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PRINTOUT, the newsletter of the Department of Computer Science of the University of Maryland at College Park, is published sporadically and distributed to faculty, staff, and students in the Department. Opinions expressed in signed articles may be those of the author, but no opinions represent the policy of the Department, or of the College Park Campus, or of the University.

Contributions may be submitted to the editor, and unless they are obscene or seditious they will probably be used, but minor editing may be done. Complaints directed to the newsletter will be investigated and publicized when possible. It is well to keep in mind however that the Department is subordinate to higher levels of administration, not the other way around; and, the Department does not provide computing service to the campus. Complaints in these areas are best directed to other publications.

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PRINTOUT

Volume 3
Number 2

CONTENTS

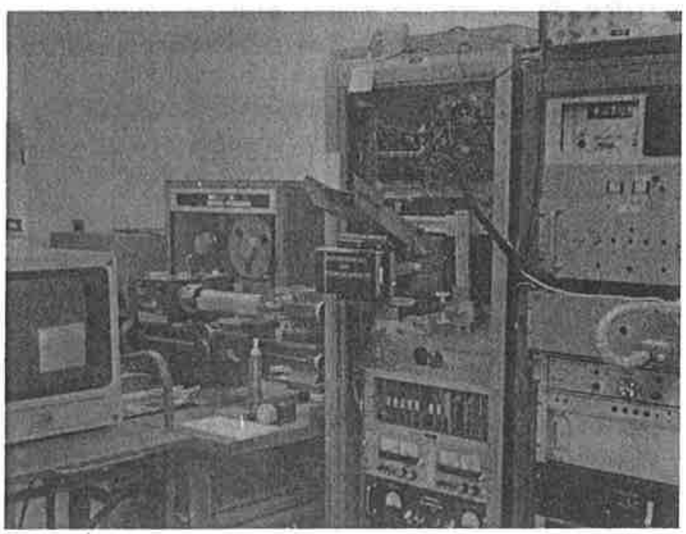
COMPUTER VISION LABORATORY of the COMPUTER SCIENCE CENTER

"Computer vision" deals with the computer processing and analysis of pictorial information. It can be regarded as a branch of pattern recognition, much of which deals with picture input; and it is also sometimes regarded as a branch of artificial intelligence, involving (eventually) the development of visual systems for robots. Its applications include

a) Document processing: reading of prited or written characters
b) Medicine: tumor detection in radiographs; pathology detection in blood and tissue smears
c) Environmental sciences: cloud cover mapping, land use classification, crop inventorying, pollution detection
d) Industrial automation: assembly, inspection.

There are many other applications in areas such as law enforcement, military reconnaissance, and visual aids for the blind. Some of these applications will be further described below.

Research in computer vision at the University of Maryland began in 1963, when Prof. Azriel Rosenfeld joined the Computer Science Center faculty. This research has been supported, over the years, by many government agencies, including the Defense Mapping Agency, the National Institutes of Health, the National Aeronautics and Space Administration, the Atomic Energy Commission, the Office of Naval Research, the Air Force Office of Scientific Research, the National Science Foundation, and the Defense Advanced Projects Research Agency. Prof. Rosenfeld's research group, recently renamed the Computer Vision Laboratory, now has a staff of over 25 and occupies the northern half of the fourth floor in the Computer Science Center.



Digitizing and display equipment. The scanner is the horizontal drum in front of the tape drive. Storage and display circuits are housed in the racks, and the camera is on the left rack. Pictures can also be displayed on the TV monitor at the left.

The Laboratory's facilities have been built or acquired over the past ten years. They include

1) A drum scanner for conversion of images to computer readable form on magnetic tape.
2) A CRT film recorder which outputs digital image arrays onto film as gray-scale pictures.
3) A scan converter memory and 1000-line TV monitor for direct viewing of output images.
4) A printer-plotter for hard-copy output.

The Laboratory has a high-speed channel from the Univac 1108, three floors below it, for image output. It also has a dedicated PDP-11/45 computer, which is used both as a display controller and as a data preprocessor. This equipment is available (at a fee) to outside users. It is maintained (and in some cases, was built) by Mr. Andrew Pilipchuk, Faculty Research Assistant.

The Laboratory has also developed extensive software for image handling on both the Univac and PDP-11.

