LINES: A COMPUTER PROGRAMME FOR THE ANALYSIS OF SPIRAL READER MEASUREMENTS OF STRAIGHT LINES

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Introduction

The purpose of the program LINES is to analyse data from straight line measurements from a spiral reader. By studying the residuals to a fitted line important information about distortions and other systematic effects can be obtained. The residuals might also be useful for the correction of event measurements since they contain detailed information about the distortion in narrow radial intervals. The programme also offers the possibility of making circle fits. The distortions on the Danish-Swedish Spiral Reader are however not fully described by simple circles which can be shown with a statistical sign test of the residuals from such a fit.

The measurement procedure

The measurement is performed in almost the same way as a chicken walk measurement. The glass plate with the engraved lines is placed in the position of the lower clamping plate. The orientation of the plate is such that the lines go in the direction of the X and Y axes respectively. The spiral is centered on the intersection between the lines, and the speed of the periscope is kept constant at 110 rcounts/rev. The operator puts four crutch points, two on each side of the vertex, on either the line in the X-direction or on the one in the Y-direction. This makes it possible to study how well one can expect that a crutch point falls on a track in a real event measurement.

Filtering of the data

The first step in the filtering procedure is to select digitizings in a θ-interval that is big enough to ensure that all digitizings belonging to the line fall inside the interval but narrow enough to prohibit too many spurious digitizings to be selected. The programme then fits a straight line $y = ax + b$ to the selected points the coordinates of which have been transformed from R and θ to X and Y. Points with a residual of 15 counts or more are removed and the line is refitted until all points fall within the limits. Normally only two or three points out of 160 are thrown away. Because of the difficulty to fit a line in the direction of the Y-axis where a becomes infinity, the fits are performed in a system that has been rotated 45° with respect to the SR-system.

Least square fits of the lines taken two by two

While in the first fit procedure each of the four lines was treated separately they are in the final fit combined two by two i.e. the forward and backward lines in the X-direction and the left and right going lines in the Y-direction are fitted together. The advantage of this joint fit is that also e.g. slit offset effects can be studied and also included in the residual table. The total number of points along such a line is about 350 and standard deviation before any correction is applied is about 2 xy counts.

Residual plots

One of the main reasons for starting the line measurements and for putting effort into the program LINES was that we felt that a straight line is an object that resembles a beam-track more than e.g. a series of crosses. By studying the distortion of a straight line important knowledge about the distortion of the beam tracks[1], could be gained. To make these studies possible and fruitful it is necessary to extract the significant information and present it in such a form that it is easy to see what is systematic effects and what is random fluctuations.

We have found that a plot on the line printer of the mean residual over an interval of 500 r-counts i.e. 4-5 points gives a good picture of the systematic effects, an example is given in Fig. 1. The effect of the averaging is that random fluctuations become less important so that the systematic effects can be seen more clearly. The interval is small enough to make variations of the distortion inside the interval unimportant and all important details can thus be displayed in such a plot. The advantages of this method for studying distortions compared to the chicken walk one are obvious. In the chicken walk method an average is taken over an interval of 2000 r-counts which is so big that important details will be lost. It is for instance impossible to describe the rather sharp hook in a region from 250-2250 r-counts by measuring a cross the center of which is at 2500 r-counts and the length of which is 2100 r-counts. That the residuals from LINES when applied to real measurements give good results for $\frac{1}{\rho}$ is shown in the report on calibration[1].

Correction of measurements by the use of residuals from LINES

The reisduals from LINES do of course not contain any information about radial distortions. This is not a serious disadvantage since the accuracy in the radial direction is of almost no importance in real event measurements compared to the importance of having good accuracy in the θ-direction. Because of this the residuals from LINES are applied as corrections not on the transformed X-Y co-ordinates, which is customary when applying the chicken walk residuals from SCALP[2], but on the raw θ value. The residual value ΔY corresponding to the actual R-value is calculated by linear interpolation between the values on each side and a small angle $\Delta\Theta=\Delta Y/R$ is added to or substracted from the raw θ value, depending on whether or not the point is in the forward or backward cone. This method has turned out to give good results both for other measurements on the straight lines themselves than those upon which the correction table was based and for beam track measurements at 19 GeV/c. A disadvantage with this method is that it can only be used in the forward and backward directions and in the directions perpendicular to these. This difficulty might be overcome by the use of a plate with several lines in a star pattern or if the straight line could be rotated in its holder.

