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# CHAOTIC BEHAVIOR CONTROL IN FLUIDIZED BED SYSTEMS USING ARTIFICIAL NEURAL NETWORK

QUARTERLY PROGRESS REPORT
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## DISCLAIMER

## Introduction

We have developed techniques to control the chaotic behavior in the Fluidized Bed (FBC) Systems using Artificial Neural Networks (ANNs). For those techniques to cross from theory to implementation, the computer programs we are developing have to be interfaced with the outside world, as a necessary step towards the actual interface with an FBC system or its experimental mock up. For this reason we are working on a Data Acquisition Board setup that will enable communication between our programs and external systems. Communication is planned to be enabled in both ways to deliver feedback signals from a system to the control programs in one way, and the control signals from the control programs to the controlled system in the other way. On the other hand, since most of our programs are PC based, they have to follow the revolutionary progress in the PC technology. Our programs were developed in the DOS environment using an early version of Microsoft C compiler. For those programs to meet the current needs of most PC users, we are working on converting those programs to the Windows environment, using a very advanced and up to date C++ compiler. This compiler is known as the Microsoft Visual C++ Version 4.0. This compiler enables the implementation of very professional and sophisticated Windows 95, 32 bit applications. It also allows a simple utilization of the Object Oriented Programming (OOP) techniques, and lots of powerful graphical and communication tools known as the Microsoft Foundation Classes (MFC). This compiler also allows creating Dynamic Link Libraries (DLLs) that can be liked together or with other Windows programs. These two main aspects, the computer-system interface and the DOS-Windows migration will give our programs a leap frog towards their real implementation.

## How the Dynamic System Imitator (DSI) Programs Will be Modified

The DSI controller programs are simulations to the DSI recurrent and dynamic nature that is capable of creating very sophisticated time behaviors [1-5]. This enables the DSI to model a variety of dynamic systems and non-linear controllers. During training, the DSI has to monitor the behavior of the controlled system and work on creating the necessary control signal to modify the system behavior and bring it to a pre-specified time behavior. In the time being the DSI simulation programs deal with models of the controlled system instead of the real system. The system models are supplied through a Runge Kutta fourth order simulation routines that solve a coupled system of ordinary differential equations. Outputs from those simulation routines are passed to the DSI network and the output of the DSI network is also passed as a control action to the simulation model. The desired output of the system is supplied to the network through other set of routines that solve some pre-specified functions. In reality, the network has to deal with the actual system, during its training and recall modes. Therefore, modification need to be made to the DSI programs to communicate with the controlled system through computer interface that performs the necessary Analog to Digital (A/D) and Digital to Analog (D/A) conversions. On the other hand almost all parts of the DSI programs will be converted in the context of the Object Oriented Programming, Microsoft Foundation classes, and Microsoft Visual C++ 4.0 compiler [6]. New classes and objects will be created to represent the network nodes, variables, interfaces, and connections. User interface tools that were not available in the old programs will be developed, such as menus, icons, pop up menus, radio buttons, and mouse handlers. Also all graphics concepts will be transferred to the Application Programming Interface (API) tools that are controlled by the Microsoft Foundation Classes.

**The Data Acquisition System**

The Data acquisition system we are working on is illustrated in Figure 1. It utilizes a National Instrument DAQ 1200 PC MCIA card, which is a multifunction I/O DAQ unit that communicates with a PC through the parallel port on IBM PC/XT/AT and compatibles, with a maximum sampling rate of 100 KHz. The DAQ-1200 has 12-bit Analog to Digital Converters (DAC) with eight analog inputs, configurable as eight single ended or four differential inputs [7]. It also have two 12-bit, double buffered Digital to Analog Converters (DACs), and programmable gains of 1, 2, 5, 10, 20, 50, or 100.

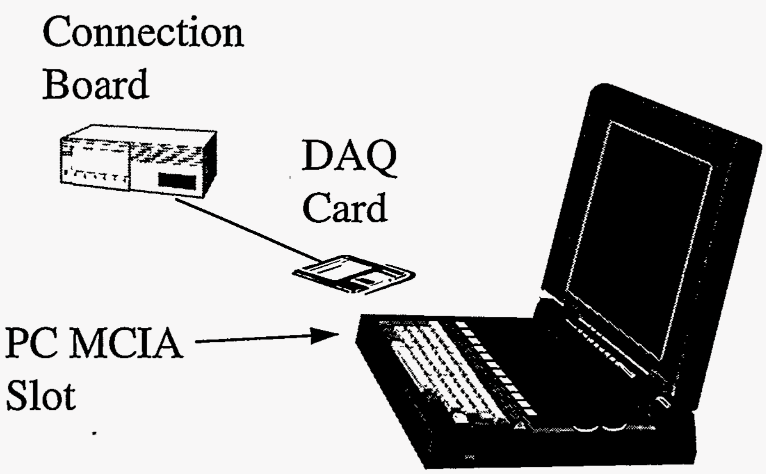


**Figure 1. The data acquisition system.**

**References**


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## Post Doctoral Research Associate:

Magdi A. Essawy, was hired as a full time Postdoctoral Research Associate at the Department of Electrical and Computer Engineering, starting October 1995; Previously, a part time Postdoctoral Research Associate at the Department of Nuclear Engineering, University of Tennessee; Received his Ph.D. in Nuclear Engineering from the University of Tennessee, Knoxville, in August 1995; has an M.S. and B.S. in Electrical Engineering; and has experience and academic interest in the fields of: Applied Artificial Intelligence, Artificial Neural Networks, Non-linear System Dynamics, Chaotic System Analysis, Chaotic System Control, Wavelet Analysis, Gabor and Fourier Analysis, Signal Processing, Dynamic System Simulation and Control, System Monitoring, Check Valve Monitoring in Power Plants, Expert Systems, Fuzzy Logic, and Electric Power System Analysis.

## Student Involvement:

Mr. James Osa, Graduate Student. He is finishing his Master Thesis, and is planning to graduate this semester, the summer 96. He is supported by this grant. His master thesis involves investigating some static neural network techniques to control the chaotic behavior in some theoretical chaotic system, known as the Logistic map.

Mr. Jihad Ababneh, Graduate Student. He is working on his Master Thesis, and is supported by this grant. He is involved on research related to the known OGY (Ott, Grebogi, and York) method to control the chaotic behavior using small perturbations. There are future plans for him to investigate the utilization of neural network techniques to estimate the general parameters for the OGY method.

Mr. Deepak Arulraj, Graduate Student. He is working on his Master Thesis, and is supported by this grant. He is involved on developing some techniques for estimating Lyapunov exponents from chaotic time series measurements.