MICROCOMPUTER SOFTWARE DEVELOPMENT

PROGRESS REPORT

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Department of Agricultural Engineering

Compiled by J. Robert Cooke

Agricultural Engineering
Microcomputer Software Development
June 1985

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INTRODUCTION

Instructional computing is undergoing dramatic change in the Department of Agricultural Engineering at Cornell. In the past two years, nearly all of the instructional computing has been shifted to microcomputers, including the four formal courses in computing (AE 102, AE 151, AE 152, and AE 304) taught by the department. (See Cooke, J.R., "Microcomputers in American Higher Education", ASAE Paper No. 84-5048, presented June 1984 at Knoxville, TN.)

Nearly all of the remaining courses include some component of microcomputer usage - either as an explicit module provided to the student or as a general computational resource. This shift has been facilitated by the presence of the CALS Microcomputer Facility located in Riley-Robb Hall which includes three clusters of 16 microcomputers each (IBM PC/XT, Macintosh and Apple II), and by more than a dozen micros in faculty offices of which half were provided by Project Ezra.

The software development effort for this "micro-revolution" has been supported actively by the entire faculty. This project appears to be unique with respect to its comprehensive nature.

Three of the projects will be presented orally. Brief abstracts for the other projects are attached. Several of the project leaders are present and can provide additional background.

FINITE ELEMENT ANALYSIS

J.R. Cooke, D.C. Davis, J.Y. Lee, E.T. Sobel, and R.S. Gates

The finite element method has emerged as one of the leading tools of analysis in modern engineering. To realize the full power and generality of the method, mainframe computers have been required. Nevertheless, existing microcomputers with interactive graphics provide a highly attractive vehicle for instruction in this important methodology. An Apple II version for Elasticity and Heat Conduction (450 pages) is being published this summer by John Wiley. This will be followed later this year by an IBM PC/XT version and subsequently by a Macintosh version.

A professional workstation version is being developed for the IBM PC/AT and will provide high quality color graphics support and is expected to rival in capacity the large mainframe programs of the recent past.

Usage:

The instructional program has been used in AE 151 and AE 685 and hopefully will be used in several other departmental courses. The PC/XT version will probably be used by Prof. Booker in Mechanical and Aerospace Engineering next year. Four other universities have already indicated plans to utilize these programs. A national workshop at the December ASAE meeting has been proposed.

Scope:

The instructional programs provide interactive graphics support and user-controlled access to intermediate calculations and help messages. Automatic mesh generation with bandwidth reduction is provided. Post-processing is complimented with graphical output. The instructional programs, when completed, will handle both two-dimensional and axisymmetrical problems in elasticity and steady state heat conduction (and other processes governed by Laplace's equation).

The professional workstation version will handle full three-dimensional plates and shells (thick and thin) and will make extensive use of color graphics.

Anticipated completion of the first commercial versions:

PC/XT - September

PC/AT - December

The IBM PC/XT and IBM PC/AT programs are being developed as part of Project EZRA.

MOUSE
(Model of Underground Solute Evaluation)

T. Steenhuis and S. Pacenka

MOUSE is a trainer covering the subject of contaminant transport. It simulates the behavior of water and contaminants from the land surface through the saturated zone. It graphically portrays the aspects of water and chemical cycles near the surface and in groundwater on a real time basis. It is intended to form conceptual models of solute transport in the mind of the users. This is accomplished by running the program several times with different combinations of soil, chemical, and climate data and then viewing the output data.

Course Usage:

The program has been successfully used in an undergraduate class: AE 371 Hydrology, Erosion, and Movement of Chemicals in the Landscape. It has proven to be extremely effective in the course because it enables the students to put the concepts together at the end of the course that they learned earlier in the course. This was difficult to do without the help of the program. Last year I gave the program as part of the Take Home Exam.

Hardware:

IBM PC, XT, AT with 256K memory and color monitor.

