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Quarterly Progress Report

Division 3

Information Processing

15 March 1962

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Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

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Quarterly Progress Report

Division 5

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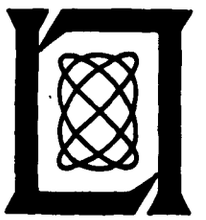
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts



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INTRODUCTION

This Division 5 Quarterly Progress Report covers the period from 1 December 1961 through 28 February 1962.

Detailed reports of research will continue to be available in the form of Technical Reports, G-Reports and Journal Articles. A list of these reports that have been issued during the present reporting period is included here.

Work done in Division 5 on Project MIDAS will be summarized in the Project MIDAS Quarterly Progress Reports; work on Project West Ford will be reported in the Division 3 Radio Physics Quarterly Progress Reports; and activity in solid state physics will be reported more fully in the new series of reports on Solid State Research at Lincoln Laboratory.

F.C. Frick
Head, Division 5

G.P. Dinneen
Associate Head

9 March 1962

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PUBLISHED REPORTS OF AUTHORS FROM DIVISION 5

15 December 1961 through 15 March 1962

Journal Articles*

JA No.			
1530	Communication in Digital Systems	I.L. Lebow	Information Theory (Butterworths, London, 1961), 99
1667	Free Versus Serial Recall	N.C. Waugh	J. Exptl. Psychol. 62, 496 (1961)
1688	Computer Languages for Symbol Manipulation	B.F. Green, Jr.	Trans. IRE, PGEC EC-10, 729 (1961)
1691	Machine Preparation of Printed-Wiring Masks	E.A. Guditz	Trans. IRE, PGPEP PEP-5, 22 (1961)
1724	Recognition of Patterns in the EEG	B.G. Farley	Computer Techniques in EEG Analysis (Elsevier, Amsterdam, 1961), 49
1730	Cryosar Memory Design	R.C. Johnston	Trans. IRE, PGEC EC-10, 712 (1961)
1737	Likelihood Ratios for Diffusion Processes with Shifted Mean Values	T.S. Pitcher	Trans. Am. Math. Soc. 101, 168 (1961)
1799	Proposal for Magnetic Domain-Wall Storage and Logic	D.O. Smith	Trans. IRE, PGEC EC-10, 708 (1961)
1818	Computer Techniques for the Study of Patterns in the Electroencephalogram	B.G. Farley L.S. Frishkopf† W.A. Clark, Jr. J.T. Gilmore, Jr.†	Trans. IRE, PGBME BME-9, 4 (1962)
MS No.			
84	Learning in Random Nets	M. Minsky O.G. Selfridge	Information Theory (Butterworths, London, 1961), 335
391	Digital Techniques in Neuroelectric Data Processing	W.A. Clark	Computer Techniques in EEG Analysis (Elsevier, Amsterdam, 1961), 75

*Reprints available.

†Author not at Lincoln Laboratory.

UNPUBLISHED REPORTS

Journal Articles

JA No.			
1682	A Transient Discrete Time Queue with Finite Storage	J.R. Kinney	Accepted by Ann. Math. Stat.
1783	Preparation of Stoicheiometric Chromites	E. Whipple A. Wold	Accepted by J. Inorg. Nucl. Chem.
1796	Noncoherent Switching in Permalloy Films	D.O. Smith K.J. Harte	Accepted by J. Appl. Phys.
1802	Tangential Limits of Functions from the Class S_α	J.R. Kinney	Accepted by Proc. Am. Math. Soc.
1825	Eyes and Ears for Computers	E.E. David, Jr.* O.G. Selfridge	Accepted by Proc. IRE
1856	Sophistication in Computers a Disagreement	J.R. Kelly, Jr.* O.G. Selfridge	Accepted by Trans. IRE, PGIT
MS No.			
227	Spin-Orbit vs Jahn-Teller Deformations in Chromium Spinels	J.B. Goodenough	Accepted by J. Phys. Soc. Japan
238	Negative Anisotropy in Iron-Nickel Films	D.O. Smith	Accepted by J. Phys. Soc. Japan
292	Some Results of Computer Simulation of Neuron-Like Nets	B.G. Farley	Accepted by Proc. Fed. Amer. Soc. Exptl. Biology
350	Cobalt Ferrite Crystal Growth from the Ternary Flux System Na_2O-CoO-Fe_2O_3	W. Kunnmann A. Wold E. Banks	
351	Vanadium Iron Oxides	A. Wold D. Rogers R.J. Arnott N. Menyuk	
356	Isotropic Stress Measurements in Evaporated Permalloy Films	G.P. Weiss D.O. Smith	Accepted by J. Appl. Phys.
361	Magnetic Properties of Mixed Vanadium-Chromium Sulfides	K. Dwight R.W. Germann A. Wold N. Menyuk	
362	Magnetic Transitions in Cubic Spinels	N. Menyuk A. Wold D.B. Rogers K. Dwight	

