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Use of Artificial Neural Networks for projection of Population of India

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Abstract- Today India is having second largest population in the world and in recent decades it will be on top in the world. Population censuses provide us with the total number of peoples, age-sex distribution, marital status, distribution as well as characteristics of population as enumerated on the census data. Generally, the censuses are conducted once in a decade. In a few countries, censuses are conducted once in a five years. So population totals and other characteristics are available only for one time in five or ten years. However, in many situations, government as well as non-governmental agencies requires population totals or population in specific age-sex group for any time, either for the past dates or for any future dates. This research focuses on population estimates on past and future dates using artificial neural networks. Present study develops a Multilayer Perceptron Model with Generalized Delta Learning to predict the population of India and the prediction has been found sufficiently accurate. The prediction is better as compared to traditional interpolation techniques.

Key Words – Behavioral evolution, evolutionary artificial neural networks, evolutionary programming, module combination, population-based learning. Population of India. Male population, female population, total fertility rate, life expectancy, prediction, chaos.

1 INTRODUCTION:

Each year India adds more people to the world's population than any other country. Indian population trend is complex attributable to various reasons. The reasons can be summarized as follows:

- Fertility rate has declined but the number of women in their reproductive age has increased rapidly
- States of India vary significantly with respect to fertility, mortality and contraceptive use.
- Since independence, average life expectancy has increased substantially
- Infant mortality rate has decreased over the years since independence
- India is facing increased rate of HIV and other sexually transmitted disease cases like other developing countries

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2 NEURAL NETWORK:

Neural network theory grew out of Artificial Intelligence research, or the research in designing machines with cognitive ability. A neural network is a computer program or hardwired machine that is designed to learn in a manner similar to the human brain. Haykin (1994) describes neural networks as an adaptive machine or more specifically: A neural network is a massively parallel distributed processor that has a natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects: Knowledge is acquired by the network through a learning process and interneuron connection strengths known as synaptic weights are used to store the knowledge. The basic building block of a brain and the neural network is the neuron. The basic human neuron adapted from Beale and Jackson (1990) is shown below in Figure 1.

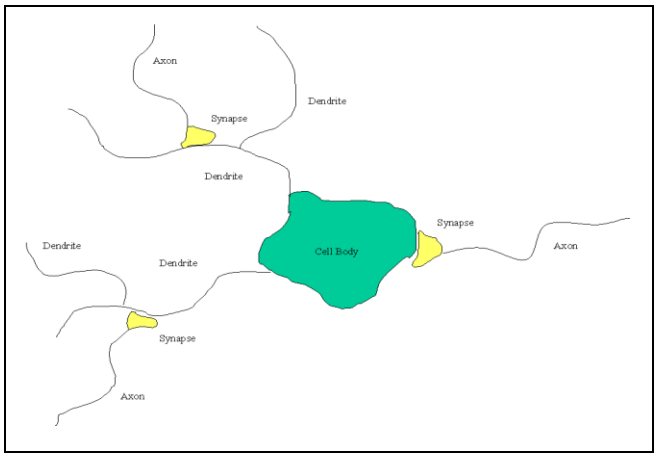

Figure 1. Biological Neuron

As described by Jackson et al. (1990), all inputs to the cell body of the neuron arrive along *dendrites*. Dendrites can also act as outputs interconnecting interneurons. Mathematically, the dendrite's function can be approximated as a summation. *Axons,* on the other hand, are found only on output cells. The axon has an electrical potential. If excited past a threshold it will transmit an electrical signal. Axons terminate at *synapses* that connect it to the dendrite of another neuron. When the electrical input to a synapse reaches a threshold, it will pass the signal through to the dendrite to which it is connected. The human brain contains approximately 1010 interconnected neurons creating its massively parallel computational capability. The artificial neuron was developed in an effort to model the human neuron. The artificial neuron depicted below in Figure 2 was adapted from Kartalopoulos (1996) andHaykin (1994). Inputs enter the neuron and are multiplied by their respective synaptic weights.

