Chapter 11

Symbolic Function Network: Application to Telecommunication Networks Prediction

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ABSTRACT

Quality of Service (QoS) of telecommunication networks could be enhanced by applying predictive control methods. Such controllers rely on utilizing good and fast (real-time) predictions of the network traffic and quality parameters. Accuracy and recall speed of the traditional Neural Network models are not satisfactory to support such critical real time applications. The Symbolic Function Network (SFN) is a HONN-like model that was originally motivated by the current needs of developing more enhanced and fast predictors for such applications. In this chapter, the authors use the SFN model to design fast and accurate predictors for the telecommunication networks quality control applications. Three predictors are designed and tested for the network traffic, packet loss, and round trip delay. This chapter aims to open a door for researchers to investigate the applicability of SFN in other prediction tasks and to develop more accurate and faster predictors.

INTRODUCTION

Delivering real-time multi-media across the Internet has become a challenge to multimedia providers, as it is an essential element in offering some advanced services as distance learning, digital libraries, video conferencing, and video on demand. These services could not be delivered across the Internet in a guaranteed quality of service due the heterogeneous makeup of the Internet that leads to unspecified bandwidth available for each application. The lack of available bandwidth, especially during periods of high demand, creates traffic jams on the Internet that result in packet loss, transmission delay, and bad quality.
Predicting the network state and conditions like traffic generated by multimedia sources (Adas, 1998), packet loss ratio (Parlos, 2002), and packet delay time (Atiya, Yoo, Chong, & Kim, 2007) can be utilized to develop the so-called predictive controllers that control the network and provide better performance. Such prediction process needs accurate and very fast (real-time) predictors.

Symbolic Function Network (SFN) is designed with the goal to impart more flexibility than the traditional Neural Networks (NNs) (Eskander & Atiya, 2009). While traditional Higher Order Neural Networks (HONNs) use higher order terms to model complex nonlinearities and correlations between system inputs and features, SFN use basic building blocks like power, logarithm, and exponential functions to model the system nonlinearities. By concatenating these terms, the features correlation can be also modeled. The wider range of available activation functions, and the evolutionary structure of SFN, is expected to permit higher modeling power with sparser structure when compared to traditional NNs and even HONNs.

The symbolic function network can be represented as a tree based neural network. The terminals of the tree are the most relevant features that affect the system output, and the weights of the neural tree are the parameters that determine its overall functionality. SFN model showed encouraging results in the field of communication networks prediction (Eskander, Atiya, Chong, Kim, & Yoo, 2007). Accordingly, we believe that more improvement can be achieved by applying more advanced optimization to the SFN model.

This chapter aims to give a background of the application of SFN to model the behavior of communication networks. Through the chapter, a background of computer networks prediction strategies is introduced followed by an overview on the SFN model. Three different predictors for traffic of MPEG video, Packet Loss Ratio (PLR) and Round-Trip-Time (RTT) are proposed based on the SFN modeling approach.

**BACKGROUND**

There are many problems faced in transporting multimedia streams, such as real-time video or audio over networks that offer no service guarantees. The majority of these problems originate from the delay-sensitive nature of multimedia content. Irrespective of the method used to transport media content over an IP network, there is a strict timing sequence that must be used by the decoder during playback. For acceptable playback experience, all relevant packets must be available at the destination for assembly when needed and in the correct sequence. An obvious and simple solution to this problem is destination-side buffering and more recently, edge-caching. The trade-off of this approach is that the media content is not delivered to the destination in real-time or even in near real-time. Even though many media applications, such as streaming and on-demand video and audio, are tolerant to such large delays in delivery, there are numerous applications that require real-time or near real-time media delivery, such as gaming, conferencing, and telephony applications.

Predicting traffic generated by multimedia sources is needed for effective dynamic bandwidth allocation and for multimedia Quality-of-Service (QoS) control strategies implemented at the network edges which is called “End To End quality-of-service control.” These techniques are needed in both QoS supporting networks, which offer a guaranteed quality of service level like ATM networks, and in the best effort Networks which doesn’t guarantee any specific quality of service levels like IP “Internet protocol” networks. For the networks that support QoS, there are many models that supporting Variable Bit Rate (VBR) applications. For example, Renegotiated Constant Bit Rate network service model (RCBR) network service model that gives applications the option to renegotiate their rate (bandwidth) after the connections have been accepted. Renegotiating for less bandwidth will always succeed, but renegotiations for more bandwidth might fail. When
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