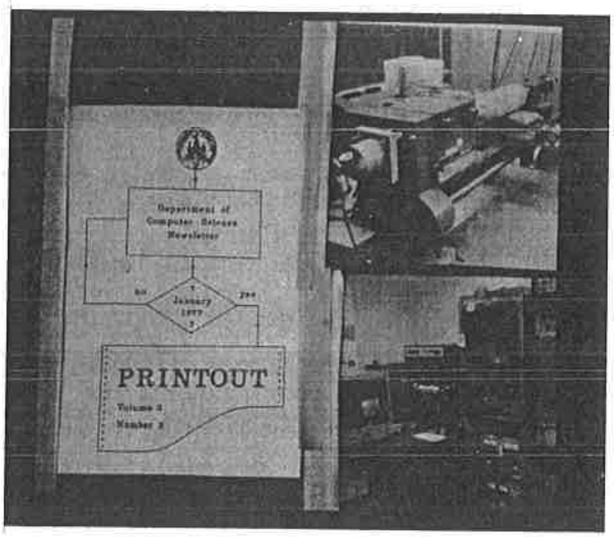
COMPUTER IMAGE PROCESSING

Image processing deals with the computer manipulation of pictorial information which is input to the computer in array form. This distinguishes it from computer graphics, in which pictures are specified in other forms -- e.g., as sets of coordinates of points, as chains of line segments, or as pieces of mathematically defined surfaces.

The first step in image processing is digitization, converting an input picture into machine-readable form. This generally involves two steps, sampling and quantization. Sampling represents the picture by a discrete array of numbers, usually corresponding to the gray shades (or colors) at a regular grid of picture points. Quantization forces these numbers to take on a discrete set of values, called gray levels. The result of sampling and quantization is a discrete-valued matrix, called a digital picture; its elements are sometimes called "pixels."

The digital pictures encountered in practice range in size from several hundred to several thousand pixels squared. Each pixel is usually quantized to 6 or 8

the cover



The photograph is the digitized version of this issue's cover, and of the photographs which appear on pages 3 and 5. The masking tape which held these items to the scanning drum is visible. The output was photographed from a cathode ray tube, and the result contains about 4,000,000 pixels, each with 64 gray levels. The actual cover was prepared as follows: The scanned image was recorded on magnetic tape, and processed on the Univac 1108. The portion of the picture containing the cover was sampled at each sixth point (hence discarding 35/36 of the information), and the result displayed on the printer using a system of overstrikes to approximate the various gray levels. There is some loss of definition because of the printer, but most of the noise comes from the infrequent sampling, and the on-off nature of the line-copy image. The resulting printer output occupied eight sheets, which when properly aligned and successively reduced on a copier, produced the cover. There is a vertical stretching of the image because the line printer does not have the same spacing horizontally (10/inch) as vertically (8/inch). The figure on page 5 shows a similar treatment of the photograph of the scanner, which fares better under the infrequent sampling.

bits, which provides enough discrete gray levels to yield a continuous-looking gray-scale when the picture is redisplayed. Thus digital pictures typically contain hundreds of thousands or even millions of bits, and their processing presents substantial data-handling problems.

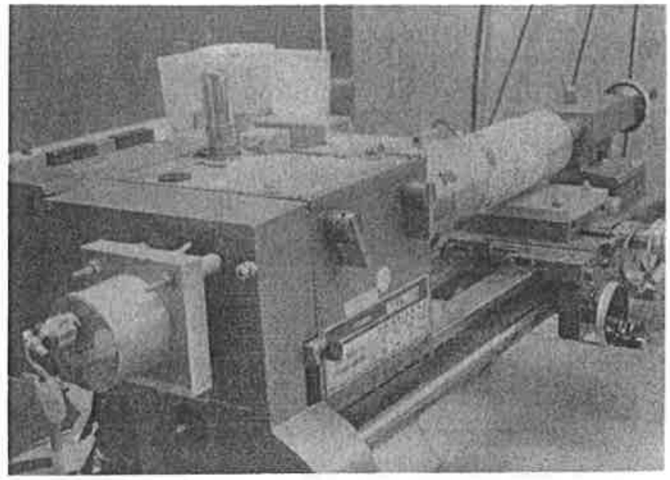
An important branch of image processing is image coding or compression, which deals with methods of reducing the number of bits needed to specify a picture. To a limited extent, this can be done without loss of information, using coding schemes based on information-theoretic concepts. However, if compressions of an order of magnitude or more are desired, information must be discarded, but in such a way that an acceptable approximation to the original picture can be reconstructed from what remains.

