Digital Healthcare Empowering Europeans
R. Cornet et al. (Eds.)

doi:10.3233/978-1-61499-512-8-622

GA-ANFIS Expert System Prototype for Prediction of Dermatological Diseases

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Abstract. This paper presents novel GA-ANFIS expert system prototype for dermatological disease detection by using dermatological features and diagnoses collected in real conditions. Nine dermatological features are used as inputs to classifiers that are based on Adaptive Neuro- Fuzzy Inference Systems (ANFIS) for the first level of fuzzy model optimization. After that, they are used as inputs in Genetic Algorithm (GA) for the second level of fuzzy model optimization within GA-ANFIS system. GA-ANFIS system performs optimization in two steps. Modelling and validation of the novel GA-ANFIS system approach is performed in MATLAB environment by using validation set of data. Some conclusions concerning the impacts of features on the detection of dermatological diseases were obtained through analysis of the GA-ANFIS. We compared GA-ANFIS and ANFIS results. The results confirmed that the proposed GA-ANFIS model achieved accuracy rates which are higher than the ones we got by ANFIS model.

Keywords. Adaptive Neuro-Fuzzy Inference System, Genetic Algorithm, Prediction, Dermatological Diseases

Introduction

When speaking about dermatologic diseases, diagnosis variety is a complex problem. The diseases observed in this group are Pityriasis Lichenoides, Pityriasis Alba, Lichen Striatus, Lichen Planus and Psoriasis. They all share clinical features of erythema and scaling with only slight differences [7] due to which is usually difficult to identify what type of disease the patient actually has. The fact is that some studies present really interesting research on how to easier identify the disease on the basis of the Artificial Intelligence (AI) techniques. In our previous study [7], we presented approach, based on ANFIS model, for the detection and recognition of different types of dermatologic diseases. We used five ANFIS classifiers in order to detect different types of dermatologic diseases. Each of the ANFIS classifiers was trained so to be more accurate for one, than for the other type of disease class. In the recent work [8] , researches presented application of a particular neuro-fuzzy system, named KERNEL, to the problem of diagnosis differentiating in erythemato-squamous diseases. The research study [1] proposed ANFIS model by combining neural network adaptive capabilities and fuzzy logic qualitative approach. In research paper [4] authors used ANFIS to train the mathematical models where GA was responsible to analyze database and possible correlations with consumption.

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Authors in research study [9] suggested hybrid GA-ANFIS model in which GA optimizes structure and the number of fuzzy IF-THEN rules by finding best value of sub-clustering method. Modern medicine is looking for a solution in a form of new technology that would help doctors in their work. Usually, biopsy is necessary for the correct and final diagnosis. Patients are evaluated by the physicians in two steps. First, they do clinical inspection of the degree of erythema, scaling and compiling historical data that configure 9 features. In the second step, skin samples are taken to histopatological examination with the use of microscope.
A novel GA-ANFIS expert system prototype for prediction of dermatological diseases is presented in our study. The purpose of this study is to reach smaller prediction errors (in regard to ANFIS model) by developing new GA-ANFIS expert system. The effectiveness of the GA-ANFIS system approach is tested and verified by the use of validation data. Modeling and validation of the novel GA-ANFIS system approach is performed in MATLAB environment. The results are compared with ANFIS [7], and they show the effectiveness of the proposed approach. Better precisness leads to better applicable value as a help to a doctor in establishing clinical diagnosis.

The paper is set up as follows; in introduction, we described problems when differentiating of dermatological disease diagnosis is concerned, and listed some research studies on different approaches. In section one; we explained the methods used in our research along with the description of ANFIS, genetic algorithm and our novel GA-ANFIS system approach covered in this work. We also described GA-ANFIS system design architecture and explained the steps taken in using GA-ANFIS Matlab user interface. Section two shows the numerical results of training and testing error compared with ANFIS results. Finally, the discussion and conclusion are summarized in section three.

