HOMEO INSPIRED CONTROL AND COMPUTING

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ABSTRACT

Based on a model that explains the "Law of Similars" of Homeopathy we propose a general strategy for enhancing control and inference systems. In this brief working paper, we describe the central idea of "Artificial Homeo Healing" and outline how it can be translated for the control and inference problem domains.

Key words: Homeopathy, Hormesis, Law of Similars, Control, Feed Forward Compensation, Pseudo Feed Forward Compensation, Inference, Artificial Neural Networks.

I. INTRODUCTION

Regulation and healing in biological systems is analogous to control in physical systems. In both situations, systems go out of the order due to environmental factors. This amounts to increase in entropy. The system is restored back to normalcy using information or administration of the correct medicine which in turn involves information. The notions of health, disorder and healing are thus connected to the fields of information theory, thermodynamics and control. Medical systems, which regulate and control the highly evolved and complex system such as the human, become very promising candidates of study for inspiring control and computing systems. In this work we present general strategies for enhancing the performance of control systems and neural networks by implementing modules that obey first law of homeopathy.

A. Homeopathy

The homeopathic medical system continues to be a controversial doctrine, according to present day science. Some claim that if homeopathy is right than all known laws of physics and chemistry should be wrong.

Nevertheless it presents an interesting challenge for logic and modeling. The homeopathic medical system has a procedure that can be described in an algorithmic way.

In what follows we describe the problematic phenomena of Law of similars found in medical systems and Hormesis found in pharmacology. We also briefly present the modern scientific view of Physiology regarding the regulatory processes of the biological systems named as control systems.

The homeopathic medical system has a procedure that can be described in an algorithmic way.

We shall describe that on the following:

1. Select a group of healthy people of various attributes.
2. Administer them with an agent known to disturb the health.
3. Record the observations that occur in all the subjects.
4. Repeat the steps 1 and 3 above with many different agents.

The process above is called as proving. The result is that we have a knowledge base which describes the general physiology of humans, as a dose – response description. This is a black box model, which does not describe the inner working of a system but answers that if questions, with respect to common disturbances.

B. The diagnosis and treatment

The homeopathic physician, namely, the homeopath observes the symptoms of the patients and forms a pattern. Next, based on the knowledge base of materia medica, the homeopath makes an inverse mapping to finds an agent that best fits the symptoms, as a cause. The treatment is simply the administration of that agent, in a highly diluted form.

II. ARTIFICIAL HOMEO CONTROLLER

The control system based partial model that explains the healing process in biological systems in the homeo mode can be applied back to industrial control systems. The advantages of the homeo approach in controlling complex biological systems can be expected to carry over to the industrial domain as well.

In order to translate the homeo control action to for the engineering systems we simply replace the roll of the physician namely the homeopath using a pattern recognition system (PRS). The PRS is initially trained to associate each disturbance over healthy stable situation with the emergent error behavior. During normal operation whenever the system undergoes disturbance due to unknown external causes the PRS estimates the equivalent pseudo disturbance and applies the converse of it to the system through the final control element. This creates a reaction that will annul the effect of the unknown disturbance. To account for the estimation error the gain must be less than unity. This must be tuned by practical experience. The complete process can be called as “Pseudo feed forward compensation” because though it appears that we are feeding forward a warning signal actually we extract the complete information from the error behavior only.

A. Components of a Homeo Controller

The homeo controller has the following components:

- A regular controller
- An error observer/analyser
- A Pattern recognition system
- A disturbance generator
- An inverter

The architecture of the HCS is presented in Figure 1.

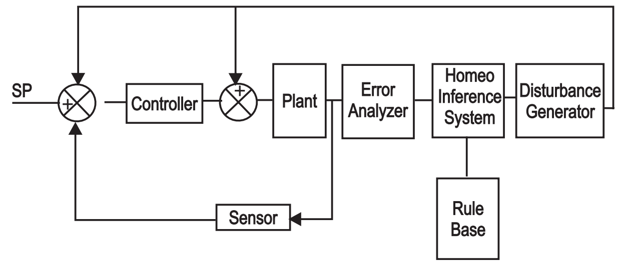

Fig. 1 Architecture of Homeo Controller

B. Homeo Control Algorithm

The procedure for training and deploying the homeo control on an existing control system can be explained using a simple algorithm.

1. In a stable state apply a step disturbance.
2. Analyse the emerging error pattern and extract an error signature.
3. Repeat steps 1 and 2 for different set points.
4. Repeat steps 1, 2 and 3 for different types of disturbances.
5. Train a pattern recognition system for associating each error signature to the disturbance that causes it.
6. During normal operation apply the negation of the estimated disturbance vector to the same point, where the original disturbance was applied.

III. HOMEO NEURAL NETWORKS

For the purpose of applying homeo strategy for inference systems we first present the requisite components for a homeo inference system and the basic issues related to a general inference system

A. The Components of Homeo Inference System

1. It houses a Feedforward compensation mechanism, which works exactly in the opposite direction to the error effect of each input.
2. It has a sensor which reacts according to the type of input.
3. The gain of the sensor is proportional to the abnormality (a function of error) of the input.
4. It has a pattern recognition system which maps the given input/output pair (Xi, Di) onto Di, where Di is the disturbance such that ($Xi - Di$, Ci) $\longrightarrow Di(t+1) = 0$ and $Ci = TCi$.

