Innovative Systems Design and Engineering
ISSN 2222-1727 (Paper) ISSN 2222-2871 (Online)
Vol.6, No.1, 2015

Dynamic Portfolio Selection to Counter Terrorism by using Quantum Neural Network Approach

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Abstract
Not only Pakistan but the whole world is facing the problems of prevailing terrorist activities and attacks in many forms. Terrorism has diverse aspects and to eradicate this growing problem a hybrid model of quantum and classical neurons is suggested for the prediction of the risk involved and returns of investments in recommended areas to minimize terrorism. These areas are recommended on the basis of the findings of Crime analysts and professionals from other related domains after a deep analysis of the situation of the country and terrorist activities. The identification of the areas which causes terrorism is a core step towards counter the terrorism. Hopfield neural network is used to predict best possible portfolio from available resources. The recommended multilayer hybrid Quantum Neural Network holds hidden layer of quantum neurons while the visible layer is of classical neurons. With the help of QNN an appropriate portfolio can be selected whose risk factor will be minimum and the output generated from investments in identified areas will be maximum.
Keywords: Quantum neural network, Portfolio selection, Resource allocation, Quantum back propagation, Quantum computation.

1. Introduction

Terrorism in Pakistan has spread an alarming behavior and horribly affecting the social fabric of our country. Now it has become crucial to deal with it otherwise it would collapse the social, political and economic structure of Pakistan. Some factors attribute the terrorism in Pakistan and these terrorist activities to the political instability, economic conditions, standard of lives of the masses, yet others attribute it to the religious extremism of portion of the masses of Pakistan. There is another school of thought that say that the discriminations done by World super powers towards the third world countries and Muslim countries have led the world to this situation and yet there is one another school of thought that attribute the current terrorism activities and the blast and suicide attacks everywhere in the world as the game of political advantages among the super powers of the world and some others termed this chaos as clash of civilization between west and Islam. What may be the reason we have to unite and work to eliminate this cancer from our beloved country Pakistan and to make it a model of Peace and prosperity for the nations of the World (Pakpolice, 2011).

The portfolio selection, in an investment decision, is a job on which a lot of work is being done. The Markowitz mean variance approach has found a wide spread acceptability in various forms. The objective of the investor is to select a portfolio which maximizes his returns with minimum risk involved. The mean variance model is required to satisfy two conflicting optimization criterion, one which minimizes risk and the other with predetermined minimum return. Moreover, it is desirable that the selected portfolio shall have a restricted number of assets, invest a minimum portion of available resources in each selected asset, and invest a maximum portion in a single asset. With such restriction the efficient frontier search becomes difficult and complex (Markowitz, 1952). Chang et al further extended the mean variance model by including cardinality constraints that limit a portfolio to have a specified number of assets, and to impose limits on the proportion of the portfolio held in a given asset (TJ Chang et. al, 2000).

Alberto Fernandez has used Hopfield Neural Network for finding the efficient frontier. He further used heuristic method to allocate fund to various assets of the portfolio (Fernández & Gómez, 2005).Quantum algorithms by L.K. Grover has received a lot of attraction. The idea of quantum neural network (QNN) can take power from quantum computation in the field of artificial intelligence (Grover, 1996).

Many prototypes for QNN similar to classical neural networks have been proposed in the literature. Ezonov and Ventur have introduced the possibilities of combining the unique computational capabilities of Classical Neural Network and Quantum Computation. This combination can produce a computational paradigm of incredible potential (Ezhov & Ventura, 2000).

Since last two decades, a great attention is visualized in the efforts of researcher on the idea of time series prediction. They have studied these fluctuations through the use of CNN.

This paper has proposed and applied, a hybrid three layer feed forward back propagation quantum inspired neural network for prediction of the areas which require investment and how much they required. The input layer is classical, the hidden layer is quantum neuron, and the output layer is classical. The output calculation is based on classical computation. Input and output to the hybrid QNN are classical as they have to

interact with the real world.

