and the fact that specialist, experienced medical practitioners are in demand, we have attempted to replicate the diagnostic process in an automated system, in order to give a wider audience access to this service. We have found that artificial neural networks (ANNs) have characteristics that make them particularly well suited for this purpose.

[0010] ANNs are computational mathematical modelling tools for information processing and may be defined as 'structures comprised of densely interconnected adaptive processing elements (nodes) that are capable of performing massively parallel computations for data processing and knowledge representation' (Hecht-Nielsen 1990; Schalkoff 1977). Single artificial neurons for the computation of arithmetic and logical functions were first described by McCulloh and Pitts (1943); fifteen years later Rosenblatt (1958) described the first successful neurocomputer (the Mark 1 Perceptron). This simple network consisted of two layers of neurons connected by a single layer of weighted links and was capable of solving problems in a way analogous to information processing in the human brain (Wei et al 1998; Basheer and Hajmeer 2000).

[0011] These early structures were however unable to predict generalised solutions for complex non-linear problems. Over the course of the following five decades complexity has increased with the development of multiple networked perceptrons; such advances have led to the application of ANNs to a colossal number of problems, and by 1994 more than 50 different types of network were in existence (Pham 1994 and Basheer and Hajmeer 2000), each possessing unique properties enabling them to solve particular tasks.

[0012] Such ANNs are capable of dealing with non-linear data, fault and failure, high parallelism and imprecise and fuzzy information (Wei et al 1998). Neural networks have been shown to be capable of modelling complex real-world problems and found extensive acceptance in many scientific disciplines (Callan 1999). The decision as to which type of ANN should be utilised for a particular task depends on problem logistics, input type, and the execution speed of the trained network (Basheer and Hajmeer 2000).

[0013] Neural networks have found increasing application in a range of clinical settings where they have produced accurate and generalised solutions compared to traditional statistical methodology (reviewed Baxt 1995, Wei et al 1998, Dybowski and Gant 2001). For example, U.S. Pat. No. 6,678,669 discloses using an ANN to diagnose endometriosis, predicting pregnancy related events, such as the likelihood of delivery within a particular time period, and other such disorders relevant to women's health.

[0014] The most commonly used ANN in such studies is the Backpropagational Multilayer Perceptron (MLP). MLPs are particularly useful in solving pattern classification problems (Wei et al 1998; Basheer and Hajmeer, 2000), which are

common in the clinical arena. In this context the ANN looks for patterns in a similar way to learning in the human mind; the more a particular pattern is represented, the stronger the recognition of it by the network.

[0015] Given the noisy, non-linear nature of clinical data utilised in the diagnosis of allergy, it has come to our attention that ANNs are a potential tool with which to facilitate access of patients to clinical diagnostic services, based on the hypothesis that ANNs can provide diagnosis for patients equivalent to that of the relevant specialists in the field.

[0016] To the best of our knowledge, this is the first time an ANN has been used to aid in the diagnosis of an allergy.

[0017] Accordingly, we have developed a method of diagnosing a medical condition using a neural network. In particular, from the vast amount of information that a clinician would have available, we have identified a manageable set of questions and tests that have clinical significance, and can be used to train a neural network to diagnose a condition, and by inputting the results of these questions and tests into a neural network thus trained the network to produce a diagnosis.

[0018] Surprisingly, we have found that an accurate diagnosis can be made by asking a patient just 5 questions and carrying out 4 medical tests, giving a total of 9 clinically significant inputs (referred to as the 9-input model), where it is currently standard practice for a medical practitioner to ask a patient up to 189 questions and carry out up to 21 different tests.

[0019] We have also identified a set of 12 (7 questions and 5 tests), 14 (7 questions and 7 tests), 15 (8 questions and 7 tests) 19 (11 questions and 8 tests), 21 (13 questions and 8 tests), 23 (14 questions and 8 tests) or 47 (29 questions and 18 tests) inputs, referred to in this description as the 12, 14, 15, 19, 21, 23 or 47-input models respectively, that can be input into a neural network to obtain a diagnosis.

[0020] The identification of these clinically significant questions and tests will mean that a neural network can be trained to diagnose a condition in considerably less time than it currently takes a consultant, which in turn will save time and money.

[0021] Additionally, a neural network offers an easy-to-use means of diagnosis, both for clinicians and non-clinicians, and will allow central aspects of diagnosis and management to be performed electronically in a way that is accessible to systematic audit and reduce inequalities in accessing allergy services, via the use of remote electronic information transfer.

[0022] According to a first aspect of the invention, there is therefore provided a method for diagnosing a condition comprising:

[0023] (a) asking a patient each of the following questions:

[0024] are any drugs being taken that are known to activate MAST cells (these drugs include alpha blockers, ACE inhibitors/ATII Receptor antagonists, aspirin, 5 HT-1 agonists, opiate or derivative medications, proton pump inhibitors, selective serotonin reuptake inhibitors and statins among others);

[0025] severity of nasal symptoms (on a scale of 0-n);

[0026] are the symptoms perennial/worse in the winter months;

[0027] are the symptoms worse during dusting and/or vacuuming/cleaning;

[0028] are the symptoms present after dietary salicylates; and

[0029] (b) carrying out each of the following tests:

[0030] skin prick test to house dust mite and/or cockroach;

[0031] skin prick test to mixed pollens;

[0032] RAST test result to house dust mite;

[0033] RAST test result to mixed pollens; and

[0034] (c) inputting the results of the questions and tests into a neural network that has been trained to diagnose said condition; and

[0035] (d) producing an output indicative of a diagnosis.

[0036] This is referred to as the 9-input model.

[0037] Reference herein to nasal symptoms includes any one or more of the following: nasal itching, sneezing runny nose, blocked nose, post-nasal drip, or itching of the palate

[0038] In a preferred method of the invention the results of the tests under part (b) above may be provided, as conventionally is the case, with a graded result and so represents an incremental unit indicative of the nature of the response. Alternatively, as is becoming increasingly popular, the results may represent a measure of a unit from a continuous scale such as kilo units of allergen-specific IgE antibodies per litre.

[0039] In a yet further preferred method of the invention said mixed pollens are selected having regard to the geographical region in which the patient lives. For example, in the UK, one would test for mixed grass pollens whereas in North America one is much more likely to include ragweed and in Northern Europe one is much more likely to test for tree birch. As will be apparent to the man skilled in the art the geographically representative allergens are well known in each geographical region and would be selected on the basis that in each region the selected allergens are known to elicit an allergic reaction of the upper respiratory tract.

[0040] The RAST test is undertaken using an antibody that is labelled with a suitable label such as a radio-label, although light emitting labels may be used as an alternative, and conventional techniques are used in order to measure the patient's immune status. RAST tests, and variations thereof, are well known to those skilled in the art and indeed have been performed for many decades. The original disclosure concerning diagnosis of an allergy by an in vitro test for allergen antibodies was described by Wide et al in 1967 and has further been assessed by Thomson & Bird, 1983.

[0041] In yet a further preferred method of the invention part (a) thereof further involves asking a patient each of the following questions:

[0042] are the symptoms worse indoors;

[0043] are the symptoms worse when gardening; and

[0044] part (b) thereof further includes carrying out the following further test:

[0045] RAST test result to cat.

[0046] This is referred to as a 12-input model.

[0047] In yet a further preferred method of the invention part (a) of the 12-input model includes asking a patient the following question:

[0048] severity of eye symptoms (on a scale of 0-n), instead of, are the symptoms worse indoors;

[0049] and part (b) of 12-input model further includes carrying out the following tests:

[0050] skin prick test result to cat; and

[0051] total IgE concentration.

[0052] This is referred to as the 14-input model.

[0053] Reference herein to eye symptoms includes reference to any one of the following: watery eyes, itchy eyes, red eyes, or gritty eyes.

[0054] According to further aspects and embodiments of the invention there are provided additional or alternative methodologies involving various additional inputs known as the 15-input, 19-input, 21-input, 23-input and 47-input models. The inputs comprise a series of questions and a series of tests. The questions are clearly indicated in Table 8 where an asterisk below the designator (reading from left to right 47, 23, 21, 19, 15, 14, 12, 9) for each input model is aligned with one of a series of questions, numbered 1-26, 45-47. Similarly, the tests are indicated by an asterisk below an input designator that is aligned with one of a series of tests, numbered 27-44. So, for example, the 15-input model involves asking questions 2, 5, 7, 13, 17, 24, 25 and 45 and also performing tests 27, 28, 30, 37, 38, 39 and 41.

[0055] The 19-input model involves asking questions 3, 5, 6, 7, 13, 17, 22, 24, 25, 26 and 45 and also performing tasks 27, 28, 30, 37, 38, 39, 41 and 42.