*Author not at Lincoln Laboratory.

Journal Articles (Continued)

MS No.			
363	Cation- -Cation Three-Membered Ring Formation	J.B. Goodenough	Accepted by J. Appl. Phys.
382	Proposal for and Demonstration of Magnetic Domain-Wall Storage and Logic	D.O. Smith J.M. Ballantyne	

Meeting Speeches*

MS No.			
292A	Activity in Networks of Neuron-Like Elements	B.G. Farley	Biophysical Society, Washington, 14-16 February 1962
450	Comments on the 3d Electron Problem	J.B. Goodenough	Colloquium, University of Minnesota, 11 January 1962
469	The Preparation of Stoichiometric Ferrites and Chromites	A. Wold	Seminar, U.S. Naval Research Laboratory, White Oak, Silver Spring, 15 February 1962
470	What Would We See if We Had Eyes?	O.G. Selfridge	Symposium on Optical Character Recognition, Washington, 15-17 January 1962
482	Some Similarities Between the Behavior of a Neural Network Model and Electrophysiological Experiments	B.G. Farley	IRE-PGBME Meeting, The Johns Hopkins University, Baltimore, 13 February 1962
492	Magnetic Films – New Possibilities – New Problems	J.I. Raffel	Lockheed Symposium, Sunnyvale, California, 27 February – 1 March 1962

* Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

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DIGITAL COMPUTERS
GROUP 51

I. INFORMATION PROCESSES

A. Activity in Networks of Neuron-Like Elements

Systematic, repeatable studies confirm the resonance-like properties observed in our neuron net model and show that the plot of "response amplitude" vs "stimulation frequency" has fine structure as well as the previously reported peak near "free oscillation."

The program system has been improved by the addition of an autocorrelation program and by a change in the method of calculating which nearly doubles the speed of the firing program.

A very significant addition to the net is the characteristic of connection "anisotropy." It is now possible for the researcher to choose, by light pen, several arbitrary sets of connections around each cell, including the assignment of a different probability to each set; the symmetry constraint is no longer present. In the near future, it will also be possible to assign an arbitrary weight to each set of connections.

II. COMPUTER DESIGN AND DEVELOPMENT

A. LINC Computer

Most of the LINC computer has been assembled and is now starting to operate. The memory subsystem is designed to run independently in several test modes and has operated very successfully in this way for occasional short periods during the past month

The four operating console modules and associated cabling to the main frame have been completed. One module holds the operating toggle switches, indicator lights, pushbuttons, etc. A second module contains jacks and plugs for input and output signals. The third module holds the two magnetic tape units; the fourth module, the display scope.

On 2 March, the entire apparatus is to be moved to Cambridge for a demonstration at a meeting of the National Academy of Sciences – National Research Council Committee on "The Use of Computers in the Life Sciences."

B. FX-1

The detailed design of the equipment required for the experiment in which the FX-1 computer will be teamed with a CDC 160-A machine to process wide-band data is essentially complete. Buffers were designed to allow communication between the two machines, and a control for operation of an IBM Mod. IV magnetic tape on the 160-A. In addition, the FX-1 input-output control was redesigned to make the synchronizing of the two machines easier and faster.

C. FX-1 Memory

A new sense amplifier design which contains no long-time-constant coupling networks is now in use; it recovers from the digit transient 100 nanoseconds earlier than did the old one. Using these amplifiers, the memory operates successfully within a cycle time of 380 nanoseconds.

