QUALITY ESTIMATION FOR DIGITIZED FEATURES-A NEW APPROACH

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1. ABSTRACT

In most of the digitized features there is not a one to one point correspondence. Then conventional methods for quality estimation can not be applied.

The ISP, through its Working Group I,Comission IV, turned to this prolem and some research was done. The results, presented at the XIVth Congress of the ISP Hamburg 1980, pointed some difficulties and recommended further investigations.

This work presents a new approach for improving quality estimation in such circumstances. This approach was implemented in a computer program and / tested. The results are shown.

2. INTRODUCTION

At any developed region there are many man made objects or part of them / which can be represented in a map by a single line. The number of them is still greater in urban regions. Along this paper we refere to those objects as linear features or simply as features or entities.

The linear features have two important characteristics: they are quite / perenial compared to control points; locating a point on a feature is / usually done more easily and precisely than locating a specific point in photogrammetric measurements.

At a time when the trend of digital mapping application increases, the use of those features as control become attractive. Its potencial was investigated and the feasibility was demonstrated (1), (2), (3).

The knowledge of the quality of the digitized entity is important for/ general purpose applications and even more important in the case of control application.

Estimating the quality of the digitized entities is quite attractive. The Photogrammetric Community turned to this problem. Research was done by WG-I, Commission IV, and at the ISP Hamburg's Congress, an invited paper was presented on the subject (4).

The pointed difficulties in estimating the precision of digitization of linear continuous features and the recommendation of further investigation motivated this work.

3. LINEAR FEATURES PRECISION

The problem of estimating the precision of observed quantities, or obtaining precision or accuracy for computed parameters is a well studied one, for the case where a one to one point correspondence between the spaces exists.

In the case of digitization of linear continuous features, the is no a one to one point correspondence because the continuous object is represent

ed by a discrete set constituted of some of its points. These points are generically, non identifiable and they are usually digitized in time mode.

If, for the sake of illustration, we represent by "+" and by "o" the points digitized in two independent digitizations of a feature f, the recorded points on the object could look like shown in Figure 1.

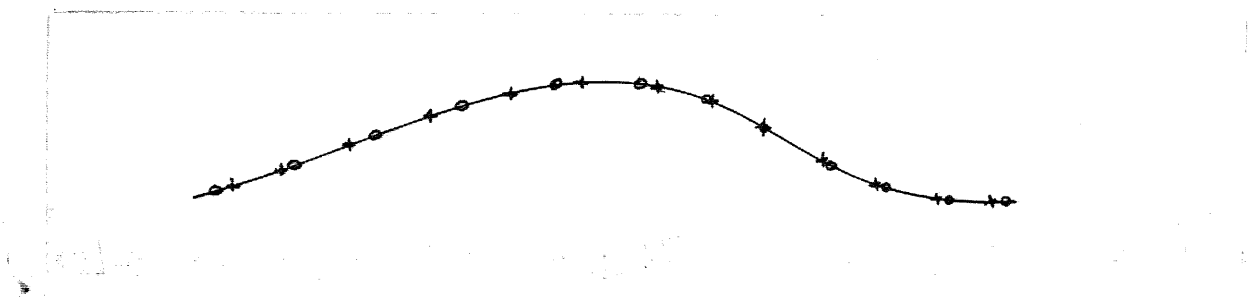

FIGURE 1. Points from two independent digitizations of the same continuous linear features usually do not coincide.

Even between two error free digitizations there are discrepancies between coordinates of digitized points. In other words, the discrepancies between digitized points can not be used for quality estimation.

In the WG-I referred paper, two methods are proposed, for estimation of planimetric accuracy. The Area Method estimator, given by

$$e_a = \frac{A}{L}$$

where A is the bounded area over the length L of the two digitizations of the tested entity; and the Generated Point Method, in which a correspond - ence of points of the two digitizations is assumed for points generated in both streams by dividing the total length by a certain number of intervals. The estimation is made based on the distance between "corresponding" points

$$e_g = E(e_{g_i})$$

and

$$e_{g_i} = \left((X_i - X_i')^2 + (Y_i - Y_i')^2 \right)^{1/2}$$

where E is the mathematical expectation.

The Point Method gives an over estimation of error due to inadequate correspondence of points, and the Area Method underestimates the error when shifts along the length occurs.

4. PROPOSED APPROACH

Since a corrected correspondence of points can not be obtained, there is no ideal solution for the problem, and improvements of the estimation should be investigated.

In order to face the difficulties, some assumptions are made:
a) two digitizations of a feature can only be compared, for the sake of quality estimation, if they are at a uniform scale with similar generaliza-

tion;
b) two entities are coincident if the two continuous curves with minimum curvature passing through their digitized points, computed for each digitization, are coincident. Any discrepancy between these curves is accounted as error;
c) the continuous line features are smooth. There are no sharp corners on them;
d) the digitized points of the independent digitizations, were transformed into a unique reference system through a length invariant transformation;
e) both streams are free of blunders and large systematic errors.

Let's assume two streams of points, as illustrated in Figure 2 below, representing two independent digitizations A and B, of a feature. Both sets of points have the coordinates of their points referred to the same system xy.