2. Fund Distribution among Causes to Counter the Terrorism

There are many factors behind the view but a slight view indicates the major reasons to which we have to eradicate and compensate by investment of resources are:

- Poverty
- Economic inequalities
- Injustice
- Hunger & Thirst
- Insecurity
- Myopic policies of government
- Illiteracy
- Dispossession
- Week interior & exterior policies
- Week political process
- Religious exploitation
- Sectarian violence
- Neighboring state intervention
- Refugees Influx
- Gain of Political Interests
- Media sensation
- Marginalization
- Social immunity to powerful and
- Vengeance

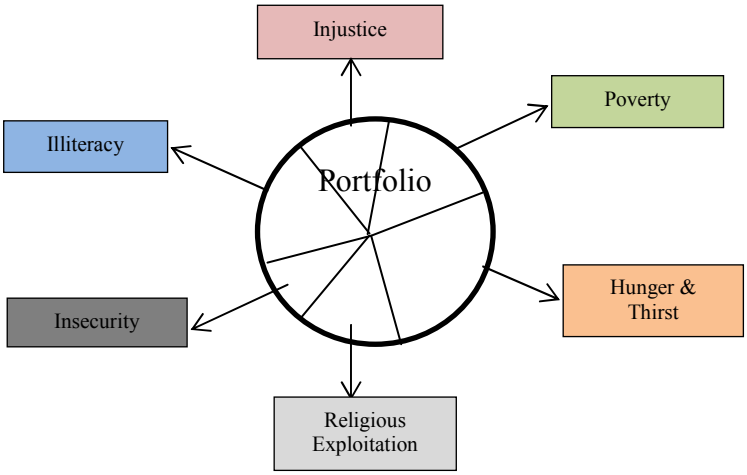

Figure 7. Indicates Portfolio selection among Reasons of Terrorism

These reasons combined offer us the idea of spatial and temporal patterns of frequency, degree of terrorism and patterns in victim, weapon, and terrorist types (Terrorism in Pakistan, 2011). Some of the above mentioned factors are related to the governance and some are related to financial matters. Here only financial issues have addressed and suggested an algorithm which can predict the involved risk and returns of each selected portfolio and can help in assigning each factor an appropriate part of investment to counter the terrorism.

The Hopfield Neural Network allocates the minimum percentage to each defined reason of terrorism followed by allocation of maximum allowable ratio to the entire reason of terrorism with high return. This ensures that all the constraint relating to lower and upper bounds are satisfied. In the next iterations the algorithm allocates free proportions from the remaining resources having returns more than the allocable proportion to all other reasons of terrorism. The allocation to a particular reason depends on the return of that of resource invested upon it. In a case where fund remains un-allotted after allocation following the lower and upper bound constraints rule, either the upper bounds are revised or the investment with higher return may be used for further allotment. The feasibility of the portfolio is evaluated by using QNN algorithm.

3. Hopfield Neural Network

Hopfield net is a form of recurrent artificial neural network and it serves as auto associator and optimizer. The units in Hopfield nets are binary threshold i.e. the units take on two different values for states and the value is determined by whether or not the units input exceed their threshold. Hopfield net can either have units that take on values 0 or 1.

- In Hopfield neural network the state is made up of N neurons, the state of the network is defined by the vector.

$$X=[x_1, x_2, x_3, \ldots\ldots\ldots, x_N]$$

Either x_i is 0 0r 1

- The alteration in the state of Hopfield model causes monotonic decrement in Hamiltonian energy or Lyapunov function.

$$E = -\frac{1}{2}\sum_{i,j} w_{i,j} x_i x_j + \sum_j \theta_j x_j$$ (Fernández & Gómez, 2005)

- $w_{i,j}$ is the strength of the connection weight from unit j to unit i(the weight of the connection). x_i is the

state of unit i and θ_j is the threshold of unit i.