Another important image processing topic is image enhancement, which deals with operations on images that make them more acceptable to viewers -- e.g., by increasing contrast, or by removing blur, noise, or geometrical distortions. A highly mathematical branch of image enhancement is image restoration, in which one attempts to estimate the degradations (blur, noise, etc.) that have affected a given picture, and to compensate for them. A problem mathematically related to image restoration is that of reconstructing images from sets of projections; in recent years, image reconstruction techniques have had a major impact on medical radiography.

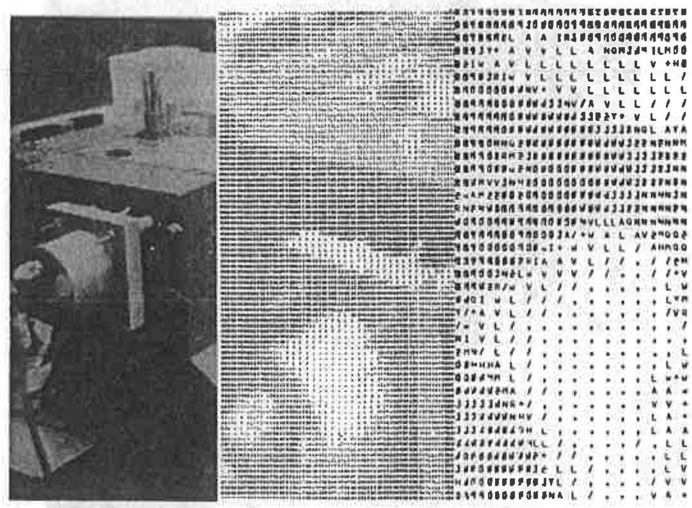
COMPUTER IMAGE ANALYSIS

Image analysis deals with the extraction of descriptive information from pictures. For example, a complex pictorial pattern can be described statistically in terms of textural properties such as "coarseness," "Directionality," etc. If objects or regions have been extracted from a picture by some type of segmentation process, one can describe their sizes and shapes in a variety of ways. Matching operations can be used to detect the presence of specified patterns ("templates") in a picture, or to register two pictures of the same scene for comparison purposes.

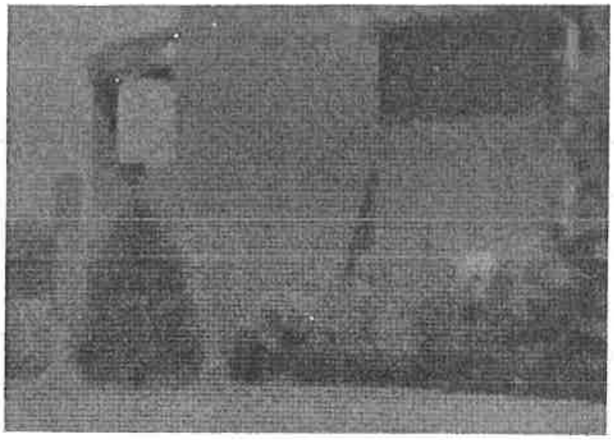
Although image analysis has been the subject of much theoretical work, it has



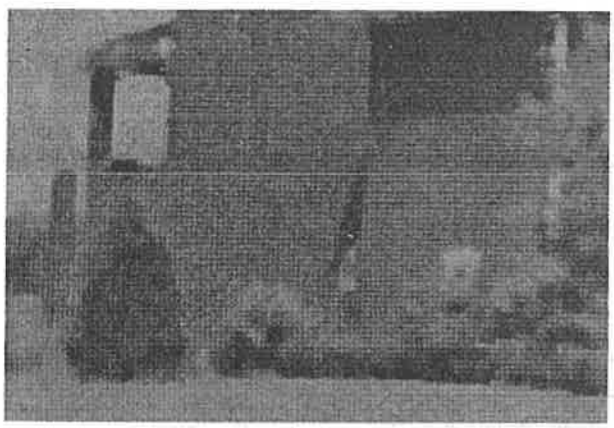
A photograph of the scanner itself. This is the original which was taped to the drum (of course not in the photo itself) and digitized as shown on page 4. The offset printing process used for this newsletter itself effects a kind of digitizing by splitting the continuous-tone photographs into patterns of almost invisible dots; even without this effect, the digitized version is almost indistinguishible from the original because it contains so many points and gray levels.