1. Material and Methods

Skin is the largest organ in the body so that protecting skin from diseases is important. Dermatology is a branch of medicine dealing with skin, hair, nail and its disease. Diseases observed in this group are Pityriasis Lichenoides, Pityriasis Alba, Lichen Striatus, Lichen Planus and Psoriasis. They all share the clinical features of erythema and scaling with very few differences [2]. Nine input attributes are: scaling, itching, family history, Koebner phenomenon, papules (follicular), head involvement, melanin incontinence, acanthosis and inflammatory mononuclear infiltrate. We used three different statuses for features (3- obviously present, 0-not present, 1-2 relative intermediate presented values). The total number in the base was 320 patients. That group was divided in two parts. In the model developing phase, we used 260 patients (i.e. data), who were used for training, testing and checking. 60 separated patients did not participate in the training and testing, but were applied on the finished model in the application phase (clinical validation). Model passed two validation types. In the developing phase, the method ANFIS itself (which is the core of GA-ANFIS system) divides 260 patients, being taken as a model, to 70% of trained, 15% for controlling overfitting-a structure (checking) and 15% for the model testing. Due to the fact that the model is an integral part of the GA-ANFIS system, we needed an additional validation of the system that goes to the application, which we achieved with the afoeremnetioned separated patients. In this approach is used triple ANFIS method [3] based on Sugeno models using fuzzy logic and fuzzy sets, each with three skin features.

Our Sugeno model has three inputs (skin features) and one output (type of diseases), as well as 27 IF-THEN knowledge base rules. The next method used in the research is genetic algorithm (GA) based on evolutionary paradigm: crossover, mutation, population, generation and fitness function. The main function of GA is to share four kinds of ANFIS parameter structure and then optimize fuzzy sets in knowledge rule base resulting in the best prediction of dermatological diseases.

2. Results

The GA-ANFIS expert system prototype was developed in MATLAB software package. The process flow chart is shown in Fig.1.

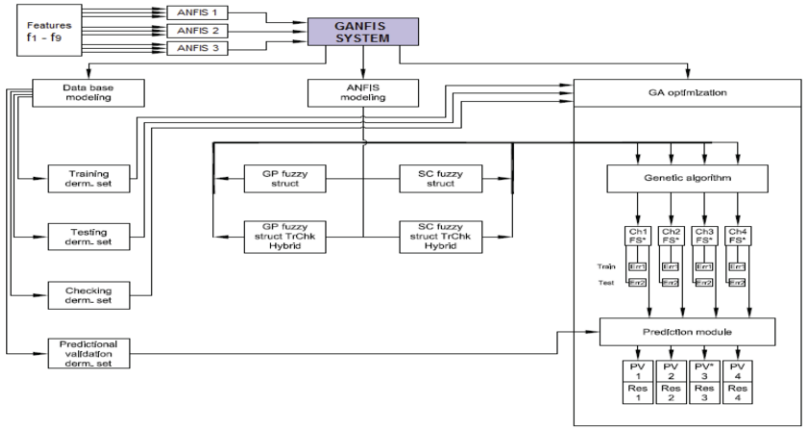

Figure 1. Process flow chart GA-ANFIS system algorithm, GP-Grid Partitioning, SC-Subtractive Clustering, TrChk -Training and Checking, CH-Chromosome, FS-Fuzzy structure, PV-Predicted Values, Res- Residuum

The size of chromosome structure-fuzzy structure (Fig. 2) was generated by ANFIS computational complexity [5] (see Table 1). Chromosome length is defined by Eq.(1)

Table 1. ANFIS computational complexity.