- The induced local field v_j is defined by

$$vj = \sum_{i=1}^{N} w_{j,i} x_i + \theta_j$$ (Fernández & Gómez, 2005)

- Neuron j is modified according to the deterministic rule.

$$x_j = \begin{cases} 1 & v_j > 0 \\ 0 & v_j \le 0 \end{cases}$$

or $$xj = Sigmoid[v_j]$$

$w_{i,i}$ =0, for all i(no unit has connection to itself)
$w_{i,j} = w_{j,i}$ (connection are symmetric)

Thus Hopfield neural network are a class of densely connected non-linear network of perceptrons.

For solving optimization problem, the Hopfield neural networks belong to the penalty method due to their recurrent single layer architecture without any hidden units.

Now, if the equilibrium points were preselected (for instance by hard coding the weights), then the system can work as an auto associator and optimizer.

Hopfield neural network is massively parallel, special purpose and can be used to solve linear programming problems, quadratic programming problems and other complicated problems.

4. Hopfield Portfolio Selection Problem

The objective function for the selection of the portfolio is

$$f(x) = \left[\lambda \left[\sum_{i=1}^{N} \sum_{j=1}^{N} x_i \sigma_{ij} x_j \right] + (1-\lambda) \left[\sum_{i=1}^{N} - \mu_i x_i \right] \right]$$

Pass the multiplicative coefficients inside the square brackets.

$$f(x) = \left[\sum_{i=1}^{N} \sum_{i=1}^{N} x_i (\lambda \sigma_{ij}) x_j + \left[\sum_{i=1}^{n} (\lambda - 1) \mu_i x_i \right] \right]$$

Multiply and divide by -2

$$f(x) = -\frac{1}{2} \left[\sum_{i=1}^{N} \sum_{i=1}^{N} x_i (-2\lambda \sigma_{ij}) x_j \right] + \left[\sum_{i=1}^{n} (\lambda - 1) \mu_i x_i \right]$$ (Fernández & Gómez, 2005)

Comparing this with energy function of the Hopfield model, it can be translated into which shows that

$$w_{ij} = -2\lambda \sigma_{ij}$$
$$\theta_i = (\lambda - 1) \mu_i$$

The constraint x_i (x_i belogs to lower and upper limit) shall be satisfied using a sigmoid threshold function since its output already lie inside the desired interval.

The cardinality constraint

$$\sum_{i=1}^{N} z_i = k \quad ; \text{Where } z_i \in (0,1)$$

The neural network has been used that has N neurons that will follow Hopfield dynamics and the selected K neurons shall be having 1 as output and rest shall be having 0 outputs (Mahajan, 2011).

5. Portfolio Fund Distribution Prediction

The efficient frontier generated from Hopfield neural network shall effectively contribute for desired return. The individual investments selected are the elements that constitute the target portfolio. The succession of values in a time series is usually influenced by a number of external information. When this information is not available

only past value of the series itself can be used to build a prediction model.
$X_{t+1}= f(x_1,……..,x_n)$; where x_{t+1} is estimated next value based on current and past values of x. The data used for fund distribution prediction are based upon the collected information about terrorism its reason in the specific period of time and the output of investment.

6. Hybrid Quantum Inspired Neural Network

- Initialize Classical neurons by assigning the minimum ratio of investment out of maximum allowable ratio.
- Transmitted output of Classical layer to Quantum layer.

The QNN is based on the methods of quantum computation. Qubit is defined as the smallest unit of information in quantum computation which is a probabilistic representation. A Qubit may either be in the "1" or "0" or in any superposition of the two.

- The state of the Qubit can be represented as:

$$|\Psi\rangle \equiv \alpha|0\rangle \pm \beta|1\rangle$$

Where α and β are the numbers that indicate the amplitude of the corresponding states such that:

$$|\alpha|^2 + |\beta|^2 = 1$$

A Qubit is defined as smallest unit of information in quantum computation. It is defined as a pair of numbers $\langle \alpha, \beta \rangle$ Angle θ a more geometrical aspect is defined such that

$$Cos(\theta) = |\alpha| \text{ and } Sin(\theta) = |\beta|$$

- Quantum gates may be applied for modifying the probabilities as a result of weight updating. One such rotation gate R can be:

$$R(\Delta\theta) = \begin{bmatrix} Cos(\Delta\theta) & -Sin(\Delta\theta) \\ Sin(\Delta\theta) & Cos(\Delta\theta) \end{bmatrix}$$ (Mahajan, 2011)

Here Δ indicates the change.
The following hybrid quantum inspired neural network is proposed for the prediction of returns of investment.