D. Advanced Circuits

The design of a faster gated-pulse amplifier is in progress. The parameters of the transformer and transistor are being investigated to determine how they affect the delay through the amplifier. A number of plug-in unit designs have been investigated, and it appears that the volume of the plug-in unit can be reduced by about one-half. Several of the proposed new designs have been sketched, and mock-ups have been built.

E. TX-2

The new TX-2 console was installed and has been in use since the early part of the quarter. Further improvements in the "operation area" will be made in the near future.

III. MAGNETIC FILM ENGINEERING

A. Adjacent-Word Disturb Problem

Bitter pattern studies have indicated why the use of narrower (10 mils vs 15 mils) rectangles in the memory did not reduce adjacent-word disturbance. The critical observation was that reverse domains propagate into the film along its long axis rather than from the edge near the active word line.

The reverse domains tend to form at the rectangle's abrupt ends where a high pole concentration exists. Film rectangles with ends which taper off over a 2-mil distance exhibit much less of this "creep."

B. Evaporated Films

A forthcoming report describes the mechanical and electrical design of the mechanism which is being used to vacuum deposit 48 sequential memory arrays in one "pump-down."

C. Plated Films

Zero-magnetostriction plated films of approximately 35 per cent cobalt, 52 per cent nickel, and 13 per cent iron are being made both here and at General Electric Company for high-density memory experiments in which higher wall coercive force is required to prevent demagnetization. Coercive-force values of H_c = 15 oersteds and H_k = 25 oersteds have been obtained.

DATA PROCESSING
GROUP 52

I. SECO TELEPHONE-LINE SYSTEM

It was reported in the last quarterly progress report that, as an intermediate goal in the SECO program, a one-way data-transmission system was being constructed with a noiseless feedback link for transmission of rate-change information from decoder to encoder. The channel to be used in the system is a telephone line. Work on the over-all system has fallen into three categories:

(a) A telephone-line modulation-demodulation system under development will be capable of transmitting approximately 10,000 binary digits per second with an error probability small enough to allow its use with SECO at one of the higher rates (1/2, 3/5, 3/4). This will result in a data-transmission rate of 5000 to 7500 bits per second. It is expected that the impulse type of noise which is predominant in current low-rate telephone-line systems will lead to error detection by SECO. Errors introduced by Gaussian noise and intersymbol interference in the high-rate system will be corrected by SECO.

(b) The conditions for requesting rate changes in SECO are being determined experimentally.

(c) The design and construction of the one-way system is being completed by (1) combining the buffer memories with the encoder and decoder, and (2) modifying the decoder to conform to the expected error distribution introduced by the modulation system.

The system and the experimental results are reported in the following sections.

A. Telephone-Line Modulation-Demodulation System

The rate of 10,000 binary digits per second is to be achieved by transmitting symbols at the rate of 2000 per second using vestigial sideband modulation, where each symbol has one of 32 amplitudes (5 bits per symbol). The standard symbol is Gaussian in shape; the amplitude 500 μsec on either side of the maximum is less than 1 per cent of the peak amplitude. Thus, if pulses are transmitted at 500-μsec intervals, successive maxima occur where adjacent pulses are less than 1 per cent of their maxima. The spectrum of this pulse is also Gaussian with a bandwidth ~2 kcps. The Gaussian pulse is used to modulate a 2.5-kcps carrier and is passed through a vestigial sideband filter and then over the phone line. Restriction of the spectrum of the modulation by careful pulse shaping maintains the transmitted energy in a region of roughly linear phase in the phone-line characteristic; hence a minimum of pulse distortion occurs.

An experimental system has been constructed and is being evaluated.

B. Experimental Results on SECO

The feedback strategy has as its purpose the transmission of as much information as possible to the customer while simultaneously maintaining the error probability negligibly small. In order to fulfill these requirements, the decoder must detect all errors and, upon each such detection, request a repeat at a lower rate. It must further initiate these requests only when a decoding error is about to be made in order to minimize the number of unnecessary feedback

requests. By the same token, a request for an increase in rate should be made only if the probability of a subsequent rate decrease request is sufficiently low.