Layer type	$O_{0,i}$ Inputs	$O_{1,i}$ Values	$O_{2,i}$ Rules	$O_{3,i}$ Normaliz.	$O_{4,i}$ Lin. funct.	$O_{5,i}$ Sum
Nodes	NumIn	(NumMf*NumIn)	$NumMf^{NumIn}$	$NumMf^{NumIn}$	$NumMf^{NumIn}$	1
Parameters	0	3*(NumMf*NumIn)	0	0	(NumIn+1)* $NumMf^{NumIn}$	0

For NumIn=3 (input variables) and NumMf=3 (number of membership functions) we have concrete chromosome structure (see Fig. 2).

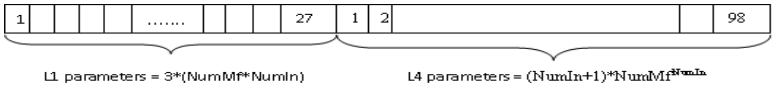

Figure 2. Chromosome structure GA-ANFIS system

$$L_{Chrom} = L_1 + L_4 = 3*(NumMf*NumIn) + (NumIn+1)*NumMf^{NumIn} \quad (1)$$

The Graphical User Interface (GUI) (Fig. 3) contains four parts. The first part (left upper) shows initialization and pre-processing dermatology data. The second part (left lower) is used for interactive training (learning) ANFIS models. The third part is aimed for initialization and parameterization of GA. The last part integrates all previously data and functions into integral GA-ANFIS operations with diseases score and errors predictions. We made validation of prototype through four experiments. In each experiment were 20 individuals for the GA initial random populations, 200 generation for the GA and fitness limit 0.015.The prediction accuracy for the training data was used as the fitness criterion in the evaluation function. Finally, Fig. 4 below shows the comparison of the predicted value versus target value of the test data. Fig. 5 shows one of hyper planes which represent part of multi-modal transformation (knowledge rules) with the possibility to map all disorder type to given input dermatological features.

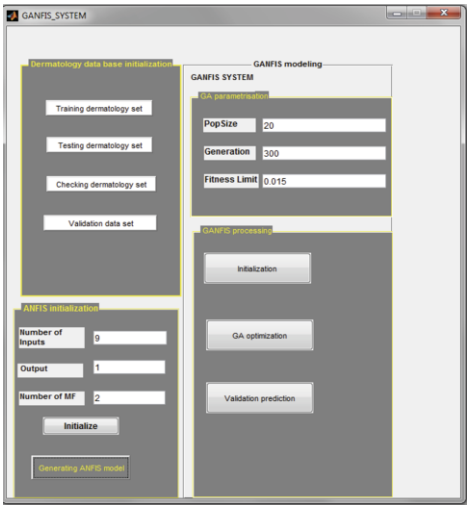

Figure 3. Screen shot of Graphical User Interface

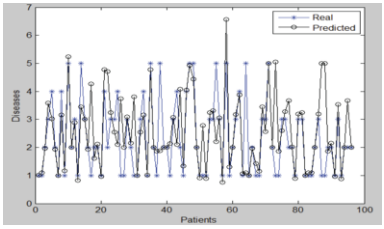

Figure 4. Real vs. predicted values.

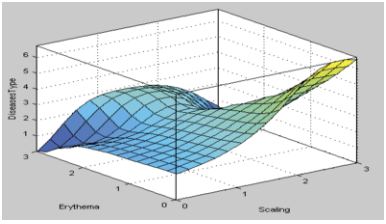

Figure 5. Surface of predicted disorders

Table 2 shows the comparison results of the test success of GA-ANFIS for different optimization method versus one used in previous work [7].