- Now in Quantum hidden Layer. Start from state $\langle 0|$ prepare the superposition.

$$\sqrt{p}|0\rangle + \sqrt{1-p}|1\rangle \text{ with } 0 \le p \le 1$$

Where p represents random probability of initializing the system in the state $|0\rangle$
The desired state can be reached by using rotation gate R.

$$R(\theta) = \begin{bmatrix} Cos(\theta) & -Sin(\theta) \\ Sin(\theta) & Cos(\theta) \end{bmatrix}$$

Now if $Sin(\theta) = \sqrt{p}$

And $Cos(\theta) = \sqrt{1-p}$

Then $R(\theta) = \begin{bmatrix} \sqrt{1-p} & -\sqrt{p} \\ \sqrt{p} & \sqrt{1-p} \end{bmatrix}$

So $\begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} \sqrt{1-p} & -\sqrt{p} \\ \sqrt{p} & \sqrt{1-p} \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix}$

- Output from quantum neuron.

$$v_j = f(\sum_{i=1}^{n} w_{ji} * x_i)$$

Here v_j depends upon the value of function f which obtained by multiplying the neurons x_i with corresponding w_{ji} weights. Where f is a problem dependent sigmoid or Gaussian function.

- Output from the network

$$y_k = f(\sum_{j=1}^{l} w_{jk} * v_j) \qquad \text{(Mahajan, 2011)}$$

Here y_k depends upon the value of function f which obtained by multiplying the neurons v_j with corresponding w_{jk} weights.

- The desired output is O_k the corresponding squared error is:

$$E_k^2 = \frac{1}{2}\left|y_k - O_k\right|^2 \qquad \text{(Mahajan, 2011)}$$

Figure 2 and 3 represents the Process of hybrid quantum neural network. Here x_1, x_2, x_3, x_4 indicate the identified areas, w_1, w_2, w_3, w_4 indicate the investments in identified areas and t indicates threshold of risk.