SUBDRAIN

R. Bottcher, T. Steenhuis, M. Walter

SUBDRAIN uses color graphics in designing and evaluates a subsurface drainage system. Its graphics make the program especially useful for teaching and demonstrations. The drainage system consists of laterals connected at any angle to one or both sides of a single mainline. All laterals are parallel and spaced at equal distances from each other. The program allows the analysis of layout schemes with various mainline and lateral configurations. Slopes, lateral direction and drain spacings can be altered.

Course Usage:

The program has been used two years in a graduate course: AE 672 Drainage. The program has made it possible for students to better understand the design procedure. Before the program was available, students could not "see through" a design procedure because they got bogged down in the calculations. The computer program now takes care of the calculations and the student can concentrate on the steps in the design. It is known that the program has also been used in a drainage course at Colorado State University.

Hardware:

IBM PC, color monitor, with 64K memory

REHABILITATION GAME

T. Steenhuis, R. Oaks, N. Uphoff, E. van der Velde

The Rehabilitation Game is a part of a game that helps engineers, social scientists, and agricultural economists to learn to cooperatively design a rehabilitation project in a nonthreatening environment. The computer acts as a source of information for the design of the irrigation game after the first information is given. The scientists of the three disciplines discuss what additional information is needed for a successful design. The computer will supply this information at a certain cost. If the total cost is exceeded, no further information is supplied and the design phase is started. At the end of the game the designs are discussed and the information available is shown.

Course Usage:

The program has been used as a prereleased version in a graduate class: AE 754 Sociotechnical Aspects of Irrigation. The students in this class are future social scientists, agronomists, economists, and engineers. Thus, a good setting for the rehabilitation game and, in fact, this game was very successful. In my eight years as a teacher it was one of the few times that students in the class volunteered that it was a very good learning experience.

Hardware:

IBM, PC, XT, AT with 172K memory

Description of Program BOX_KANE

by

Dr. L. P. Walker
Associate Professor
Agricultural Engineering Dept.
Riley-Robb Hall
Cornell University
Ithaca, NY 14853
(607) - 256 - 4473

The program BOX_KANE is a nonlinear parameter estimation algorithm. This mathematical modelling tool is used to estimate parameters appearing in mathematical models found in engineering and natural science. Parameters are estimated by minimizing the differences between empirical measurements and the model.

The numerical method employed is the Box-Kanemasu interpolation method, which is a modification of the Gauss method[1]. Depending on the amount of information available about the nature of the error associated with the data or with the parameters, one of the following estimators is minimized:

- ordinary least squares (OLS),
- maximum likelihood (ML),
- maximum a posteriori estimation (MAP),

The user must provide the mathematical model,PROCEDURE eta_mod, and a procedure for calculating the sensitivity coefficient(s) for each observation, PROCEDURE sen_coef. In addition the following inputs are required:

y	- dependent variable,
t	- independent variables,
sigma	- standard deviation,
bs	- initial estimate of coefficient(s),
p	- initial estimate for the covariance matrix.

Example

The following example is a heat transfer problem. Equation 1 is a model which describes the relationship between temperature , n_i, and time, t_i. An experiment was conducted which yielded the experimental observations given below. Our goal is to estimate the value of parameters B_1 and B_2 such that Equation 1 will simulate the system behavior.

$$n_i = B_1 \exp(-B_2 t_i) \qquad (1)$$

Time,	t_i	0	0.125	0.25	0.375	0.5
Temperature	y_i	101	66	44	28	20
Std. Dev.	o_i	1	3	6	2	1

PSYCHROMETRICS, WEATHER SPACES, VENTILATION

L.D. Albright

The work described below was commenced in January, 1985. To date, three programs have been completed, or almost completed, and are intended for use in the course Agricultural Engineering 482, Environmental Control for Animals and Plants. This course is taken by approximately 20 students each year, and is a senior level engineering design course.

Programs Essentially Complete:

1. Psychrometrics

This program acts as a psychrometric chart for the students. Variables are dry bulb temperature, wet bulb temperature, dew point temperature, water vapor pressure, humidity ratio, relative humidity, degree of saturation, density and specific volume, and enthalpy. Two of the above variables, plus the atmospheric pressure, are entered and the program calculates the others. It is used as a general purpose program in the course. The students use it to determine required psychrometric parameters for a variety of homework problems and a term project.