Criteria for repeat requests are being determined experimentally by using the SECO decoder and a simulated binary-symmetric channel with variable error probability. A critical Hamming distance $D_c(R)$ has been determined for each rate R. If this distance is exceeded for N(R) successive decodings, a repeat is requested. Values of $D_c(R)$ and N(R) have been found which result in almost perfect error detection with few unnecessary feedback requests.

Similar criteria are being investigated for the initiation of rate increase requests.

II. SPEECH COMPRESSION

A second computer program for speech pitch extraction has been written.* The primary concern is the development of a program providing the basis for a real-time pitch period computer for use with the Vocoder now under construction. This change in emphasis has led to a substantially different system.

At any instant of time, the program remembers the three most recent periods generated by each of six simple pitch detectors. On the basis of this information, it chooses the most recent period from the "most popular" pitch detector as the correct period. "Popularity" is ascertained by noting how the available numbers cluster about each of the six nominees.

The three simple pitch detectors of the previous program are also being used in this program. The total is now six because each detector operates on both the speech wave and the negative of that wave.

Preliminary design of a real-time pitch period computer based upon the method described above has begun. It appears that the machine may be divided into two parts: (a) an analog section realizing the six individual pitch detectors, and (b) a digital section making the pitch period decisions by evaluating the six individual detectors.

* The first such program was described in Division 5 Quarterly Progress Report dated 15 March 1961.

COMPUTER COMPONENTS
GROUP 53

I. TRANSITION-METAL COMPOUNDS

The Heisenberg exchange Hamiltonian $H_{ex} = \Sigma_{ij} J_{ij} \mathbf{S}_i \cdot \mathbf{S}_j$ has served as a divide in the theoretical development of magnetism. During the past year and a half, a method was developed and applied to obtain the ground-state spin configurations (collinear and noncollinear) that result from a rigorous solution of this many-body (10^{23}) problem for several crystallographic symmetries. Writing of the final papers in this series was nearly completed during this quarter.

To relate this phenomenological Hamiltonian to chemical composition and crystal structure, the origin of the coupling parameters J_{ij} and the atomic spins $\mathbf{S}_i$ are being studied. This has led to a distinction between localized electrons, which may give rise to localized atomic moments, and collective electrons, which may be spin-polarized by the presence of localized electrons with a net spin. Coupling of localized 4f electrons via conduction electrons has been investigated for rare-earth metals, and it was found that, in addition to the isotropic term above, the Hamiltonian must, in this case, include anisotropic terms of the form previously invoked[1] phenomenologically to explain the interesting spin configurations that are observed in these metals.

In the transition metals, the localized 3d electrons are thought to be coupled via narrow-band collective 3d electrons, and further support for this contention follows from the interpretation during this quarter of atomic moments and ferromagnetic vs antiferromagnetic coupling in several alloy systems with perovskite structure and with $B8_2$ structure.

Such considerations have led to a study of vanadium spinels in which it was hoped to vary the lattice parameter (by means of suitable choices for the A-site cation) sufficiently that the B-site-vanadium d electrons were varied from metallic, collective to semiconducting, localized. Since the structures are ionic, the s-p electrons do not contribute significantly to the conductivity, and it is possible to study the 3d-electron transport properties as a function of cation separation through the critical region. It has been found that where the cation separation would be small enough for metallic $V^{3+} - V^{3+}$ bonding, the spinel phase may not be stable. However, separations were obtained sufficiently small that samples with stoichiometric V^{3+} sublattices had activation energies as low as 0.06 ev. Substitution of foreign atoms into the all V^{3+} sublattice increases the activation energy even if simultaneously reducing the V-V separation, which is to be expected if the low activation energies represent a collective-electron behavior with large electron-lattice interactions. In both the CoV_2O_4-Co_2VO_4 and the FeV_2O_4-Fe_2VO_4 systems, it is possible to identify compositional ranges in which there appears to be a transition from collective-electron to localized-electron behavior. Construction of a hot press, which is being assembled during this quarter, should permit similar studies of the chromites.