[0056] The 21-input model involves asking questions 2, 3, 5, 6, 7, 13, 17, 22, 24, 25, 26, 45 and 47 and also performing tests 27, 28, 30, 37, 38, 39, 41 and 42.

[0057] The 23-input model involves asking questions 2, 3, 5, 6, 7, 17, 18, 20, 22, 24, 25, 26, 45 and 47 and also performing tests 27, 28, 30, 37, 38, 39, 41 and 42.

[0058] The 47-input model involves asking questions 1-26, 45-47 and also performing tests 27-44.

[0059] As mentioned, in a preferred method of the invention the results of the tests under part (b) above may be provided, as conventionally is the case, with a graded result and so represents an incremental unit indicative of the nature of the response. Alternatively, as is becoming increasingly popular, the results may represent a measure of a unit from a continuous scale such as kilo units of allergen-specific IgE antibodies per litre.

[0060] Further, as mentioned said mixed grass or tree pollen may be substituted for a pollen that is representative of the geographical region in which the patient lives. For example, in the UK, one would test for mixed grass pollens whereas in North America one is much more likely to test for ragweed and in Northern Europe, one is much more likely to test for tree birch. As will be apparent to the man skilled in the art the geographically representative pollen is well known in each geographical region and would be selected on the basis that in each region the selected pollen is known to elicit an allergic reaction of the upper respiratory tract.

[0061] In some cases it may be useful to save results for analysis at a later time, for example if they cannot be obtained simultaneously. In this instance the results may be stored on a computer system and applied to a neural network subsequently.

[0062] In another aspect of the invention, there is provided a computer system or apparatus, configured to aid in the diagnosis of a condition, comprising:

[0063] (a) a device for obtaining data relating to a patient, wherein the data comprises answers to any selected combination of questions and results of tests outlined in any of the 9-, 12-, 14-, 15-, 19-, 21-, 23- or 47-input models outlined above;

[0064] (b) optionally, a device for storing the data in storage means of the computer system;

[0065] (c) a device for transferring the data to a neural network trained on samples of the data; and

[0066] (d) a device for extracting from the trained neural network an output, the output being an indicator for the diagnosis of the condition.

[0067] In a preferred computer system or apparatus the data comprises information obtained using the 9-, 12-, 14-, 15-, 19-, 21-, 23- or 47-input model.

[0068] As will be appreciated, this aspect of the invention may also be adapted so that the computer is linked to an intranet or Internet with a neural network, thereby allowing patients and/or medical practitioners to input information from remote locations and obtain a preliminary diagnosis.

[0069] The results of any of the 9-, 12-, 14-, 15-, 19-, 21-, 23- and 47-input models, or any selected combination thereof, may also be used to train a neural network to diagnose a condition.

[0070] Accordingly, in a further aspect of the invention there is provided a method for training a neural network to aid in diagnosing a condition, comprising:

[0071] a) obtaining data relating to a group of patients in whom the condition is known, wherein the data comprises any selected combination of the results of the questions and tests outlined in any of the 9-, 12-, 14-, 15-, 19-, 21-, 23- or 47-input models;

[0072] (b) training a neural network to identify the pattern of data which corresponds to the condition; and

[0073] (c) storing the neural network in storage means of a computer or on a computer-readable medium.

[0074] A neural network may also be trained using other methods, which methods will be apparent to a man skilled in the art.

[0075] The invention further comprises a computer or a computer system comprising at least one neural network embodying any one or more of the aforementioned models or methods for the purposes of performing a diagnosis.

[0076] Furthermore, the invention comprises at least one neural network that has been trained for diagnosis using data from the 9-, 12-, 14-, 15-, 19-, 21-, 23- or 47-input models. Such a neural network may be sold separately, or put on a server so that it can be accessed remotely.

[0077] Yet further, the invention comprises a data carrier comprising the aforementioned methodology of the invention and/or a software interface for enabling a user to communicate with a neural network trained for the diagnostic purpose of the invention.

[0078] According to another aspect of the present invention there is provided a computer program product comprising:

[0079] a computer usable medium having computer readable program code and computer readable system code embodied on said medium for aiding in the diagnosis of a condition, said computer program product including:

[0080] computer program code means, when the program code is loaded, to make the computer execute a procedure to:

[0081] (a) obtain data relating to a patient, wherein the data comprises answers to any selected combination of questions and results of the tests outlined in any of 9-, 12-, 14-, 15-, 19-, 21-, 23- or 47-input models above;

[0082] (b) optionally, store the data;

[0083] (c) transfer the data to a neural network trained on the aforementioned data; and

[0084] (d) extract from the trained neural network an output, the output being an indicator for the diagnosis of the condition.

[0085] According to a further aspect of the invention there is provided a computer system comprising a first means for:

[0086] (a) obtaining data relating to a patient, wherein the data comprises answers to any selected combination

of questions and results of tests outlined in any of 9-, 12-, 14-, 15-, 19-, 21-, 23- or 47-input models above; and

[0087] a second remote means, wherein said second means comprises means for:

[0088] (b) optionally, storing the data;

[0089] (c) transferring the data to a neural network trained on the aforementioned data; and

[0090] (d) extracting from the trained neural network on output, the output being an indicator for the diagnosis of the condition.

[0091] In one embodiment of the invention, the condition to be diagnosed is an allergy associated with the upper respiratory tract. The term 'allergy' in this context is taken to mean any disease, condition or disorder in which the immune system is triggered by a substance to which it has become sensitive.

[0092] In another embodiment, the condition to be diagnosed is rhinitis or sinusitis. 'Rhinitis' is taken to mean any condition that results in the inflammation of the nasal mucous membrane, and includes conditions such as allergic perennial rhinitis, allergic seasonal rhinitis, idiopathic perennial rhinitis, idiopathic seasonal rhinitis, drug-induced rhinitis, dietary salicylate-induced rhinitis, rhino-sinusitis or rhino-conjunctivitis. 'Sinusitis' is taken to mean a condition resulting in inflammation of any one of the air-containing cavities of the skull that communicate with the nose, and includes conditions such as ethmoid sinusitis, frontal sinusitis, maxillary sinusitis, sphenoid sinusitis and nasal sinusitis.

[0093] In yet another embodiment of the invention, the condition to be diagnosed is any one of the following:

[0094] allergic perennial rhinitis, allergic seasonal rhinitis, idiopathic perennial rhinitis, idiopathic seasonal rhinitis, drug-induced rhinitis, dietary salicylate-induced rhinitis or rhino-sinusitis.

[0095] The present invention will now be illustrated with reference to the following method and results.

EXAMPLE 1

[0096] Table 1 shows the distribution of diagnoses in patients presenting to the Welsh Clinical Allergy Service outpatient clinics in 2001, and is representative of the caseload seen in this regional allergy centre. Given the high proportion of patients presenting to the service with symptoms of rhinitis, it was decided to utilise this patient group for our study.

TABLE 1

Distribution of diagnoses in patients seen in WCAS outpatient clinics in 2001 (n = 213)

Diagnostic Category	No. of patients with diagnosis	Percentage of all patients (%)
Urticaria/Angioedema	46	21.6
Rhinitis	43	20.2
Drug-induced angioedema/reaction	28	13.1
Food allergy	26	12.2
Food intolerance	14	6.6
Salicylate intolerance	11	5.2
Venom insensitivity	7	3.3
Non-allergic/miscellaneous conditions	38	17.8
Total	213	100

Methods

Ethical Considerations

[0097] Bro Taf Local Research Ethics Committee granted ethical approval for all aspects of this study and the project was registered with Cardiff and Vale NHS Trust Research and Development Office. All participants were required to complete a consent form. Data was anonymised prior to analysis and handled in accordance with the Data Protection Act 1998.

Structured Questionnaire Design

[0098] This study made use of a standard questionnaire (Table 7) comprising 189 questions and 6 tests were created using the commercial Cardiff TELEform information capture system v7.0 Designer module. This questionnaire was devised as an integral part of the Nurse Practitioner-based diagnosis and management evaluation program and aimed to gather demographic and clinical information in a structured format. This questionnaire was endorsed by a multidisciplinary panel of experts and piloted in WCAS clinics throughout 2001.

Patient Recruitment and Data Collection

[0099] Patients aged 18 to 75 referred to the WCAS by General Practitioners or hospital doctors due to symptoms of rhinitis were drawn from the routine non-urgent outpatient waiting list and recruited using an approved protocol. All consenting patients with predominant presenting symptoms of rhinitis were entered into the study. There were no exclusion criteria. Participants underwent Skin Prick Testing immediately prior to an initial conventional consultation with either the Consultant Clinical Immunologist or Allergy Nurse Practitioner. The order of consultation was randomized so that roughly equal numbers of patients were seen first by the Nurse Practitioner as by the Consultation Clinical Immunologist. Findings were recorded on the standard questionnaire ensuring all sections were fully completed. Patients were then seen independently by the other practitioner, and findings annotated upon a separate questionnaire. Total serum IgE and RAST testing were performed upon clinical discretion. As per current WCAS protocol, a clinic letter outlining the final diagnosis and management plan was dictated by the Consultant Clinical Immunologist and posted to the referring medical practitioner and patient. A similar letter was dictated independently by the Allergy Nurse Practitioner, which was retained as supporting evidence to her questionnaire, for analysis in a later study.