2. Weather Spaces

This program is unique in that it calculates the weather conditions (the weather space) which correspond to designated indoor conditions in an animal housing facility, and the control setpoints specified, and displays the weather space on a set of psychrometric axes. It is very useful for visualizing the effects of changing setpoints, building properties, and animal population characteristics. Such topics are central to the subjects in AE 482.

3. Ventilation Graphs

This program calculates and graphs the required ventilation rate for specified weather, building, and animal population data. The required ventilation rates for temperature, humidity, and carbon dioxide level control are computed. The value of the program lies in its ability to permit students to ask the "what if" questions related to ventilation. Previously, the students developed a single graph by hand to learn the procedure, but the work involved in the development prevented them from exploring options in building design and operation.

Programs Planned

1. Condensation in Walls

This program will calculate and graph the water vapor pressure, and saturation vapor pressure, in walls of buildings, and pinpoint potential condensation problems.

2. Building Heat Loss

This program will permit students to specify building construction, and calculate heat loss factors.

3. Ventilation System Graphs

This program will permit students to specify fans, and inlet types, and calculate and graph the system ventilation graph (air flow as a function of pressure difference).

4. Psychrometric Processes Programs

These programs will calculate and graph on a psychrometric chart various psychrometric processes such as mixing, heat and humidifying, air conditioning, and dehumidification.

PAVEMENT ANALYSIS PROGRAMS

L. Irwin and D. Speck

Pavement analysis programs (NELAPAN and MODCOMP) based on a layered elastic mainframe program developed by Chevron Research, have been modified to run on the PC/XT with 8087 co-processor. These programs are used as a design tool in almost 30% of AE 692 Highway Materials and Pavement Design.

This work was done as part of Project EZRA.

LOGON PROCEDURES FOR A PUBLIC PC/XT INSTRUCTIONAL FACILITY

J.R. Cooke, C. Mabry, and C. Haller

A logon protocol has been implemented in the 160 Riley-Robb XT facility to provide: 1) minimal security for commercial software, 2) multiple course access to common software on the hard disk, and 3) more convenient 'housekeeping' for the public use of hard disks.

This now complete project was supported by EZRA.

POULTRY APPLICATIONS - THERMAL CHARACTERISTICS AND PRODUCTION COSTS

M.B. Timmons

We have been successful in developing interactive software to allow the user to simulate the effects of available management options:

1. thermal characteristics of building
2. placement date
3. weather, climate
4. production cost parameters, e.g., feed, fuel, electricity, and product (eggs or meat) price
5. environmental limits, e.g., when to activate heating or cooling equipment

Programs have been written for broiler, turkey and layer production systems to date. These programs have already been used by New York Extension personnel in evaluating the feasibility of raising broilers in New York and may in part have been responsible for a commercial firm to begin broiler growing operations this past year.

The modeling efforts are just being completed which will allow an equitable distribution of return from broiler operations between the grower (the person who owns the buildings and equipment and manages) and the intergrator (corporation which owns the feed, the birds, and processes and distributes the product).

The above software is planned to be integrated into our coursework which addresses the economic efficiency of management alternatives and allows the student to quickly grasp the relative effects of different building and management parameters.

SOLVER

AN INTERACTIVE STRUCTURES ANALYZER FOR MICROCOMPUTERS

by

Kifle G. Gebremedhin, Assistant Professor

and

Jae Y. Lee, Graduate Student
Agricultural Engineering Department
Cornell University
Ithaca, NY 14853

Abstract

SOLVER is a powerful engineering and teaching program for the analysis of 2 and 3 dimensional frames and trusses. The program is menu-driven and is designed such that any type or combination of loads oriented in any direction can be entered. No extra nodes are needed to input loads between nodes. Joints can be assumed pinned, rigid, or partially rigid. Initial displacements of nodes can be entered. Non-prismatic or curved members can be analyzed.