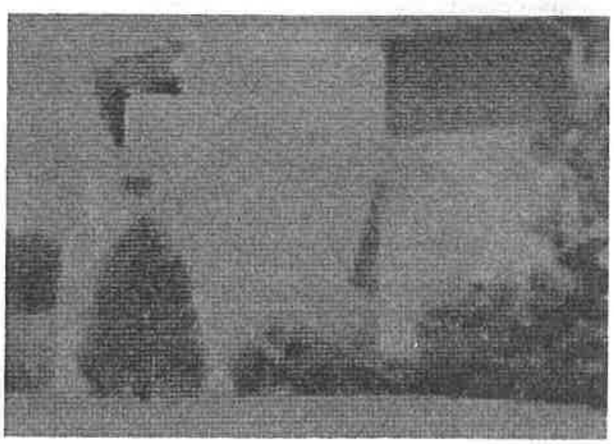


The digitized version of the scanner photograph sampled at each sixth point, as it appears directly on the display, after line-printer display to a scale comparable to that used for the cover, and at an early stage in the reduction showing the overstrike characters.



A digitized version of a photograph of a red brick house in Pittsburgh, which is taken from R. B. Ohlander's Ph.D. thesis (Carnege-Mellon, 1975). The original is in color, and this version is actually obtained by point-by-point averaging of images digitized from the usual three spectral separations. The digitized red and green separations are shown below.





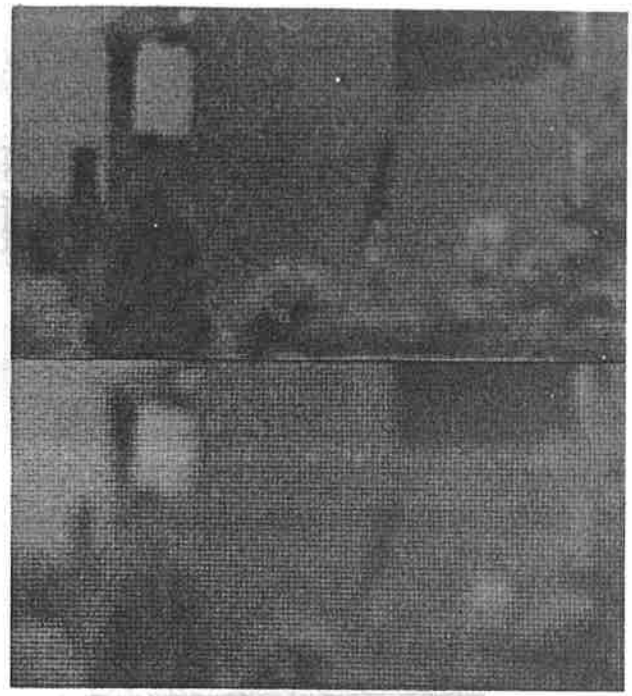
been largely motivated by applications. Some of these are discussed in the following paragraphs.

One of the earliest areas to which image analysis techniques were applied was that of character recognition. This area has seen numerous commercially successful applications which constitute significant steps in the automation of document processing. The following examples illustrate the types of materials for which automatic reading techniques have been extensively used: bank and account numbers imprinted in magnetic ink on bank checks, item and price codes imprinted (as bar patterns) on items in supermarkets, credit card numbers on sales slips, cash register tapes, and addresses (in particular, zip codes) on letters. Some of these applications involve special printing media and sensors (magnetic ink); others involve specially designed symbols (bar codes, special OCR fonts); while still others can handle ordinary printed material in a wide variety of fonts. Much has also been accomplished in connection with reading hand-printed and handwritten material, as well as exotic character sets (e.g., Chinese), but research is still going on in these areas.