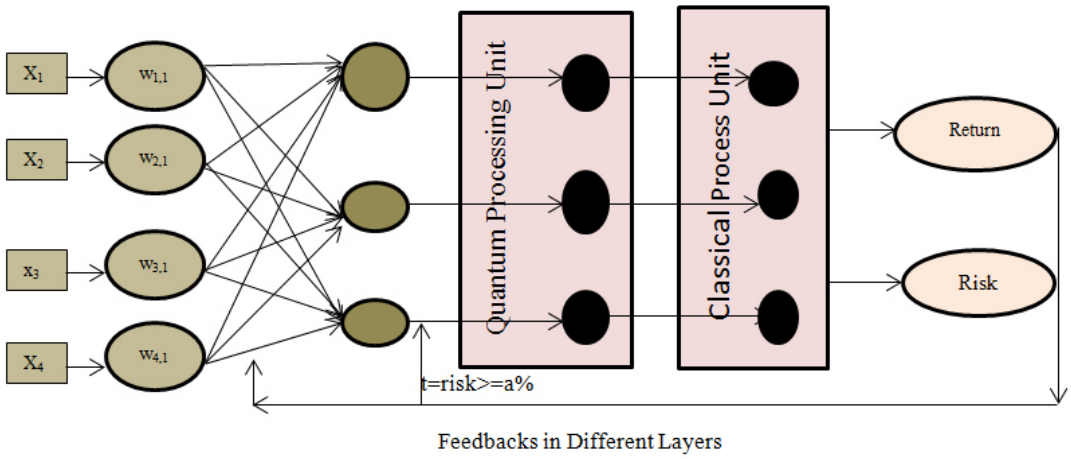

Figure 2

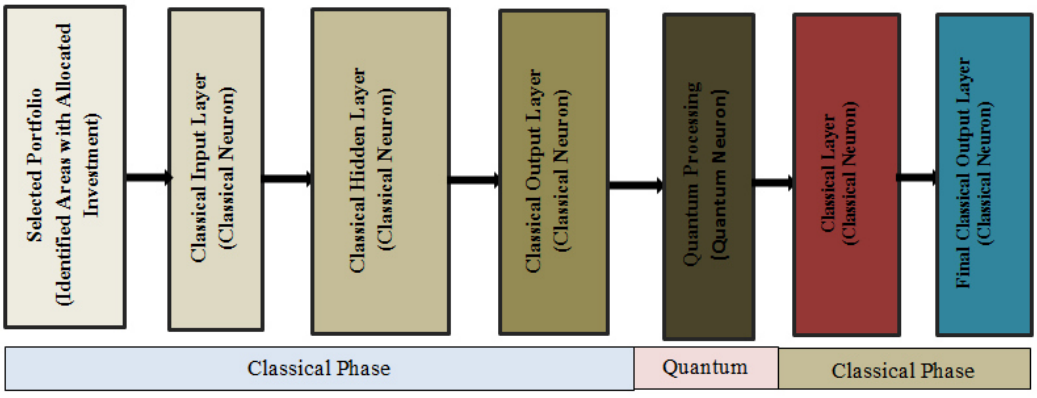

Figure 3

7. Learning in Quantum Neural Network

The learning follows the rules of feed forward back propagation algorithm.

- Updation of output layer weight

$$\Delta w_{jk} = \eta e_k f v_j \qquad \text{(Mahajan, 2011)}$$

- Updation of quantum hidden layer weight in quantum BP algorithm the weights are updated by quantum gate according to equation (iii), in this case the equation shall be

$$\begin{bmatrix} \alpha i_j \\ \beta i_j \end{bmatrix} = \begin{bmatrix} Cos(\Delta\theta) & -Sin(\Delta\theta) \\ Sin(\Delta\theta) & Cos(\Delta\theta) \end{bmatrix} \begin{bmatrix} \alpha i_j \\ \beta i_j \end{bmatrix}$$ (Mahajan, 2011)

8. HNN Algorithm for Portfolio Selection

Step1: Start with the setting of lower & upper bounds i.e., thresholds of investments of each factor

Step2: For each factor of terrorism assign minimum ratio of investment out of maximum allowable ratio of investment

{

Step3: If (factor shows return greater than threshold level of return)

{

It will remain constant

}

Else

{

Increase its ratio of investment according to the set parameter

}

step4: While all factors show returns greater than threshold level of return

{

Select the current portfolio

}

}

Step5: End

9. QNN Algorithm for Portfolio Feasibility Prediction

Step1: Start with presenting the above selected portfolio to the classical input neurons and initialize quantum hidden neurons by transmitting the output of classical neurons to the Quantum processing unit passing through quantum gate

Step2: Compute hybrid hidden node return and risk of investment for each factor

Step3: Compute the network output

Step4: Compute the network output with target output

Step5: While mean squared error is unsatisfactory and computational bounds not exceeded

Step6: Do

Step7: For each input factor x_1,……, x_n;

{

Step8: Modify weights between hidden and output node

Step9: Apply quantum gate and modify hidden node weights

}

Step10: End while

Step11: End Do

Step12: End For

Step13: End

10. Conclusion

The portfolio selection problem has been dealt by generating the efficient portfolio using the Hopfield Neural Network. The involved risk and returns from the investment in identified areas to counter the terrorism are predicted using the Quantum Neural Network. Hopfield Neural Network is able to help in making financial strategies and QNN can help in refining the financial policies by predicting the future outcomes and these features of Hybrid Neural Network will prove helpful to counter the terrorism.

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