Artificial Neural Networks Applied to the Monitoring of Cost and Durations in Juvenile Reformatories

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ABSTRACT— ***The artificial neural networks (ANN) are a branch of artificial intelligence and can be defined as structural models of nonlinear regression that allow to emulate the functioning of the human brain. This paper presents an ANN (multilayer perceptron) trained with the retro propagation technique, in order to identify the costs and stays durations of adolescent lawbreakers of the Specialized Attention Center (SAC) "El Redentor" in Bogotá, Colombia. According to the results, the types of diseases, complications or psychological disorders that present adolescents at the time of your income is the main factor that allows you to determine the time and rehabilitation costs.***

Keywords— Adolescent Lawbreakers, Crime, Drugs, Neural Networks, Prevention Policies

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1. INTRODUCTION

The sanitary conditions in juvenile reformatories, also known as Specialized Attention Centers (SAC) for adolescents in conflict with the law have a role of great importance in the rehabilitation process. Specifically, in some SAC located in Colombia, the insalubrious conditions, overcrowding, lack of staffing and administrative difficulties within them, have led to the realization of revolts, riots, and damage to the physical installations [1] this problem that generates material losses, makes it more difficult the rehabilitation process and the work of the psycho-social teams [1].

The objective of this paper is to present an ANN trained with the retro propagation technique for monitor the costs and stays durations of the adolescents of the SAC "El Redentor" in Bogotá, Colombia. We used data related to the offenses committed by adolescents under rehabilitation, who were admitted to the institution in the year 2015. It was also considered the specialized treatment of some adolescents and their associated medicaments.

In the paper proposes the formulation of an ANN for classification of adolescents, through a multilayer perceptron, supported in the statistical software IBM-SPSS Statistics 23. This paper concludes that the types of diseases, complications or psychological disorders that present adolescents at the time of your income, are a factor that allows you to determine the time and rehabilitation costs of the adolescent lawbreakers.

2. JUVENILE DELINQUENCY

In Colombia simultaneously coexist the conflict and criminality, to such an extent that in the collective imagination are identified as the same thing, since the common factor between them is violence [2]. At present, the adolescents are seduced by the immediacy [3], these are more inclined to the automated recreation, participation in social networks, by the interactive learning and interaction [4]. The first steps of the criminal career start at an early age, adolescence is considered a key period for the implementation of preventive programs [5]. The antisocial and criminal behavior are perpetrated primarily by adults with a delinquency history [6].

Despite the scarcity of official information sources on the number of adolescents who commit crimes in Colombia, it is estimated an approximate of seven thousand per year throughout the country -Law 1098 of 2006- Juvenile crime is now a global phenomenon, which exceeds the physical-territorial frameworks of the problem. Until just a decade ago were isolated cases involving adolescents with social adjustment profile that came to juvenile courts; however, it has now become a constant [3]. In addition to this, the continuous appearance of new synthetic drugs, which represent a threat to adolescents and for public health, is a factor that contributes to the increase in juvenile crime, as these can be used as a abuse drug and generate dependency [7].

The crimes committed by adolescents are classified in: against property and against persons [8]. In both is more likely

to find a male juvenile offender with inconsistent parental educational guidelines [8]. In the offenses against the person dominate as major risk factors for aggression, cholera attacks, low tolerance or little concern for others [8]. To prevent recidivism, it is vital to understand the factors that contribute to young offenders that come out of his criminal career to return to crime [6]. The risk of recidivism of young lawbreakers is increased by their limited capacity to solve problems, and his impulsiveness when faced with difficulties [3].

The majority of adolescent lawbreakers with conduct disorders are one of the most important causes of resource consumption and use of legal and social devices [9]. In addition, they have socialization problems, low emotional intelligence and tend to employ unproductive strategies in the solution of conflicts [8]. There is a direct relationship between the behavior disorders and other significant aspects such as the school performance, family dynamics and social relations [9]. Adolescents who do not have a family nucleus, either by the absence of one of the two parents, are more likely to commit a crime [10]. The satisfaction level with life among the offenders may be affected by the subjective experience of their social status and by the feeling of being a "loser" compared with other [11].