Data Transfer

[0100] Once available, all RAST and other test results were added to data recorded during respective consultations. Completed questionnaires were processed using the commercial Cardiff TELEform information capture system v8.2 Scan station, Reader and Verifier modules (see FIG. **1**)./Data was exported into separate Microsoft Excel files for each clinician.

Data Preprocessing and Normalisation

[0101] Data imported into Microsoft Excel was anonymised. All input variables were inspected for transfer accuracy and errors corrected manually. Data was normalised (scaled) within a uniform range for each input variable, some variables removed (e.g. domestic demographic data, ethnic

origin and marital status) and a number of new input variables created following recoding of defined input groups (e.g. 17 inputs assessing the presence of asthma, eczema, hayfever or perennial rhinitis in the patients mother, father, siblings or children recoded as a single input—'positive family history'). The final aetiological diagnosis for each patient was coded into one of six output categories (allergic perennial, allergic seasonal, idiopathic perennial, idiopathic seasonal, drug induced or dietary salicylate-induced rhinitis).

Data Partitioning

[0102] Data was partitioned into two separate Excel parent databases (i.e. separate Excel worksheets) (i) 'all questionnaire inputs' (189 input variables; six output variables) and (ii) 'clinically selected inputs' (47 input variables; six output variables) (see Tables 7 and 8), as it became available. ANN models were developed using data and diagnoses from the Consultant Clinical Immunologist. Model development required data from each parent database to be divided into two subsets: (i) training and test data and (ii) validation.

[0103] At present there are no mathematical rules governing the required size of data subsets and most ANN-based studies utilize anecdotal rules derived from experience and analogy with statistical regression techniques (Basheer and Hajmeer et al 2000). Data utilised for the ANN training and test subset for both parent databases was drawn from patients 001-062 since these were collected first and data from patients 063-093 were used as test data.

Balancing of Training and Test Subset Data

[0104] It is desirable that data used in ANN training is nearly evenly distributed between output categories to prevent the ANN model generated from being biased to over-represented output classes (Swingler 1996). Table 2 shows the distribution of diagnoses amongst patients 001-062. Traditional approaches to dealing with such unbalanced data include removing examples from over-represented output classes or adding examples pertaining to under-represented classes (Basheer and. Hajmeer 2000). The relatively small size of the training and test data subset (62 patients) made the first option undesirable. Furthermore, whilst there is no published epidemiological data with which to compare the distribution of diagnoses in these first 62 patients, it seemed unlikely that significant numbers of under-represented diagnoses would be made in patients 063-093. It was therefore decided to use unbalanced training and test data on the premise that models created would reflect what appeared to be a real-world bias to allergic perennial rhinitis in patients presenting to the WCAS.

TABLE 2

Distribution of Diagnoses in Patients 001-062 (ANN Training and test data subset)

Diagnostic Output Category	No. of patients with diagnosis	Percentage of all patients (%)
Allergic Perennial Rhinitis	34	55
Allergic Seasonal Rhinitis	7	11
Idiopathic Perennial Rhinitis	13	21
Idiopathic Seasonal Rhinitis	1	2
Drug-induced Rhinitis	5	8
Dietary salicylate-induced Rhinitis	2	3
Total	62	100

Optimisation of ANN Architecture

[0105] The study used a commercially available ANN the Neuroshell Predictor™. Neuroshell Predictor™ can operate in one of two modes: neural mode of analysis, this uses a neural net that dynamically grows hidden neurons to build a model which generalises well and trains quickly. When applying the trained network to new data, the Neural Training Strategy may enable better results to be obtained on "noisy data" that is somewhat dissimilar from the data used to train the network.

[0106] Alternatively, the Neuroshell Predictor™ can be used in a genetic mode of analysis. The Genetic Training Strategy trains slowly. When applying the trained network to new data, the Genetic Training Strategy gets better results when the new data is similar to the training data. It also works better when the training data is sparse.

Neuroshell Predictor™ Data Output Format in Neural Analysis Mode

[0107] The Neuroshell Predictor™ analysis of 47 input fields in neural analysis mode is shown below. The program optimised the analysis of the data on patients 1-62 (training data), with an upper limit of hidden nodes of 100. The program calculated that 4 hidden nodes were optimal, and produced the Table below classifying the input data into different categories.

TABLE 3

Patients 1-62 Training data for neural learning

	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
Classified as "Allergic perennial (hdm)"	34	0	0	0	0	0	34
Classified as "Allergic	0	6	0	0	0	0	6

TABLE 3-continued

Patients 1-62 Training data for neural learning

	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
seasonal (mgp)"							
Classified as "Drug induced"	0	0	5	0	0	0	5
Classified as "Idiopathic perennial"	0	1	0	13	0	0	14
Classified as "Idiopathic seasonal"	0	0	0	0	1	0	1
Classified as "Salicylate induced"	0	0	0	0	0	2	2
Total	34	7	5	13	1	2	62
True-pos. ratio	1	0.8571	1	1	1	1	
False-pos. ratio	0	0	0	0.0204	0	0	
True-neg. ratio	1	1	1	0.9796	1	1	
False-neg. ratio	0	0.1429	0	0	0	0	
Sensitivity	100.00%	85.71%	100.00%	100.00%	100.00%	100.00%	
Specificity	100.00%	100.00%	100.00%	97.96%	100.00%	100.00%	

[0108] In the above Table row 9, designated as Total, indicates the number of patients that were clinically diagnosed as having the condition described at the top of each column. For example, in the second column a clinical diagnosis indicated that 34 of the patients (from Group 1-62) had allergic perennial rhinitis to house dust mite. Using data from these patients the Neuroshell Predictor™ programme was trained so that it too classified the same 34 patients as having allergic perennial rhinitis to house dust mites. In other words there was 100% match. This was true of all the other columns except for column 3 labelled "allergic seasonal mixed grass pollen" where, of the 7 individuals (from Groups 1-62) that were clinically diagnosed as having allergic seasonal mixed grass pollen rhinitis, 6 were classified as such by the ANN program whereas one was classified as having idiopathic perennial rhinitis. In other words there was not quite a 100% match. Nevertheless, having regard to FIG. **2** it can be seen from the ROC curve that there was almost a 100% match. It can therefore be seen that training the ANN program when in neural mode of analysis worked extremely well. Accordingly, when the trained ANN operating in this mode was given test data, i.e. data from patients 63-92, the results in Table 4 were obtained.

TABLE 4

Patients 63-92 Training data for neural learning

	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
Classified as "Allergic perennial (hdm)"	12	1	0	0	0	1	14
Classified as "Allergic seasonal (mgp)"	1	2	0	0	0	0	3
Classified as "Drug induced"	2	2	0	0	0	0	4
Classified as "Idiopathic perennial"	1	2	1	4	0	1	9

TABLE 4-continued

	Patients 63-92 Training data for neural learning						
	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
Classified as "Idiopathic seasonal"	0	0	0	0	0	0	0
Classified as "Salicylate induced"	0	0	0	0	0	0	0
Total	16	7	1	4	0	2	30
True-pos. ratio	0.75	0.2857	0	1	N/A	0	
False-pos. ratio	0.1429	0.0435	0.1379	0.1923	0	0	
True-neg. ratio	0.8571	0.9565	0.8621	0.8077	1	1	
False-neg. ratio	0.25	0.7143	1	0	0	1	
Sensitivity	75.00%	28.57%	0.00%	100.00%	0.00%	0.00%	
Specificity	85.71%	95.65%	86.21%	80.77%	100.00%	100.00%	

[0109] It can therefore been seen that of the 16 patients (from Group 63-92) that were classified by a clinician as suffering from allergic perennial house dust mite rhinitis, 12 of these individuals were classified by the ANN program as suffering from the same condition. One further individual was classified by the ANN as suffering from allergic seasonal mixed grain pollen rhinitis, 2 were classified as suffering from drug induced rhinitis and one was classified as suffering from idiopathic perennial rhinitis.

[0110] The ROC curve for this data is shown in FIG. **3** where it can be seen that there is a satisfactory correlation.

Neuroshell Predictor™ Data Output Format in Genetic Analysis Mode

[0111] When the Neuroshell Predictor™ program was run in the genetic mode of analysis the data shown in Table 5 was obtained.