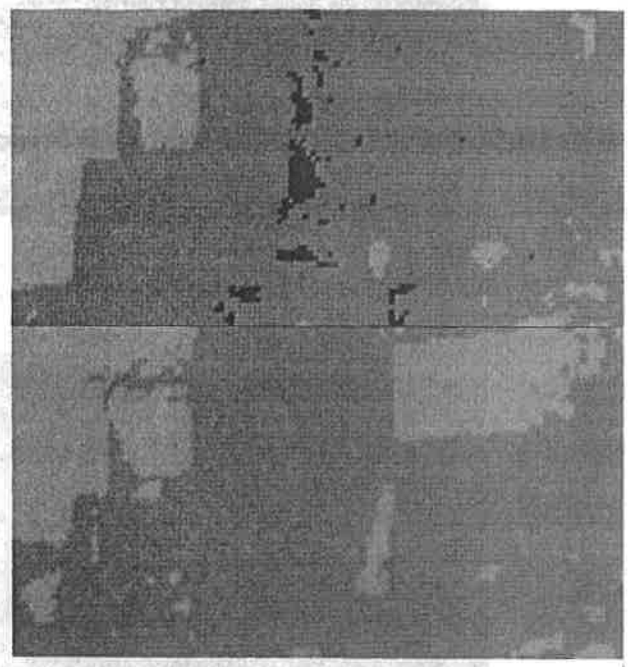
A second major application area for image analysis is medicine. In radiology, it has been extensively applied to the analysis of brain scans, mammograms, chest radiographs (e.g., for quantitative measurement of lung disease by texture analysis, or of heart disease by shape analysis), and so on; and image enhancement techniques have been used to improve the quality of radiographs so as to facilitate their analysis by radiologists. The recent development of efficient algorithms for image reconstruction from projections has led to a major breakthrough in radiology, since it is now possible to display cross-sections of the body, derived from X-ray exposures made at many different angles. In cytology, there have been commerical applications of image analysis in cell counting (e.g., differential blood counts), and extensive work has also been done in the analysis of tissue smears (detection of pathologies in Pap smears, for example) and in cytogenetics (automatic chromosome mapping).

A third area of application is environmental sciences and natural resources management. Remote sensing of the environment has always been a major source of data for computer analysis, but a further stimulus to this field was provided by the advent of meteorological and earth resources satellites. Applications include weather forecasting, pollution detection, natural resource inventories, prospecting, crop inventories, damage assessment, transportation planning, and urban studies, among many others. The most common form of input is multispectral imagery, in which individual pixels can be calssified (and the image segmented) on the basis of their spectral signatures.

A fourth area, rapidly coming into prominence, involves industrial automation of assembly and inspection tasks. This area is closely related to robotics research. There are many other application areas, including TV and facsimile bandwidth compression; enhancement of TV images obtained from space probes; astronomical image restoration; superresolution in microscopy; detection of "events" in nuclear particle chambers; recognition of fingerprints; reading machines for the blind; and others too numerous to list. Many of the applications which were the subject of research efforts only a few years ago have now become commercial realities, and this trend is expected to continue.



The effect of averaging on an image. In the top picture, each point is replaced by the average gray level of the 2 x 2 square around it. In the next picture, the replacement is for a 4 x 4 square.



Point-wize division between spectral separations. The first picture is red/green, the second blue/green. The largest quotients appear black. This emphasizes differences, but in an asymetrical manner.

SOME RECENT WORK AT THE LABORATORY

Many different research projects are in progress at the Laboratory. The examples listed below are all recent or current M.S. or Ph.D. theses.

1. Discrimination between clouds and sea ice on satellite TV images using texture analysis (Donald J. Gerson, M.S.)
2. Comparative study of various types of texture features for white blood cell classification (Hsi-Huang Yen, M.S.)
3. Threshold selection for image segmentation based on minimizing the "busyness" of the thresholded image (Joan S. Weszka, M.S.)

4) Detection of freehand forgeries on bank checks, by analysis of shape features of the signature (Roger N. Nagel, Ph.D.)

5) Construction of "natural" polygonal approximations to shapes, and their application to fast shape matching (Larry S. Davis, Ph.D.)

6) Cloud pattern classification from visible and infrared satellite images (JoAnn Parikh, Ph.D.)

7) Detection and identification of linear features (roads, rivers, geological faults) on satellite images (Gordon J. VanderBrug, Ph.D.)

8) Recognition of handwritten words using a hierarchy of cooperating processes to identify local features, strokes, and letters (Kenneth C. Hayes, Jr., Ph.D.)