2.1 Adolescent criminal responsibility system in Colombia (ACRS)

The ACRS is the set of principles, rules, procedures, specialized judicial authorities and administrative bodies that govern or are involved in the investigation and prosecution of crimes committed by persons who are between fourteen and eighteen years of age at the time of committing a punishable act [12]. In the case of adolescents, the law 1098 of 2006 establishes offenses for which the punishment shall be deprivation of liberty, which must be carried out under conditions that guarantee the fulfillment of human rights [13].

The institutions responsible for providing the educational therapeutic treatment to young lawbreakers, are made up of professionals teams whose main task is to help them recognize their errors and to control their emotions so that you can reintegrate society without having to resort to physical or verbal violence. These are based on the provisions of the childhood and adolescence code and international laws. Depending on the offense, a juvenile lawbreaker may enter under one of the following modalities: transient, preventive detention, restoration internship and specialty attention center [14]. In each of them, the type of conviction, the costs and stays durations varies.

The SAC must clearly identify the costs and time that will remain, in order to ensure an adequate rehabilitation process and sanitary conditions, otherwise you can adversely affect your quality of life in the future physical, emotional and intellectual development, a situation that can lead to increased difficulties for their rehabilitation and social reintegration [1]. Considering that the recidivism risk of young lawbreakers is increased by their limited capacity to solve problems, and his impulsiveness when faced with difficulties [3]. The majority presents a low linguistic and communicative capacities, reason why the professionals that make up the psycho-social teams must implement literacy strategies for improvement [15] contributing to a better development in the society once they have fulfilled the sentence.

3. ARTIFICIAL NEURONAL NETWORKS

The ANN are a branch of artificial intelligence made up of processing units that allow you to exchange data and information, are capable of learning through a training and perform complex tasks of pattern recognition and estimation of parameters [16]. These were created to obtain an information processing system that simulate the human brain [16], which has a non-linear and parallel operation, so it cannot be represented by linear models response [17]. Due to the possibility of parallel implementation and its relatively quick response, the ANN constitute an incentive for research in problems involving nonlinear dynamic systems [18], since they have the ability to adapt their synaptic weights to changes in the environment that surrounds them, and get low processing times due to its operation in parallel [16].

3.1 Multilayer perceptron

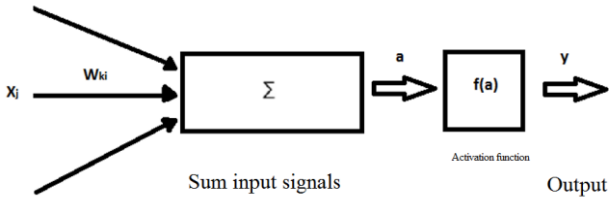

Figure 1: Neuron structure

The MP is an ANN that consists of a network based on multiple layers of neurons-type multilayer perceptron, trained by the retro propagation technique [19]. This can have multiple entries but a single output, and is one of the most commonly used classes of ANN. The MP allows to generate predictive models for one or more dependent variables on the basis of predictive values [19]. The MP are characterized by a non-linearity in the output, hidden layers of neurons and a high degree of connectivity, it is of supervised training and uses the back-propagation algorithm. This algorithm is

based on the rule of learning by error correction, considered as a generalization of the least-squares algorithm (LMS), used in adaptive filtering using simple linear networks [20]. Figure 1 presents the basic structure of a neuron [16].