TABLE 5

	Patients 1-62 Training data for genetic learning						
	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
Classified as "Allergic perennial (hdm)"	33	1	0	0	0	0	34
Classified as "Allergic seasonal (mgp)"	1	5	0	0	0	0	6
Classified as "Drug induced"	0	0	5	1	0	0	6
Classified as "Idiopathic perennial"	0	1	0	12	1	0	14
Classified as "Idiopathic seasonal"	0	0	0	0	0	0	0
Classified as "Salicylate induced"	0	0	0	0	0	2	2
Total	34	7	5	13	1	2	62
True-pos. ratio	0.9706	0.7143	1	0.9231	0	1	

TABLE 5-continued

Patients 1-62 Training data for genetic learning

	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
False-pos. ratio	0.0357	0.0182	0.0175	0.0408	0	0	
True-neg. ratio	0.9643	0.9818	0.9825	0.9592	1	1	
False-neg. ratio	0.0294	0.2857	0	0.0769	1	0	
Sensitivity	97.06%	71.43%	100.00%	92.31%	0.00%	100.00%	
Specificity	96.43%	98.18%	98.25%	95.92%	100.00%	100.00%	

[0112] Here it can be seen that there is an extremely good correlation for diagnosing allergic perennial house dust mite rhinitis and allergic seasonal mixed grain pollen rhinitis. In the former instance, of the 34 individuals (from patients 1-62) that were classified by a clinician as suffering from allergic perennial house dust mite rhinitis, 33 were also similarly classified by the ANN. In the latter instance, of the 7 individuals (from Group 1-62) that were diagnosed by a clinician as suffering from allergic seasonal mixed grain pollen rhinitis 5 were similarly classified by the ANN. One individual was further classified as suffering from allergic perennial rhinitis and a further was classified as suffering from idiopathic perennial rhinitis. The ROC curve for this data is shown in FIG. **4**.

[0113] The relative importance of all the data entries as assessed and of the 189 questions shown in Table 7, 47 were considered to be particularly important. These 47 questions are shown in Table 8. Moreover, the ANN software program produced a graph showing the relative importance of these selected 47 questions and this data is indicated in FIG. **5**.

[0114] Once the Neuroshell Predictor™ program had been trained in the genetic mode of analysis test data from patients 63-92 was fed therein and the data shown in Table 6 was obtained. The ROC curve for this data is shown in FIG. **6**.

TABLE 6

Patients 63-92 Training data for genetic learning

	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
Classified as "Allergic perennial (hdm)"	14	5	0	0	0	1	20
Classified as "Allergic seasonal (mgp)"	0	1	0	2	0	0	3
Classified as "Drug induced"	0	0	1	0	0	0	1
Classified as "Idiopathic perennial"	1	1	0	2	0	0	4
Classified as "Idiopathic seasonal"	0	0	0	0	0	0	0
Classified as "Salicylate induced"	0	0	0	0	0	0	0
Total	15	7	1	4	0	1	28
True-pos. ratio	0.9333	0.1429	1	0.5	N/A	0	
False-pos. ratio	0.4615	0.0952	0	0.0833	0	0	
True-neg. ratio	0.5385	0.9048	1	0.9167	1	1	
False-neg. ratio	0.0667	0.8571	0	0.5	0	1	

TABLE 6-continued

Patients 63-92 Training data for genetic learning

	Actual "Allergic perennial (hdm)"	Actual "Allergic seasonal (mgp)"	Actual "Drug induced"	Actual "Idiopathic perennial"	Actual "Idiopathic seasonal"	Actual "Salicylate induced"	Total
Sensitivity	93.33%	14.29%	100.00%	50.00%	0.00%	0.00%	
Specificity	53.85%	90.48%	100.00%	91.67%	100.00%	100.00%	

Data Analysis with View to Optimising Data Input and Diagnosis

[0115] The information shown in Tables 3-6 and FIGS. **1-6** clearly show that the commercially available product Neuroshell Predictor™ can be used to produce an ANN that is capable of performing a clinical diagnosis. However, further data analysis is needed in order to determine the optimum number of reliable data inputs needed to obtain an acceptable tool for diagnosis. Accordingly, the number and combination of data inputs was progressively reduced and varied, respectively, with a view to determining a preferred number and nature of inputs for producing a reliable diagnosis. In Table 8 we present the results of eight input models using 47, 23, 21, 19, 15, 14, 12 or 9 data inputs. The inputs are specified having regard to indicators 1-47 which represent one of a number of questions or tests listed in column 1 of Table 8. Using each input model, and each mode of operation of the ANN, data was obtained concerning the ANN reliability of diagnosis vis a vis use of clinical analysis.

TABLE 7

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
1	Sex	Patent gender	1 = male 2 = female	*	*			
2	Age	Patient age in years	—	*				
3	DIY/Dec	Indoor hobbies: DIY/Decorating	0 = no 1 = yes	*				
4	Cooking	Indoor hobbies: Cooking	0 = no 1 = yes	*	*			
5	Arts	Indoor hobbies: Arts/Crafts	0 = no 1 = yes	*				
6	Gardening	Outdoor hobbies: Gardening	0 = no 1 = yes	*	*			
7	Sports	Outdoor hobbies: Sports	0 = no 1 = yes	*				
8	Walking	Outdoor hobbies: Walking	0 = no 1 = yes	*	*	*	*	
9	NumHosAdmiss	Number of hospital in-patient admissions	—	*				
10	Eczema	Suffer from eczema	0 = no 1 = yes	*				
11	Asthma	Suffer from asthma	0 = no 1 = yes	*				
12	High BP	Suffer from hypertension	0 = no 1 = yes	*	*	*	*	
13	Arthritis	Suffer from arthritis	0 = no 1 = yes	*				
14	Thyroid	Suffer from thyroid trouble	0 = no 1 = yes	*	*	*		
15	AlphaBlocker	Take any Alpha Blockers	0 = no 1 = yes	*				
16	ACE/ATII	Take any ACE Inhibitors/ATII Receptor antagonists	0 = no 1 = yes	*	*	*	*	*
17	Aspirin	Take Aspirin	0 = no 1 = yes	*				
18	FemHormonal	Take any products containing female sex hormones	0 = no 1 = yes	*				
19	5HT1Agonist	Take any 5HT1 Agonsts	0 = no 1 = yes	*				
20	InhalB2Agonist	Take any inhaled B2 Agonists	0 = no 1 = yes	*				
21	InhalCorticosteroid	Take any inhaled corticosteroids	0 = no 1 = yes	*				

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
22	Opiates + derivatve	Take any opiate or derivative medications	0 = no 1 = yes	*				
23	PPI	Take any Proton Pump Inhibitors	0 = no 1 = yes	*				
24	SSRI	Take any Selective Serotonin Re-uptake inhibitors	0 = no 1 = yes	*				
25	Statins	Take any Statins	0 = no 1 = yes	*				
26	TCA	Take any Tricyclic Antidepressants	0 = no 1 = yes	*	*			
27	Smoker	Do you smoke	0 = never 1 = previously 2 = currently	*				
28	Cigarette	Smoke/smoked cigarettes	0 = no 1 = yes	*	*	*		
29	Pipe	Smoked/smoked a pipe	0 = no 1 = yes	*				
30	NumYrsSmoked	Number of years smoking	—	*				
31	NumCigDay	Number of cigarettes smoked per day	—	*				
32	MumAst	Mother suffers from asthma	0 = no 1 = yes	*				
33	MumEcz	Mother suffers from eczema	0 = no 1 = yes	*	*			
34	MumHay	Mother suffers from hayfever	0 = no 1 = yes	*				
35	MumRhin	Mother suffers from perennial rhinitis	0 = no 1 = yes	*				
36	DadAst	Father suffers from asthma	0 = no 1 = yes	*				
37	DadHay	Father suffers from hayfever	0 = no 1 = yes	*				
38	BroAst	Brother(s) suffer from asthma	0 = no 1 = yes	*				
39	BroEcz	Brother(s) suffer from eczema	0 = no 1 = yes	*				
40	BroHay	Brother(s) suffer from hayfever	0 = no 1 = yes	*	*			
41	BroRhin	Brother(s) suffer from perennial rhinitis	0 = no 1 = yes	*				
42	SisAst	Sister(s) suffer from asthma	0 = no 1 = yes	*				
43	SisEcz	Sister(s) surf from eczema	0 = no 1 = yes	*				
44	SisHay	Sister(s) suffer from hayfever	0 = no 1 = yes	*				
45	ChildAst	Children suffer from asthma	0 = no 1 = yes	*				
46	ChildEcz	Children suffer from eczema	0 = no 1 = yes	*				
47	ChildHay	Children suffer from hayfever	0 = no 1 = yes	*				
48	ChildRhin	Children suffer from rhinitis	0 = no 1 = yes	*				
49	SevRunNose	Severity of runny nose	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*				
50	SevitchNose	Severity of itchy nose	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*				
51	SevBlkNose	Severity of blocked nose	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*	*			