Table 2. Test success of GA-ANFIS system vs. ANFIS in previous work [7]

Opt. method Hybrid	Number of generation	Bit String Mask	Train error ANFIS	Train error GANFIS	Test error ANFIS	Test Error GANFIS	Check error ANFIS	Check error GANFIS
Train and Test/SC	200	Crossover Heuristic	2,9560	3.4336e-6	2,6771	1,4598e-05	2,6192	1,1344e-05
Train and Test/GP	200	Crossover Heuristic	0,36408	0.19777	1,2389	0.18373	1,0020	0.01916
Train/test/check SC	200	Crossover Heuristic	2,54e-05	3.6587e-08	1,0717	1,9024e-05	0,99406	1,3041e-05
Train/test/check GP	200	Crossover Heuristic	2,61e-02	0.19408	1,4179	0.18118	1,3085	0.19854

3. Discussion, conclusion and future work

The comparison results show that our expert system prototype has better performances than the previous classical approach that is based on single ANFIS model [7]. First of all, it is an approach based on cascade optimization, as we have presented in this work and it gives better results comparing to previous ANFIS approach.
The results we have achieved by this novel approach are more useful because we got better prediction by knowing only clinical features. It is important, because patient is usually not medicated before obtaining histopathological results. The proposed GA-ANFIS expert system combines ANFIS and GA capabilities. The total classification accuracy of our GA-ANFIS model was about 98%. This improving of 98% referrs to our system that was optimized for ANFIS level. Originality is in the approach that uses global optimization of the genetic algorithm, so to find ANFIS structure whose parameters give the best preciseness, from the aspect of model accuracy. If it had worked without GA, finding of ANFIS optimal structure would have taken very long time, and we would not have objective results (because we did not do thorough research, as GA did). We have therefore concluded that the proposed model can be used in detecting classes of dermatological diseases by taking into consideration only clinical features.
In our approach we use two-stage cascade optimization, where eight types of ANFIS were parallel processed within GA algorithm. The next phase of our research will be focused on fusion GA-ANFIS model with chromosome configuration composed of three parts: four ANFIS parameters, L1 and L4 parameters as in presented approach.

References

[1] E. Derya Ubeyli, I. Guler, Automatic detection of erythemato-squamous diseases using adaptive neuro fuzzy inference systems, Elsevier -Computers in Biology and Medicine 35 (2005) 421–433.
[2] J.-S.R. Jang, ANFIS: Adaptive-network-based fuzzy inference system, IEEE Trans. Syst. Man Cybern. 23 (3), (1993) pp. 665–685.
[3] J.-S.R. Jang, Self-learning fuzzy controllers based on temporal backpropagation, IEEE Trans. Neural Networks 3 (5), (1992) pp. 714–723.
[4] K.Kampouropoulus, F.Andrade, A. Garcia, L. Romeral, A Combined Methodology of Adaptive Neuro-Fuzzy Inference System and Genetic Algorithm for Short-term Energy Forecasting, Advances in Electrical and Computer Engineering (2014), Volume 14, Issue 1, page(s): 9 – 14, ISSN: 1582-7445, e-ISSN: 1844-7600, DOI: 10.4316/AECE.2014.01002.
[5] Pierro Bonissone, Adaptive Neural Fuzzy Inference System, Analysis and Application, http://homepages.rpi.edu/~bonisp/fuzzy-course/Papers-pdf/anfis.rpi04.pdf.
[6] S.Olusanya Olatunji, H Arif, Identification of Erythemato Squamous Skin Diseases using Extreme Learning Machine and Artifical Neural Network, Ictact Journal on Soft Computing, 2013,Vol 4, Issue 01.
[7] Z. Avdagic, L. B. Fazlic, H. Fatkic, Automatic detection of dermatological diseases using Adaptive Neuro Fuzzy Inference Systems, Acta Informatica Medica;2007, Vol. 15 Issue 2, p89.
[8] G. Castellano, C. Castiello, A.M. Fanelli, C. Leone, Diagnosis of dermatological diseases by neuro fuzzy system, Conference: Proceedings of the 3rd Conference of the European Society for Fuzzy Logic and Technology, Zittau, Germany, September 10-12, 2003.
[9] M.Zanganeh, S.J. Mousavi, A.E.-Shahidi, Genetic Algorithm based Fuzzy inference system based in prediction of wave parameter, Computational Intelligence, Theory and Application, 2006, Vol. 38, pp. 741-750.