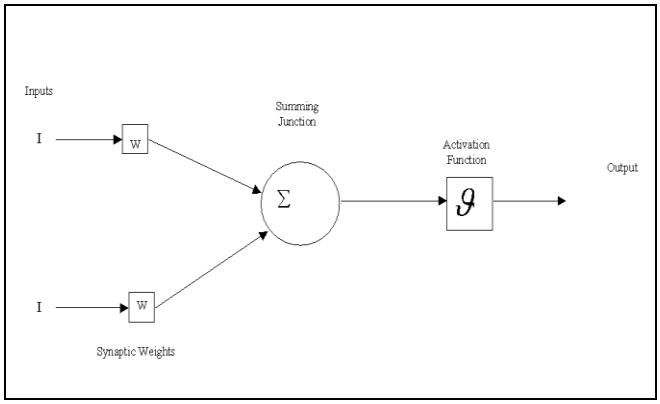

Figure 2. Artificial Neuron Model

In the present paper, data are collected from "The Office of the Registrar General & Census Commissioner, India, Population Enumeration Data (Final Population). All the population data are available in the scale of thousands. To frame the input matrix for the ANN, the gender wise population is divided into age groups 0 to 14, 15 to 64, 65 and over. Male and female population (in thousands) in each subclass, married female population (in thousands) in each subclass, average life expectancy of male, average life expectancy of women, and total fertility rate are considered for the years 2001 and 2002. Purpose is to predict the population (male and female) (in each age group) in the year 2011 on the basis of the data pertaining to 2001 and 2002. From the whole dataset, 75% are considered as training set and 25% are considered as test set. To avoid the sigmoid effect, the data points are transformed into small numerical values through the transformation:

$$x_i=0.1+0.8\ \{(x_i-x_{min})/(x_{max}-x_{min})\}$$

Initial weight matrix is framed with arbitrary values between –0.5 and +0.5. Now, a non-linear ANN in the form of Multilayer Perceptron is generated with Generalized Delta Learning. The learning procedure is done using the equations (1) through (6). Positive constant μ, called the learning rate is taken as 0.9. After training and testing, correlation coefficients between actual and predicted population of the year 2011 are found to be very high. The overall prediction errors are calculated according to

$$PE=<\square x_{actual}-x_{predicted}\square>/<x_{actual}>$$

Where, <> implies the average over the whole test or training set. When, PE is found to be much smaller than 1, the predictive model is found to be adroit. The correlation between actual and prediction and the relevant prediction errors are presented in Fig.01.

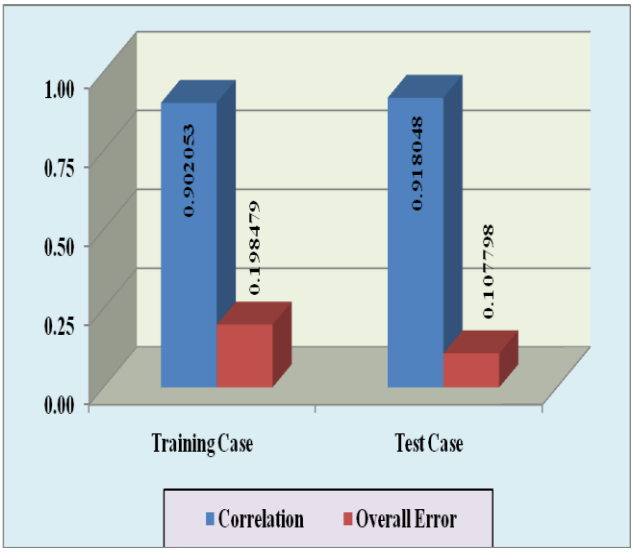

Figure 3: Overall Prediction Error and Correlation between actual and predicted data

A line diagram (Fig.02) is presented to show the association between actual population in 2011and the predicted population through non-linear ANN.

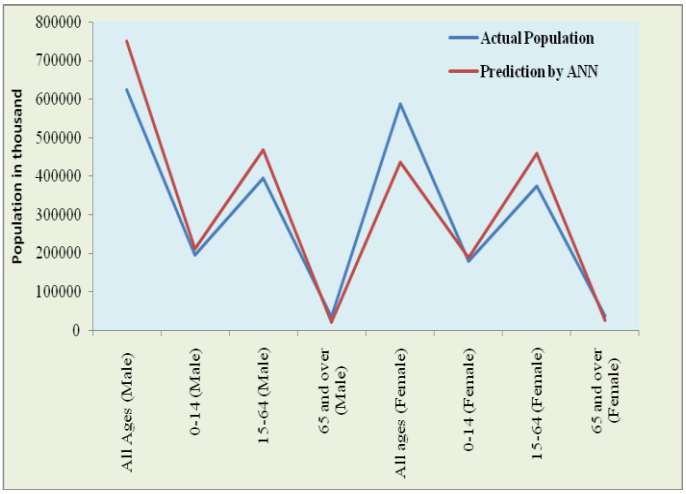

Figure 4: Actual population of 2011 and the predicted by three layer non-linear ANN

3 RESULTS AND CONCLUSION

It is apparent from Fig.01 that correlation between actual and predicted population in 2011 is very high both in training and the test phase. Moreover, prediction errors are found to be very less than 1 both in training and test phase. In addition, the error is almost equal to zero in the test phase. These give a qualitative support to the non-linear ANN as a predictive model for population in India. In Fig.02, the actual and predicted populations for both sexes are presented. A close association between actual and predicted data is apparent. Furthermore, correlation between actual and prediction for male is 0.94 and that for female is 0.98. From these correlation values it can be said that, the result is more accurate for female population, from which, it can be inferred that male population is more chaotic.

Thus, the paper establishes suitability of non-linear ANN as predictive tool for population in India. Furthermore, male population in India is found to be more chaotic than female population.

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