Analysis of Networked Control of Speed of DC Motor using Neural Network

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Abstract: ***In this paper we explain about the Networked control systems (NCS).NCS are distributed computing and control systems where the sensors, actuators and controllers that communicate over a shared medium. The distributed nature of NCS and issues related to the shared communication medium pose significant challenges for control design, as the control system no longer follows the rules of classical control theory. The main problems that are not well covered by the traditional control theory are varying time delays and packet losses. The change of communication architecture introduces different forms of time delay uncertainty in the closed loop system dynamics. These time delays come from the time sharing of the communication medium as well as the computation time required for physical signal coding and communication processing. Moreover, the time delays in a control application can degrade a system's performance and even cause system instability.***

Keywords: Network, communicate, control, challenges, signal, design.

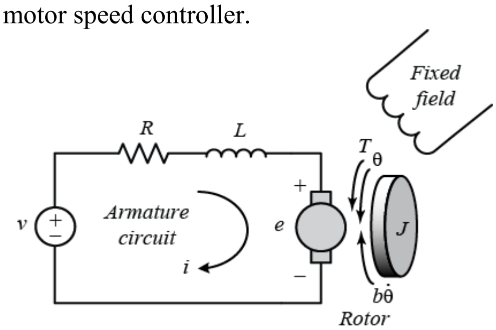
1. Introduction

A major trend in modern industrial commercial systems is to integrate computing, communication, and control into different levels. In every practical control loop there is a time-delay resulting from sampling, computations of the control signal and the limited speed of the measurement sensors. In most cases such a delay is time-varying and stochastic in nature. Moreover the time delays in control applications can degrade the system's performance and even cause system instability. So first and foremost priority is to design the controller for varying time delay to make the system stable. The input-output relations of the system may be uncertain and they can be changed by varying time delay. Intelligent scheme are needed to address such problems. Two such approaches are to utilize neural network.

In this paper work the problem of varying time delay and system instability is solved by implementing neural network and network control system for DC motor speed controller. The performance of this controller is compared with neural network using Network Control System with time delay and packet losses via communication link. Recently, the neural network (NN) is widely used as a universal approximator in the area of nonlinear mapping and uncertain nonlinear control problems [3]. The NN structure is to be implemented by input-output (nonlinear) mapping models and is constructed with input, output and hidden layers of sigmoid activation functions. Because the NN can be used for a universal approximator like fuzzy and neural systems [4], it has been introduced as a possible solution to the real multivariate interpolation problem. However, there must inevitably be a reconstruction error if the structure of the NN (the number of activation functions in the hidden layer) is not infinitely rich. These errors are introduced into the closed-loop system and deteriorate the stability. To compensate for the reconstruction error, a sliding mode like compensating input term is widely used, and its input gain is closely concerned with the system uncertainties. Thus, it is used to being overestimated or obtained from the off-line learning phase.

Model of System

In this section we are studying the mathematical modeling of DC motor speed controller.



$$T = K_t i \qquad 1$$

Where 'T' torque generated by a DC motor is proportional to the armature current

$$e = K_e \dot{\theta} \qquad 2$$

Where 'e 'is back emf, *e*, is proportional to the angular velocity of the shaft by a constant factor *Ke*.

$$J\ddot{\theta} + b\dot{\theta} = Ki \qquad 3$$

$$L\frac{di}{dt} + Ri = V - K\dot{\theta} \qquad 4$$

Where J is moment of inertia of the rotor, L is electric inductance's' motor viscous friction constant ,Kt is motor torque constant

Transfer Function

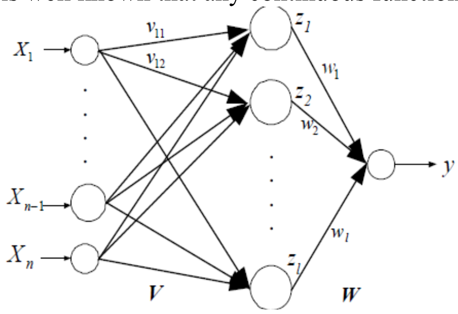
$$P(s) = \frac{\dot{\Theta}(s)}{V(s)} = \frac{K}{(Js+b)(Ls+R)+K^2} \qquad [\frac{rad/sec}{V}]$$