9) Analysis of bone marrow smears for pathology detection (Peter H. Lemkin, Ph.D.)

10) Biological shape synthesis using transform representations (Bruce A. Shapiro, Ph.D.)

11) Analysis of fuzzy spatial relations and their application to robot planning (Robert L. Haar, Ph.D.)

12) Computational complexity of image analysis operations as implemented on serial or parallel computers (Charles R. Dyer, Ph.D.)

References

1. CMSC 498, "Computer image processing" (given annually)

2. CMSC 733, "Computer processing of pictorial information" (digitization, coding, enhancement, restoration; given every two years)

3. CMSC 838, "Picture and scene analysis" (segmentation, property measurement, description; given every two years)

4. A. Rosenfeld and A. C. Kak, Digital Picture Processing, Academic Press, New York, 1976.

5. A. Rosenfeld, series of review papers, in Computing Surveys (1969, 1973) and Computer Graphics and Image Processing (1972, and annually since 1974)

-- A. Rosenfeld

SYSTEMS COURSES

The Systems Field Committee has revised the systems curriculum. Although the changes will not go into effect until next fall, they might affect your choice of courses this semester. For further information, get a bulletin from the Education Office.

---P. Zave

Awards

DR. JACK MINKER has been awarded a grant supplement from NASA for "Research in Problem Solving Systems" for approximately one year in the amount of $29,928.

DR. VICTOR R. BASILI and DR. MARVIN V. ZELKOWITZ have been awarded a $53,594 grant from the Air Force Office of Scientific Research for the period January 1, 1977 to December 31, 1977 for research entitled "Programming Language Construct Evaluation."

Publications, Etc.

Zelkowitz, M. V., P. R. McMullin, K. R. Merkel, and H. J. Larsen. Error checking with pointer variables. ACM National Conference, Houston, Texas, October 1976, 391-395.

Zelkowitz, M. V. A compiler designed to aid in reliable program development. USE Fall Meeting, Walt Disney World, Florida, October 1976.

Zelkowitz, M. V. Automatic Program Analysis and Evaluation. 2nd International Conference on Software Engineering, San Francisco California, October 1976, 158-163.

Rosenfeld, A. (ed.), Digital Picture Analysis, Springer, Berlin, 1976.

Hamlet, R. G. High-level binding with low-level linkers. CACM 19 (Nov., 1976), 642-644.

C. S. O. S.

The editors of this periodical are pleased to announce a series of articles which we hope will contribute substantially to the stature of this department. It is called "The Computer Science Outline Series."

The authors of the articles will be faculty members whose concern for education has led them to notice that many of our students are lacking important professional skills. The articles in the series will be short tutorials on these skills. In this issue we present "How to Prove a Theorem on the Blackboard" and "Important Speaking Techniques."

How to Prove a Theorem on the Blackboard

by Pamela Zave
and Pete Stewart

Proving theorems on the blackboard, to a skeptical audience, is an important and difficult skill. This is because most "proofs" are actually well-organized, convincing arguments rather than formal, and therefore infallible, constructions. (Truly formal proofs are only possible within a fully axiomatized domain, and are always tedious.) Thus it is necessary to convey to your audience that spark of intuition, or <u>whatever</u>, that makes them believe the theorem is true.

This article consists of a list of techniques for inducing belief which are particularly well suited to the lecture format.

PROOF BY OBFUSCATION:

The basic idea here is to confuse your audience into belief. Spend a great deal of time on details which are conceptually simple (and therefore convincing), and evade the crucial points.

PROOF BY NOTATION:

This is actually a special case of Proof by Obsfucation, in which notation is the major tool. It works particularly well when the existence of some quantity is the heart of the proof: by naming this quantity with a Greek letter, you have established its existence <u>de facto</u>.

PROOF BY VELOCITY:

Write on the blackboard so fast that you have wrapped around and erased the leftmost panel before your audience has absorbed it. Having thus lapped them, you are above criticism.

PROOF BY ASPHYXIATION:

Attack the blackboard with so much energy that a cloud of chalk dust rises. Complete your derivation while the audience is blinded and coughing. When the cloud settles, you should be standing proudly by a fully erased blackboard, except for the conclusion in a big box. (Warning: beware of dustless chalk.)