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
52	SevPostNasDisch	Severity of post nasal discharge	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe					
53	SevSneexe	Severity of sneezing	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*				
54	SevitchPalate	Severity of itching of palate	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*				
55	SevWatrEye	Severity of watery eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*				
56	SevitchEye	Severity of itchy eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*				
57	SevSoreEye	Severity of sore eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*	*			
58	SevSwollEye	Severity of swollen eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe	*	*			
59	NumYrsSymp	Number of years symptomatic	—	*				
60	SympJan	Symptoms occur in January	0 = absent 1 = present 2 = present + severe	*				
61	SympFeb	Symptoms occur in February	0 = absent 1 = present 2 = present + severe	*				
62	SympMar	Symptoms occur in March	0 = absent 1 = present 2 = present + severe	*				
63	SympApr	Symptoms occur in April	0 = absent 1 = present 2 = present + severe	*				
64	SympMay	Symptoms occur in May	0 = absent 1 = present 2 = present + severe	*				
65	SympJun	Symptoms occur in June	0 = absent 1 = present 2 = present + severe	*				
66	SympJul	Symptoms occur in July	0 = absent 1 = present 2 = present + severe	*				
67	SympAug	Symptoms occur in August	0 = absent 1 = present 2 = present + severe	*				

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
68	SympSep	Symptoms occur in September	0 = absent 1 = present 2 = present + severe	*				
69	SympOct	Symptoms occur in October	0 = absent 1 = present 2 = present + severe	*				
70	SympNov	Symptoms occur in November	0 = absent 1 = present 2 = present + severe	*				
71	SympDec	Symptoms occur in December	0 = absent 1 = present 2 = present + severe	*				
72	BetHome	Symptoms better at home	0 = no 1 = yes	*				
73	BetWork	Symptoms better at work	0 = no 1 = yes	*				
74	BetOverseas	Symptoms better overseas	0 = no 1 = yes	*	*			
75	WrseMorn	Symptoms worse in the morning	0 = no 1 = yes	*	*	*	*	
76	WrseEve	Symptoms worse in the evening	0 = no 1 = yes	*				
77	WrseDay	Symptoms worse throughout the day	0 = no 1 = yes	*				
78	WrseNight	Symptoms worse at night	0 = no 1 = yes	*				
79	AwakeWithSymp	Awake with symptoms	0 = no 1 = yes	*				
80	NumDaysSympWeek	Number of days symptomatic per week	—	*				
81	NumHrsSympDay	Number of hours symptomatic per day	—	*	*	*		
82	WrseIndoors	Symptoms worse indoors	0 = no 1 = yes	*				
83	WrseOutdoors	Symptoms worse outdoors	0 = no 1 = yes	*				
84	SameIn + Out	Symptoms the same indoors and outdoors	0 = no 1 = yes	*	*			
87	WrseDusting	Symptoms worse dusting	0 = no 1 = yes	*	*			
86	WrseGardening	Symptoms worse gardening	0 = no 1 = yes	*				
87	WrseVacuuming	Symptoms worse vacuuming/cleaning	0 = no 1 = yes	*	*	*	*	*
88	WrseTraffic	Symptoms worse sitting in traffic jams	0 = no 1 = yes	*				
89	TriedAviod	Tried avoiding anything	0 = no 1 = yes	*	*			
90	AviodEffective	Avoidance provides symptomatic relief	0 = no 1 = yes	*	*			
91	ContCat	Regular contact with cats	0 = no 1 = yes	*				
92	WrseCat	Cats make symptoms worse	0 = no 1 = yes	*				
93	ContDog	Regular contact with dogs	0 = no 1 = yes	*				
94	WrseDog	Dogs make symptoms worse	0 = no 1 = yes	*				
95	ContDust	Regular contact with dusts	0 = no 1 = yes	*				
96	WrseDust	Dusts make symptoms worse	0 = no 1 = yes	*				
97	ContChem	Regular contact with chemicals	0 = no 1 = yes	*				
98	WrseChem	Chemicals make symptoms worse	0 = no 1 = yes	*				

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
99	HomeDGlaz	Home double glazed	0 = no 1 = yes	*				
100	HomeCHeat	Home centrally heated	0 = no 1 = yes	*				
101	HomeFittCarp	Fitted carpets in home	0 = no 1 = yes	*				
102	HomeDampPat	Damp patches in home	0 = no 1 = yes	*	*			
103	HomeMouldPat	Mould patches in home	0 = no 1 = yes	*				
104	PiritMths	Months therapeutic trial with Piriton	—	*				
105	PiritEffect	Therapeutic trial with Piriton effective	0 = never trialled 1 = no 2 = yes	*	*	*	*	
106	PiritStill	Still take Piriton	0 = never trialled	*				
107	ZirtMths	Months therapeutic trial with Zirtek	—	*				
10	ZirtEffect	Therapeutic trial with Zirtek effective	0 = never trialled 1 = no 2 = yes	*				
109	ZirtStill	Still take Zirtek	0 = never trialled 1 = no 2 = yes	*				
110	ClaritMths	Months therapeutic trial with Clarityn	—	*				
111	ClaritEffect	Therapeutic trial with Clarityn effective	0 = never trialled 1 = no 2 = yes	*				
112	ClaritStill	Still take Clarityn	0 = never trialled 1 = no 2 = yes	*				
113	TriludMths	Months therapeutic trial with Triludan	—	*				
114	TriludEffect	Therapeutic trial with Triludan effective	0 = never trialled 1 = no 2 = yes	*				
115	TriludStill	Still take Triludan	0 = never trialled 1 = no 2 = yes	*				
116	HismanMths	Months therapeutic trial with Hismanal	—	*				
117	HismanEffect	Therapeutic trial with Hismanal effective	0 = never trialled 1 = no 2 = yes	*				
118	HismanStill	Still take Hismanal	0 = never trialled 1 = no 2 = yes	*				
119	TelfMths	Months therapeutic trial with Telfast	—	*				
120	TelfEffect	Therapeutic trial with Telfast effective	0 = never trialled 1 = no 2 = yes	*				
121	TelfStill	Still take Telfast	0 = never trialled 1 = no 2 = yes	*				
122	BeconMths	Months therapeutic trial with Beconase	—	*				
123	BeconEffect	Therapeutic trial with Beconase effective	0 = never trialled 1 = no 2 = yes	*				
124	BeconStill	Still take Beconase	0 = never trialled 1 = no 2 = yes	*	*	*	*	*
125	FlixMths	Months therapeutic trial with Flixonase	—	*				
126	FlixEffect	Therapeutic trial with Flixonase effective	0 = never trialled 1 = no 2 = yes	*				
127	FlixStill	Still take Flixonase	0 = never trialled 1 = no 2 = yes	*				
128	RhinoMths	Months therapeutic trial with Rhinocort	—	*				
129	RhinoEffect	Therapeutic trial with Rhinocort effective	0 = never trialled 1 = no 2 = yes	*				

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
130	RhinoStill	Still take Rhinocort	0 = never trialled 1 = no 2 = yes	*	*	*	*	*
131	NasoMths	Months therapeutic trial with Nasonex	—	*				
132	NasoEffect	Therapeutic trial with Nasonex effective	0 = never trialled 1 = no 2 = yes	*	*	*	*	
133	NasoStill	Still take Nasonex	0 = never trialled 1 = no 2 = yes	*	*			
134	NasactMths	Months therapeutic trial with Nasacort	—	*				
135	NasactEffect	Therapeutic trial with Nasacort effective	0 = never trialled 1 = no 2 = yes	*				
136	NasactStill	Still take Nasacort	0 = never trialled 1 = no 2 = yes	*	*			
137	RapOptMths	Months therapeutic trial with Rapitil/Opticrom	—	*				
138	RapOptEffect	Therapeutic trial with Rapitil/Opticrom effective	0 = never trialled 1 = no 2 = yes	*				
139	RapOptStill	Still take Rapitil/Opticrom	0 = never trialled 1 = no 2 = yes	*				
140	SudaMths	Months therapeutic trial with Sudafed	—	*				
141	SudaEffect	Therapeutic trial with Sudafed effective	0 = never trialled 1 = no 2 = yes	*	*	*	*	*
142	SudaStill	Still take Sudafed	0 = never trialled 1 = no 2 = yes	*				
143	OtrivMths	Months therapeutic trial with Otrivine	—	*				
144	OrtivEffect	Therapeutic trial with Otrivine effective	0 = never trialled 1 = no 2 = yes	*	*	*	*	*
145	OtrivStill	Still take Otrivine	0 = never trialled 1 = no 2 = yes	*	*			
146	Wheeze	Have persistent wheeze	0 = no 1 = yes	*				
147	Cough	Have persistent cough	0 = no 1 = yes	*				
148	ChestTight	Have persistent chest tightness	0 = no 1 = yes	*				
149	DiagAsthma	Diagnosed with bronchial asthma	0 = no 1 = yes	*				
150	InhalerUse	Use of inhaler(s) for chest	0 = not applicable 1 = prn 2 = regular	*				
151	VentYrs	Years therapeutic trial with Ventolin	—	*				
152	VentEffect	Therapeutic trial with Ventolin effective	0 = never trialled 1 = no 2 = yes	*				
153	VentStill	Still take Ventolin	0 = never trialled 1 = no 2 = yes	*				
154	SerevYrs	Years therapeutic trial with Serevent	—	*				
155	SerevEffect	Therapeutic trial with Serevent effective	0 = never trialled 1 = no 2 = yes	*				
156	SerevStill	Still take Serevent	0 = never trialled 1 = no 2 = yes	*				
157	BecotYrs	Years therapeutic trial with Becotide	—	*				
158	BecotEffect	Therapeutic trial with Becotide effective	0 = never trialled 1 = no 2 = yes	*				