Lack of stoichiometric single crystals has hampered magnetic studies of the ferrospinels. Growth of single crystals from a flux $Na_2Fe_2O_4$ and from the melt at high oxygen pressures have been developed. The optimum ratio of flux to $NiFe_2O_4$ for growth of $NiFe_2O_4$ crystals has been determined to be 1:1.5. It is expected that stoichiometric single crystals will be pulled during the next quarter with a refined, water-cooled "cold finger." The addition of 5 per cent $Na_2Fe_2O_4$

to a $CoFe_2O_4$ charge in the high-pressure furnace lowered the melting point to $1570°C < T_{mp} < 1585°C$ at 1650 psig O_2 pressure, which permitted the growth of a $3 \times 7 \times 5\,mm^3$ single crystal of $CoFe_2O_4$ containing no Fe^{2+}.

Magnetic data have been obtained for the (100) plane of a single crystal of MnP at low temperatures. Below 50°K, the crystal appears to exhibit metamagnetism, which is indicative of a noncollinear ⇄ collinear spin-configuration transformation. The saturation magnetization corresponds to $1.25\,\mu_B$ per molecule.

II. MAGNETIC COMPONENTS

Basic work directed at understanding anisotropy and switching in magnetic films continues. The design and construction of equipment for studying the changes of anisotropy with time and temperature by means of ferromagnetic resonance is near completion. Also, resonance techniques are being developed to measure the anisotropy of very small regions (~10 μ dia) of a film in an effort to demonstrate directly the presence of negative H_k in local regions of certain films.

A study of the residual gases present in a commercial vacuum coater has been made. The results are in agreement with others[2] who found water vapor, carbon monoxide, and various hydrocarbons present in the residual vacuum. Successful efforts were made to reduce the partial pressures of the above gases. Films were made under a wide variety of conditions. Magnetic measurements were made in each case, and the results compared. In general, for many of the residual gases the partial pressure can be varied from 10^{-7} to 10^{-5} mm Hg during deposition with no significant change in the magnetic properties.

An extensive study of anomalous films has been completed and submitted for publication.[3] Anomalous films contain local deviations of anisotropy from the average (anisotropy dispersion) that dominate the magnetic behavior. Briefly, it has been shown that, although a wide variety of detailed magnetic behavior is observed for films prepared in different ways, in all cases the structural origin of the anisotropy dispersion appears to be magnetoelastic coupling to inhomogeneous strain that is generated during film preparation.

A more sophisticated version of the domain-wall shift register previously described is being constructed.[4] Pulse drives will be used, and the wiring will be made by multilayer film deposition. These techniques will also be used in experimental switching studies undertaken to support theoretical studies that predict the generation of unstable spin waves during switching.

Calculations have been made that predict the appearance of a set of growing spin waves in a magnetic film undergoing rapid, rotational magnetization reversal. Amplification of an initial disturbance (such as magnetization ripple caused by anisotropy dispersion) occurs through the interaction of its volume demagnetizing field with the coherent rotation providing the wavelength of the disturbance is greater than about 10^{-5} cm (exchange fields stabilize shorter-wavelength modes). The back reaction of one or more of these spin-wave instabilities on the coherent rotation results in an effective damping; this appears to be the primary damping mechanism for large-angle rotation.

III. ELECTRONIC COMPONENTS

The development of a UHF switching transistor having an f_T of 5 to 10 kMcps is continuing. Mesa transistors from Texas Instruments with f_T in the range of 2.5 kMcps represent substantial progress; however, the r_b, of these units is ~200 ohms, which is about 10 times too large to

perform well in a practical switching circuit. Modifications by Texas Instruments to lower $r_{b'}$ are currently in progress.

Electrochemical transistors from Philco Corporation with f_T in the range of 1 kMcps have been received; in addition, the $r_{b'}$ of these units is satisfactory (~30 ohms). A special difficulty with these units has been lead inductance which is due to the method of mounting. Modifications are in progress.

The possibility of an amplifying device based on the collection of electrons that tunnel from a metal through a thin, insulating barrier to electronic states in the order of one ev above the Fermi level in a second metal[5] has led to an investigation of the emitting-diode portion of this device. Metal-metal oxide-metal diode structures have been made that exhibit V-I characteristics attributable to electron tunneling through the metal-oxide insulator. The diodes were obtained by vacuum depositing an aluminum stripe onto a glass substrate, oxidizing the aluminum surface by exposure to dry oxygen at room temperature and atmospheric pressure for various times ranging from 15 minutes to one day, and then vacuum depositing a second stripe crosswise to the first, thereby forming the desired diode structure at the intersection. Excellent agreement between tunneling theory and experiment has been obtained.

