

26.0 Cognitive Information Processing

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26.1 Advanced Television Research Program

Sponsorship: Members of the Center for Advanced Television Studies, an industry group consisting of American Broadcasting Company, Ampex Corporation, Home Box Office, Kodak, Public Broadcasting Service, National Broadcasting Company, RCA Corporation, Tektronix, Zenith

26.1.1 Goals

The purpose of this program is to conduct research relevant to the improvement of broadcast television systems. Some of the work is carried out at RLE and some at other parts of MIT, including the Media Laboratory by Prof. Andrew Lippman, Prof. Edward Adelson, Prof. Stephen Benton, and Adjunct Prof. Arun Netravali. Audience research is carried out by Prof. W. R. Neuman in the Political Science Department. Reporting is by means of theses and published papers.

26.1.2 Background

The Japan Broadcasting Company (NHK) has demonstrated a high definition television system of 1125 lines, 30 frames, 60 fields, 25 MHz bandwidth, with image quality comparable to 35 mm motion pictures. A bandwidth-compressed version requiring an 8.1 MHz baseband has been developed. Both of these systems were originally intended for use in DBS (direct broadcasting from satellites) systems. A so-far unsuccessful attempt has also been made to have the wideband version adopted as an international standard for production and program interchange. Japanese interests have announced their intention to introduce some version of this system into the United States in 1990 via recorded media such as tape cassettes and video disks.

The latter possibility is widely seen as a serious threat to the financial stability of American television broadcasters, and the Federal Communications Commission has

launched an inquiry into the situation. The MIT group is fully participating in the Inquiry.

26.1.3 Research Activities

In this contract year, we have put into operation a simulation facility that permits computed image sequences to be observed in real time. This is being used to study problems in motion rendition. We have also started developing new systems that might be used for transmission of improved TV images, both enhanced (EDTV) and "true" high definition (HDTV), using only one standard TV channel.

We have carried out a number of studies at the Audience Research Facility in Danvers, Massachusetts for the principal purpose of determining viewer reaction to improved images and sound, and, in particular, to finding out whether audiences are willing to pay a premium for better pictures independent of program material.

We are continuing our studies of motion estimation and perception; motion-compensated interpolation, noise reduction, and demodulation; optimum filtering; and TV system modeling.

Publications

Herrmann, F.P., *A Four-Input Digital Video Combiner with High Definition Output*, S.B. thesis, Dept. Electr. Eng. and Comp. Sci., MIT, 1987.

Jesurum, D.A., *A Microprocessor-Controlled Dynamic Raster Convergence System*, S.B. thesis, Dept. Electr. Eng. and Comp. Sci., MIT, 1987.

Kuo, D.D., *Design of Dual Frame Rate Image Coding Systems*, S.M. thesis, Dept. of Electr. Eng. and Comp. Sci., MIT, 1987.

Krause, E.A., *Motion Estimation for Frame-Rate Conversion*, Ph.D. diss., Dept. of Electr. Eng. and Comp. Sci., MIT, 1987.

Kung, K., *Evaluation of a Single Channel High Definition Television System*, S.B. thesis, Dept. of Electr. Eng. and Comp. Sci., MIT, 1987.

Oh, M.H., *Improved NTSC*, S.B. thesis, Dept. of Electr. Eng. and Comp. Sci., MIT, 1987.

Schreiber, W.F., "Improved Television Systems: NTSC and Beyond," *SMPTE J.* 66(8) (1987).

Schreiber, W.F., "HDTV Technology: Advanced Television Systems and Public Policy Options," *Telecommun.* (1987).

Singer, L.A., *An Ultra-High-Resolution Display Monitor*, S.M. thesis, Dept. of Electr. Eng. and Comp. Sci., MIT, 1987.

Teng, P., *Design and Construction of a 1K x 1K Frame Buffer*, S.B. thesis, Dept. of Electr. Eng. and Comp. Sci., MIT, 1987.

26.2 Computer-Aided Fabrication System Structure

DARPA/U.S. Navy - Office of Naval Research (Contract N00014-85-K-0213)

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26.2.1 Abstract

The Computer-Aided Fabrication (CAF) system structure carried out within RLE is part of a larger project within MTL. The overall goal of the CAF project is to integrate computers into the control, data collection, modeling, and scheduling of the integrated circuit fabrication process.