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
159	BecotStill	Still take Becotide	0 = never trialled 1 = no 2 = yes	*				
160	BecloYrs	Years therapeutic trial with Beclofort	—	*				
161	BecloEffect	Therapeutic trial with Beclofort effective	0 = never trialled 1 = no 2 = yes	*				
162	BecloStill	Still take Beclofort	0 = never trialled 1 = no 2 = yes	*				
163	FlixoYrs	Years therapeutic trial with Flixotide	—	*				
164	FlixoEffect	Therapeutic trial with Flixotide effective	0 = never trialled 1 = no 2 = yes	*				
165	FlixoStill	Still take Flixotide	0 = never trialled 1 = no 2 = yes	*				
166	SeretYrs	Years therapeutic trial with Seretide	—	*				
167	SeretEffect	Therapeutic trial with Seretide effective	0 = never trialled 1 = no 2 = yes	*				
168	SeretStill	Still take Seretide	0 = never trialled 1 = no 2 = yes	*				
169	GrSptHDM	Graded skin prick test result to house dust mite	0 = negative 1 = <histamine 2 = ≥histamine	*	*	*	*	*
170	GrSptCat	Graded skin prick test result to cat	0 = negative 1 = <histamine 2 = ≥histamine	*				
171	GrSptDog	Graded skin prick test result to dog	0 = negative 1 = <histamine 2 = ≥histamine	*				
172	GrSptMGP	Graded skin prick test result to mixed grass pollens	0 = negative 1 = <histamine 2 = ≥histamine	*	*	*	*	*
173	GrSptMTP	Graded skin prick test result to mixed tree pollens	0 = negative 1 = <histamine 2 = ≥histamine	*				
174	GrSptEgg	Graded skin prick test result to egg	0 = negative 1 = <histamine 2 = ≥histamine	*	*	*		
175	GrSptMilk	Graded skin prick test result to milk	0 = negative 1 = <histamine 2 = ≥histamine	*	*	*		
176	GrSptRice	Graded skin prick test result to rice	0 = negative 1 = <histamine 2 = ≥histamine	*	*			
177	GrSptPeanut	Graded skin prick test result to peanut	0 = negative 1 = <histamine 2 = ≥histamine	*				
178	GrSptHzInut	Graded skin prick test result to hazeInut	0 = negative 1 = <histamine 2 = ≥histamine	*				
179	MagIgE	Graded result of total IgE concentration	0 = 0-40 1 = 41-80 2 = 81-200 3 = 201-1000	*	*			
180	GrRstHDM	Graded RAST test result to house dust mite	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*	*	*	*	*
181	GrRstCat	Graded RAST test result to cat	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				

TABLE 7-continued

189 'Questionnaire' Inputs and Normalised Values

No	Input code	Input question	Normalised values	Models input utilised in (*): 189	40	20	15	10
182	GrRstDog	Graded RAST test result to dog	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				
183	GrRstMGP	Graded RAST test result to mixed grass pollens	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*	*	*	*	*
184	GrRstMTP	Graded RAST test result to mixed tree pollens	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				
185	GrRstMilk	Graded RAST test result to milk	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				
186	GrRstHzInut	Graded RAST test result to hazeInut	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				
187	GrRstHDst	Graded RAST test result to house dust	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				
188	GrRstDFar	Graded RAST test result to D. Farinae	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				
189	GrRstMxMould	Graded RAST test result to mixed moulds	0 = not undertaken 1 = negative 2 = mild (1, 2) 3 = moderate (3, 4) 4 = severe (5, 6)	*				

TABLE 8

No	Input question	Normalised values
1	Patent gender	1 = male 2 = female
2	Patient age in years	—
3	Do you have asthma or eczema	0 = no 1 = yes
4	Taking thyroxine for thyroid disease	0 = no 1 = yes
5	Taking any drugs known to activate mast cells	0 = no 1 = yes
6	Number of first degree relatives with asthma, eczema or rhinitis	0 = none X = No specified
7	Severity of runny nose	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
8	Severity of itchy nose	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
9	Severity of blocked nose	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
10	Severity of post nasal discharge	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
11	Severity of sneezing	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
12	Severity of itching of palate	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
13	Severity of watery eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
14	Severity of itchy eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
15	Severity of sore eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
16	Severity of swollen eyes	0 = no symptoms 1 = very mild 2 = mild 3 = moderate 4 = severe
17	Symptoms perennial/worse in winter months	0 = no 1 = yes
18	Symptoms worse in summer months	0 = no 1 = yes
19	Symptoms better at home	0 = no 1 = yes
20	Symptoms better at work	0 = no 1 = yes

TABLE 8-continued

21	Symptoms in the morning, at night, or waking with symptoms	0 = no 1 = yes
22	Symptoms worse indoors	0 = no 1 = yes
23	Symptoms worse outdoors	0 = no 1 = yes
24	Symptoms worse dusting and/or vacuuming/cleaning	0 = no 1 = yes
25	Symptoms worse gardening	0 = no 1 = yes
26	Effective therapeutic trial with antihistamine or topical nasal steroid	0 = no 1 = yes
27	Graded skin prick test result to house dust mite	0 = negative 1 = <histamine 2 == histamine
28	Graded skin prick test result to cat	0 = negative 1 = <histamine 2 == histamine
29	Graded skin prick test result to dog	0 = negative 1 = <histamine 2 == histamine
30	Graded skin prick test result to mixed grass pollens	0 = negative 1 = <histamine 2 == histamine
31	Graded skin prick test result to mixed tree pollens	0 = negative 1 = <histamine 2 == histamine
32	Graded skin prick test result to egg	0 = negative 1 = <histamine 2 == histamine
33	Graded skin prick test result to milk	0 = negative 1 = <histamine 2 == histamine
34	Graded skin prick test result to rice	0 = negative 1 = <histamine 2 == histamine
35	Graded skin prick test result to peanut	0 = negative 1 = <histamine 2 == histamine
36	Graded skin prick test result to hazeInut	0 = negative 1 = <histamine 2 == histamine
37	Graded result of total IgE concentration	0 = 0-40 1 = 41-80 2 = 81-200 3 = 201-1000
38	RAST test result to house dust mite	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
39	RAST test result to cat	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
40	RAST test result to dog	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
41	RAST test result to mixed grass pollens	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
42	RAST test result to mixed tree pollens	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
43	RAST test result to milk	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
44	RAST test result to mixed moulds	0 = neg 1, 2 = mild 3, 4 = moderate 5, 6 = severe
45	Symptoms after dietary salicylates	0 = no 1 = yes
46	Symptoms after contact with cats, dogs, birds or rodents	0 = no 1 = yes
47	How many years have symptoms been present for	X = No specified

	Models Input utilised in (*):							
No	47	23	21	19	15	14	12	9
1	*							
2	*	*	*		*			
3	*	*	*	*				
4	*							
5	*	*	*	*	*	*	*	*
6	*	*	*	*				
7	*	*$	*$	*$	*$	*$	*$	*$
8	*							
9	*							
10	*							
11	*							
12	*							
13	*	*$$	*$$	*$$	*$$	*$$		
14	*							
15	*							
17	*	*	*	*	*	*	*	*
18	*	*						
19	*							
20	*	*						
21	*							
22	*	*	*	*			*	
23	*							
24	*	*	*	*	*	*	*	*
25	*	*	*	*	*	*	*	
26	*	*	*	*				
27	*	*	*	*	*	*	*	*
28	*	*	*	*	*	*		
29	*							
30	*	*	*	*	*	*	*	*
31	*							
32	*							
33	*							
34	*							
35	*							
36	*							
37	*	*	*	*	*	*		
38	*	*	*	*	*	*	*	*
39	*	*	*	*	*	*	*	
40	*							
41	*	*	*	*	*	*	*	*
42	*	*	*	*				
43	*							

TABLE 8-continued

44	*							
45	*	*	*	*	*	*	*	*
46	*							
47	*	*	*					

$ = severity of nasal symptoms
$$ = severity of eye symptoms

[0116] The following Table, Table 9, summarises the number of patients who were correctly classified as having any form of rhinitis (columns 2 and 3) or allergic perennial rhinitis (columns 4 and 5) using input models 47, 23, 21, 19, 15, 14, 12 or 9 (column 1).