The cutoff frequency of these diodes is $f_m = 1/2\pi R_d C_d$, where R_d and C_d are the resistance and capacitance of the diode respectively, i.e., $C_d \propto 1/a_o$ and $R_d = dJ/dV$, where a_o is the thickness of the insulating barrier and J is the tunneling current. Table 53-I shows theoretical values of f_m (V = 0) for several values of a_o(Å). At present, diodes with $a_o \sim 12$Å have been made with the corresponding f_m (V = 0) in the 10-Mcps range.

TABLE 53-I

TUNNEL DIODE CUTOFF FREQUENCY
f_m vs BARRIER THICKNESS a_o*

a_o	f_m (V = 0)
20	15 cps
15	26 kcps
10	45 Mcps
5	73 Gcps

* Calculated for electron effective mass in the barrier = 1, barrier potential height = 2 ev, and barrier dielectric constant = 6.

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ANALYSIS
GROUP 55

I. RICCATI ALGEBRAS

The investigation reported in the last quarterly progress report has been completed. In addition to extensions and generalizations of the algebraic results previously mentioned, more analytical results have been obtained. In particular, it has been shown that, if the initial matrix for the differential equation belongs to a certain ideal, then the solution exists on $-\infty < t < \infty$. This generalizes the one-dimensional case where, except in the trivial case, only the trivial solution exists on $-\infty < t < \infty$.

II. MAXIMAL IDEALS OF A MEASURE ALGEBRA

The set of finite measures on the space of continuous functions over a finite interval with convolution as a product is a Banach algebra. A slight generalization of a theorem of Levy on characteristic functions proves that it is semi-simple. Let w be the measure associated with a Gaussian stochastic process with mean 0 and correlation function R, and δ_f the probability measure concentrated on the function f. If φ is the homomorphism associated with a maximal ideal not containing w, then for any continuous f and square integrable g we have

$$\log \varphi\left(\delta_{f+R^{\frac{1}{2}}g}\right) = \log \varphi(\delta_f) + i \int f(t)\, H(t)\, dt \quad ,$$

where H is a square integrable function depending only on R.

III. RANGE MEASUREMENT

Work has continued on the problem of accurate range measurement over long distances by means of binary sequences with useful correlation properties. These are known as "acquirable codes." The previous results can be improved in the sense that the number of computations required can be reduced, thus shortening the time delay; moreover, storage requirements in the computer now become tractable.

IV. EXPLICIT SOLUTIONS OF DIFFERENTIAL EQUATIONS ON A DIGITAL COMPUTER

Two methods were created for obtaining some plausible substitutions in first-order, first-degree, ordinary differential equations.

V. BOUNDARY BEHAVIOR

The boundary behavior of functions f(z) analytic in the unit circle, subject to the restriction that $\iint_{|z|<1} |f'(z)|^2\, dx\, dy$ is being considered. The conjecture is that, for approaches for which

$$1 - |z(t)| > |e^{i\psi} - z(t)|\, [\log |e^{i\psi} - z(t)|^{-1}]^{-1+\delta} \quad ,$$

$\lim_{z(t)\to e^{i\psi}} f(z(t)) = \lim_{r\to 1} f(re^{i\psi})$, except possibly for a set E with log cap E = 0.

VI. SCATTERING THEORY

Efforts to determine the structure of the resolvants of certain Hermitian operators arising in scattering problems are being continued. An attempt to find a unified treatment for both potential and boundary-layer scattering is under study.

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I. AUTOMATIC SPEECH RECOGNITION

A program has been developed to recognize the English fricative consonants |f| and |θ|. By combining a number of relatively unreliable cues, recognition scores of about 70 per cent have been obtained. A listening test is now being prepared that will enable comparison of the program's performance with that of humans on an equivalent task.