PROOF BY COMPACTION:

An unusual and subtle technique, based on Occam's Razor. We have only seen it used once, when Scottery was proved superior to VDL by waving in front of the audience books defining PL/I in each of the schemes. Although the Scottery was a mere pamphlet, members of the audience were audibly skeptical about its readability and usefulness. This technique is not suggested for beginners.

PROOF BY INTIMIDATION:

This obviously works best in a classroom situation. Insist that the theorem is true no matter what you do in class and do it belligerently enough so that students will see they are annoying you with their stupid questions.

PROOF BY SEDATION:

Put the audience to sleep with a droning voice and stylized movements. Do not wake them up until your conclusion (it is elegant and effective to shout "Q. E. D.!"), after which they will have to believe the theorem, having missed its proof entirely.

Important Speaking Techniques

by Pete Stewart
and Pamela Zave

It is hardly to be expected that our typical graduate student, already burdened with courses, comprehensives, and interminable BS sessions, could find time to attend our coloquia (for faculty, the excuse is teaching courses, grading comprehensives, and interminable BS sessions). This is unfortunate, for among the participants have been some truly exceptional speakers whose styles are well worth observing. To help those who have missed these speakers to develop a mature style of their own, we give here thumbnail sketches of some of the more important speaking techniques that have been inflicted on our colloquium series.

THE WALT DISNEY TECHNIQUE

In its simplest form this technique consists of transferring the rainbow to transparencies. The value of color in disguising lack of content is not to be underestimated; an appropriately random use of tinted pens will have the entire audience trying to crack a color code that does not exist, during which time the speaker can slip in absurd statements ad libitum. (And of course, note takers have no chance to record the proceedings.) In its extended form, the technique uses cutsie pictures, overlays, and even multimedia productions in which the speaker dashes back and forth between two overhead projectors with all the grace of Charlie Chaplin filmed at five frames a second. The encore is a showing of a movie, usually beautifully crafted but having at best a dubious connection with the preceding talk.

THE ALFRED HITCHCOCK TECHNIQUE

Like the mad scientist of old hunched over his double throw knife switches and Tesla coils, the speaker crouches at the overhead projector, dealing out his wares line by line as he moves a piece of opaque material down the transparency. His object is to create an atmosphere of suspence, but he actually leaves the room and his audience in the dark.

THE RIP VAN WINKLE TECHNIQUE

In the time-honored tradition of after dinner speeches, the audience is put to sleep, though perhaps not for twenty years. For a technical speech, however, the problem is more difficult, since the speaker does not have an audience sated by food, drink, and sluggish digestions. There are two basic sleep-inducing subtechniques.

The Eric Severide Subtechnique - In the style of a Presbyterian minister, the speaker mouths platitudes with an air of glacial profundity. Properly done, this will send the audience off to slumberland in 15 minutes. The chief thing to avoid is actually saying something; the slightest hint of an idea will jar the dozing audience into wakefulness. Adepts at this art have been known to leave their own talk half way through with no one noticing.

The Carl Friedrich Gass Subtechnique - It was René Descarte who first noted the soporific effects of a string of equations, but Gauss, as a teacher, developed the technique to such a high state that it rightly bears his name. The speaker merely presents transparency after transparency of equations, reading each one in a monotone. Although the equations may follow logically one from the other, care must be taken to insure that they give no insight into the problem at hand, as this will disturb the slumbers of the audience. Aficionados number their equations and keep score. Low score wins with twenty equations par to bring the sandman tiptoeing through the lecture hall.

THE T. J. WATSON TECHNIQUE

In the Washington area this is also known as the Pentagon technique. The speaker, who is immaculately groomed, bases his talk on transparencies of goldenrod and midnight blue mounted in oversize cardboard frames. At least three of them have consumed the full capacity of a Madison Avenue graphics team. He is accompanied by a stereo recording of softly rustling money. What glitters in his talk is not its content.

THE METHUSELAH TECHNIQUE

So named because only Methuselah lives long enough to see the end of the talk. The essence here is timing; the talk must extend half again beyond its alotted span, excluding, of course, the question session. To heighten the agony, the speaker may insert phrases that hint of an ending - "to summarize" and "in conclusion" are customary; but like a mirage the termination must vanish as it is approached. It takes great courage to continue talking while the audience slips away like leaves deserting an autumnal tree; but the skilled practitioner of this technique will be rewarded in the end by an audience, consisting solely of the poor slobs who invited him, shifting grimly from aching cheek to aching cheek.