In the MP each connection has its own synaptic weight (w_{ki}), which varies by training to adapt to the desired output and join the input signal (x_j) with the neuron k, which is multiplied by the weight (Anastassiou, 2011). The sum of the input signals varies by synaptic weights; the activation function is responsible for limiting the extent of the output. To limit the range of response values of the neuron activation function employment hyperbolic tangent tanh x, x ∈ R [21]:

$$\tanh = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}} \qquad (1)$$

This function complies property tanh 0 = 0, −1 < tanh x < 1, ∀x ∈ R, and tanh (−x) = − tanh x. Furthermore, tanh x → 1 as x → ∞, and tanh x → −1, as x → −∞, which constantly increasing in R [21] - [22]. Neural networks are putting the neurons in different layers and connecting the outputs of a layer to the input for the next. Mathematically a neuron can be represented as:

$$\alpha = \sum_{j=1}^{n} w_{kj}.x_j + \theta_j \qquad (2)$$

4. METHODOLOGY

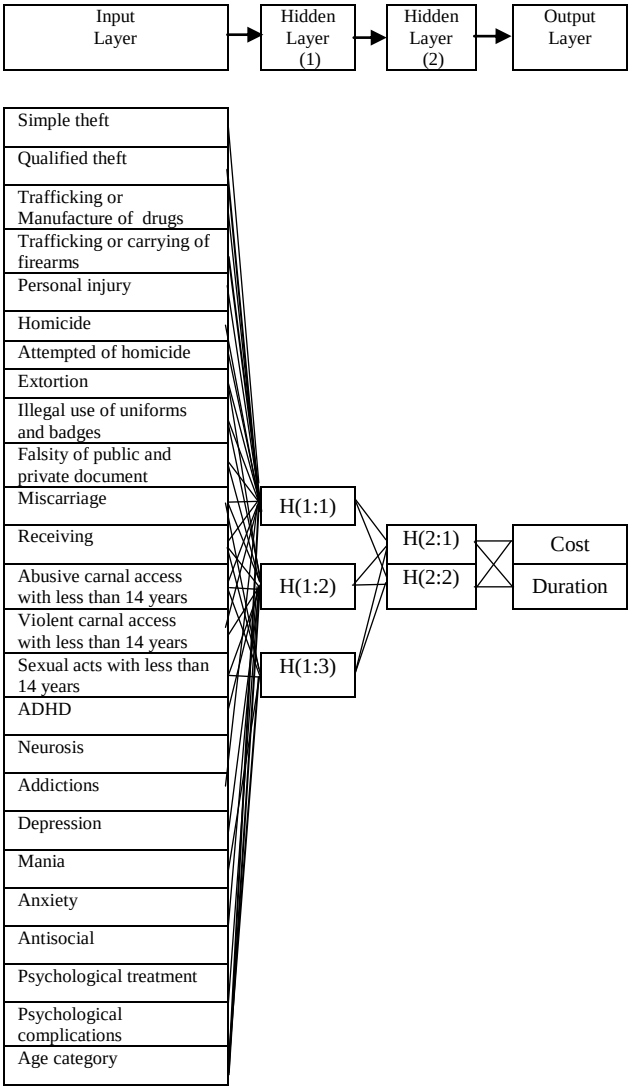

Figure 2: ANN structure

For the ANN construction was used a database with the crimes committed by 400 adolescents who entered the SAC "El Redentor" in Bogotá, Colombia in the year 2015: simple theft, theft qualified, traffic or manufacturing of drugs, traffic - making or carrying of fire weapons, personal injury, murder, attempt to murder, extortion, illegal use of uniforms and badges, falsification of public and private document, miscarriage , receiving stolen devices, abusive or violent carnal access with less than fourteen years, sex with minor of fourteen years, sexual violence in protected person, damage to the object of others , domestic violence, violence against public servants, and terrorism. Figure 2 presents the network structure:

5. RESULTS AND DISCUSSION

Table 1 presents the results of the training. 218 cases were assigned to the training sample, 66 to the test sample and the sample 33 reserved. The 83 cases excluded from the analysis were adolescents who entered the SAC but came out the same day of admission (transitional mode).

