*genetic algorithms, neural networks,*
*hybrid systems, myocardial infraction*

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# EVOLUTIONARY ALGORITHMS AND NEURAL NETWORKS APPLIED TO THE COMPUTER – AIDED MEDICAL DIAGNOSIS

SHORT NOTE

The purpose of presented work is to create a project and computer implementation of complex decision support system used in an important medical field, which is cardiology. This system is applied to support physical diagnosis concern different kinds of myocardial infraction. The system - called NEUROGEN v.01, is a kind of hybrid system, which is a combination of Genetic Algorithm (GA) and Neural Network (NN). The idea of this specific combination is that GA is used as a evolutionary method of learning of NN. In accordance with this special task, the NN is a three-layer feedforward network with eight numbers of input neurons, six numbers of hidden and five number of output neurons. The number of neurons in each layer was appointed on the base of data of the task. In this work, the purpose was to look for the optimal values of the parameters of algorithm, which are: crossover probability, mutation probability, the number of individuals in population, the number of generations of the algorithm and $\lambda$ - parameter of function of activation which characterize neurons in NN. An extra task is to check if the beginning population has any influence on effectiveness of the system. In this paper there will be presented the way of rising of NEUROGEN v.01 and achieved results.

## 1. INTRODUCTION

A major class of problems in medical science involves the diagnosis of disease, based upon various tests performed upon the patient. When several tests are involved, the ultimate diagnosis may be difficult to obtain, even for a medical expert. This has given rise, over the past few decades, to computerized diagnostic tools, intended to aid the physician in making sense out of the welter of data. In Section 2 the medical problem (myocardial infraction) is presented. This is followed by an exposition in Section 3 of the idea of hybrid system, where used methods are presented – GA and NN. In Section 4 achieved early results and concluding remarks are described, followed by plans concern further experiments in Section 5.

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## 2. MEDICAL PROBLEM

*Angina Pectoris, Prinzmetal's (Variant) Angina, Subendocardial Myocardial Infarction and Transmural Myocardial Infarction* are the most important illnesses of the human heart.
First of them - *Angina Pectoris* is a recurring pain or discomfort in the chest that happens when some part of the heart does not receive enough blood. It is a common symptom of coronary heart disease. *Prinzmetal's (Variant) Angina* is another forms of angina pectoris. This type is caused by vasospasm, a spasm that narrows the coronary artery and lessens the flow of blood to the heart. The differences between *Subendocardial Myocardial Infarction* and *Transmural infarction with Q wave* are perceptible only at the electrocardiograph [4, 5].

There was a lot of different features (including 59 ones) that characterize each kind of myocardial infraction and chest pain (including 901 case records). There were for example: age, sex, pain – its location, chest pain radiation, pain character, onset of pain, numbers of hours since onset, duration of the last episode, associated symptoms, palliative factors, history of similar pain, past medical history, current medication usage, physical examinations and ECG examination. Most of them were binary features, remaining were discreted by author.

## 3. METHODS

The idea of applying the biological principle of natural evolution to artificial systems, introduced more than four decades ago, has seen impressive growth in the past few years. In this paper there is consider the evolutionary methodology known as genetic algorithms and neural network.

With regard to the system NEUROGEN v.01 and to it's important part which is genetic algorithm, the fitness function, that characterize the GA, is the "0-1 lost function", which define the fitness value – the difference between actual and expected output of NN for each individual. Another feature of GA is selection procedure. One of the simplest is fitness-proportionate selection and this kind of selection was used in the system NEUROGEN v.01. The termination condition of GA is, for example, the maximal number of generations – which was implemented in the system NEUROGEN v.01 as a parameter in algorithm. With regard to artificial neural network, it's worth mention, that it's mathematical model inspired by the structure of neural neurons, the power and complexity of neural networks as well as the adaptive learning mechanisms in the human brain. In this application, neural network is used to classify profiles of different kind (5 output neurons) of myocardial infraction and chest pain. The number of input neurons is given by number features. To make the system efficient, there was needed to select and reduce the available features. There was used a special kind of measure, which is called *Kolmogorow measure* [2], which let to emerge a smaller number of features. Finally there was decided, that the eight of them all, was the best that differenced the kinds of myocardial infractions. It turned up, that there was eight features from the ECG examination block. This number of features determine the number on inputs neuron of the NN. The number of output neurons is defined by the number of classes. The number of hidden layers as well as the number of hidden neurons is pre-defined by the classification task. The function of activation of each neuron in the network is the same and characterized by the unipolar

sigmoidal function. These connection weights store the knowledge necessary to solve specific problems. This part of the NEUROGEN v.01 system is done by the GA.

COGANN – Combinations of Genetic Algorithms and Neural Networks is well developing part of Artificial Intelligence [1]. The NEUROGEN v.01 is so an example of hybrid system, based on such combination, where GA is used as a learning method to the NN.