TABLE 9

% correctly classified with 47, 23, 21, 19, 15, 14, 12 and inputs				
No of inputs	% of total, neural analysis	% of total, genetic analysis	% of allergic perennial, neural analysis	% of allergic perennial, genetic analysis
47	53.3	64.3	75	93
23	89.7	82.8	93	100
21	93	82.8	100	93
19	89.7	79.3	93	100
15	86.3	70	93	93
14	82.8	70	93	93

TABLE 9-continued

% correctly classified with 47, 23, 21, 19, 15, 14, 12 and inputs				
No of inputs	% of total, neural analysis	% of total, genetic analysis	% of allergic perennial, neural analysis	% of allergic perennial, genetic analysis
12	82.8	75.9	93	93
9	82.8	75.9	93	93

[0117] With this information we were able to determine that the input models we had selected provided a satisfactory level of diagnosis.

[0118] Moreover, it could be seen that the predictive value of the data using the 9-input model was as good as the 12-input model. However, when we examined the relative importance of each input in each model we found that only 6 of the 9 inputs in the 9-input model had an appreciable influence in determining the ANN categorisation (Table 10) whereas 11 of the 12 inputs in the 12-input model had such an influence (Table 11).

TABLE 10

Importance of 9 inputs		
0.304	RAST grade house dust mite	
0.283	Graded SPT result to house dust mite	0 = neg 1 = <hist 2 = >hist
0.143	RAST grade grass pollens	
0.103	Symptoms after dietary salicylate	0 = No 1 = Yes
0.097	Taking Mast Cell Activating drugs	0 = No 1 = Yes
0.069	Are nasal symptoms perennial or worse in winter	0 = No 1 = Yes
0.001	Graded SPT result to grass pollens	0 = Neg 1 = <hist 2 = >hist
0.000	Are symptoms worse after dusting or hovering	0 = No 1 = Yes
0.000	Severity of nasal symptoms	0 = none 1 = very mild 2 = mild 3 = moderate 4 = severe

TABLE 11

Importance of 12 inputs		
0.149	Graded SPT result to house dust mite	0 = neg 1 = <hist 2 = >hist
0.138	RAST grade cat	
0.134	Graded SPT result grass pollens	0 = neg 1 = <hist 2 = >hist
0.101	Taking Mast Cell Activating drugs	0 = No 1 = Yes
0.100	Severity of nasal symptoms	0 = none 1 = very mild 2 = mild 3 = moderate 4 = severe
0.093	Are symptoms worse after dusting or hovering	0 = No 1 = Yes
0.084	Graded SPT result to grass pollens	0 = Neg 1 = <hist 2 = >hist
0.064	Are symptoms worse indoors	0 = No 1 = Yes
0.051	Are symptoms worse after gardening	0 = No 1 = Yes
0.043	Are nasal symptoms perennial or worse in winter	0 = No 1 = Yes
0.039	Symptoms after dietary salicylate	0 = No 1 = Yes
0.005	RAST grade house dust mite	

[0119] Moreover, we were also mindful of the fact that an input model with too few data fields might skew the classification and so for this reason the 12-input model is our favoured model because it seems to strike a balance between decision making with as few input data fields as reasonably possible whilst not missing the possible important influence of the extra input data fields in determining categorisation when a large number of patients are analysed using the ANN.

Statistics

[0120] The performance of the optimal model on bootstrap test data and blind validation data was assessed using Receiver Operating Characteristic (ROC) curves. These curves provided information on the predictive accuracy, sensitivity, specificity, positive predictive value and negative predictive value for output diagnoses. The area under the curve (AUC) was calculated as a measure of discrimination.

Results

Patient Characteristics

[0121] During the data collection period 6 Oct. 2003, to 29 Jan. 2004, 93 patients referred to the WCAS with symptoms of rhinitis attended outpatient clinics and consented to participation in the study. Two patients in whom final diagnoses of infective sinusitis were made were excluded from the study; the remaining 91 patients (31 [34.1%] men, 60 [65.9%] women; mean age 41.3 years [SD 15.6]) were included. Consultant Clinical Immunologist-derived data from patients 001-062 (n=62) was used to train the ANN. Data from the remaining 29 patients was utilised for blind validation of the optimal ANN model produced following parameterisation. The training and validation groups were similar in terms of demographic features and distribution of output diagnoses (Table 12).

TABLE 12

Characteristics of patients presenting to the WCAS with symptoms of rhinitis

Characteristic	Training and test subset (6 Oct. 2003-12 Jan. 2004) (n = 62)	Validation subset (15 Jan. 2004-29 Jan. 2004) (n = 29)
Mean age in years (SD)	43.1 (15.7)	37.5 (14.9)
Male/Female	21 (33.9%)/41 (66.1%)	10 (34.5%)/19 (65.5%)
Output diagnosis allergic perennial	43 (69%)	16 (55.2%)
Output diagnosis allergic seasonal	7 (11%)	8 (27.7%)
Output diagnosis idiopathic perennial	3 (5%)	3 (10.3%)
Output diagnosis idiopathic seasonal	2 (3%)	1 (3.4%)
Output diagnosis drug induced	5 (8%)	1 (3.4%)
Output diagnosis dietary salicylate	2 (3%)	0 (0%)

CONCLUSION

[0122] This study has provided evidence that data collected by structured questionnaire and analysed by ANN software can correctly diagnose upper respiratory tract disorders, such as rhinitis, by aetiological cause.

REFERENCES

[0123] Basheer, I, A and Hajmeer, M. (2000). 'Artificial neural networks: fundamentals, computing, design and application'. *J. Microbiol Methods* 43: 3-31.

[0124] Baxt, W, G. (1995). 'Application of Artificial Neural Networks to Clinical Medicine.' *Lancet* 346: 1135-1138.

[0125] Callan, R. (1999). 'The Essence of Neural Networks'. Hemel Hempstead: Prentice Hall Europe.

[0126] Das, A; Ben-Menachem, T; Cooper, G, S, et al. (2003). 'Prediction of outcome in acute lower-gastrointestinal haemorrhage based on an artificial neural network: internal and external validation of a predictive model.' *Lancet* 362: 1261-1266.

[0127] Dybowski, R and Gant, V (eds) (2001). '*Clinical Applications of Artificial Neural Networks'*. Cambridge: Cambridge University Press.

[0128] Hanley, J, A and McNeil, B, J. (1982). 'The meaning and use of the Area under a Receiver Operating Characteristic (ROC) Curve.' *Radiology* 143: 29-36.

[0129] Hecht-Nielsen, R. (1990). '*Neurocomputing'*. Massachusetts: Addison-Wesley.

[0130] Holgate, S, T. (1999). 'The epidemiology of allergy and asthma'. *Nature* 402: (suppl) B2-B4.

[0131] Holgate, S, T and Broide, D. (2003). 'New targets for allergic rhinitis—a disease of civilisation'. *Nature Rev Drug Discovery* 2: 1-12.

[0132] Lancashire, L, J; Mian, S; Rees, R, C, et al. (2003). 'Preliminary artificial neural network analysis of SELDI mass spectrometry data for the classification of melanoma tissue'. *Proceedings of the* 17th *European Stimulation Multiconference.*

[0133] Linneberg, A; Nielsen, N, H; Madsen, F, et al. (2000). 'Increasing prevalence of specific IgE to aeroallergens in an adult population: two cross-sectional surveys 8 years apart: the Copenhagen Allergy Study'. *J. Allergy and Clin Imm* 106: 247-252.

[0134] McCulloh, W, S and Pitts, W. (1943). 'A logical calculus of the ideas immanent in nervous activity.' *Bull. Math. Biophys* 5: 115-133.

[0135] Metz, C, E. (1978). 'Basic principles of ROC analysis.' *Semin. Nuc Med* 8: 283-298.

[0136] Roadknight, C; Palmer-Brown, D and Al-Dabass, D. (1997). 'Simulation of correlation activity pruning methods to enhance transparency of ANNs.' *Int. J. Simulation* 4: 68-74.