The program is developed with various output options from detailed information useful to an instructor and students of structural analysis to a summary report useful to a structural design engineer. With the program, students are now able to analyze structures with a high degree of indeterminancy, do more detailed analysis, identify critical members or joints, and develop more material efficient designs of wood members and structures in conjunction with the latest code. This type of analysis is impossible to accomplish in a classroom without a computer.

Hardware

IBM PC/XT computer, 256K memory, a disk drive, PC DOS 1.1 or 2.1, and printer (optional) are required to run the program.

Application

SOLVER will be fully utilized in AE 481, Agricultural Structures Design, a senior level course for agricultural engineering students and AE 332, Farm Building Design, a course for agricultural engineering technology majors. The software was developed as part of Project EZRA.

LABORATORY APPLICATIONS OF THE PC IN AGRICULTURE AND LIFE SCIENCES

D.J. Aneshansley

ABSTRACT:

The personal computer is an excellent tool with which to demonstrate applications and provide general instruction in the area of the life science laboratory. IBM PC-XTs and ATs are being used in the Agricultural Engineering Instrumentation Course (AG ENG 652) for data acquisition, data processing, process control, simulation and general instruction.

Specifically, students learn to use the PC for data acquisition and data analysis, including statistical treatment of their data. Temporal and frequency characteristics of first and second order systems are evaluated and characteristic data from a variety of transducers (pressure, flow, temperature, photo, etc.) are collectd and analyzed with the PC. The computer is also used to calibrate and linearize certain sensors (hot wire and film anemometers, thermistors, thermocouples). An attempt is made to apply the computer whenever possible to the routine task of data acquisition and analysis.

For their final project, the students implement two control systems. Both systems control the temperature of a water bath. However, one system (a thermistor and heater circuit) controls the temperature without computer control. The computer provides an analog voltage which indicates the temperature the independent controller is to establish in the bath and then monitors the performance of the controller. The second system (a thermocouple with appropriate amplification and heater circuit) is completely under computer control. The students design and construct all circuitry and develop all the software needed to perform the control functions and monitor performance of both controllers.

We are just beginning to develop our applications of the PC in the laboratory and I know these applications will grow and be refined. However, as an educator, as well as an engineer, I see the computer as an educational tool, as well as a laboratory tool, and believe we are challenged to provide innovative instructional uses of the PC. We are just at the beginning of this process with exciting paths to pursue.

HARDWARE:

4 Laboratory Workstations with the following equipment:

a) IBM PC-XT with 512 KB of memory and math co-processor

b) Enhanced Color Display and Enhanced Graphics Adapter with graphics expansion care and memory module

c) Graphics Printer and accessories

d) Data Acquisition and Control Adapter with Distribution Panel

e) Asynchronous Communication

f) PC Network Adapter

1 File Server and Development System

a) IBM PC-AT with 512 KB of memory and math co-processor

b) Professional Graphics Display and Adapter

c) Graphics Printer and accessories

d) Data Acquisition and Control Adapter with Distribution Panel

e) PC Network Adapter, Translator Unit and accessories

f) 6 Pen Plotter (anticipated)

g) Laser Printer (anticipated)

COURSE USAGE:

Agricultural Engineering 652: Instrumentation

SOFTWARE:

Software developed is and will be part of Project EZRA.

7 June 1985

DEPARTMENT OF AGRICULTURAL ENGINEERING
CORNELL UNIVERSITY

TITLE: Computer Aided Design of Food Processing Systems

AUTHORS: Gerald E. Rehkugler, Professor and Chairman
Yip-Fong Chia, Graduate Assistant
Dale L. Nafziger, Graduate Assistant

ABSTRACT: Computer programs for modeling heat exchanger, pumping, evaporator, and tunnel dryer systems form an important component of the academic instruction provided in the Agricultural Engineering Analysis and Design of Food Processing Equipment course. These programs were written in PLC and have been used on Cornell's mainframe computing system (IBM 4341) since 1982. The programs are written in a format which enables the student to design a particular system by specifying appropriate parameter values. Once the design is completed, the student has the option of repeating the design any number of times to observe the effect of parameter variation upon system specifications.