State-Space

$$\frac{d}{dt}\begin{bmatrix} \dot{\theta} \\ i \end{bmatrix} = \begin{bmatrix} -\frac{b}{J} & \frac{K}{J} \\ -\frac{K}{L} & -\frac{R}{L} \end{bmatrix} \begin{bmatrix} \dot{\theta} \\ i \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{1}{L} \end{bmatrix} V$$

1.1 Neural Network

The universal approximators (UAs) such as NN, FL, and hybrid system of FL and NN have been successfully applied to many nonlinear control problems. The design objective of NN or FL is aimed at approximating some nonlinear mappings into idealistic approaches. This means that an arbitrary function $f\colon Rn \rightarrow R$ is to be approximated by NN or FL. It is well known that any continuous function



Structure of the neural network

1.2 Networked Control System

The feedback control systems [1], where the process sensors, actuators, and controllers are interconnected by a communication networks are called Networked Control Systems (NCSs). It is a type of distributed control systems. There are the advantages of using the network in terms of reliability, reduced wiring, re configurability and ease of system diagnosis as all the information is available everywhere in the system. However implementing the communication network induces the stochastic and time varying delay which can degrade the performance of the system and even could make the system unstable. Moreover the time delays are the function of device processing times and communication rate. Research in NCSs is different from that in conventional different from that in conventional time-delay systems where time delays are assumed to be constant or bounded. Because of the variability of network-induced time delays, the NCSs may be time-varying systems which make analysis and design more difficult.

1.3 Factor Affecting the Network Control Systems

a) Sampling rate constraints and resulting distortions of the signals from the sensors or to the actuators;
b) Network capacity for communications;
c) Disturbances introduced in communications;
d) Time delay in the measurement and control loops;
e) Data loss or package drop if using package-based ncs. In wireless network situations, data packets may arrive at variable times, not necessarily in order, and sometimes lose at all.

1.4 Varying Time-Delay Systems

One major challenge for NCS design is the network induced delay effect in the control Loop. Some delays, i.e the transmission time delay that it takes for a transmitter to send out data, are constant. Others including sequencing time caused by the waiting consequence of medium access are naturally time-varying and sometimes hard to estimate .A simple approach is to examine the longest time delay that can be tolerated if the controller is given. For instance, one simple method is to analyze the maximum allowable frequency-domain shift of the systems' Eigen values caused by time delay [10]-[11]. Similarly in time-domain, the Maximum Allowable Transfer Interval (MATI) was proposed in [12]-[13] to examine the maximum allowable time delay for linear NCS. However, this usually leads to time consuming search-test procedure. Network caused delay directly contributes to the delay in the control loop and contributes towards instability of the system.

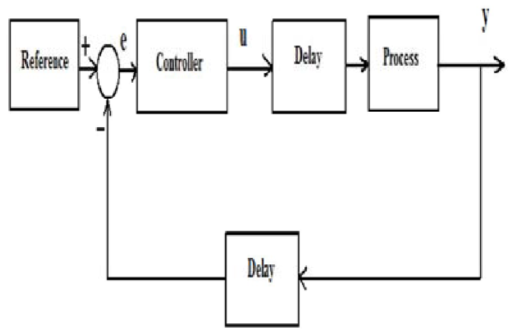


Fig.1 Delay Caused By the Network

1.5 Simulation and Result

In this section some simulation results are shown to confirm the validity of the proposed control algorithm.