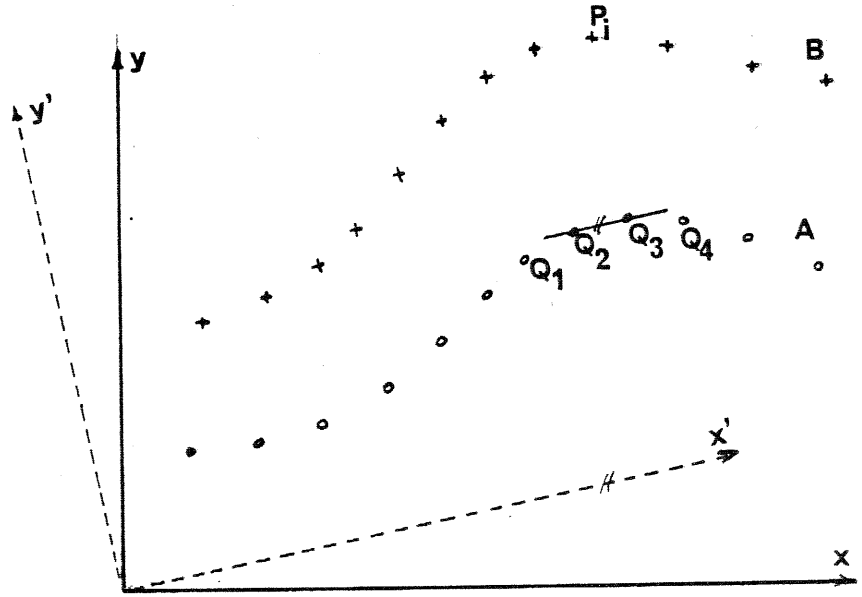

FIGURE 2. A and B are sets of points digitized in two digitizations. All given coordinates are referred to the xy system.

Let's select, in A, the four points Q_j, j = 1,4 closest to P_i of B and transform the (x,y) coordinates of these five points into a rotated system x' y' , where the x' axis direction is given by the direction of the segment Q_k Q_{k+1} (Q_k and Q_{k+1} are the two points closest to P_i).
A continuous curve is obtained for the region Q_j, j = 1,4 of the A stream, by using Q_j as nodes for a spline fiting as illustrated in Figure 3.

Through this spline function, and the input argument x'_{p_i} , the ordinate $y'^{*}_{p_i}$ is interpolated.
The misclosure

$$W_i = Y'_{Pi} - Y'^{*}_{Pi}$$

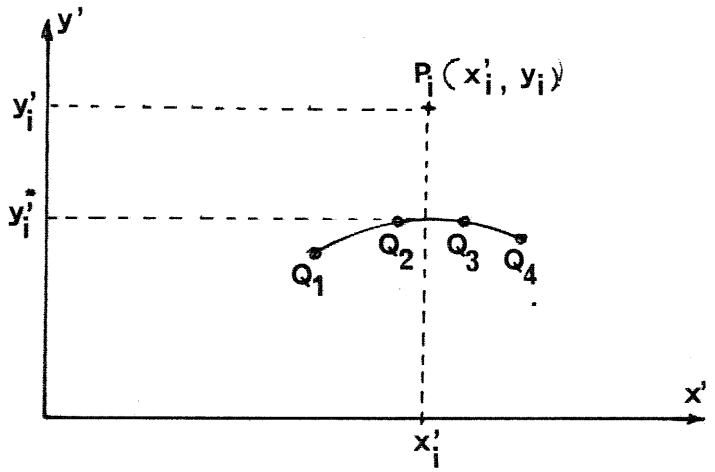

FIGURE 3. Spline interpolation of the Y'^*_i

is estimated for all the points P_i of B, except for the extreme points of the set (this is to avoid extrapolation).

These misclosures W_i seem to be a good measure for the discrepancies. The average and the RMS error were estimated from it.

5. TESTS AND RESULTS

The presented method was implemented in a computer program and tested twice. First, three pairs of digitizations made for the ISP test were processed and the results are presented on Table 1, together with results obtained by the WG-1. The table is self explanatory.

TABLE 1. Estimate Precision for Digitized Entities

ENTITY (DIGITIZ.PAIR)	ISP TEST RESULTS		NEW APPROACH RESULTS		
	Average cm	RMS cm	Average cm	RMS cm	BIAS cm
1	54	160	65	94	0
2	48	102	51	68	-28
3	68	138	74	118	3

In a second test, the approach was used to estimate the quality of ground

planimetric coordinates, obtained from correcting the Skylab image (frame 03-151 of the S-190B Earth Terrain Camera, approximate scale of 1:950 000).

The model used to parameterize the distortion was the projective trans - formation, whose parameters were computed using conventional control (results given in columns 2 and 3); using curve features as control (columns 4 and 5) and using straight features as control (columns 6 and 7).

In Table 2 a comparison can be done betwen the presented approach of quality estimation (the two first rows of the results were obtained through this feature approach) and the well known check point method that was used and is presented on the third row.

TABLE 2. Quality of Ground Coordinates Transformed from the Skylab Image through Linear Transformation.

METHOD USED FOR QUALITY ESTIMATION	METHOD USED TO COMPUTE TRANSFORMATION PARAMETERS					
	CONVENTIONAL		9 CURVE ENTITIES		9 STRAIGHT ENTITIES	
	AVERAGE m	RMS m	AVERAGE m	RMS m	AVERAGE m	RMS m
CHECK FEATURES	20	23	22	26	18	26
ALL FEATURES	20	23	26	29	22	25
CHECK POINTS			22	26	21	27

6. CONCLUSIONS

The results obtained in the first test (Table 1) seems to confirm what was expected, to minimize the over or under estimation of discrepancies pointed by (Masry et al 1980).

The second test shows that this new approach gives results comparable to the conventional check point. It shows additionally that features can be used as control.

7. REFERENCES

(1) LUGNANI, J.B. "Using Digitized Entities as Control". Ph.D. Thesis, Department of Surveying Engineering, U.N.B., 1979.

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(4) MASRY, S.E. et al. "Accuracy and Time Comparisons of Digital Maps - an International Test". Presented at ISP 14th Congress, Hamburg (1980).