HEATEX PLC: HEAT EXCHANGER DESIGN - The design of heat exchangers for food products presents a unique problem arising from the non-Newtonian behavior of many food-product fluids. In such a design, the influence of the consistency coefficient (m) and flow behavior index (n) parameters must be accounted for. The program HEATEX provides a tool whereby the effect of these parameters upon tubular heat exchanger design may be explored.

PUMP PLC: PUMPING SYSTEM DESIGN FOR FOOD TRANSPORT - Many liquid food products are non-Newtonian in nature. Non-Newtonian fluids are those in which shear-stress versus rate-of-shear exhibits a non-linear relationship. In designing a system for pumping non-Newtonian fluids, special considerations must be taken into account including utilization of the generalized Reynolds number and use of the fluid-dependent constant α in specifying kinetic energy relationships. The program PUMP is set up to account for non-Newtonian fluid characteristics in the design of a system for pumping food products.

NEVAPOR PLC: EVAPORATOR SYSTEM DESIGN - Evaporation is one of the most important and also one of the most energy intensive operations in the food processing industry. In recent years particularly, there has been a vast increase in interest in maximizing energy usage efficiency in evaporation processes. One possible method of achieving this goal is that of joining a group of evaporators in series to form a multiple effect system. Solving mass and energy balance equations for an n-effect system thus becomes a task of solving n simultaneous linear equations. By providing the required input information, the program NEVAPOR generates and solves the set of equations and evaluates the performance of the system. With the appropriate parameter specifications we can generate and solve the equations for determining the system steam flow rate, vapor liberation for each effect, heat transfer surface area for each effect, and the system steam economy.

TUNNEL: DESIGN OF A TUNNEL DRYER FOR FOODS - A tunnel dryer system is used to reduce the moisture content of solid food products to an acceptable level for storage. The system consists of placing the product in trays which, in turn, are placed in stacks. Several stacks are then placed in an air tunnel. Hot air is introduced either parallel or counter-flow to the movement of product through the tunnel. Proper timing of the product resident time within the drying tunnel is essential for the preservation of product quality. Often such timing must be determined on the basis of experimentation. The computer program TUNNEL utilizes empirically derived data in the calculation of parameters relevant to the design and operation of a tunnel dryer system.

HARDWARE: IBM 4341 Mainframe
VT100 Terminals

COURSE USAGE: Agricultural Engineering 466
Engineering Design and Analysis of Food Processing Equipment
Utilized by up to 20 students per year.
Approximately 50% graduate and 50% upper level undergraduate
Engineering and Food Science students.

DEVELOPMENT: Independent of Project EZRA to date.
Project EZRA proposal now pending to develop computer aided design and computer graphics output to facilitate better design understanding.

MOBILE COMPUTER TEACHING FACILITIES FOR COOPERATIVE EXTENSION

R. Koelsch

During the past year, two mobile computer teaching facilities were established. Their prime purpose is to assist with the presentation of educational programs to Cooperative Extension clientele which require computer facilities. Presently, we see these facilities being used in two formats:

1. Where computers allow better illustration of principles of a specific subject matter area. For example, the data base and calculation capabilities of a computer are being used in educational programs to illustrate human nutrition principles.

2. Where computer literacy can be used as a tool in a business or home. For example, dairy farmers who currently own or anticipate owning a computer are taught concepts related to electronic spreadsheets and data base managers and how such software can be applied to such tasks as financial management, ration balancing, etc.

Currently, 13 county Cooperative Extension programs are involved in a pilot effort of these two mobile computer facilities. More than 100 field staff have been exposed to a minimum of a two-day training session. The two facilities have received heavy use to date and are almost fully scheduled through summer. Most education programs are being directed at farmers, local government officials, families, and 4-H youths.

Each mobile computer teaching facility consists of seven Apple IIc computers (one disk drive), one printer, one modem, and one extra disk drive. In addition, each computer is provided with a series of supporting software including electronic spreadsheet, data base manager, and word processing. One communications package is provided for the entire facility.

[This project is not part of Project EZRA]