B. Inference Systems

An inference system (IS), generally maps a pattern in a domain to another pattern in the same or different domain. Thus, the IS generates an estimate of the desired output for a given input. The relationship of the input to the output is either learnt from examples or embedded in the knowledge base using rules. The process by which the parameters of an IS are modified is known as training. During training the desired output for the given input is known. By comparing the actual output with the desired output the deviation or error is computed. The parameters of the IS are modified in a way that reduces the error. Once an IS is trained, tested and validated it is put into normal use. Thereafter the IS produces an output corresponding to the input given. The important point is that during normal operation the target output is not at all known. This is in contrast to the control system, where the target, actual output and hence the error are always known. Thus, to apply the homeo mechanism for an IS we need to use an indirect strategy by which we can estimate the error in the predicted output. With this in mind we shall now propose the general algorithm for Homeo Inference System (HIS).

C. Algorithm for HIS Training

1. Train the IS with the training data.
2. After reasonable amount of training (based on time, performance, or lack of improvement) stop training and divide the data set into well behaved and ill behaved data set.
3. Apply a well behaved data input to the system. Now perturb the system using a specific method, and observe the deviations in output. Deviation of output means an abnormality because the input is well-behaved and the output is normal.
4. Train a supplementary memory that associates the deviations back to the perturbation.
5. Repeat steps 3 & 4 with various kinds of disturbance.
6. Repeat steps 3, 4 & 5 for all well behaved patterns.
7. For a misclassified pattern, find the nearest well behaving pattern of the same target output, using some criteria. Compute the deviation say

   $\Delta X\,mis = X\,mis - X\,well.$

8. Train the supplementary unit to associate the error vector back to the perturbation vector.
9. Repeat steps 7 & 8 for all well behaved patterns.

D. Algorithm for HIS Operation

1. Apply any pattern *X*.
2. Compute output $Y = NN1\,(X)$.
3. Compute $E = NN2\,(X, Y)$.
4. Compute Perturbation Vector $PV = NN3\,(E, Y, X)$.
5. Apply $PV\,(X(p))$ to the source.
6. Repeat steps above while

   $$(E > \varepsilon_1 \;\&\&\; PV > \varepsilon_2)$$

7. Output *Y*

This general description, though abstract gives a pluralistic approach to the enhancement of any IS. In the next section, we take the neural network (NN) for the problem of classification as an example and describe the issues related to the implementation of homeo mechanism.

E. Homeo Neural Networks (HNN) for Classification

Neural networks are IS which learn the correct mapping from examples, by modifying their weights. For implementing HNN, we need a mechanism for

(i) Perturbing the existing state of the Neural Network

(ii) Extracting the deviation from the desired output and

(iii) An associative memory which maps the error vector back to the perturbation.

F. Proposed Architecture of HNN

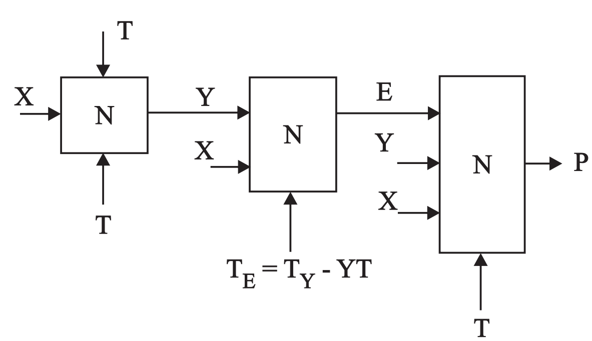

Fig. 2. Perturb and Train to Estimate Perturbation

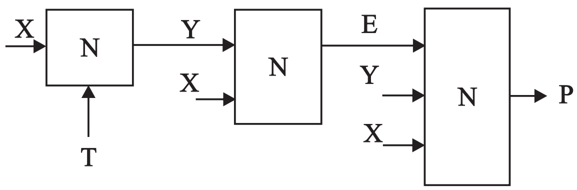

Fig. 3. Normal Operation of HNN

G. Perturbation

Perturbation is any change that worsens the error at the output layer is. The system parameters and signals are the two types of subjects of perturbation. The parameter set includes the weights and biases, gain of activation functions, the learning rate, adaptation rate and even the output tolerance. Much work has been done along these lines. Also, the dimensionality of the parameter space is extremely large making the homeo learning a very costly process. During normal operation the learning and adaptation are not applicable. The tolerance parameter tuning may best be carried out at the end of the entire training process. Dynamic modification of weights and activation gains can be equated by dynamic modification of the signal vectors of the system. The signals of the NN are the input pattern X, feature vectors of each hidden layer and even the output vector. By modifying the input vector X, we actually move the presented pattern towards the nearest well classified pattern. The performance depends heavily on the smoothness of the error surface. But this is essentially a local minima seeking approach. Similarly, each of the feature vectors can be perturbed and its effect learnt.

However, for backtracking, we need to know the target first, which is a paradoxical requirement. Thus we need to train a second unit to map $(X, Y) \to PV$. To make the learning easy, we may also consider training with three units that learn the mappings $X \to Y$, $(X, Y) \to E$ and $(X, Y, E) \to PV$. The need to cascade the signals of previous stage to the next stage has a sound reason. During normal operation it is impossible to differentiate correct classification and misclassification when the outputs are valid. For example when $T = (0, 1, 0)$ and $Y = (1, 0, 0)$ we can't predict it to be wrong unless we have a memory that associates Y with X.

IV. CONCLUSION

Using a partial model that explains the homeopathic principle of law of similars, a complimentary approach to control systems and neural networks is presented. Implementation and study of various schemes are underway.

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Place acknowledgments at the end of the text, before the references.

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