References

1. Calibration of the Danish-Swedish Spiral Reader (SAAB-type). Contribution to ESRS, Stockholm 1972.

2. SCALP, The Spiral Reader Calibration programme, E.H. Eichmann, CERN/D.Ph.II/69

FIT OF LINES 1 + 3 TOGETHER
332 POINTS COEFFICIENTS IN Y=AX+B, A = 9,85888-001 B = 4,53541-001 SIGMA = 2,11102+000

PLOT OF LINES 1 AND 3 TOGETHER 10 STEPS = 1 XY-COUNT

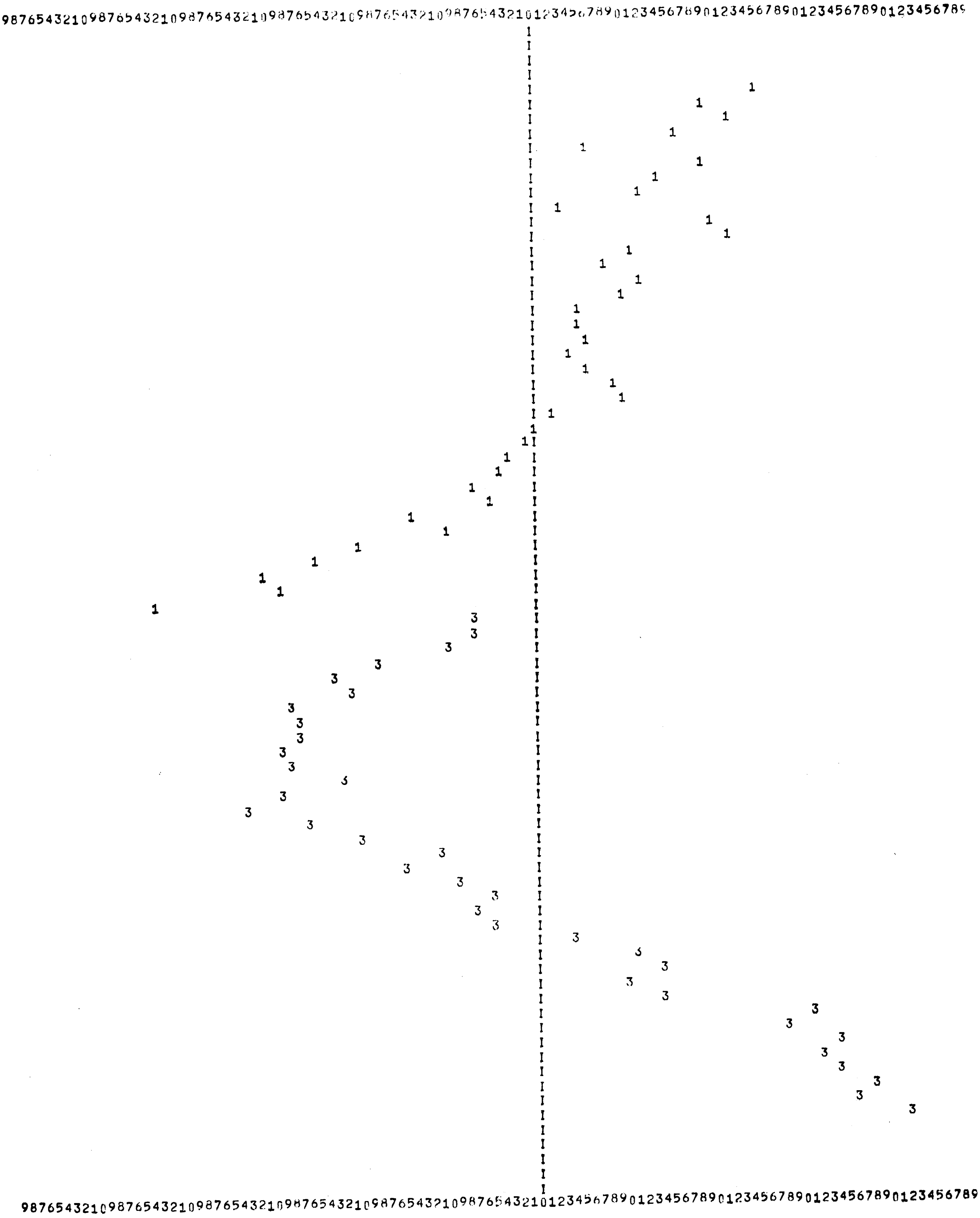

Fig. 1