Table 1: Summary of the processing cases

	N	Percent
Example		
Training	218	68,8%
Test	66	20,8%
Reserve	33	10,4%
Valid	317	100,0%
Exclude	83	
Total	400	

Table 2: Network information

Input layer	Factors	
	1	Simple theft
	2	Qualified theft
	3	Trafficking or Manufacture of Narcotic Drugs
	4	Trafficking or carrying of firearms
	5	Personal Injury
	6	Homicide
	7	Attempted of homicide
	8	Extortion
	9	Illegal use of uniforms and badges
	10	Falsity of public and private document
	11	Miscarriage
	12	Receiving
	13	Abusive carnal access with less than 14 years
	14	Violent carnal access with less than 14 years
	15	Sexual acts with less than 14 years
	16	ADHD
	17	Neurosis
	18	Addictions
	19	Depression
	20	Mania
	21	Anxiety
	22	Antisocial
	23	Psychological Treatment
	24	Psychological Complications
	25	Age Category
Hidden Layers	Number of units	56
	Number of hidden layers	2
	Number of units in the hidden layer 1	3
	Number of units in the hidden layer 2	2
	Activation function	Hyperbolic tangent
Output Layer	Dependent Variables	Treatment costs / Length of stay
	Number of units	2
	Method of change of scale	
	Activation function	Corrected standard
	Error function	Hyperbolic tangent
		Sum of squares

In Table 2 it can be seen that the number of units of the input layer, 25, is equal to the total number of factors, there are no covariates. We used two hidden layers, since only one did not resolve the problem satisfactorily. The procedure selected 3 units in the first hidden layer and 2 in the second. For each of the dependent variables of scale was used a different output unit, the method standardized corrected for the change of scale, and the activation role of hyperbolic tangent to the output layer.

Table 3 presents the results of training and apply the final network to the sample.

Table 3: Model summary

Training	Error Sum of Squares	3,647
	Global average relative error	,056
	Relative Error	,035
	Stop rule used	1 consecutive step without reducing the error
	Training time	0:00:00,05
Sample	Error Sum of Squares	2,200
	Average relative error global	,138
	Relative Error - The costs of treatment	,029
	Relative Error - duration of the stay	,243
Reserve	Global average relative error	,182
	Relative Error - The costs of treatment	,046
	Relative Error - duration of the stay	,302

The squares sum error is generated due to the dependent variables (length of stay - rehabilitation costs) are of type scale. The relative error of each dependent variable is the ratio between the sum of the quadratic error of the dependent variable, and the sum of the quadratic error of the null model. In Table 3, it can be seen that the error is greater for the forecasts for stay lengths that for treatment costs, both in the test sample model. The relative error average is the quotient between the sum of the quadratic error of all the dependent variables and the sum of the quadratic error of "null" model, using the average values of the dependent variables as forecasted values for all cases. The network also forecast adequately the treatment costs. See Figure 3:

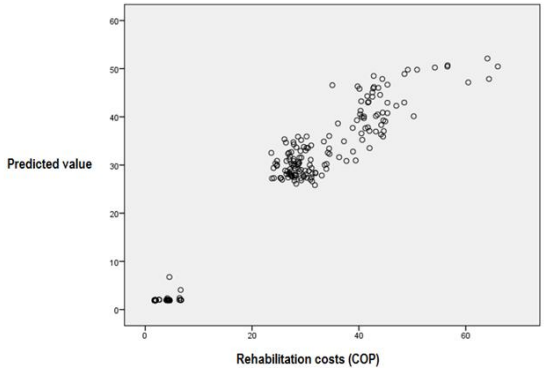

Figure 3: Value Vs Cost

In Figure 3, there are three adolescent clusters. In the bottom left are adolescents who have not been subjected to psychological or psychiatric treatments and their costs are relatively low, not exceeding $ 1650 USD. The following cluster of adolescents have treatment costs between $ 8.250 USD and $ 11.549 USD, are adolescents whose sentences range between four and eight years, have been subjected to psychological or psychiatric treatments and are medicated for any type of disease or mental disorder: depression, schizophrenia, bipolar disorder, anxiety disorder, ADHD, etc., which increases the costs. Figure 4 presents the predicted by observed, which consists of a scatter diagram with the predicted values on the Y axis and the values observed in the X-axis for the training and testing samples combined. Most of the values are located along a line of 45 degrees that part of the source. The points of this graphic form diagonal lines in each number of duration years of stay observed:

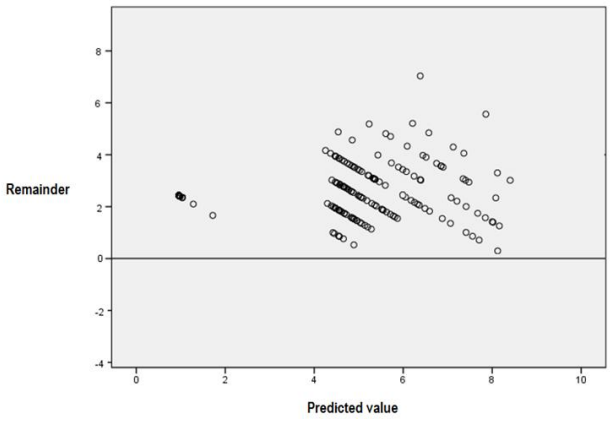

Figure 4: Stay duration

In Figure 4 it can be seen that the network forecast the stays durations adequately. The adolescents cluster located between 0 and 2 years is likely to have not been medicated or subjected to psychological treatment. The second cluster, where the stay duration varies between 4 and 6 years, it is likely that correspond to adolescents who committed a mayor crime and need psychological treatment. The normalized importance graph presented in Figure 5, enables you to see that the results are dominated by the psychological treatment received by adolescents, with a weight of 0.4, followed by psychological complications with a weight of 0.22 and for other types of predictors. While more amount of psychological disorders have the adolescents at the time of admission to the SAC (depression, schizophrenia, bipolar disorder, anxiety, DAHD, etc.) there is a greater probability that the duration of the stay and treatment costs are higher.

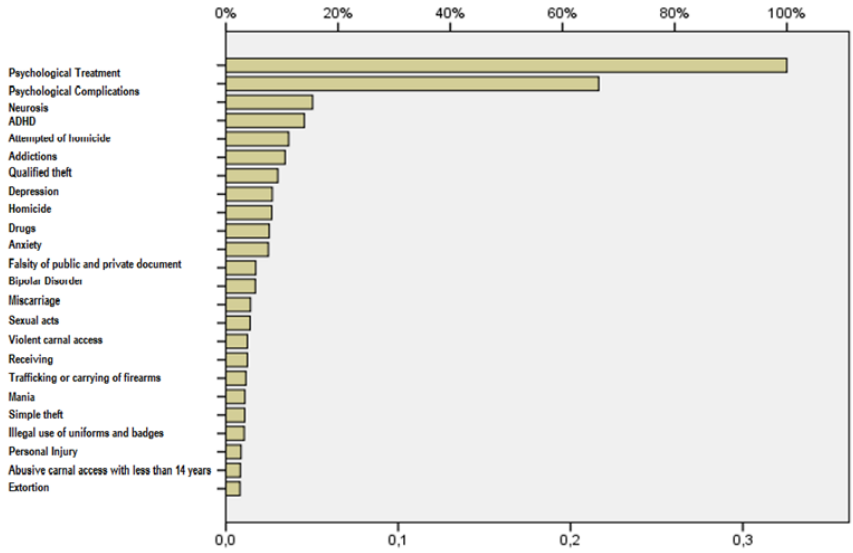

Figure 5: Standard importance

6. CONCLUSIONS

Juvenile crime in the last decade has become a social problem that allows you to see the reflection of other social problems; poverty, social inequality, unemployment, substance abuse, family disintegration, school dropout, insecurity, violence, among others, which is why should take measures to combat the problem and provide greater support to adolescents. It is undeniable the importance of identify and intervene the health needs of adolescents to the interior of the SAC and must become a constant concern of the psycho-social teams, otherwise, if you are not guaranteed health conditions, you can adversely affect the rehabilitation process and social reintegration.

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