26.2.2 Computer-Aided Fabrication System Structure

The Computer-Aided Fabrication (CAF) system structure carried out within RLE is part of a larger project within MTL. The overall aim of the CAF project is to integrate computers into the control, data collection, modelling, and scheduling of the integrated circuit fabrication process. The goals of Computer-Aided Fabrication (CAF) of integrated circuits can be stated in different ways. One is to provide effective management of information associated with the fabrication of integrated circuits to improve flexibility, portability, and quality and to minimize turnaround time, development cost, confusion, error, and manufacturing cost. Another is to provide a way to operate a fabrication facility without using paper in the clean room. Another is to provide a framework for the creation of information that has usually not been available in a concise or precise way.

To realize these goals we must provide mechanisms and tools for data acquisition, analyses, reports, and instructions (guidance) for the actual operation of the fabrication equipment. Some data collection, analysis, and report generation is ongoing and automated. However, most of the data collected is either entered or entry is initiated by a person.

During the past year we have defined and installed both a hardware configuration and an initial CAF software system architecture. Central to the hardware architecture is the use of computer networking, both to provide integration of functions performed on different computers and to provide access to these computers from the integrated circuit processing facility and also from the users' offices.

The primary computer used for the actual operation of the CAF system within the integrated circuit processing facility consists solely of a Sun 3/280 processor with disk and network interface. Our processing facilities and offices are equipped with ASCII terminals which are interfaced to diskless terminal concentrators, which in turn provide network connections to any available computer. There are eight terminal concentrators, each of which has provision for up to 48 9600 baud RS 232 ports. These concentrators

also provide for communication paths and connection of some of the actual integrated circuit processing equipment.

Another Sun 3/280 is used as a development test bed for enhancements, tests, and debugging fixes. This insulates the users of the primary CAF system from the introduction of untested software, and it also helps to provide faster response time for the present users in that they do not have to share their cpu resources with the developers of new software. The second Sun 3/280 allows the developers of new software in particular to experiment with data base application programs without corrupting the actual data base used for ongoing processing of integrated circuits.

A third computer system consisting of a DEC 785 serves as a common meeting ground for the somewhat wider community of people concerned with integrated circuit design and manufacture. This computer provides the bulk of the text processing, printing, mail, simulation, and other facilities which are related to, but not directly concerned with, the actual operations in the integrated circuit processing facility. The 785 also provides a connection to an MIT Physical Plant computer and maintains an active alarm log for the building containing the integrated circuits fabrication facility.

Our initial CAFE (Computer-Aided Fabrication Environment) software system was based on the Berkeley Roving Shell with a file based data storage system. Our present CAFE system is based on the Berkeley system with an enhanced user interface menu and uses a commercial version of RTI INGRES data base system. Users log into this facility in the gowning room and then attach to the CAFE system at a terminal close by the equipment to be operated.

We have provided an ever growing number of functions to be accessed via the CAFE system. We have implemented a personal laboratory notebook facility. We have developed a standard forms based user interface mechanism which is used for most of our applications functions. Our implementation of an equipment reservation mechanism has been enthusiastically accepted by our laboratory users. We have implemented a number of transaction type applications such as defining of facilities and machines, starting lots, and reports which show machine status and the status of lots being fabricated. Just recently we have implemented an initial version of a process flow language and have provided two interpreters and a browser for this language.

We have interfaced to some processing and measuring equipment. The Dektak profilometer has been interfaced with the CAF computer, and software has been developed for transmitting screen plots and for printing these plots on either a laser printer or a terminal. The Nanospec has been interfaced and data collection software installed. We have also provided a connection to the BTU furnace controller both for creating and downloading furnace recipes.

We have continued our development of a generalized forms based user interface program, fabform. This single program, when called with a parameter file, produces a terminal display and allows a user to move from field to field and enter data. The type and content of the screen display are specified by an ASCII file which is referenced by data included in the parameter file. The form may have arbitrary length and the user can scroll up or down. At present, user interface commands are much like EMACS commands. When the user exits, or saves the data, an updated parameter file is written.

Using fabform, we have implemented a new version of the equipment reservations program which enables users to sign up for multiple machines at once. Users specify a list of machines that they will use in their next processing operation and access the data base for the current status of reservations. A locking mechanism has been devised so that multiple users cannot make conflicting entries. However different users may make reservations for different machines or different days. This program is in daily use and stores the sign up data in our data base.

We have also used fabform to implement a new multilevel menu system for the CAFE shell. We required a multilevel menu as we are accumulating quite a number of functions and were running out of space on the two level menu system that we ported from Berkeley. By using fabform we were able to implement this change fairly smoothly and also provide users with a more uniform interface.

We have continued to make substantial progress in the development of a data model and schema. Our system architecture is based on the Multibase system developed at CCA. This provides a uniform query interface to data residing in multiple autonomous, heterogeneous data bases.

