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Memorandum M-1584

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Digital Computer Laboratory  
Massachusetts Institute of Technology  
Cambridge, Massachusetts

SUBJECT: QUARTERLY STATUS REPORT, CONTRACT N5ori-06002  
JANUARY through MARCH, 1952

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This report is a survey of the work done on ONR project NR 232-001, under the extension of Contract N5ori-06002, for the first quarter of 1952. Work is continuing on application of the computer to a control system. During this period work on the problem of describing linear computer operations has been completed, further design techniques have been developed on feedback control systems involving digital computers, and work is continuing on non-linear operation of the computer.

In connection with description of linear computer applications, experiments have been completed on the application of the Wiener-Lee statistical filtering technique to the radar data smoothing problem. A report R-210<sup>1</sup> is being published which summarizes the general results of this work and a Memorandum M-1438<sup>2</sup> describes specifically the application to the data smoothing problem. A condensed summary of the doctoral thesis<sup>3</sup> of John Salzer is being written and will be published as a report. The work described digital computer operations in the frequency domain. This work along with the work on the Wiener-Lee optimum linear system design allows one to handle with circumspection all the linear operations of the computer.

The theoretical study on feedback control systems using digital computers as components applies the frequency-domain description of computers and allows one to draw striking parallels between continuous and sampled-data servomechanisms. An equivalent circuit approach was developed which allows similar simplifications of sampled-data servo block diagrams to those used in conventional servomechanisms. A master's thesis<sup>4</sup> is being written this term on a simplified speed-control problem in which a radar set measures aircraft position at a regular sampling rate and a digital computer calculates throttle settings for the airplane engine so as to maintain a time schedule along a straight-line path. For this particular problem the dynamics of the speed-control system of the aircraft turn out to be so slow that no special problems arise because of the sampling of the position measurement. It turns out to be necessary to compensate the control system in order to reduce its velocity error coefficient. A simple direct approach is used to indicate how serious quantization errors are in measuring position of the aircraft.

The non-linear applications of the computer studies so far deal mainly with its ability to make choices. The radar-data processing problem

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which has been handled by linear filtering techniques is also being studied from a more general point of view. The point of view adopted in this study is that the path of an aircraft may be specified by a sequence of values of position and velocity governed by a set of probability distributions (this set is derivable from physical considerations). The radar data which will be received for a given path may also be described by a set of probability distributions which takes into account both noise and quantization. These assumptions lead to an expression for the a posteriori probability distributions of the desired quantity (e.g. present velocity or next position) in terms of the given sets of a priori probability distributions and the observed radar data. From this expression, it is possible to choose a "best" value of the desired quantity in accordance with any desired criterion (least mean square error or most probable value). Thus far, the formal mathematics for arbitrary sets of probability distributions have been worked out. It still remains to find the appropriate distributions corresponding to the physical situation and possibly to work out convenient approximations to simplify the mechanization of this method. Whether the proposed approach is ultimately useful depends largely upon how realistically a simple and manageable set of probability functions can characterize the data. One simplified example has been worked out, coded for Whirlwind and tried on some typical target paths. The results are described in Memorandum M-1492<sup>5</sup>.

Signed William K. Linvill  
William K. Linvill

WKL:sfc

References:

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3. Salzer, J.M., Treatment of Digital Control Systems and Numerical Processes in the Frequency Domain, 1951, M.I.T., Sc.D. Thesis in Electrical Engineering.
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5. Cooper, Gerald, Limit Mean Smoothing, May 16, 1952, Memorandum M-1492, CONFIDENTIAL, Digital Computer Laboratory, M.I.T.

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