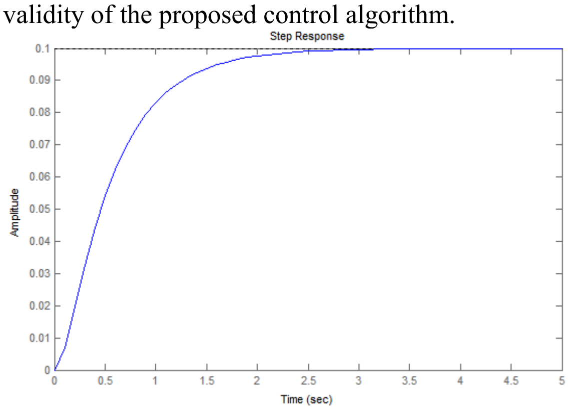


Fig.2 Response of dc motor speed controller

From above figure shows the response of DC motor speed controller with open system, and that response is not controller, for controlling the speed we need to use to neural network with network control system.

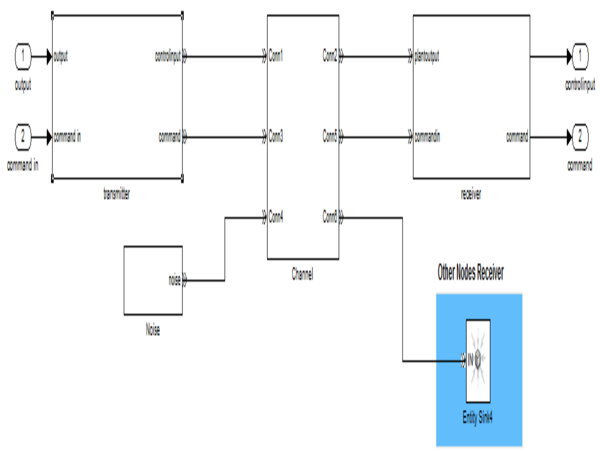


Fig 3.Block diagram Communication network

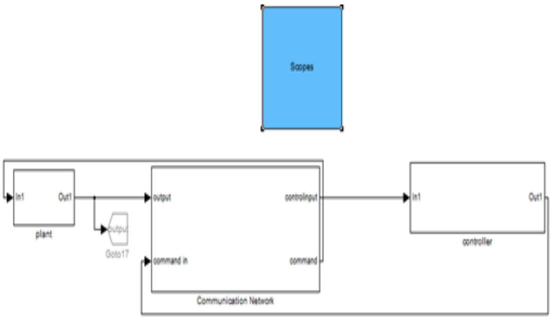


Fig.4 Communication network block diagram with controller and DC motor

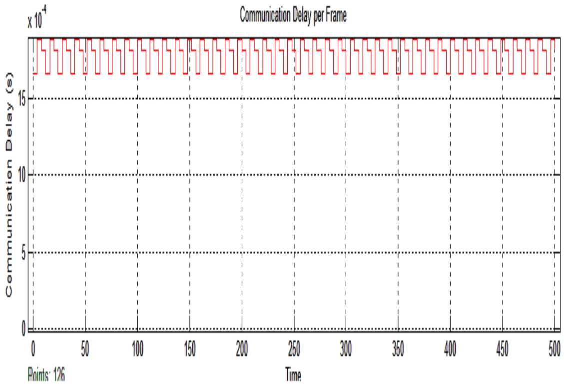


Fig.5 Result with delay

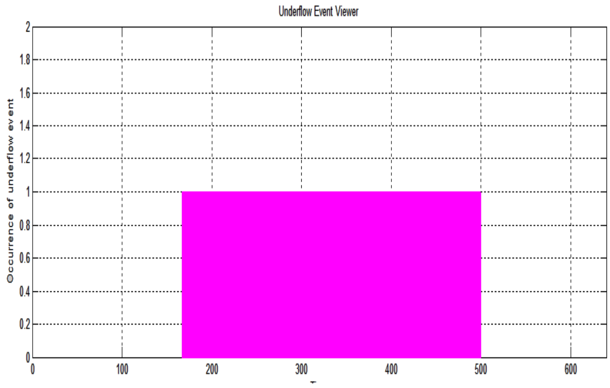


Fig 6. Response of underflow

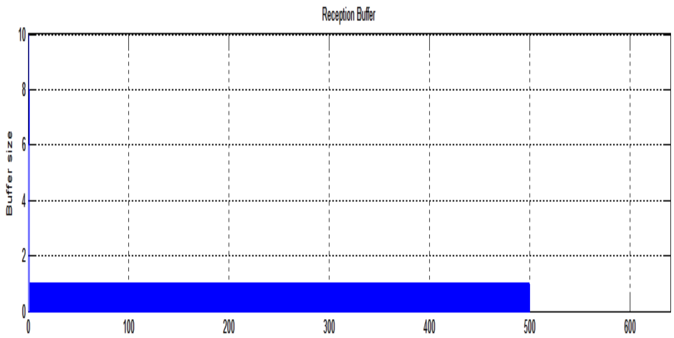


Fig 7

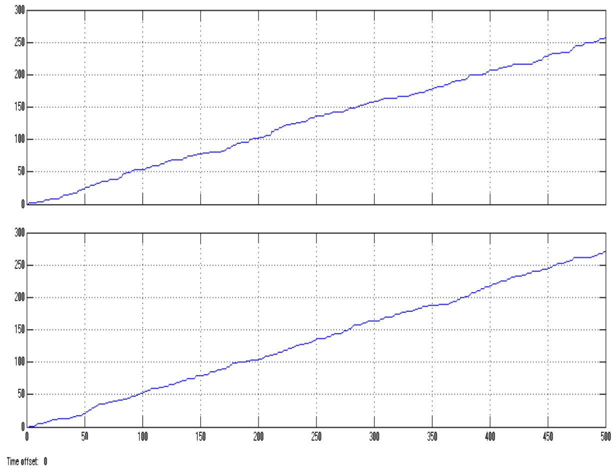


Fig 8. No of dropped packet

The above figure is showing the response of number of packet dropped during controlling the system to other place via communication Network. Its explain the how many data loss in communication of two systems

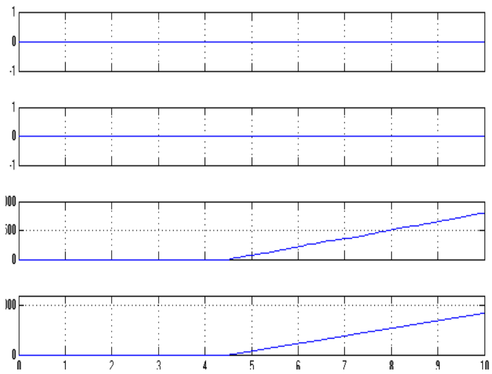


Fig.9 No of packet time out

The above figure is show that the no of packet of data time out during the transferring to other network via communication, from one place to other place using the neural network.

2. Conclusions and Future Scope

From result it is clear that when 35% plant data losses and 5% controller signal losses with sampling period of 0.001 sec of both, a delay of 1 second is produced in response .If plant data losses is 90% with a sampling period 0.5 second then a delay of approximate of 5.4second is produced in response .If both plant and controller data losses is 90% with same sampling period of 0.5 second then delay is same of 5.4 second .It means controller signal must not losses for un delayed response with high sampling rate because in final result no. 5 only 1 % plant and controller data losses with sampling period 0.001 second of both plant and controller then there is no delay in response.

This study integrates the Ethernet, the control area network (CAN) network, and the wireless 802.11b in the present NCS. The TCP/IP and the CAN protocols are adopted as the communication gateway in a remote control system for an AC 400 W servo motor. The time delay between the application layer of the client and the application layer of the remote control target has been measured and analyzed

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Author Profile

Sunil Kumar received the B.E. in Electronics and communication engineering from Anna University Chennai in 2009 and M. Tech degrees in Electrical Engineering from, YMCA, UST, Faridabad 2012, During2009-2010, he did job as production manager, after competed M. Tech I joined DCE Gurgaon as Assistant Professor in ECE Dept.