Our data model is the functional model with support of extended data types, including various temporal types as well as inexact, interval, and null values. The schema captures several important aspects of plant and process management: fabrication facilities and equipment, users, equipment reservations, lots, lot tracking, wafers, process flow descriptions, work in progress (wip) tracking, and lab activity information.

Primarily because of the interface layer between the application programs and the data base accesses we were able to change the data base out from under the application programs without requiring changes in those applications when we ported the data base to the Suns and RTI INGRES.

We have continued to progress on the development of a process flow language (PFL). The creation of a PFL and associated interpreters is the key to our approach for generating actual fabrication instructions and for collecting the data resulting from actual fabrication steps. The interpreters provide the actual meaning of the process flows expressed in the flow language. Our PFL development is based on a two stage process step model which relates the goal of a change in wafer state first to the physical treatment parameters and finally to the actual machine settings used to process the wafers.

We have completed initial versions of walk through and fabrication interpreters and a browser all of which utilize our generalized forms based user interface program, fabform. The walk-through interpreter enables a process developer or potential user to see what will happen when the process is executed. The fabrication interpreter is similar, but in addition, allows for convenient entry of data as the wafers are actually processed. We have also completed an initial version of a past history browser which allows a user to review what actually happened in the fabrication of a lot of wafers.

26.3 Programmable Frame Buffer Systems

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26.3.1 Abstract

Our research during the past five years has focused on the architecture of interactive graphics work stations, the user interface, the manipulation of subimages, and algorithms for shading, texture mapping, and antialiasing. This year we have implemented a window system for the IBM YODA, experimented with progressive rendering of graphics images, completed a graphics system processor based on the TMS34010, and continued our investigation of the antialiasing of color graphics images.

26.3.2 Frame Buffer Systems

Our research during the past five years has focused on the architecture of interactive graphics work stations, the user interface, the manipulation of subimages, algorithms for shading, texture mapping, and antialiasing, and the raster display itself.

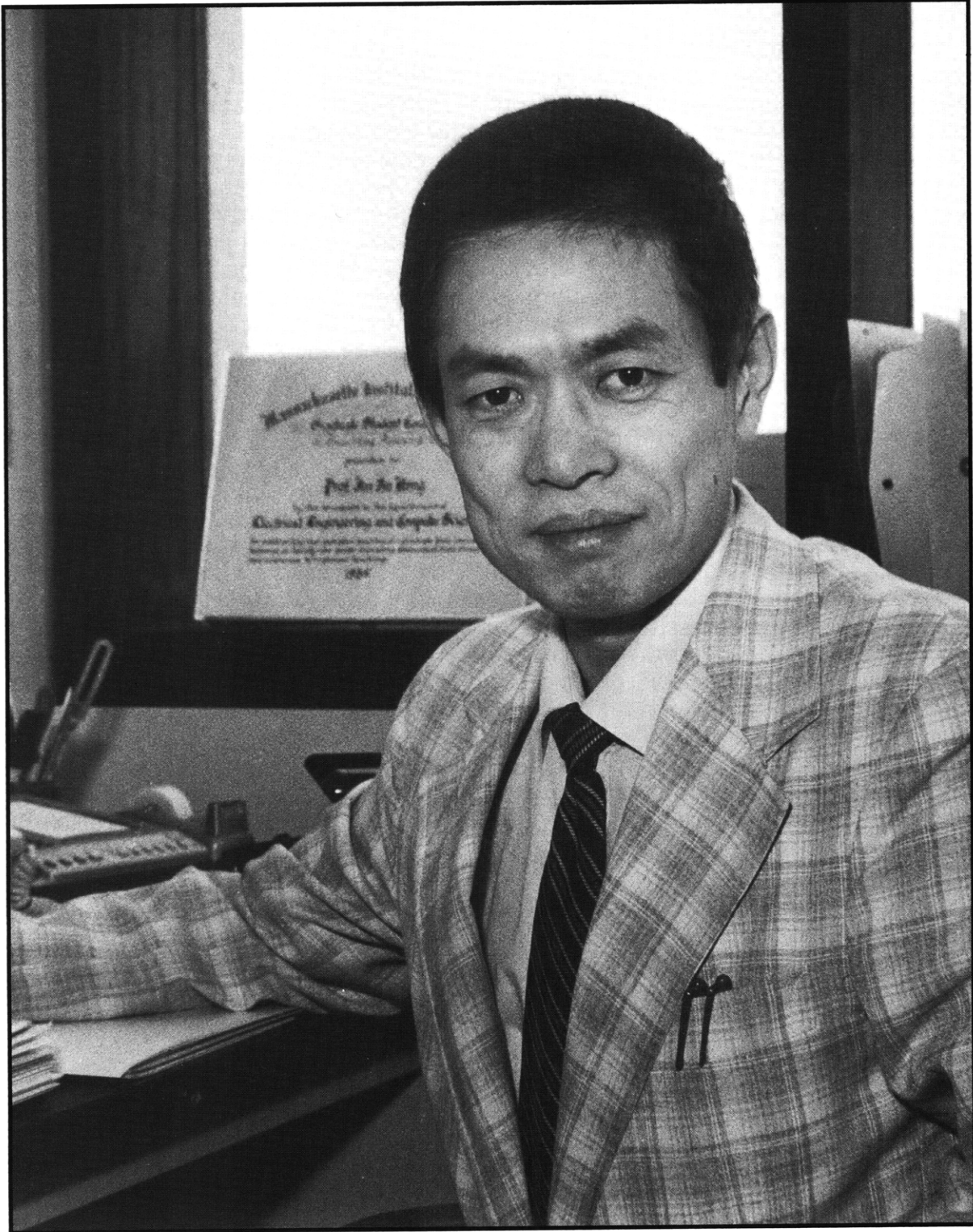
The use of color in computer graphics is now prevalent in many areas and at many levels of sophistication. Color provides additional realism to images and greatly enhances visual presentation quality. Spatial aliasing on finite resolution color displays remains a problem, however, although the problem has many applicable solutions for monochromatic images. In most cases the same monochromatic techniques are generally applied to color images, treating each color channel as a separate image to be antialiased and later merged for the full color result. This produces various problems with the color transition involving dark fringes and incorrect lightness rates along edges which are antialiased. Solutions to general color antialiasing have been developed which allow multicolored objects to be rendered on backgrounds of nonuniform color with minimum aliasing artifacts. These solutions involve optimized trajectories through a perceptually appropriate hybrid color space, parameterized by the position across each antialiased edge. Several related issues concerning local adaptation and proper system modeling and calibration are described. Data from tests of the algorithm on a set of human viewers is also presented in support of these new solutions. These solutions can also provide perceptually pleasing transparency effects, boundary blending for image composition, color correct scaling and zooming, and multivalued function displays. The tools developed for the determination of the solution also provide a convenient framework for the manipulation of color on graphic display systems.

