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Memorandum M-1155

Electronic Computer Division
Servomechanisms Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: BI-WEEKLY REPORT, PROJECT 6782, JANUARY 19, 1951

To: J. W. Forrester

1. GENERAL

(R. A. Nelson)

The NDRC material mentioned in the previous bi-weekly has all been looked over. A fair amount of it was of interest to this project; several other reports were removed for 6673 and the Laboratory in general and were incorporated in the Barta Library. Prof. Hazen has now decided to keep the rest of the material somewhere at MIT instead of having it sent to Wright Field.

Some time was spent also in going over material of the RDB's Scientific and Synthetic Analysis Committee, whose Air Defence Panel has finally issued its report. A few items of possible interest to 6673 were separated, and the rest will be returned to Washington.

Work has been started on the draft of our second quarterly report.

2. THE FIRE CONTROL PROBLEM

2.1 Data Smoothing and Target Position Prediction

(R. A. Nelson)

Not much time was spent on the prediction problem this period. The constants for helical flight were derived from knowledge of the target's position at three instants. Their evaluation by WWI appears more complicated than that depending on the knowledge of the target's velocity and acceleration (mentioned in the last bi-weekly) although computing smoothed values of velocity and acceleration may more than offset this difference. The situation was simplified by the assumption that the position readings referred to $t = -T, 0,$ and $+T$.

2.2 Ballistic Considerations

(A. Katz)

For some time we have been concerned with the problem of storing the large quantities of empirical data which comprise the firing tables. Since the data of interest are, in general, functions of two variables -- predicted range (R2) and predicted elevation (E2) -- one possible approach is to pass on approximating surface through the data and evaluate the expression:

$$f\,(R2,\ E2) = f_1(R2) + f_2(R2)\ f_3(E2)$$

This method was used with success in establishing the approximating polynomial representing the relation of normal superelevation (Vfn) to R2 and E2. Using third degree polynomials for R2 and a second for E2, I obtained computed values for Vfn which agreed well, within practical limits, with the empirical data except at long ranges (R2 $>$13000 yds). The resulting polynomial may be coded in 24 orders and 15 storage registers. By using a fourth degree polynomial for R2, the degree of fit would be improved considerably at the longer ranges. This would require 28 orders and 17 storage registers, and would effectively represent a table of 449 data.

In the next bi-weekly period I propose to raise the degree of the polynomial for R2 to four and to convert the resulting polynomial in normalized coordinates to one in E2 and R2. I shall then investigate the feasibility of storing the entire table in an external magnetic drum as an alternative to the use of approximating surfaces.

3.0 CODING

(J. M. Dodd)

Except for the equations in the Ballistic Section, the Mark 47 coded program has been completed, but not yet typed. The equations solved have been listed in order and are available in ozalid form.

The present solution is for the problem involving one target, one director, one computer, and one gun. No provision is made for tracking initiation. Target position is assumed to vary as a linear or parabolic function of time. Further assumptions:

Maximum range	32,768 yards
Maximum velocity	512 yds./sec. (910 knots)
Maximum acceleration	64 yards./sec.^{2} (5.96 G)

3.0 CODING (continued)

(J. M. Dodd) (continued)

Other points: 1.) The digital approximation to Mark 47's analog differentiation assumes that the quantities operated on are linear functions of time. 2.) Smoothing, following Mark 47's solution, is single exponential for velocities and double exponential for accelerations (both with respect to unsmoothed position data). 3.) the tendency in programming has been to consider more important the minimization of solution time rather than of storage requirements.

No study has been made of the accuracy of the present coded program. This will probably be done for some individual sections at some later time; but an investigation of overall accuracy (and stability) of the solution by ordinary theoretical methods is out of the question. However, the quality of the solution may be determined to some extent by running test sequences from the program in WWI.

It may be possible to carry out a theoretical study (in the frequency domain) of accuracy and stability by means of techniques now being developed by John Salzer. Such a study would be closely allied to the problems of improving the operations of differentiation , smoothing, and prediction.