No winner!

CONTESTS

The response to the call for limericks and 1100 computer horror stories (PRINTOUT 3, #1) has been disappointing. Four of the five limericks received are reproduced below, but although the first one seems clearly the best, I don't feel that it merits a prize. (That there <u>was</u> no prize strengthens this belief...) The fifth limerick was signed "T. Pynchon," and it was a screamer which may be examined by contacting the Editor in person.

Processes, too, get the blues,
Like this pair whom Cupid did choose:
 But instead of wedlock,
 They ended in deadlock
Waiting on separate queues.

--P. Zave

He belonged to the party of Red;
Took a fancy to LISP in his head:
 But programs recursive
 Were declared subversive,
And now he needs SNOBOL instead.

--P. Zave

Response time was much less than great
While using the 1108
 Then I heard a loud bash,
 The machine it did crash
And my program was handed in late!

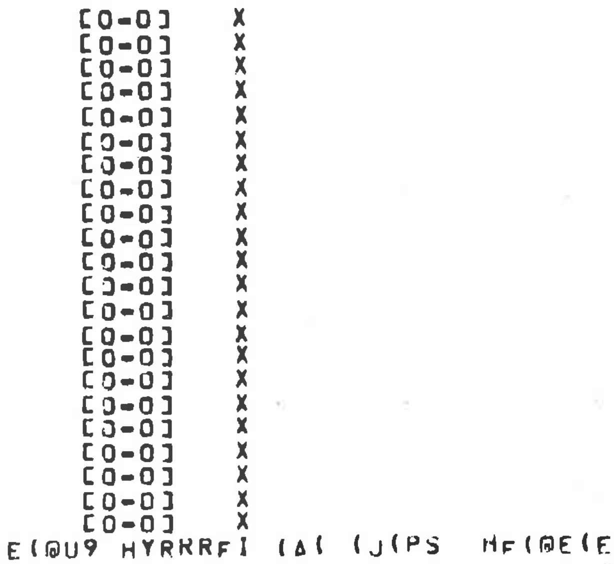
--D. Keller

There once was a μcomputer,
Who thought she needed a tutor.
 She tried a few
 But said, "They won't do--
What I really need is a suitor."

--Anon.

No 1100 horror stories were received, but one listing was submitted (although not clearly in the proper category). The listing was several inches thick, but each page was identical -- apparently from a program in a print loop. What was interesting was the system message at the end, which is reproduced below following a sample of the repetition:

```
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
[0-0]   X
```



News

Ms. JoAnn Thompson will leave the Department on January 14 to become an Accounting Associate with the Maryland State Agency for Surplus Property.

Ms. Alice Eichman, our Scientific Typist, left the Department on November 5, 1976, to become a secretary with the Astronomy Department.

Ms. Peggy Strand came to work in the Department Office as a secretary on November 8, 1976. We are glad to have her on our staff.

more classified ads

FOR SALE

Late Model 1106--Slightly used. Fairly good shape, but some rotting in core. Disks in the front, drums in the rear. Air conditioned, passed inspection. Make offer. Call computer center after 1 PM.

Diamond Write Rings. Show your woman that this one's for keeps. Many enticing colors. This month--1000 rubberbands free with every purchase. Shop at Dispatch Dealerships. Only funded accounts please.

Richard Nixon's new best seller, Executive Priviledge and the 1108. A Bantam book, available at the Umporium, $18.

Parsed, threaded, pruned, binary and quad trees. Only 353 days until Christmas. See Dr. H. Samet.

RIDES

Going to Floating Point, Massachusetts. Need someone to share expenses and driving. Send address to Box AO, College Park, MD. 45201.

FOR RENT

We rent tux and tails for all your formal parameters. Queue Clothier - "We're the best on the block."

Campus Heads--Need a place to crash? For just a little scratch you can stay at my pad for the night. x5401.

MISCELLANEOUS

This Monday's meeting of the PL/1 Standardization Committee has been CANCELLED due to lack of agreement on suitable time or place.

Just inherited attributes, but can't afford the tax. Will give them away as token of my appreciation. x4821.

--D. Keller