[0137] Rosenblatt, F. (1958). 'The perceptron: a probabilistic model for information storage and organisation in the brain.' *Psychol Rev* 65: 386-408.

[0138] Rumelhart, D, E and McClelland, J, L. (1986). '*Parallel distribution processing: Explorations in the microstructure of cognition:* Volume 1: Foundations'. Cambridge USA: MIT Press.

[0139] Schalkoff, R, J. (1977). '*Artificial Neural Networks'*. New York: McGraw-Hill.

[0140] Swingler, K. (1996). '*Applying Neural Networks: A Practical Guide'*. NewYork: Academic Press

[0141] Thompson, R. A, Bird A. G (1983). How necessary are specific IgE antibody tests in allergy diagnosis? *Lancet,* 321, 169-173.

[0142] Wei, J, T; Zhang, Z; Barnhill S, D, et al. (1998). 'Understanding artificial neural networks and exploring their potential applications for the practicing urologist'. *Urology* 52: 161-172.

[0143] Wide, L, Bennich H, Johansson SGO (1967). Diagnosis of allergy by an in vitro test for allergen antibodies. *Lancet,* 2:1105.

[0144] Zweig, M, H and Campbell, G. (1993). 'Receiver-Operating Characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine.' *Clin. Chem* 39: 561-577.

1. A method for diagnosing rhinitis or sinusitis comprising:
(a) asking a patient each of the following questions:
are any drugs being taken that are known to activate MAST cells said drugs selected from the group consisting of alpha blockers, ACE inhibitors/ATII Receptor antagonists, aspirin, 5 HT-1 agonists, opiate or derivative medications, proton pump inhibitors, selective serotonin reuptake inhibitors and statins;
severity of nasal symptoms on a scale of 0-n;
are the symptoms perennial/worse in the winter months;
are the symptoms worse during dusting, vacuuming, or cleaning;
are the symptoms present after dietary salicylates; and
(b) carrying out each of the following tests:
skin prick test to house dust mite and/or cockroach;
skin prick test to mixed pollens;
RAST test result to house dust mite and/or cockroach;
RAST test result to mixed pollens; and
(c) inputting the results of the questions and tests into a neural network trained to diagnose said condition; and
(d) producing an output indicative of a diagnosis.

2. A method according to claim **1** wherein said mixed pollens are selected having regard to the geographical region where the patient resides.

3. A method according to claim **1** wherein said one or more tests involves the provision of a graded result.

4. A method according to claim **1** wherein part (a) thereof further involves asking a patient each of the following questions:
are the symptoms worse indoors;
are the symptoms worse when gardening; and
part (b) thereof further includes carrying out the following further test:
RAST test to cat.

5. A method according to claim **1** wherein part (a) thereof further involves asking a patient the following questions:
severity of eye symptoms (on a scale of 0-n);
are the symptoms worse when gardening;
and part (b) further includes carrying out the following tests:
RAST test to cat;
skin prick test to cat; and
total IgE concentration.

6. A method according to claim **1** wherein part (a) thereof further involves asking a patient the following questions:
patient age in years;
severity of eye symptoms;
are symptoms worse when gardening; and
part (b) thereof involves performing the further tests:
skin prick test to cat;
total IgE concentration;
RAST test to cat.

7. A method according to claim **1** wherein part (a) thereof further involves asking a patient the following questions:
do you have asthma or eczema;
number of first degree relatives with asthma, eczema or rhinitis;
severity of eye symptoms;
symptoms worse indoors;
symptoms worse when gardening;
effective therapeutic trial with antihistamine or topical nasal steroid; and
part (b) thereof involves performing the following further tests:
skin prick test to cat;
total IgE concentration;
RAST test to cat; and
RAST test to mixed pollens.

8. A method according to claim **1** wherein part (a) thereof involves asking a patient the further questions:
patient age in years;
do you have asthma or eczema;
number of first degree relatives with asthma, eczema or rhinitis;
severity of eye symptoms;
symptoms worse indoors;
symptoms worse when gardening;
effective therapeutic trial with antihistamine or topical nasal steroid;
how many years have symptoms been present; and
part (b) thereof involves performing the further tests:
skin prick test to cat;
total IgE concentration;
RAST test to cat;
RAST test to mixed pollens.

9. A method according to claim **1** wherein part (a) thereof further involves asking the following questions:
patient age in years;
do you have asthma or eczema;
number of first degree relatives with asthma, eczema or rhinitis;
severity of eye symptoms (0-n);
symptoms worse in summer months;
symptoms better at work;
symptoms worse indoors;
symptoms worse when gardening;
effective therapeutic trial with antihistamine or topical nasal steroid;
for how many years have symptoms been present; and
part (b) thereof comprises performing the following further tests:
skin prick test to cat;
total IgE concentration;
RAST test to cat;
RAST to mixed pollens;
RAST test to mixed grass pollens;
RAST test to mixed tree pollens.

10. A method according to claim **1** which comprises in part (a) thereof further involves asking a patient all the questions in Table 8; and
part (b) thereof involves performing all the tests in Table 8.

11. A computer system or apparatus, configured to aid in the diagnosis of rhinitis or sinusitis, comprising:
(a) a device for obtaining data relating to a patient, wherein the data comprises answers to any selected combination of questions and results of tests outlined in an input

model selected from the group consisting of 9-, 12-, 14-, 15-, 19-, 21-, 23- and 47-input models above;

(b) a device for storing the data in storage means of the computer system;

(c) a device for transferring the data to a neural network trained on samples of the data; and

(d) a device for extracting from the trained neural network an output, the output being an indicator for the diagnosis of rhinitis or sinusitis.

12. A method for training a neural network to aid in diagnosing rhinitis or sinusitis, comprising:

a) obtaining data relating to a group of patients in whom rhinitis or sinusitis is known, wherein the data comprises any selected combination of the results of the questions and tests outlined in an input model selected from the group consisting of 9-, 12-, 14-, 15-, 19-, 21-, 23- and 47-input models;

(b) training a neural network to identify the pattern of data which corresponds to the rhinitis or sinusitis; and

(c) storing the neural network in storage means of a computer or on a computer-readable medium.

13. A computer program product comprising:

a computer usable medium having computer readable program code and computer readable system code embodied on said medium for aiding in the diagnosis of rhinitis or sinusitis, said computer program product including:

computer program code means, when the program code is loaded, to make the computer execute a procedure to:

(a) obtain data relating to a patient, wherein the data comprises answers to any selected combination of questions and results of the tests outlined in an input model selected from the group consisting of 9-, 12-, 14-, 15-, 19-, 21-, 23- and 47-input models;

(b) store the data;

(c) transfer the data to a neural network trained on the aforementioned data; and

(d) extract from the trained neural network an output, the output being an indicator for the diagnosis of rhinitis or sinusitis.

14. A computer system comprising a first means for:

(a) obtaining data relating to a patient, wherein the data comprises answers to any selected combination of questions and results of tests outlined in an input model selected from the group consisting of 9-, 12-, 14-, 15-, 19-, 21-, 23- and 47-input models; and

a second remote means, wherein said second remote means comprises means for:

(b) storing the data;

(c) transferring the data to a neural network trained on the aforementioned data; and

(d) extracting from the trained neural network on output, the output being an indicator for the diagnosis of rhinitis or sinusitis.

15. (canceled)

16. A method according to claim **1** for diagnosing any one of the following conditions:

allergic perennial rhinitis, allergic seasonal rhinitis, idiopathic perennial rhinitis, idiopathic seasonal rhinitis, drug-induced rhinitis, dietary salicylate-induced rhinitis or rhino-sinusitis.

17. (canceled)

18. A computer system or program according to claim **11** wherein the allergy is any one of the following conditions:

allergic perennial rhinitis, allergic seasonal rhinitis, idiopathic perennial rhinitis, idiopathic seasonal rhinitis, drug-induced rhinitis, dietary salicylate-induced rhinitis or rhino-sinusitis.

19-20. (canceled)

21. A computer system or program according to claim **13** wherein the allergy is any one of the following conditions:

allergic perennial rhinitis, allergic seasonal rhinitis, idiopathic perennial rhinitis, idiopathic seasonal rhinitis, drug-induced rhinitis, dietary salicylate-induced rhinitis or rhino-sinusitis.

22. A computer system or program according to claim **14** wherein the allergy is any one of the following conditions:

allergic perennial rhinitis, allergic seasonal rhinitis, idiopathic perennial rhinitis, idiopathic seasonal rhinitis, drug-induced rhinitis, dietary salicylate-induced rhinitis or rhino-sinusitis.

* * * * *

专利名称(译)	使用神经网络诊断上呼吸道过敏的方法和装置		
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摘要(译)

本发明涉及一种使用人工神经网络进行医学病症诊断的方法和装置，特别是与上呼吸道相关的过敏症。