Mulchman

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Memorandum M-1100

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

SUBJECT: BI-WEEKLY REPORT, PROJECT 6782, SEPTEMBER 15, 1950

To: J. W. Forrester

1. GENERAL.

(R. A. Nelson)

Abraham Katz, a new research assistant, is joining the project, starting specialized orientation to our work on Monday, September 18.

2. THE FIRE CONTROL PROBLEM

2.1 Data Smoothing and Target Position Prediction

(R. A. Nelson)

During the first week of the period I continued studying the monograph on smoothing by Blackman, Bode, and Shannon.

(J. M. Dodd)

Future target position prediction involves the extrapolation of a weighted average of past target data. Though not the most highly recommended, one of the most elementary types of prediction is based on so-called "exponential smoothing" in which past data is weighted according to a decaying exponential function (diminishing in the direction of past time). It appears that exponential smoothing is admirably well suited to Whirlwind and that a program for it will require only about 4 to 6 orders per quantity to be smoothed for each receipt of new data (assuming constant time intervals between receipt of data).

Further investigation along this line will be carried out as time permits. Apparently it will also be relatively easy for Whirlwind to smooth data on the basis of a weighting function composed of the difference of two decaying exponentials, or a weighting function which is the product of a decaying exponential and a linear term.

2.3 Coordinate Transformation

(J. M. Dodd)

The exact expression for deck tilt correction (difference between target bearing as measured in the deck plane, and as measured in the horizontal plane) has been evaluated for various amounts of deck tilt from 0° to 30°. In this range, the correction is sometimes as great as 15°.

For values of deck tilt up to 20°, the correction given by the approximate expression used by Computer Mark I is in error (as compared with the exact expression) by as much as 1.5°. A modified approximation has been developed which reduces errors in this range to less than 0.5°.

3. CODING

(J. M. Dodd)

Both exact and approximate expressions for deck tilt correction have been coded. Length of these programs is as follows:

Exact expression	161 orders
Approximate expression	56 orders

About half of the equations used by Computer Mark 47 have been gathered and coded, on the basis that all independent variables appearing in each expression have been previously computed or measured. Actually, however, some of these relations (particularly in the Ballistic and Prediction sections below) are based on empirical data and occur as sets of simultaneous non-algebraic equations. It appears that the present codes for these will have to be revised in order to permit a complete solution. Lengths of the sections of Mark 47's overall solution which have been coded are as follows:

	Main Program	Sub-routine
Present Position Section: converts from unstabilized (deck) coordinates to stabilized (earth) coordinates (includes exact expression for deck tilt correction plus evaluation of five other related quantities).	70 orders	140 orders
Apparent Wind Section: computes components of ship motion and wind velocity.	23 orders	70 orders

3. CODING (continued)

	Main Program	Sub-routine
Ballistic Section: computes time of flight and superelevation, and correction to these quantities to allow for non-standard conditions.	496 orders*	35 orders
Prediction Section: combines target motion (including acceleration) and ballistic effects to predict position of target when projectile reaches it.	73 orders	214 orders

* Includes evaluation of 12 functions below by a standard sequence of 38 orders each.

Coding of the ballistic section assumes--and the assumption has not yet been justified--that 12 of the ballistic functions involved (which are all functions of two variables, according to the Mark 47 report) may be represented as

$$f_1(x, y) = f_2(x) + f_3(x)\, f_4(y),$$

where f_2, f_3, and f_4 are polynomials of fifth degree or less. Such a representation was suggested by a note in Everett's work on the fire control problem.

Sections of the Mark 47 treatment of the AA fire control problem which have not yet been coded are:

Linear Rates Section: computes and smooths velocity and acceleration of target.

Parallax Correction Section: corrects for parallax between gun director and gun stations.

Gun Order Section: converts computer gun orders from stabilized (earth) coordinates back to unstabilized (deck) coordinates. (Includes "trunnion tilt correction" mentioned in last Bi-Weekly.)

Fuse Section: computes fuse setting order.

cc: R. R. Everett
H. Fahnestock
W. G. Welchman
C. R. Wieser