A recently completed master's thesis by Joanne Ono developed software for a demand paged window manager. The objective of this thesis was to develop and implement in C language a method to efficiently redisplay the window information that is exposed as a result of a screen modification. The implementation uses offscreen display memory and PC main memory to store bit maps of the obscured portions of the windows currently in use. The method utilizes the offscreen memory that is available in the display memory for a demand paged type of storage between main memory and the

display. The program is implemented for a desk top window system currently being developed for the IBM YODA and its updated version, BETTY, that will run on an IBM XT, RT, or AT.

A recently completed bachelor's thesis by Alexander P. Cherkassky concerned a general purpose graphics system based on a TMS34010. The architecture of this graphics system provides a cost effective means for achieving high performance in color (as well as in monochrome) bit mapped graphics displays for personal computers and work stations. Much of the power of this system is due to the use of TMS34010 Graphics System Processor. This system can be adapted to a variety of resolutions and scanning frequencies and can be used in color as well as monochrome modes. It is capable of handling 1024 by 1024 resolution displays with four bits per pixel, and can contain up to 16 frame buffers in memory. Alternatively, this system can handle up to 16 bits per pixel with corresponding decrease in frame buffer storage. For demonstration purposes, the system was programmed to deliver resolution of 320 pixels per line, there being 250 lines per screen, four bits in a pixel.

A simple progressive rendering system for computer graphic images was developed to explore the trade off of computation time versus image quality. Five distinct levels of improving image quality were implemented, and a sequence of algorithms was developed that would generate the images sequentially. Algorithms were chosen that mesh well together, share as much information as possible, and minimize redundant calculations. The main use of such techniques is in interactive environments where the amount of time needed to produce a very realistic version of the image may be substantial. The idea of progressive rendering is well known in the area of image transmission, but relatively new to the computer graphics field. The challenge is to display as realistic an image as possible given a fixed computation time, and then to subsequently improve image realism in the most time efficient manner, making pass after pass, until some action by the viewer requires that the rendering process be started all over again on a new image (perhaps a zoomed or rotated view of the previous image). The desired set of algorithms should have the property that each builds upon the one before it, using results obtained by the latter so that the final image is approached in an incremental fashion.



Professor Jin Au Kong