## 4. EARLY RESULTS

In this chapter, there will be presented selected achieved simulation results. The plane of the simulations is as follows [3]: first change of the number of generation of the algorithm, then change of the probability of crossover in GA, change of the probability of the mutation GA, change of the λ parameter of activation function of the neuron in NN and finally change of the size of the beginning population. Below are presented only two of those examinations: the influence of the probability of crossover in GA on the effectiveness of the algorithm presented on Fig. 1 with the following guidelines: size of the beginning population: 20 individuals, probability of mutation: 0.1, number of generations: 40, λ: 1.

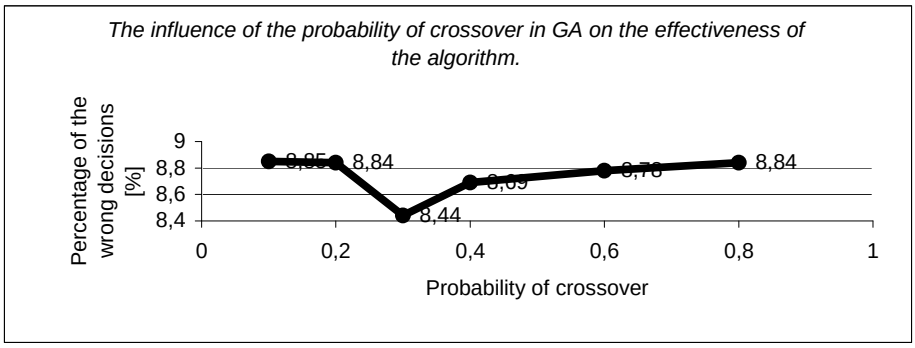


Fig.1. The influence of the probability in GA on the effectiveness of the algorithm

The second examination is: the influence of the size of the beginning population on the effectiveness of the algorithm presented on Fig. 2 with following guidelines: number of generations: 40, probability of mutation: 0.1, probability of crossover: 0.3, λ: 1.

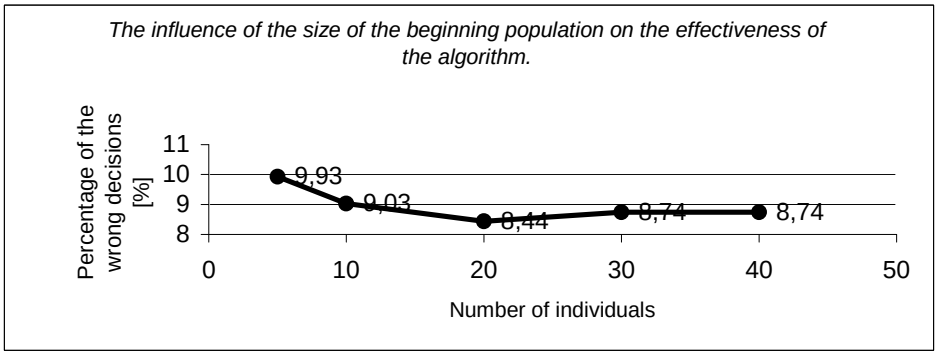


Fig.2. The influence of the size of the beginning population in GA on the effectiveness of the algorithm

Finally, there were achieved the following values of the parameters of the NEUROGEN v.01 system: established beginning population, 0-1 lost function, number of generations: 40, number of individuals: 20, probability of crossover: 0.3, probability of mutation: 0.1, λ: 1.

Neural network with genetic algorithm as a learning paradigm was trained using the selected feature sets. Finally there was achieved system with high classification performance – *91.56%* (that is *8,44%* wrong decisions made by this system). It's very satisfied result. It seemed to be very good and helpful diagnostic tool.

The concept of the hybrid system in AI has a certain lure to it. It seems as if by combining two artificial intelligence techniques, some kind of super-algorithm can be created. The goal of this thesis is to create a way to create a neural network with simple learning algorithm that can easily learn and classify a certain kind of data. To do this, the genetic algorithm is used to find the best set of weights for the job. When it's all over, the result is a population of domain-specific neural networks, ready to take on a world of fresh data. This research presents the implementation of, and experiments resulting from a hybrid system that utilizes the genetic algorithm to search the structure-space of a neural network in order to find an optimal set of weights.

## 5. FUTURE WORK

There is a lot of things that can be changed to improve the NEUROGEN v.01 system, for example the method of selection. Maybe changing the way of encoding from binary to decimal of the individuals, will help to achieve better results. It's possible, that the change of the topology of the network or the method of selecting and reducing the available information (features) may made the system more effective. Another problem is to compare this algorithm with a classic method like k-NN algorithm. In fact good computerized diagnostic tool should posses following characteristic. Namely, the tool must attain the highest possible performance. Moreover, it would be highly desirable to be in possession of a so-called *degree of confidence*: those system not only provides a certain diagnosis, but also outputs a numeric value that represents the degree to which the system is confident about its response. It is possible, when a new method will be applied to this system – that is *fuzzy logic*. The major of advantage of fuzzy systems is that they favour *interpretability*. This anyway complicate this task, because there is a great possibility that there is no database, which consist cases of patients with features assigned as for example integer value from certain interval with concrete hart diagnosis.

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