A word-recognition program using the segmentation and phonemic analysis programs currently available has been completed. The program has been tried out with a vocabulary of 46 simple words, but recognition scores are not yet available for any reasonable number of speakers. The number of words which can be reliably recognized at present is small, since the program now uses only the phonemic analysis routines for fricative consonants. The program is designed to allow new phonemic routines to be incorporated as they are developed.

Improvements are being made in the procedures for segmentation of continuous speech into syllables. An audio display facility has been programmed to enable one to listen to the stretch of speech which the computer interprets as a syllable. This facility will make it easier to evaluate the performance of the syllable segmentation program. Work is also being directed toward use of more of the results of the phonemic analysis programs in making syllable segmentations.

II. AUTOMATIC SPEAKER RECOGNITION

The speaker recognition program is in the final stages of check-out. The program is designed both to recognize speakers for whom data already exist in the computer and to learn to identify new speakers. The basic data for the recognizer are the vowel segments of about 80 seconds of speech from each of 15 subjects. The recognition procedure itself is an on-line, real-time system. When the microphone is turned on and the speech begins, the computer detects vowel segments, transforms their spectra and accumulates an average. At the end of each word, the input thus far is compared to the averages of "known" speakers. As soon as the input data are both close enough to one speaker and far enough from the others, an interim decision is typed by the computer and the accumulation continues. At the end of reading in speech, a final decision – either that the speaker is new to it or an identification – is typed. Finally, the operator informs the machine of the correct identification and the data are either added to that of the correct speaker or a new "known" speaker is formed. All systems except the identification of new speakers have been checked out and are working. About 50 trials at identifying known speakers have resulted in one error and one lack of recognition. The identification of new speakers depends critically on a parameter setting which will have to be determined through further experimentation.

III. AUTOMATIC LANGUAGE PROCESSING

The first version of the Baseball program is now in operation, although a few minor revisions are still required to put it in final form. A first draft of a report describing the program in detail has been prepared.

IV. HUMAN INFORMATION PROCESSES

Work has begun on the development of improved analytical procedures for the study of psychological similarity. In these procedures, observed degrees of similarity or difference are interpreted formally as estimates of the distance between stimuli in a multidimensional similarity space. The estimates of interstimulus distance are used to determine the configuration of stimuli in a Euclidean space of minimum dimensionality that accounts for the observable relations. Such multidimensional scaling procedures are ordinarily sensitive both to variations in procedures used to measure similarity and to variations in the function used to transform the similarity measures into estimates of distance. Computer programs have been written that yield solutions (stimulus configurations) that are substantially invariant over any monotonic transformation of the original measures. Given n stimuli, one program requires as data an entire set of $n(n-1)/2$ monotonically adequate distance estimates. A second program has been written for incomplete matrices, in particular, for the case where the stimulus set can be partitioned into two subsets with distance estimates available only between stimuli of different subsets.

Studies continue on human decision-making behavior on multidimensional stimuli. Subjects report vertical and horizontal displacement of a dot in the visual field, a simple psychophysical task. An analysis of the results shows that the criterion levels on each dimension differ markedly among individuals and are very sensitive to small changes in instruction. The analysis permits identifying interaction between dimensions at several levels of complexity. Results thus far suggest that the human judgment process may show radical qualitative changes as a result of apparently minor changes in instructions or in the physical parameters of the stimulus situation.

Several studies of human perceptual and memory processes are in progress. One study is concerned with the use of binaurally presented signals as an output for a reading machine. Two subjects are being trained to associate a letter of the alphabet with each of the 26 different signal sets, after which their ability to recognize letter sequences will be tested. Preliminary work with two observers on the ability to identify or discriminate overlapping, circular, normally distributed clusters of dots led to the discovery of minor distortions in the computer generated set of displays. A new distortion-free set is being developed.

An earlier experiment on the immediate recall of lists of digits heard in noise suggested that perception and memory are two independent processes. In this experiment, it appeared that the subject first decided the identity of each digit as he heard it and then attempted to remember the decisions. The ease with which the decisions could be remembered did not seem to depend on the ease with which they were made. Results of a second experiment indicated that the independence of the two processes may depend upon the rate at which the digits are presented to the subject. In order to permit increased rates of presentation without introduction of extraneous variations in the stimuli themselves, the TX-2 computer is now being programmed to generate the lists of stimuli.