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GRAPHICAL-DATA-PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION

FINAL REPORT

By

J. H. Munson

December 1968

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UNITED STATES ARMY ELECTRONICS COMMAND · FORT MONMOUTH, N.J. 07703

CONTRACT DA 28-043 AMC-01901(E)

STANFORD RESEARCH INSTITUTE
Menlo Park, California 94025

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GRAPHICAL-DATA-PROCESSING RESEARCH STUDY AND EXPERIMENTAL INVESTIGATION

REPORT NO. 33, FINAL REPORT

1 FEBRUARY 1966 TO 30 NOVEMBER 1968

SRI Project 5864

CONTRACT DA 28-043 AMC-01901(E)

Continuation of Contract DA 36-039 AMC-03247(E)

Prepared by

J. H. MUNSON

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA 94025

For

U.S. ARMY ELECTRONICS COMMAND, FORT MONMOUTH, N.J. 07703

ABSTRACT

The complete MINOS III facility has been delivered by SRI to USAECOM at Fort Monmouth, New Jersey, and demonstrated to the sponsor's technical personnel. Operation can be demonstrated under the control of three different computer programs: an operating program, a diagnostic program, and the CALM IV learning-machine program.

Accomplishments during the three years of the project are reviewed. Collected tables of contents are provided to guide the reader to appropriate references among the ten Quarterly Reports of the project.

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I ACCOMPLISHMENTS UNDER CONTRACT DA 28-043 AMC-01901(E)

A. Delivery of the MINOS III Facility

The complete MINOS III pattern-recognition facility, including the MINOS II learning machine, the SDS 910 computer, the 1,024-image preprocessor, the computer-controlled TV camera scanning system, and the extensive interface connecting these units, was delivered by SRI to the sponsor (UAECOM) at Fort Monmouth during November 1968. In the period from 2-13 December 1968, Dr. John Munson and Mr. Peter Johanson of Stanford Research Institute checked out the system at Fort Monmouth and demonstrated its operation to the sponsor's technical personnel, Mr. William A. Huber and Mr. Richard Loiselle. The same persons had also witnessed demonstrations of the operation of the equipment at SRI in late October 1968, before the system was shipped.

During both demonstration periods, the MINOS III facility successfully performed the full sequence of activities required for the pattern recognition of graphical data. These activities included scanning under computer control, selective attention and isolation of character images, edge-detecting preprocessing, and adaptive pattern classification. Hardware methods and alternate software methods were demonstrated for both preprocessing and classification.

The system performs under any of three functionally integrated computer programs. The diagnostic program affords a convenient means of checking out, unit by unit, the hardware components of the MINOS III facility. The CALM IV program, the descendant of a number of learning-machine simulation programs, allows extremely flexible control of the entire range of operations of both the hardware and software adaptive pattern classifiers (learning machines). The main demonstration and operating vehicle, the operating program, allows flexible control of any operating sequence involving scanning, hardware and/or software preprocessing, classification with MINOS II, and display of the data at various stages.

Complete documentation, running to several volumes, was included with the delivered system. The documentation included listings and operating descriptions of the three main computer programs and their myriad component subprograms, drawings of the MINOS II and interface circuitry, descriptions and notes for the facility subsystems, manuals for commercially manufactured equipment included in the facility, etc.

B. System Integration

The successful delivery of the MINOS III facility was the culmination of what may be called, from the hardware standpoint, the period of system integration. During the preceding contract,* emphasis was on equipment-building, and the major elements of the MINOS III facility--the MINOS II learning machine, the 1,024-image preprocessor, the SDS 910 computer, and the TV camera input--were all built or acquired. These units were not tied together, however, in a fully operating system; thus patterns could not be carried through the scanning, preprocessing, and classification operations in a single run. In particular, it was not possible for patterns scanned by the TV camera and isolated in the computer to be presented to the 1,024-image preprocessor.

During the present contract, under the impetus of our experimental needs, this integration of the system components was completed to produce the MINOS III facility. The integration of the facility has yielded a degree of operating convenience in running experiments and demonstrations that far exceeds what was possible in the previous modes of operation.

C. Experiments in Hand-Printed Text Recognition

Our major effort in the present contract, aside from system-building, went into experiments aimed at applying the facility to a potentially important problem: the automatic recognition of texts of hand-printed characters on coding sheets. We believe that our research broke new ground in several areas. First, of course, was the use of the particular techniques embodied in the MINOS III facility to perform experiments on a significant body of hand printing. Second, we found a striking

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*DA 36-039 AMC-03247(E). The final report for that project is available as an ASTIA document, AD 632 563.

improvement in performance in going from multiple-coder recognition to single-coder recognition, and an additional improvement when we harnessed multiple-pattern views and multiple preprocessor classifier combinations in parallel. Finally, we performed a pioneering study on the use of context in a specific language to improve recognition performance.

Our work was described and summarized in a pair of technical papers presented at the 1968 Fall Joint Computer Conference, as well as being described throughout the Quarterly Reports of this project. The papers appear in the Conference Proceedings under the common title of "Experiments in the Recognition of Hand-Printed Text," with Part I, "Character Recognition," by J. Munson, and Part II, "Context Analysis," by Richard O. Duda and Peter E. Hart. The support of the USAECOM for this project is acknowledged in both papers. During the session on "Hand-Printed Character Recognition" at the conference, the papers were presented to a standing-room-only audience of over 200 persons.

II COLLECTED TABLES OF CONTENTS

The work performed during this project has been described in detail in the ten Quarterly Reports issued during the project. As a necessary consequence, the overall arrangement of material is chronological, rather than by subjects. In order that this Final Report constitute a convenient first point of reference for the various subjects--hardware subsystems, classification experiments, context experiments, etc.--we collect below the Tables of Contents from the ten Quarterly Reports. The reports pertinent to any subject area can be determined by scanning the collected contents.

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